Spring 2016

Oregon Wine Research Institute
Viticulture & Enology Technical Newsletter

Welcome to the Spring 2016 Newsletter

Our latest edition of the OWRI Technical Newsletter contains helpful Extension information, updates and research discoveries. Dr. Jay Pscheidt, Professor and Extension Plant Pathologist, OSU, opens the newsletter with an article about the potential effects of climate change on powdery mildew; a timely topic for the 2016 growing season. Dr. Bob Martin, Research Plant Pathologist (Virology), USDA-ARS provides a research update on grapevine red blotch disease that provides growers with tools on how to identify and test for the disease. Dr. James Osborne, Enology Extension Specialist, OSU, discusses the importance and concentration of nitrogen on wine aroma. Lastly, please read our guest piece from Marie Vicksta, Yamhill Soil and Water Conservation District, for an update on the recycling tunnel sprayer program.

Make sure to check out the practical guides and resources section. We have some fantastic new resources, most of which are available online.

Cheers,
The OWRI Team

Will Climate Change Powdery Mildew?

Dr. Jay W. Pscheidt, Professor of Botany and Plant Pathology and Extension Plant Pathology Specialist, OSU

This is not an article about climate change, but it is about powdery mildew. The last two summers have been characterized as unusually hot. During 2014 in the Willamette Valley, however, we never got over 100°F. It is not unusual to break 100°F for a stretch of time in July or August most years anywhere in Oregon. During 2014 we had many days over 90°F where temperatures rapidly increased to over 90°F shortly after sunrise and stayed there until near sunset. This was uncharacteristic for most of the state and was noticeably hot by everyone's standards. The summer of 2015 was literally the hottest on record for the Pacific Northwest since records have been collected starting in 1895.

We also noticed that powdery mildew pressure in our research blocks was uncharacteristically low in 2014 but "normal" (=very high) in 2015. We found the first infections of the 2014 season on June 2, which was about the average over the last 22 years. In the past, we have found powdery mildew

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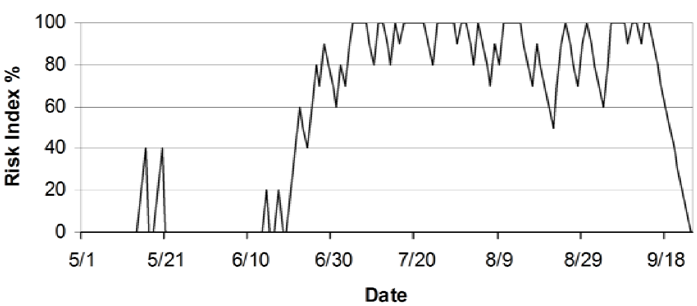
as early as May 13 or as late as June 28. During 2014, the disease did not increase as rapidly as it usually does. By verasion we still managed to have 100% incidence and about 50% severity on vines that had no fungicides applied. In 2015, powdery mildew first appeared on May 4, the earliest ever.

Almost every year we have the same pattern of climate that is outrageously favorable for powdery mildew development. There are nuances of rain, humidity and temperature that interact all season to affect how this fungus develops. A good way to look at it is with the Gubler-Thomas model (Gubler et al. 1999) that calculates a powdery mildew risk index (Figure 1).

Figure 1. Gubler-Thomas grape powdery mildew risk index for the 2009 growing season.

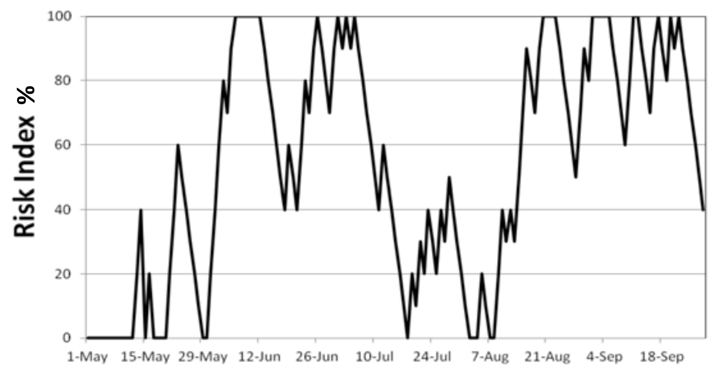


The pattern in 2009 is typical for the Willamette Valley where the risk index climbed above 60% on June 22 and remained high throughout the summer until mid September (Figure 1) (Pscheidt and Bassinette 2009).

The real value of this model is in potential fungicide savings. Spray intervals between fungicide applications can be lengthened when the risk index is intermediate or low. The risk index typically drops below 60% when a cool weather system, or a heat wave, dominates the region. These periods inhibit spore and subsequent disease development. Rather than spray every 7 days with sulfur, or 14 days with synthetic fungicides, a grower can lengthen the time before reapplication to 14 days for sulfur and 21 days for synthetics under low risk situations. In theory, the end result is fewer overall fungicide applications.

Generally, the index is always high once we begin our fungicide applications. The few days that it drops below 60 is not enough to delay an application, as the risk quickly returns to a high level. The result for growers in the Willamette Valley is the need to apply fungicides on short intervals and thus making many applications. However, the risk pattern in 2014 was different (Figure 2) (Pscheidt and Bassinette 2014).

Figure 2. Gubler-Thomas grape powdery mildew risk index for the 2014 growing season.



The risk index during the 2014 growing season was typical for May and early June; varying from 0 to 60 during May then rising above 60 by early to mid-June. However, by mid-July the index moved to below 50 until mid-August. It then returned to the typical high risk of infection from the end of August through September (Figure 2). That month-long drop in the risk index was due to a combination of cooler temperatures in part of July followed by sustained weather over 90°F during that period. The temperature was cool in the mornings but rapidly transitioned through favorable temperatures to remain high for much of the day before rapidly descending again in the evening.

If you normally use sulfur and were not aware of the month-long drop in the risk index you would have been spraying every week (like any other year). But monitoring the risk index would have allowed you to extend the interval between sprays to 14 days saving you at least two applications!

The hot summer of 2015 had a risk pattern more typical to

2009 but had an 11-day drop below 60 (Pscheidt and Bassinette 2015). You might have saved a spray by lengthening the reapplication interval at this time. The point is that just because it is a hot summer does not always translate into unfavorable powdery mildew weather.

So what will the powdery mildew risk index do in 2016? No matter your stance on the climate change debate, the powdery mildew fungus will react to whatever weather comes its way. Will you be monitoring the weather to take advantage of unfavorable periods? In the past, I might have said there was no need. Today, I think it might be very wise.

Note: Several forecasting programs are available for scheduling fungicide applications. The standard Oregon phenology-based program begins applications at 6 to 8 inches shoot growth and continues at regular intervals based on grapevine development. The Gubler-Thomas (Gubler et al 1999) program uses leaf wetness and temperature early in the year to predict ascospore infection periods and only temperature during the summer to predict conidial infection periods. The New York (Gadoury) program is based on rainfall and temperature. The Kast (Oi Diag) program incorporates relative humidity along with temperature and rainfall. All programs have been effective at timing fungicides and controlling powdery mildew in western Oregon. Additional models have been developed in Canada (Carisse) and Italy (Caffi et al 2012) but may not be effective in the PNW. The use of rose bushes at the end of rows is based only on anecdotal accounts and has no basis in the scientific literature.

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Grapevine Red Blotch Disease

Dr. Robert R. Martin, Research Plant Pathologist (Virology), Research Leader, USDA-ARS, OWRI Core Faculty

Background

More than 70 virus and virus-like agents infect grapevines worldwide but relatively few of these occur in Oregon. The major grapevine viruses that cause disease in Oregon are Grapevine red blotch associated virus (GRBaV), the Grapevine leafroll associated viruses (GLRaVs) and Tomato ringspot virus (ToRSV). Grapevine rupestris stem pitting virus is also common but has little to no detectable impact on yield and fruit quality.

In 2008, GRBaV symptoms were described in Cabernet sauvignon in Napa Valley. During a multi-state (CA, OR, WA) research project conducted from 2008-2011, many vineyards had 'leafroll-like' symptoms but tested negative for all known leafroll viruses. Samples from the GLRaV study were then archived for future use and identification. In 2012, a new virus was identified in Cabernet franc in New York's Finger Lakes region, and again in Cabernet sauvignon in the Napa Valley. Plants exhibited leafroll-like symptoms but tested negative for leafroll viruses. At a meeting of the *International Committee on the Study of Viruses and Virus-like Diseases of Grapevine* in October of 2012, researchers agreed upon the name Grapevine red blotch associated virus (GRBaV) and Dr. Mysore Sudarshana, USDA-ARS in Davis, CA provided a molecular diagnostic method to detect the new virus in the field.

In the winter of 2012-2013, nucleic acids (DNA and RNA) from the Oregon archived samples were tested with the molecular diagnostic method for GRBaV. Samples from the Rogue, Umpqua and Willamette Valleys tested positive for GRBaV, with the majority of the positive samples came from the Rogue Valley. The virus was detected in red-fruited cultivars (Barbera, Cabernet sauvignon, Cabernet franc, Grenache, Malbec, Merlot, Pinot noir, Syrah and Tempranillo) and in white-fruited cultivars (Chardonnay, Pinot gris, Roussanne, Semillon and Viognier), which indicates that the virus is widespread in Oregon vineyards.

Symptoms

The symptoms of GRBaV virus are easily confused with those caused by GLRaV. In red-fruited cultivars, red blotch symptoms start in late July and August as irregular interveinal red blotches on the lower leaves and the veins may turn red or remain green. The leaves generally do not show the downward rolling margins often seen with leafroll disease shown in Figure 1.

Figure 1. Downward rolling margins often seen with leafroll disease in Merlot. Note the reddening of leaves. Other foliar colors vary depending on the grapevine variety.

As the season progresses, the reddening increases and symptoms develop higher in the canopy, similar to the symptom development pattern seen with GLRaVs. Of the viruses and viroids known to infect grapevines worldwide, only GRBaV and GLRaVs are known to cause such symptoms, and more importantly to cause reductions in soluble solids in the fruit in some vineyards (figure 2).

Figure 2. Symptoms of red blotch: Red blotches and specks appear on leaves of infected red wine cultivars, sometimes accompanied by reddening of veins underneath the leaf blade or cupping.

Figure 3. Chardonnay often exhibits leaf rolling and a yellowish color by late in the season when leafroll disease is present.

In white-fruited cultivars, it is difficult to recognize red blotch symptoms as infected vines develop irregular chlorotic areas that may become necrotic late in the season in some cultivars. It is impossible to distinguish between leafroll and red blotch based on symptoms alone (Figure 3). Only testing can identify which virus is present. Research identified Grapevine red blotch associated virus in herbarium samples from California collected in 1940, demonstrating that the virus has been around for at least 75 years in California vineyards. It has been detected in Pinot noir plants that were planted in the 1970's in the Willamette Valley. The infected block is surrounded by other clones of Pinot noir and Chardonnay that were planted at the same time but are not infected, suggesting that the plants were infected at planting.

GRBaV is widespread in the United States and has been identified in California, Idaho, Maryland, New Jersey, New York, Oregon, Pennsylvania, Virginia, and Washington. Internationally, it has been reported in vineyards in Canada and in a research block in Switzerland.

Disease Impact

GRBaV impacts fruit quality rather than yield, though reduced yield was reported in Washington in vines infected with GRBaV, but these vines were also infected with other viruses. The virus can cause reduced soluble solids in red- and white-fruited cultivars and higher titratable acidity. Research from Washington State University and California showed the impact of GRBaV on fruit quality is at least as serious as the impact of GLRaV-3, the most severe of the leafroll viruses, and can reduce Brix° levels by as much as 5 degrees. In Oregon, the impact on infected Pinot noir soluble solids has been inconsistent. For instance, in 2013 one Willamette Valley vineyard showed no difference in Brix° between fruit from GRBaV-infected and healthy vines. In a Pinot noir vineyard located in the Rogue Valley, there was a 0.9 Brix° reduction for infected vines compared to fruit from healthy vines. Therefore, differences in virus symptoms and impact on fruit quality across multiple sites and cultivars can make GRBaV's impact difficult to determine.

In Pinot gris, no difference in Brix° was observed between infected and healthy vines in a vineyard in southern Oregon, although a significant reduction in fruit yield and plant growth was observed; however, this vineyard had issues with several other viruses in addition to GRBaV. Further work is needed to clarify the impact of GRBaV on fruit quality in Pinot gris. Work in Sonoma and Napa Valleys suggests that impact on soluble solids is dependent on cultivar and growing site. Cabernet franc and Pinot noir infected with GRBaV have shown delayed and uneven ripening in some Oregon vineyards.

Detection

GRBaV was first characterized in 2012 in New York and California, and a molecular diagnostic method using PCR was developed from that work. This method has been published and is in use by private and public laboratories for GRBaV diagnosis in grapevines. PCR detection is relatively expensive and in nurseries only a subset of plants are tested. Using the PCR detection method, Foundation Plant Services (FPS) has tested all vines in the new Russell Ranch Foundation block and found all were free of GRBaV. However, this block was initially set up in 2011 and there are limited cuttings available to nurseries for propagation. GRBaV has been detected in a few vines in the FPS Classic Foundation Block (~15 out of >5000). The Clean Plant Center Northwest (CPCNW) in Prosser, Washington also has a Foundation Block that has tested free of GRBaV, additionally, this block has been tested and found free of Agrobacterium that causes crown gall in grapevine and Grapevine rupestris stem pitting virus. Grapevines grown by nurseries that are in California's, Oregon's and Washington's grapevine certification program are being tested for GRBaV, but be aware that some nurseries are selling uncertified grapevines that have not been tested.

Transmission

So far, no insect vector of GRBaV has been identified. Movement of GRBaV in vineyards after planting has been documented, which clearly indicates the presence of some kind of a vector. An increase in the incidence of GRBaV over time in young, healthy vineyards that are adjacent to infected vineyards also suggests the existence of a vector.

Virus transmission by grafting has also been demonstrated. Based on the large number of infected cultivars and wide geographic distribution of GRBaV, it is likely that spread has occurred primarily through movement of infected propagation material. Symptoms of GRBaV on grapevine rootstocks is unknown. Therefore, it is critical that rootstocks as well as scion material are tested prior to propagation and grafting to minimize the risk of graft transmission of GRBaV and other viruses. An initial report from Washington that the Virginia creeper leafhopper vectored GRBaV has not been repeatable. This leafhopper is not known to occur in Oregon, but GRBaV has been shown to spread in Oregon. Vector transmission trials in Oregon with the western grape leafhopper and the blue green sharpshooter have been unsuccessful. It is possible to detect GRBaV in western grape leafhoppers that have fed on infected plants, however, when transferred to healthy vines, these insects did not transmit the virus. Probably any sucking insect or nematode that feeds on infected vines can pick up the virus, but to date, none has been proven to transmit the virus to healthy plants. Based on the pattern of spread observed in vineyards, it is very unlikely that nematodes vector GRBaV. Therefore, it is still unclear how the virus is spreading and under what conditions, especially given that it seems to spread in some vineyards but not in others. Further research is underway to determine how the virus is transmitted in the field.

What to do

People are the most efficient vector of grapevine viruses as they can move the viruses planting stocks over great distances in a very short period of time. Therefore, care must be taken to obtain high quality, clean material when purchasing vines. Ask the nursery for its testing records. This information should include the year the testing was conducted, how many vines were tested in each block, which laboratory did the testing, and which viruses were tested for. Be careful you don't focus so intently on GRBaV that you forget those other viruses. If you suspect you have GRBaV, get it tested; **TEST – DON'T GUESS**.

GRBaV is on Oregon's list of quarantined pests for grape; do not accept any vines from an out-of-state nursery unless that shipment is accompanied by an official phytosanitary certificate verifying the vines are free of quarantine pests including GRBaV. Also, receipt of interstate shipments must be reported to the Oregon Department of Agriculture (notification@oda.state.or.us). Reporting these shipments helps the ODA verify other states are complying with our quarantine rules and helps protect you from re-ceiving infected vines.

When starting a new vineyard, **START CLEAN!**

Establishing a vineyard is a long-term investment. Don't necessarily go for the least expensive vines, they may be cheap for a reason. Starting clean is the most important component of a virus management program. Once a vine is infected with a virus, it cannot be cured in the field. That infected vine also serves as a source of inoculum for further spread of the virus within your vineyard or to neighboring vineyards. Remember, there are over 70 virus and virus-like agents that infect grapevines and relatively few of those are present in Oregon. Let's work together to minimize the risks of introducing new viruses into the state that could threaten our vineyards by starting new vineyards with high quality plants.

Laboratories that test for GRBaV and other viruses of grapevines are below. This is not a complete list and is not an endorsement for any of these laboratories.

- Washington State University – ELISA laboratory - Prosser, Washington: http://plantpath.wsu.edu/diagnostics/
- Eurofins STA Laboratories - Gilroy, California: http:www.eurofinsus.com/sta-laboratories/
- Agri-Analysis - Davis, California: http://www.agri-analysis.com/
- AL&L Crop Solutions, Inc. – Vacaville, California: http://www.allcropsolutions.com/

Sources of Additional Information on Grapevine Red Blotch Associate Virus:

National Clean Plant Network for Grapes: http://ncpngrapes.org. This site has fact sheets on Red Blotch, Leafroll, and Vein Clearing Viruses and Crown Gall.

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An advisory committee has been formed to develop and distribute information on Grapevine red blotch associated virus in Oregon, this committee includes: David Beck, Ted Casteel, Geoff Hall, Joel Myers, Nancy Osterbauer, Dipak Poudyal, John Pratt, Patty Skinkis, Vaughn Walton, and Bob Martin. Several members of this committee have reviewed this article.

Wine Aroma and the Importance of Nitrogen Concentration and Composition

Dr. James Osborne, Extension Enologist, OSU

The nitrogen content of grape juice and must is an important parameter to consider when conducting alcoholic fermentation because it impacts wine quality in a number of ways. First and foremost, nitrogen is an essential nutrient for yeast growth and metabolism, so adequate amounts must be present for yeast to complete fermentation. Low nitrogen concentration is often cited as one of the prominent causes of stuck and sluggish fermentations (for more details, view the 2009 OSU Wine and Grape Research and Extension Newsletter. The concentration of nitrogen during fermentation can impact the formation of hydrogen sulfide (H_2S), a rotten egg smelling compound that may be detrimental to wine quality (for more details, read my article in the fall edition of the 2013 OWRI Technical Newsletter).

Grape nitrogen concentration is commonly measured at harvest so that any deficiencies can be identified and addressed by supplementation at the winery. Two specific forms of nitrogen are commonly measured (free alpha amino acids and ammonium) and these combined forms of nitrogen are reported as yeast assimilable nitrogen (YAN). YAN concentrations in grapes range widely (50 to 500 mg/L) and are impacted by many factors in the vineyard including variety and/or rootstock, climate, soil, seasonal growing conditions, fertilization, and grape maturity (Schreiner et al. 2013; Bell and Henschke 2005).

Since YAN is important to ensure completion of fermentation and minimize H_2S production, developing general minimum YAN requirements for wine is also important. There is still debate about what minimum YAN levels are needed to ensure completion of a fermentation, but the general suggestion is between 140-200 mg/L for a 21°Brix juice/must and between 250-300 mg/L for a 25°Brix juice/must (Bisson 1999; Dukes and Butzke 1998).

While YAN recommendations are aimed at ensuring sufficient nitrogen for completion of the alcoholic fermentation, nitrogen concentration and composition can also influence the flavor and aroma of a wine. Specifically, yeast production of esters and higher alcohols can be impacted by the concentration of amino acids and ammonium present during fermentation. Amino acids (transported into the yeast cell from the surrounding environment or generated internally from various building blocks) can be transformed into higher alcohols via a process called the Ehrlich reaction, and depending on their composition these higher alcohols can positively or negatively impact wine quality.

2-phenylethanol can impart desirable floral notes while isobutanol imparts an undesirable solvent note at high concentrations (Styger et al. 2011). Higher alcohols can also indirectly impact wine aroma through reactions with certain acids (primarily Acetyl CoA) to form esters. Different combinations of higher alcohols and acids will lead to production of a number of different esters with varying sensory attributes, and ethanol can also react with acids to form ethyl esters. The most common ethyl ester in wine is ethyl acetate (nail-polish remover smell) which is formed through the reaction of ethanol and Acetyl CoA (Styger et al. 2011).

In addition, overall YAN concentration can also impact the formation of these compounds. YAN concentration may alter the speed of the fermentation and the rate of yeast growth. This in turn will affect a number of yeast metabolic functions that can alter the production of certain esters and higher alcohols (Styger et al. 2011). In this way, nitrogen concentration and composition both play key roles in determining the formation of wine aroma compounds during fermentation. If you add in other factors known to influence yeast production of aroma compounds such as yeast species/strain, temperature, pH, and redox status you can begin to see how complicated the role of nitrogen is in wine aroma production.

A number of practical questions arise if we now consider how to manage nitrogen to manipulate wine aroma as well as ensure a complete fermentation. For example, what concentrations of YAN should be targeted? Does it matter what type of nitrogen you supplement with? Is nitrogen content best dealt with at the winery or in the vineyard, or does it matter?

Researchers are studying these questions. Ugliano et al. (2010) reported the effect of nitrogen supplementation on volatile and sensory properties of Shiraz wines where a low YAN Shiraz must (100 mg/L) was supplemented with diammonium phosphate (DAP) to either 250 or 400 mg/L YAN. DAP additions resulted in higher production of ethyl fatty acid esters and acetate esters and a decrease in some higher alcohols. Similar work was conducted in Chardonnay (Torrea et al. 2011) and the authors reported the highest amount of fruity ethyl esters in moderate DAP supplemented wines (350 mg/L YAN) and very high ethyl acetate (nail polish remover smell) in high DAP supplemented wines (480 mg/L).

The overall conclusion of that study was that moderate DAP additions resulted in the largest potential aromatic impact while large DAP additions reduced potential aromatic impact and caused solvent off-odors. It should be noted that the DAP additions in both of these studies were quite high (supplementing to 400 or 480 mg/L YAN) compared to what is typically added in the northwest. Torrea et al. (2011) also reported differences in Chardonnay wine aroma depending on whether inorganic nitrogen (ammonium added as DAP) or organic nitrogen (amino acids) was used as a supplement. Higher concentrations of organic nitrogen resulted in wines with increased floral and tropical notes. However, if the same YAN value was reached using DAP additions the wines had increased solvent and acetic notes.

Researchers at the OWRI are studying the relationship between nitrogen and wine quality. Dr. Paul Schreiner's current research is investigating the impact of vineyard nutrient supply on several Pinot noir vine, grape, and wine parameters. He found that nitrogen supply in the vineyard significantly affected the concentration of YAN in the grapes. This in turn impacted a number of wine aroma compounds with the largest impact being on yeast–derived esters and higher alcohols. Decreasing YAN concentrations resulted in an increase in some esters while decreasing the concentration of other esters and higher alcohols. Preliminary sensory analysis indicated that wine made from lower YAN fruit had increased floral and dark fruit characteristics. A more detailed report of the findings from this study can be found in the [2015 Viticulture and Enology Technical Newsletter].

My lab recently conducted an experiment to determine the impact of YAN concentration and composition on Pinot gris wine aroma. A low YAN Pinot gris juice (133 mg/L) was amended to 230 mg/L YAN by the addition of DAP or a mixture of amino acids that mimicked the amino acid composition of the Pinot gris juice. When wines were assessed for volatile aromas by the Tomasino sensory lab large differences were noted for a number of aroma compounds. Increasing YAN concentration impacted a range of yeast-derived aroma compounds with significant differences between DAP amended wines and amino acid amended wines.

Increasing YAN increased acetate ester concentrations with the largest differences being noted in amino acid amended treatments. The percentage changes in relative concentration of compounds compared to the control are illustrated in Figure 1.

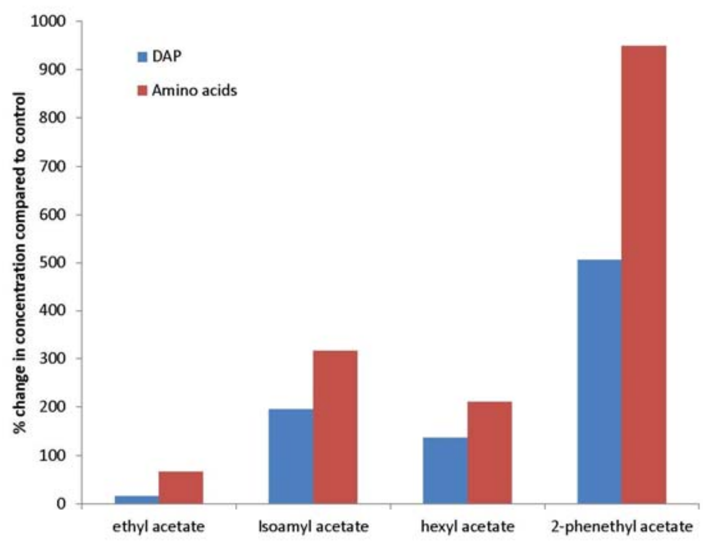

Figure 1. Percentage change in concentration of ethyl esters in Pinot gris wine produced from juice supplemented with DAP or amino acids to 230 mg/L YAN relative to the control Pinot gris wine (low YAN)

Note the significant increase in 2-phenethyl acetate (fruity, floral, honey) in amino acid amended wines (900% increase compared to the control). Higher alcohols showed a different trend with higher YAN resulting in lower concentrations compared to the control except for 2-methyl-1-propanol shown in Figure 2.

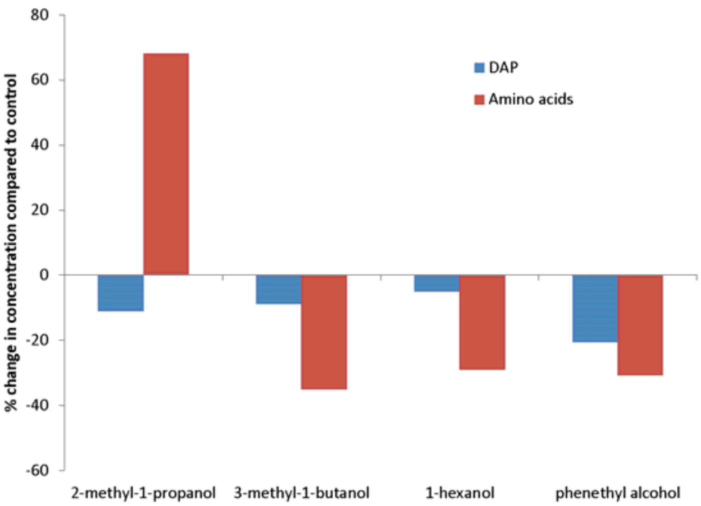

Figure 2. Percentage change in concentration of higher alcohols in Pinot gris wine produced from juice supplemented with DAP or amino acids to 230 mg/L YAN relative to the control Pinot gris wine (low YAN)

During an informal tasting of these wines at an industry conference it was noted that the amino acid amended wines had elevated "tropical" and "fruity" notes while the DAP amended wines were often described as "harsh" or "sharp".

As we learn more about the relationship between YAN and yeast-derived aromas it becomes clear that YAN concentration and composition can have a significant impact on wine aroma. In the future, a better understanding of the role of various nitrogen components on wine aroma may allow nitrogen to be managed in the vineyard and winery with a focus on wine quality in addition to the successful completion of fermentation. At this time our understanding of this process is still too limited to allow effective management strategies to be developed. For example, we do not yet have a clear idea of what our target YANs should be if we want to consider aroma impacts as well as fermentation success. It is also likely that these YAN targets will differ between grape varieties and styles (red vs. aromatic whites for example). Furthermore, should you focus on adjusting YANs primarily in the vineyard or the winery? While it is more efficient and precise to amend YANs in the winery, YAN composition via amendment will be different then that achieved by boosting nitrogen in the vineyard. It is also important that we consider the balance between grape derived aroma compounds and yeast-derived ones. While it may be possible to boost the production of certain esters and higher alcohols through YAN management, these may overwhelm or mask grape derived aromas that are characteristic of the variety.

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Recycling Tunnel Sprayers: Coverage, Drift and Grower Feedback

Marie Vicksta, Conservation Planner, Yamhill Soil and Water Conservation District

In 2012, the Yamhill Soil and Water Conservation District (SWCD) received a grant through the USDA Natural Resource Conservation Service (NRCS) Conservation Innovation Grant program (CIG) to encourage the use of recycling tunnel sprayers in vineyards. The grant provided incentive payments to local growers who purchased recycling tunnel sprayers in Yamhill County. These sprayers were encouraged because of their potential to reduce pesticide drift into the environment. The technology allows recycling of chemical that does not reach the target (vine canopy or fruit), and studies found a 95% reduction in drift, 30% increase in deposition and 40% reduction in chemical (Ade et. al., 2005; Landers, 2008). Cornell University researchers document impressive savings in fuel and chemical application in field studies with these sprayers, and Yamhill SWCD gathered feedback from participating growers on equipment use and savings to determine whether this technology performed as advertised, and was appropriate for use in Oregon.

The Yamhill SWCD also purchased a demonstration unit to run field tests on trellised crops other than grapes. This article provides a small portion of the results of the program that focuses on the differences in coverage and drift between tunnel and air blast sprayers as well as the feedback on performance we received from growers who used recycling tunnel sprayers.

Comparing coverage and drift between recycling tunnel and air blast sprayers on Marionberries:

Yamhill SWCD Board Director Sam Sweeney set up a side-by-side comparison of two sprayers, including a sprayer retrofitted to be a recycling tunnel sprayer and an air blast sprayer. He tested them in his marionberries on July 31, 2015. The recycling and air blast sprayers were both set to spray at 100 psi, but the application rates were 52 gal/acre for the tunnel sprayer and 75 gal/acre for the air blast sprayer. Rows were at 10 foot spacing. We put indicator paper in the canopy at multiple levels (top, middle and bottom) to compare spray coverage by each sprayer type. When indicator paper gets wet, the color turns from yellow to blue. We observed the indicator paper after spraying and found that the tunnel sprayer created a turbulence within the tunnels that allowed for better coverage inside the plant canopies (Figure 1) than the tunnel sprayer (Figure 2).

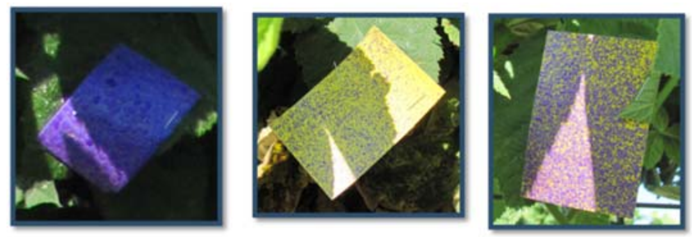

Figure 1. Recycling tunnel sprayer coverage at 100 PSI. Left to right, over-sprayed, good coverage, and good coverage.

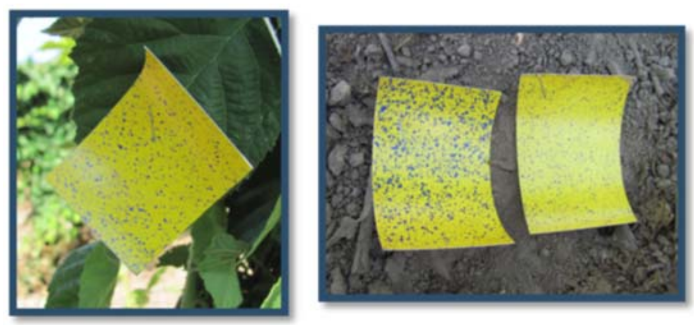

Figure 2. Air blast sprayer coverage at 100 PSI with under-sprayed (left) and under-sprayed with high potential for drift since cards were blown out of the canopy (right).

Drift from the two machines was evaluated by stapling indicator paper to wood blocks and laying them on the ground in the center of the row that was being sprayed, the adjacent row, and two rows over. This offered a visual indication of the off-target spray drift. With the tunnel sprayer, there was no drift detected on the indicator paper in the adjacent rows (Figure 3). With the air blast, the indicator paper revealed drift on the ground in the row sprayed, in the adjacent rows and even two rows over (Figure 4). The spray pattern in the canopy from the air blast (Figure 5) matches the pattern on the ground in the adjacent rows.

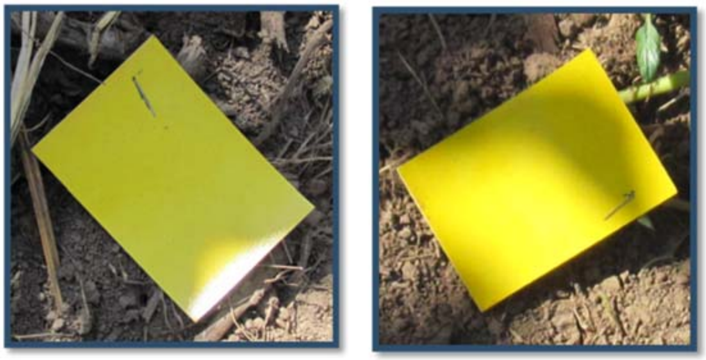

Figure 3. Indicator paper collected from the first (left) and second (right) rows adjacent to the recycling tunnel sprayer application show no drift (lack of blue dots).

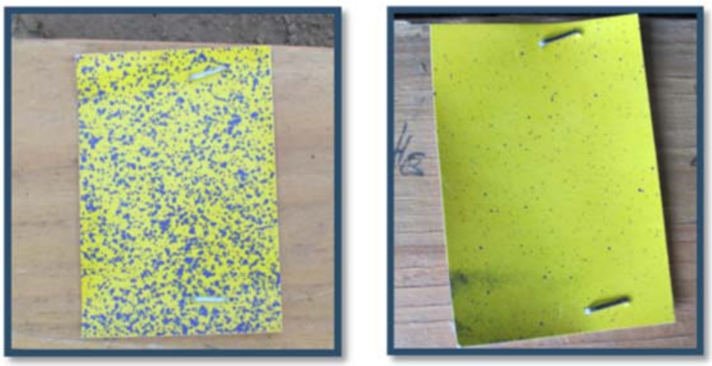

Figure 4. Indicator paper collected from the first (left) and second (right) rows adjacent to the air blast sprayer application show significant drift (blue dots).

Figure 5. Some drift was apparent at the ground level between vine rows for those plots sprayed with the airblast sprayer as indicated by blue dots on the indicator paper shown.

User feedback on recycling tunnel sprayers

We solicited feedback from early adopters of this technology, asking whether they were in the cost-share program or not, to understand their experiences using these sprayers in the field.

Vineyard Producer 1: This producer used the CIG funds to retrofit a Gearmore Venturi P45 with 2 LIPCO recycling tunnels. The sprayer was used on a 55 acre vineyard. The unit required a larger capacity pump and hydraulic angular post for the tunnels because of the steep slope of the vineyard. These parts were not included in the quote and the grower incurred additional costs.

A lot of time was spent at the beginning of the season making adjustments to get proper pressure for best deposition. Tunnel sprayers do no use air assist so instead rely on nozzle pressure to deliver spray into the canopy. After the first adjustments, some of the hoses and fittings failed and needed to be replaced. The vineyard manager and his field operator are uncertain why this happened. They speculate that the lines and fittings were not designed for the amount of pressure they are using with the tunnel sprayer.

Tunnel filters were cleaned after spraying each day. They were surprised that the sprayer worked well even when the filter screen at the bottom of the tunnel was full.

The double tunnels helped cut down on fuel usage, as two rows could be sprayed at once. They also said that the recycling tunnel system required lower PTO RPMs to run than the Gearmore, which provides fuel savings.

The vineyard manager and field operator emphasized the importance of having a distributor familiar with the new technology. This was a new product for the local distributor and they needed to bring in a regional representative from California a number of times to ensure the unit was working properly. The lack of expertise of the local distributor led to delays in troubleshooting and service.

Vineyard Producer 2:

This producer purchased two tunnel sprayers, including a retrofit kit for a Rears air blast sprayer to fabricate in their shop and a new tow-behind unit. The sprayer was used on 25 acres. This producer was polled for their feedback on sprayer use but had not participated in the cost-share program. They believe that the retrofit unit they used was not a good investment. They put a single tunnel on the side of an air blast sprayer which led to an off-balance weight distribution that put the sprayer at risk for roll-over. They retired the retro LIPCO tunnel and built their own tunnel sprayer.

They thought the new LIPCO unit was a better investment than the retrofit kit, but the frame was made with fairly weak metal that was not suited to hillside use. They had to rebuild the frame after the second year of use, which took about a month for their mechanic to complete.

They thought that the tunnel sprayer had better coverage than the traditional air blast and allowed them to spray on windy days. The retrofit was not used for an entire spray season due to repairs, but it recycled about 50% of the chemical sprayed during the two times it was used. They did not see a change in fuel usage or labor and thought their operators were able to use and service the equipment easily. They thought the fruit quality was the same whether using their older air blast sprayer or the tunnel sprayer.

Vineyard Producer 3:

This producer purchased a new tow-behind LIPCO unit which was used on 45 acres of vineyard. They were not a part of the cost-share program but were willing to share their experiences. They believed the sprayer performed as advertised and noticed better coverage and a 30% decrease in annual pesticide application. They also reduced labor inputs by 25% and saved on fuel, although they did not document the changes. Like producer 2, they also found that they were able to spray on windy days. They believe that they saw an improvement in disease control when combined with early leaf removal.

Safety was a concern, as they overturned the sprayer once on a steep part of the vineyard, and they experienced problems operating it on side slopes.

There was a steep learning curve on operating this equipment, and it took their operators a few sprays before they were comfortable using the equipment. They also mentioned that parts had to be ordered from Germany, which took about two weeks.

In the end, they still would recommend tunnel sprayers to others. They believe it is an effective new spray technology, but it performs better on vineyards with level land and well balanced canopies. They stated that they will not go back to their air blast sprayer because the coverage was poor compared to the tunnel sprayer. They would consider purchasing the recycling tunnel sprayer again, but are interested in exploring other technologies on the market that minimize spray application and have excellent coverage.

Vineyard Producer 4: This producer retrofitted a Rears 350 gallon air blast sprayer with 2 LIPCO recycling tunnels and used it on a 34 acre vineyard. The vineyard manager was initially very enthusiastic about the recycling tunnel technology when they applied for the retrofit cost-share program. Unfortunately, the local distributor who also fabricated the retrofit on their spray unit returned their sprayer to them several weeks after bud break, forcing the vineyard manager and operator to quickly learn how to use the machine and test it in the vineyard. The sprayer worked very well on the flat, even areas of their vineyard and provided excellent coverage as measured by indicator paper placed in the canopies. However, in areas where there were sloped headlands or terraced rows, the mounting configuration did not give the driver enough clearance to operate the sprayer safely. The configuration also presented a challenge for entering and exiting rows on slightly sloped ground, and the inside sprayer curtain was too wide to clear the rows, despite the flexibility of the outside curtain. The weight distribution of the sprayer was too far behind the tractor which made it challenging for the operator to drive and prone to rolling over when coming into and out of the vine row. Eventually, they removed the recycling tunnels and brought the sprayer back to original specifications.

Conclusions:

We had hoped to get more growers involved in the cost share program. However, cost of equipment was the most common factor cited for non-adoption by growers. If NRCS were to provide cost share on this, or similar technology, in the future, we will need to take all of the factors and components that contribute to total cost into account and provide adequate incentive to convert.

Expertise of the local dealer is one of the most important links for successful adoption of new technology. Dealers must understand the limitations and requirements for recycling tunnel sprayers in order to ensure proper function and to assist producers in smooth adoption and evaluation.

This technology has the potential to drastically reduce pesticide drift and inputs but there are some concerns about its adoption for use in vineyards. It should be used on the appropriate terrain for operator safety. We recommend further field testing on trellised berry crops that are grown on relatively flat ground where there would be fewer safety concerns about overturning the sprayers.

The grant program ran from 2012 through October 2015, and a final technical report was prepared for the NRCS. Contact Marie Vicksta, (marie@yamhillswcd.org) for a full copy of the report.

Practical Guides & Resources

This section provides resources written by members of the Oregon Wine Research Institute and our partners. Many of these publications are developed and delivered through Extension and are available online, and others are from reputable trade magazines.

Are Your Weed-control Products Damaging Nearby Vineyards?

This brief informational guide will help anyone living near a vineyard understand the damaging effects common herbicides can have on grapevines. The Oregon grape industry is growing rapidly near urban boundaries throughout the state. Herbicides used in home gardens, residential and urban landscapes can cause serious damage to local vineyards. This document was released in February 2016 by *Oregon State University Extension Publishing* (EM 9132). Authors: M. Kennedy and P. Skinkis. https://catalog.extension.oregonstate.edu/em9132

Compendium of Grape Diseases, Disorders, and Pests. Second Edition

This book contains valuable information for growers and vineyard managers. Divided into four parts, this comprehensive guide provides information on grape diseases, disorders, and pests ranging from mites, and insects to abiotic factors. And, lastly, tips that help managers save money and minimize pesticide use. Editors: Wayne Wilcox, Walter Gubler, and Jerry Uyemoto. This book is available for purchase through the American Phytopathological Society: http:// www.apsnet.org/apsstore/shopapspress/Pages/44792.aspx

Field Guide for Integrated Pest Management in Pacific Northwest Vineyards

The guide provides practical information about pest and disease management throughout the Pacific Northwest. It is beautifully illustrated and includes information about specific pests, management techniques (chemical and cultural), and IPM principles. This guide was published in June 2013 by Washington State University, Oregon State University, and University of Idaho through *Pacific Northwest Extension Publishing* (PNW 644). Edited by M.M. Moyer and S.D. O'Neal, this book is available for purchase online at http://cru.cahe.wsu.edu/CEPublications/PNW644/PNW644.pdf.

Fungicide Efficacy Trial Results Available Online

Dr. Jay Pscheidt, OSU Extension Plant Pathologist, conducts research on the efficacy of fungicides for many crops throughout Oregon, including winegrapes. Results of his research are summarized and published annually in the *Pest Management Guide for Wine Grapes in Oregon*. This information is important to consider when designing a disease management program, and we suggest that you explore the full fungicide booklet online for further details about Jay's trials: http://www.science.oregonstate.edu/bpp/Plant_Clinic/Fungicidebooklet/index.htm.

Loss of Pinot Noir Color and Polymeric Pigment

An article written by Dr. James Osborne, OSU Enology Extension Specialist, assessing the loss of Pinot noir wine color and polymeric pigment due to malolactic fermentation (MLF) and the potential causes. *Practical Winery and Vineyards*. February 2016. http://www.winesandvines.com/

Mobile Access to Pesticides and Labels (MAPL) (www.npic.orst.edu/mapl)**:** The National Pesticide Information Center at OSU developed this tool to access federal pesticide labels and information. MAPL retrieves data from two EPA databases and can be queried by product name, pest, site, and registration number. This tool functions on computers but is best displayed on mobile devices. If you want further information or have feedback on this tool, please contact Dave Stone, Associate Professor and Director, National Pesticide Information Center at OSU (Dave.Stone@oregonstate.edu, 541-737-4433).

Noncrop Host Plants of Spotted Wing Drosophila in North America

Noncrop habitats can meet requirements that favor Spotted Wing Drosophila (SWD) adults and in addition, many noncrop fruits can support developing larvae of SWD. As populations of SWD build in noncrop hosts, these areas can become "hot spots" from which SWD can move into fields as commercial fruits begin to ripen. In some regions, these plants may be more important in post-crop dynamics by providing opportunities for late season population buildup. This document was released in February 2016 by *Oregon State University Extension Publishing* (EM 9113). https://catalog.extension.oregongonstate.edu/em9113

Pacific Northwest Weed Management Handbook
This is the most comprehensive guide for weed management for the region. It is authored by Extension specialists from throughout the Pacific Northwest, and provides information on weed management strategies, herbicide lists, herbicide resistance, and more. This online handbook is edited by E. Peachey and available through *Pacific Northwest Extension Publishing*. It is updated quarterly, and the most recent revision was published in June 2015.http://pnwhandbooks.org/weed/

2016 Pest Management Guide for Wine Grapes
This publication is updated annually by Extension experts at Oregon State University and scientists at the USDA-ARS. This publication reviews the growth stages of grapes and lists the more effective pesticides used to control insects, weeds, and disease, their rates, and application timing for Oregon grape growers. Published by *Oregon State University Extension Publishing* (EM8413), this document was revised in March 2016. Authors: P. Skinkis, J. Pscheidt, E. Peachy, A. Dreves, V. Walton, and C. Kaiser. The document may be downloaded online here: https://catalog. extension.oregonstate.edu/em8413

Recognize the Symptoms and Causes of Stunted Growth in Vineyards
This Extension publication is also a free app that can be downloaded and viewed offline. Spring frost, herbicide drift, water or nutrient stress, diseases, insect and mite pests can all cause similar symptoms of stunting or distorted growth in grapevines. Recognizing symptoms and distinguishing their causes is the first step in diagnosing problems and developing a management plan. With many color photos, this publication will help identify probable causes of distorted shoot and vine growth in vineyards and provide resources that can lead to solutions. This document was released in February 2016 by *Oregon State University Extension Publishing* (EM 8975). Authors: P. Skinkis, V. Walton, A. Dreves, C. Kaiser, S. Renquist, S. Castagnoli, R. Hilton and L. Bewer. https://catalog.extension.oregonstate.edu/em8975

Scouting for Grape Powdery Mildew
This publication provides vineyard owners with approaches for finding the first occurrence of grape powdery mildew. The publication covers tactics to manage powdery mildew, including use of fungicides and canopy management. It also discusses effective scouting techniques based on the key characteristics of the fungus. This document was released in May 2013 by *Oregon State University Extension Publishing* (EM 9067) and authored by Jay W. Pscheidt. https://catalog.extension.oregonstate.edu/files/project/pdf/em9067.pdf

Winter Cutworm: A New Pest Threat in Oregon
Damage from winter cutworm is a growing concern. In 2015, large numbers of larvae were observed around homes, within golf courses, field crops located in Oregon and Washington and in some Willamette Valley vineyards. This publication highlights general information about winter cutworm, including identification, scouting recommendations, and potential control measures. This document was released in February 2016 by *Oregon State University Extension Publishing* (EM 9139). https://catalog.extension. oregonstate.edu/em9139

Research Publications

Results of research conducted in viticulture and enology are published in peer-refereed academic journals, peer-reviewed reports, or books, which validates the scientific work of the authors. The following articles were released in 2014 and describe research conducted by members of the Oregon Wine Research Institute at Oregon State University.

Viticulture

Feng H, F. Yuan, P.A. Skinkis, and M.C. Qian. 2016. Influence of cluster zone leaf removal on Pinot noir grape chemical and volatile composition. *Food Chemistry* 173:414-423. http://www.sciencedirect.com/science/article/pii/S0308814614015374

Howland, A., P.A. Skinkis, J.H. Wilson, E. Riga, J.N Pinkerton, R.P. Schreiner, I.A. Zasada. 2015. Host status of own-rooted *Vitis vinifera* varieties to *Meloidogyne hapla*. *Journal of Nematology.* 47:141-147. http://ars.sportdecals.org/research/publications/publications.htm?seq_no_115=313415

Howland, A. D., R.P. Schreiner, and I.A. Zasada. 2014. Spatial distribution of plant-parasitic nematodes in semi-arid *Vitis vinifera* vineyards in Washington. *Journal of Nematology.* 46: 321-330. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4284083/

Schreiner, R. P., C.F. Scagel, and J. Lee. 2014. N, P, and K supply to Pinot noir grapevines: Impact on berry phenolics and free amino acids. *Am. J. Enol. Vitic.*65:43-49. http://www.ars.usda.gov/SP2UserFiles/person/5018/PDF/2013/2013%20AJEV%2064-26-38.pdf

Schreiner, R. P. and J. Lee. 2014. Effects of post-véraison water deficit on 'Pinot noir' yield and nutrient status in leaves, clusters, and musts. *HortScience.* 49:1335-1340. http://hortsci.ashspublications.org/content/49/10/1335.abstract

Song, J., R. Smart, H. Wang, B. Dambergs, A. Sparrow, and M.C. Qian. 2016. Effect of grape bunch sunlight exposure and UV radiation on phenolics and volatile composition of *Vitis vinifera* L. cv. Pinot noir wine. *Food Chemistry*. 173:424-431. http://www.sciencedirect.com/science/article/pii/S0308814614015386

Vondras, A., S. Gouthu, J. Schmidt, A. Petersen, & L.G. Deluc. 2016. The Contribution of flowering time and seed content to uneven ripening initiation among fruits within Vitis vinifera L. cv. Pinot noir clusters. *Planta*. In Press. http://www.ncbi.nlm.nih.gov/pubmed/26874729

Enology

Chescheir, S.C., D. Philbin, and J.P. Osborne. 2016. Impact of *Oenococcus oeni* on wine hydroxycinnamic acids and volatile phenol production by *Brettanomyces bruxellensis*. *Am. J. Enol. Vitic*. (In press) doi: 10.5344/ajev.2016.14108. http://ajevonline.org/content/early/2016/04/24/ajev.2016.14108.abstract?sid=a103592c-67cd-4498-9b57-d2cab01c1ccd

Burns, T.R., and J.P. Osborne. 2016. Loss of Pinot noir Wine Color and Polymeric Pigment after Malolactic Fermentation and Potential Causes. *Am. J. Enol. Vitic.* (In press) doi: 10.5344/ajev.2014.14061. http://ajevonline.org/content/early/2014/10/22/ajev.2014.14061.abstract?sid=a103592c-67cd-4498-9b57-d2cab01c1ccd

Schopp, L.M., J. Lee, J.P. Osborne, S.C. Chescheir, and C.G. Edwards. 2013. Metabolism of nonesterified and esterified hydroxycinnamic acids in red wines by Brettanomyces bruxellensis. *J. Agric. Food Chem*. 61: 11610–17. http://pubs.acs.org/doi/abs/10.1021/jf403440k

Song, M., Y. Xia and E. Tomasino. 2016. Investigation of a Quantitative Method for the Analysis of Chiral Monoterpenes in White Wine by HS-SPME-MDGC-MS of Different Wine Matrices. Molecules. 20 (4):7359-7378. http://www.mdpi.com/1420-3049/20/4/7359

Thesis

Navarrete, A.M. 2015. Characterizing Grapevine Canopy Architecture. Thesis, Oregon State University, Corvallis.