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ICCVE: Leading the Midwest in Viticulture and Enology Research and Extension

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THE MIDWEST WINEGROWER

QUARTERLY NEWSLETTER

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Welcome!

Welcome to the premier issue of The Midwest Winegrower, the official newsletter of the Institute for Continental Climate Viticulture and Enology (ICCVE). The ICCVE is responsible for grape and wine research, extension, and education program at the University of Missouri in Columbia. We are the editors of the newsletter, Rebecca Ford and Andy Allen, the Extension Enologist and Extension Viticulturist with the ICCVE, respectively.

The newsletter will be published four times each year in spring, summer, fall, and winter. It will include research reports and educational articles on grape and wine production in the Midwest, reports on meetings, workshops, and events as well as announcements of upcoming events and other news items of interest to the Midwest grape and wine industry. Contributors to the newsletter will include leading experts in many areas related to viticulture and enology from around the country. We trust that with each issue you will find information that will be useful to your operation.

The Editors

Training young grapevines

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Grapevine training is manipulating the growth of the vine to develop its intended form. Grapevine training practices during the vineyard establishment phase are designed to guide the development of the permanent or semi-permanent woody structures of the vine in as quick and efficient a manner as possible. Through good vineyard management and actively training the vines' growth from the beginning of shoot growth in the first year, it can be possible to get the trunks and cordons established within the first season in regions with long, warm growing seasons.

Grapevine training incorporates the choice of vineyard trellis system and vineyard management practices that maximize vine growth and guides the decisions made during dormant pruning. While there are still a few instances of head-trained, cane-pruned training systems being utilized within the Midwest, this article will only be concerned with cordon-trained vines.

Before Training Begins…

There are two important decisions that must be made before training begins. The first is to which trellis/training system the vine will be trained. The trellis/training system used determines the form of the vine. This choice should be made before the vines are ever planted in that it affects row spacing. The second choice is the number of trunks the vine will have. For cold-tender vines such as all *Vitis vinifera* cultivars and the less-hardy hybrids, double-trunking is recommended in all areas of the Midwest. For more hardy native and hybrid cultivars, a single or double trunk may be used. This assumes a good vineyard site with proper cold air drainage.

The trellis system chosen for the vineyard block will determine the height of the vine's head region, the length of cordons, and the orientation and spacing of arms. The trellis can be either low-

cordon or high-cordon, divided or undivided canopy. Low-cordon systems include the Vertical Shoot Positioned trellis (VSP) and its divided canopy variations, such as the Smart-Dyson and the Ballerina. Cordon support wires in these systems are typically set at a height of 38-42 inches, with the divided canopy versions set at 42 inches. In the standard VSP, all of the canopy originates from arms along the tops of the cordons and is positioned directly above the cordons through pairs of foliage catch wires. In the Smart-Dyson and the Ballerina variations, approximately two-thirds of the canopy originates from arms on the tops of the cordons and is positioned directly above them while the remainder of the canopy originates from arms along the bottom or the sides of the cordons and is positioned directly below or to the sides of the cordons, respectively. The high-cordon system most commonly utilized in the Midwest is the high-wire bilateral-cordon system. The cordon support wire for this system is typically set at a height of 66 inches and the canopy originates from arms in the lower 180 degrees of the cordon and cascades downward. In all of these systems, the head of the vine is located about 4-6 inches below the cordon support wire.

Training vines in the first season

Vines will usually arrive from the nursery already pruned back to a 2 or 3 bud stub above the crown or graft union. If they aren't, then prune them back to 2 or 3 buds before or just after planting. This will direct the vines' growth into fewer shoots, resulting in stronger growth that can be trained earlier. If growth tubes are going to be used, then at bud swell or when shoots are just a few inches long, thin the buds or shoots to the 2 or 3 strongest, put the growth tube around the vines, and seal the base of the tubes with 2-3 inches of soil. The tubes should be securely fastened to a bamboo pole, training stake, or wire to prevent them from shaking in winds and damaging or breaking the tender shoots. The growth tubes will encourage rapid and straight shoot growth in the early part of the season until the young shoots emerge from the tops of the tubes. If growth tubes are not being used, then after shoot growth commences, select the 2 or 3 strongest shoots and remove any others that may have developed. In either case, the shoots retained will be trained as the new trunks.

To maximize growth during this period, it is important to eliminate stress and competition so that the vines have all of the resources necessary to make rapid and strong growth. Weeds within the vine row should be kept to a minimum or eliminated. Many young vineyards fail to make adequate growth during the first season due to competition from poorly controlled weed growth. Irrigation during the first season can greatly increase growth, even when vineyards are not planted in droughty soils. It is important to remember that the young vines' root systems are not yet well-established. A dry summer can bring new vines' growth to an early halt. Also important is to provide young vines with adequate nutrition, particularly nitrogen. Even if the soil was properly prepared and amended before planting, nitrogen is highly mobile and can be leached below the young vines' root zone early in the growing season while shoot growth can take place all summer. Any flower clusters that develop should be removed as soon as they appear. Never allow vines to crop during the first growing season. Fruit development will divert a lot of the vine's energy and growth potential into attempting to produce a crop, thus reducing vine growth.

As the young shoots continue to grow, they need to be secured to training stakes, bamboo poles, or other supports as they elongate in order to develop straight trunks. Straight trunks permit safe passage of tractors and equipment down the row without risk of damaging the trunks. This is particularly important where vineyard operations are to be mechanized. Fasten the shoots to the support being used by loosely tying them with a biodegradable string. Tying too tightly will result in the shoots being girdled as they increase in diameter, resulting in structurally weak trunks that are prone to breaking. If you can get 2 fingers into the loop, this is adequately loose to prevent girdling.

As the young trunks grow, lateral shoots will develop in the axils of the leaves along the trunks. Rub or pinch these laterals out as soon as they develop so that the vines' growth continues to be directed into the growing tip of the developing trunks. Be careful not to remove or damage the leaves along the main shoots when removing laterals. These will still be needed to support the shoots' growth and development. Removing laterals while they are still small will mean frequent passes through the vineyard to remove the laterals as they appear. Don't wait until several weeks have passed and then go in to remove them. By this time the vine will have invested precious growth into the laterals that will have been wasted. The intent is to have all of the vines' growth going into the developing trunks and cordons with the goal of getting the trunks up to the training wire and cordons developed as quickly as possible. For single-trunked vines, laterals that develop along the young trunk within the region 6-8 inches below the cordon wire should be retained to use in cordon development.

Once the trunks reach the training wire, how you proceed depends on whether the vines are to be single- or double-trunked. If the vines will have single trunks, allow the shoot growth to develop about 8-12 inches above the cordon wire and then cut the shoot back to about 3-4 inches below the cordon wire. This will allow the trunk to develop a good diameter in what will become the head region of the trunk and will promote stronger lateral

growth just below the pruning cut. The laterals that develop within this area will be retained for use as cordons. Select two laterals on opposite sides of the trunk and in line with the cordon wire. They should originate at least 3-4 inches below the wire.

Laterals originating closer than 3 inches to the wire will have to be pulled into a nearly flat angle to be attached to the wire. This will very often result in breakage when the laterals are positioned. At 3-4 inches below the wire, the laterals can be gently arched onto the wire when it is time to fasten them to it. Allow the laterals to grow to a length of about 18 inches before beginning to attach them to the wire. If laid down as cordons and tied to the wire too soon, the shoot tips of the new cordons will stop growing strongly and laterals will begin to develop off of them. If necessary, loosely tie them in an upright position to the training stake or cordon wire to prevent them being broken by strong winds. Once the laterals reach a length of about 18 inches, they can be gently pulled to the wire and loosely tied. Do not tie within about 6-8 inches of the shoot tip; forcing the tip to remain horizontal will result in decreased growth. As the developing cordons extend in length, continue to loosely tie them to the wire at about 1-foot intervals. Allow the developing cordon to grow about 12 inches past the halfway point between adjacent vines and then prune it back to about 3-4 inches short of the halfway point. This will encourage the development of laterals that will become fruiting spurs or canes and will prevent excessive overlapping and shoot crowding where the cordons of adjacent vines meet.

For double-trunked vines, proceed as with single trunks in terms of removing laterals from both trunks, except that the laterals should be removed all the way up to the cordon wire. Allow the developing trunks to grow about 18 inches above the cordon wire and then gently lay them onto the wire in opposite directions, crossing them as they are laid down, and loosely tie them to it. These extensions of the trunks will be the new cordons. Crossing these cordons as they are laid down will prevent the trunks from pulling apart and leaving a large gap between cordons along the wire. Continue to tie the cordons to the wire as they extend in length and as with the single-trunked vines, let them grow about a foot beyond the halfway point between adjacent vines before pruning them back.

Vine training in year 2

In areas with long, warm growing seasons, if vine growth is properly encouraged and managed, the trunks and cordons can be fully established in the first growing season for undivided canopy systems, even on high-cordon trellises. However, in areas with shorter or cooler growing seasons, or in situations of droughty or poorly fertile soils where irrigation or fertilization was inadequate to alleviate vine stress, vine growth may be inadequate to establish cordons or perhaps even trunks. If vine growth did not reach the cordon wire of the trellis, then cut the vines back to where the trunk is about 5/16 to 3/8 of an inch in diameter and continue vine growth and development with the shoot from the bud below the cut. If the growth was very poor or spindly, prune the vine back to a 2- or 3-bud stub and treat it like a newly planted vine. The root system will be larger and much better established and will promote stronger growth. Train this growth as instructed for the first growing season. If vine growth reached the cordon wire but adequate growth did not occur in the cordons, prune the cordons back to where the diameter is about 5/16 to 3/8 of an inch. This situation is also very likely to occur in Geneva Double Curtain training systems, where the goal is to develop 12-16 feet of cordon per vine (depending on vine spacing). Prune to a downward facing bud. Shoots arising from an upward-oriented bud will grow strongly upright and be more difficult to train down to the cordon wire; those arising from a bud on the underside of the cordon will grow outward and then up and will be easier to train down to the wire. Continue cordon development with this shoot. If cordon development was very poor, prune the cordons back to a downward-oriented bud near the head region of the vine and continue cordon development as described above.

If cordons were well-established during the first season then a small crop can be produced in the second year. This crop will be borne on laterals shoots on the cordon that later will be trained to become the fruiting spurs or canes for following seasons. If cordons were not well-established, then the vines should be de-fruited and cordon development should continue. Once they are established during the second season, development and training of lateral shoots can take place. The goal of the second season should be to develop the fruiting spurs or canes appropriate for the trellis/training system used. In high-cordon systems, rub off any laterals that originate on the top of the cordon. Those developing on the sides or lower area of the cordon should be shoot-positioned below the cordon during the growing season, both to develop properly-positioned spurs for the system and to allow adequate illumination of the renewal zone to develop very fruitful buds. Even with cultivars that have a more upright growth habit (such as Vignoles) it is possible with shoot positioning and selective removal of upright-oriented shoots to develop a vine with all of its fruiting spurs/canes in a downward orientation.

With low-cordon training systems, lateral development and orientation will depend on the particular system. In the standard VSP training system, all canopy growth is trained directly above the cordons. In this case rub off any shoots developing on the underside of the cordon and train all others directly above it by positioning them between the pairs of foliage catch wires. With the variations on the VSP trellis such as the Smart-Dyson and

the Ballerina, a portion of the canopy, approximately one-third, will be positioned downward from the cordon. In these systems shoots arising from the lower 180 degrees of the cordon's circumference will be trained to the sides (Ballerina) or straight down (Smart-Dyson), while the majority of the canopy will be trained directly above the cordon as in the VSP training system.

Training in year 3 and beyond

By the end of the second growing season, vines should be fully developed and capable of producing a partial crop in the third season. Any vines that are still lagging in development should be treated as previously outlined for vines still in the establishment stage. Vines that experienced good growth in the first year and carried a crop in the second season should be capable of producing a three-quarters crop if they were properly cared for during the second season. The laterals that developed on the cordon during the second season should be pruned to form fruiting spurs or canes of appropriate length, orientation, and distribution for the training system. Vine training during this season and beyond will be oriented toward maintaining strong healthy shoot growth in the proper position to maintain the canopy architecture and to provide good fruiting wood for the following season. Vine training at this stage in the vineyard cycle consists of proper dormant pruning and good canopy management during the growing season.

Vineyards are expensive to establish. The goal in vine training should be to develop a strong and healthy vine structure as quickly as possible to minimize the establishment period and bring the vineyard into production sooner.

Additional Reading

Hellman, E. and A. Humphrey. 2003. Training Young Vines. In: Oregon Viticulture. Oregon State University Press.

Winkler, A.J., et al. 1974. General Viticulture. Univ. of California Press.

Wolf, T.K. and E.B. Poling. 1995. The Mid-Atlantic Winegrape Growers Guide. NC State Univ.

This article was adapted from:
Andy Allen. 2008. Grapevine Training in the Early Years. In:23rd Annual Midwest Grape and Wine Conference Proceedings. Pp. 54-57.

The antibacterial activity of red wine against foodborne pathogens and probiotic bacteria

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Introduction

Numerous health benefits have been linked to consumption of red wines, including prevention and reduction of risks associated with cardiovascular diseases, diabetes, stroke, and various cancers. Grapes and wines contain a large array of polyphenolic phytochemical compounds and stilbenes, which act as antioxidants that are mainly responsible for these health benefits. In addition to the antioxidants, the alcohol and organic acids that are present in red wines may also act synergistically with polyphenolic compounds to result in antimicrobial effects, especially at the low pH of wine. The amounts of polyphenolic compounds present in red wine primarily depend on the variety of grapes used and the vinification process (Rodriguez Vaquero et al., 2007). Resveratrol (trans-3, 5, 4'-trihydroxystilbene) has been identified as the major active compound of the stilbene phytoalexins (Burns et al., 2001). These phytoalexins act as nature's defenses during environmental stresses and against diseases. Resveratrol showed an inverse correlation between consumption of red wine and the incidence of cardiovascular diseases, and their natural function as a primary protection against fungal diseases in the field, suggest that they may have antimicrobial activities against other types of microorganisms as well. In fact, the consumption of wine has been reported to have a protective effect against *Helicobacter pylori*, *Salmonella* Enteritidis (Bellido-Blasco et al., 2002) and hepatitis A virus (Desenclos et al., 1992) foodborne infections. The

benefits accrue mainly through the additive or synergistic interactions between resveratrol (and its metabolites) with other chemical compounds found in wine or food (Friedman et al., 2006). Red and white wines without added sulfite were tested for antibacterial activity against the foodborne pathogens, *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Salmonella* Typhimurium and *Staphylococcus aureus* (Moretro et al., 2004). The wines showed bactericidal activity against all the tested strains, with the red wine being the most potent. The exact mechanisms responsible for the bactericidal and antimicrobial effects of red wine are not completely understood. Despite wine's ethanol content, studies have demonstrated that ethanol diluted to a concentration commonly present in wine (10-14%) exhibit a lower antibacterial effect than wine itself. The antibacterial agent in red wine was suggested by Murray et al. (2002) to be resveratrol.

Foodborne pathogens

Foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States each year (CDC). Foodborne pathogens account for an estimated 14 million illnesses, 60,000 hospitalizations, and 1,800 deaths (Bresee et al., 2000). *Salmonella* is one of the most common causative agents of intestinal infections in the U.S. The CDC estimates that 73,000 cases of *E. coli* O157:H7 infections occur annually in the U.S. In addition, *L. monocytogenes* is estimated to cause approximately 1,600 cases of listeriosis annually, resulting in 415 deaths. *H. pylori* regularly colonizes the human stomach and may lead to the onset of various gastric-related diseases (Dunn et al., 1997).

Probiotics

Probiotics are viable microorganisms that have been associated with a number of health beneficial effects upon colonization and implantation in a host. There is evidence to believe that probiotics compete with and suppress the growth of undesirable microorganisms in the colon and small intestine and, thus, help stabilize the digestive system (Sanders, 1999). Certain strains of lactobacilli and bifidobacteria that naturally exist in the human colon are considered probiotics. Probiotics can also be taken as foods or supplements and can help treat or prevent illness, such as vaginal yeast infections and diarrhea, following treatment with certain antibiotics. Clinical studies indicate that probiotic foods can help improve gastrointestinal health, protect against infection and enhance immunity.

Table 1. pH, titratable acidity, and alcohol and t-resveratrol contents of red wine.

Red wine	Variety	pH	% Titratable acidity	*t*-Resveratrol mg/mL	% Alcohol
Merlot 1	Merlot	3.62	6.375	0.2724	13
Merlot 2	Merlot	3.48	5.475	3.5384	13
Shiraz	Shiraz	3.63	5.925	2.2745	13.5
Cabernet Sauvignon	Cabernet Sauvignon	3.77	5.775	0.2781	13
Pinot Noir	Pinot Noir	3.58	6.60	1.6069	12
Grenache Shiraz	Grenache 60% & Shiraz 40%	3.52	6.225	1.0683	14
Tempranillo 2004	Tempranillo 2004	3.46	6.525	1.8632	13
Chambourcin	Chambourcin	3.36	7.125	0.3979	14
Zinfandel & Carignane 2000	Zinfandel & Carignane 2000	3.72	6.075	0.5136	13.5
Cherry wine	Cherry wine	3.58	13.125	0.1275	12
Hybrid and American blend	Hybrid and American blend	2.33	6.675	0.1373	12
Red Zinfandel	Red Zinfandel	2.86	6.225	0.4949	13.9
Blush Zinfandel	Blush Zinfandel	3.25	7.875	0.1826	9
White Zinfandel	White Zinfandel	2.31	8.550	0.0770	9

Research objectives

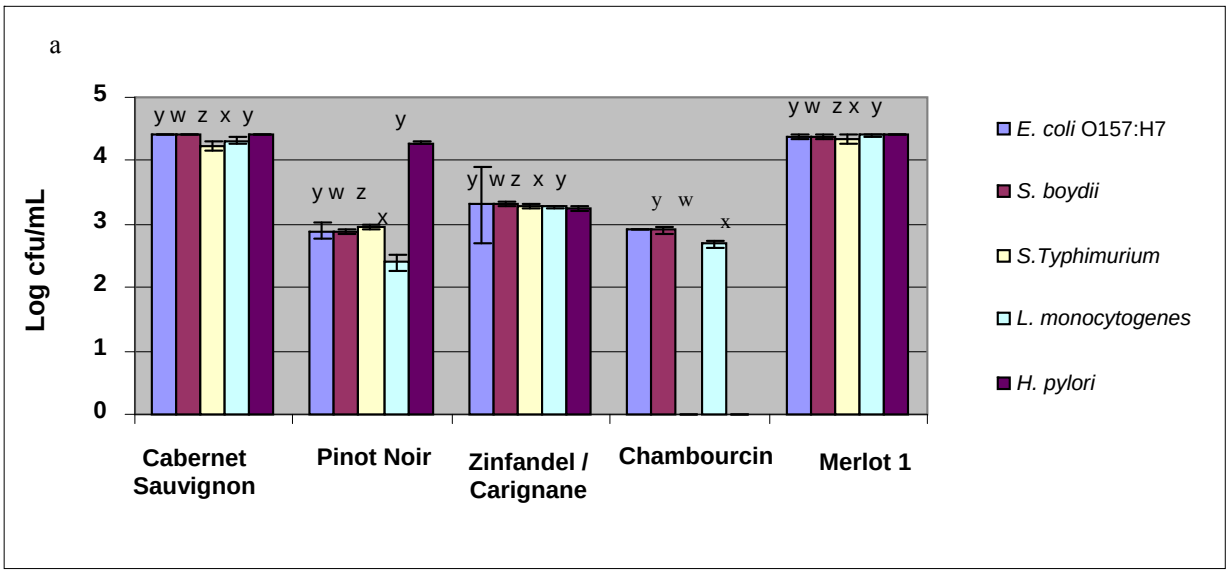
We believe that red wines will exhibit bactericidal activity against common foodborne pathogens at varying degrees. The overall objectives of this research were to determine the antibacterial effects of commonly consumed red wines on foodborne pathogens and probiotic bacteria and to correlate the effects to the pH, TA, ethanol and resveratrol contents of each red wine.

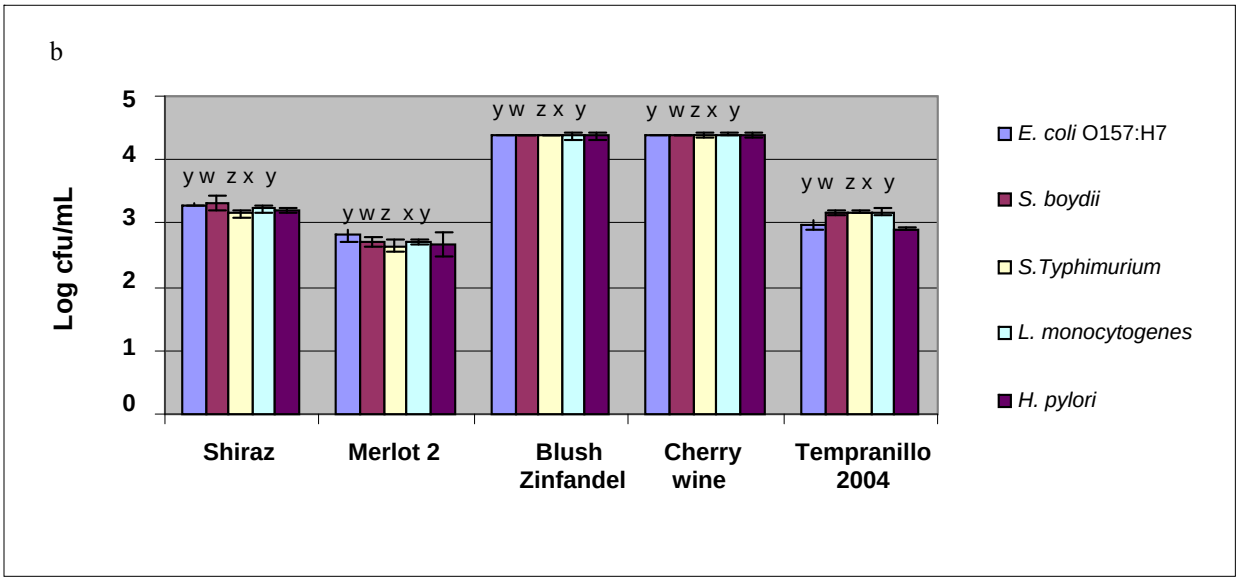
Approach

Red wines, which included, Cabernet Sauvignon, Tempranillo, Chambourcin, Grenache Shiraz, Merlot, Pinot Noir, Zinfandel, and two table wines, were analyzed for pH, titratable acidity and resveratrol concentration. A White Zinfandel served as a control. Foodborne pathogens, specifically, *H. pylori*, *L. monocytogenes*, *E. coli* O157:H7, *S.* Typhimurium and *Shigella boydii*, and the probiotics, *Lactobacillus paracasei*, *L. acidophilus*, *L. rhamnosus* and *Bifidobacterium longum*, were exposed to varying dilutions of each red wine to determine their survival and tolerance to the wines. Upon evaporation of the alcohol from each red wine, the total polyphenols from each were also tested against each bacterium.

Results and discussion

Table 1 lists the pH, titratable acidity, alcohol content and *t*-resveratrol content of each red wine tested. The *t*-resveratrol content of Merlot 2, Pinot Noir, Shiraz and Tempranillo, 2004 was much higher than that of the other red wines tested. The two table wines tested, Cherry wine and Hybrid and American blend, had the lowest concentration of *t*-resveratrol, comparable to that of Blush and White Zinfandels. Table wines and Zinfan-





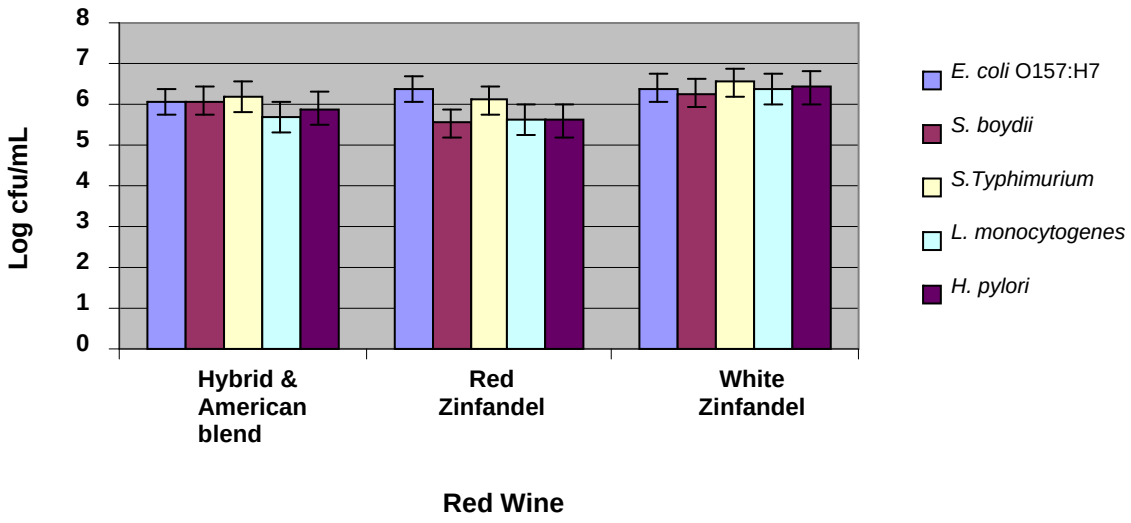
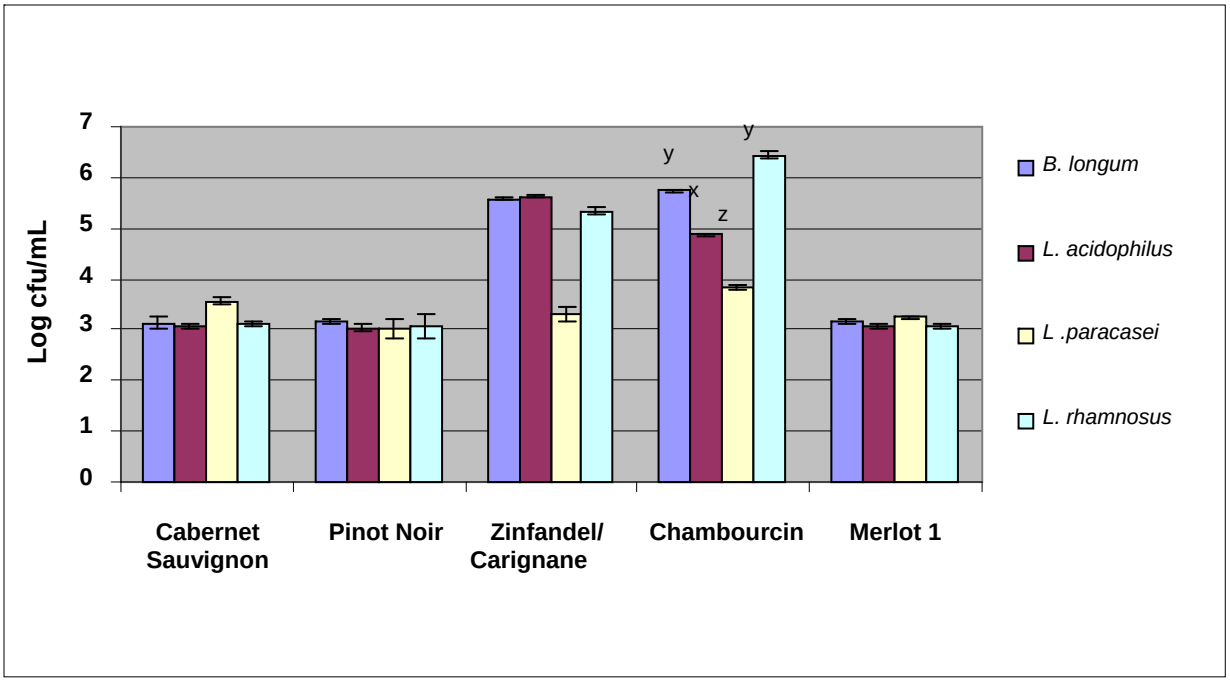


Figure 1 Red wine activity against pathogens when tested at 40% concentration. The initial numbers of each pathogen were 10^8-10^9 CFU/mL. Means with the same letters are not significantly different at $P \leq 0.05$.

dels are considered sweeter wines and their lower levels of *t*-resveratrol support the fact that drier red wines typically contain higher concentrations of polyphenols. The alcohol content among all the red wines tested was in the range of 12-14%, while the pH ranged from 2.33 for Hybrid and American blend to 3.77 for Cabernet Sauvignon.

All the red wines, except the Zinfandels and Cherry wine, were effective against all five foodborne pathogens tested at a lowest concentration of 40%. The lowest effective concentration of the Zinfandels and Cherry wine was 50%. Concentrations of higher than these, completely killed all the pathogens tested, as demonstrated by zero counts via pour plating. Figure 1 shows the antibacterial activity of 40% v/v red wines against the pathogens via the pour plate technique. The initial concentration of each pathogen was 10^8-10^9 CFU/mL. After treatment with 40% (v/v) red wines, numbers of each pathogen decreased to 10^4-10^5 CFU/mL, indicating the potent antibacterial property of the wines tested. The bactericidal pattern for *E. coli* O157:H7 and *H. pylori* was not significantly different from each other when treated with the different red wines, except for Pinot Noir and



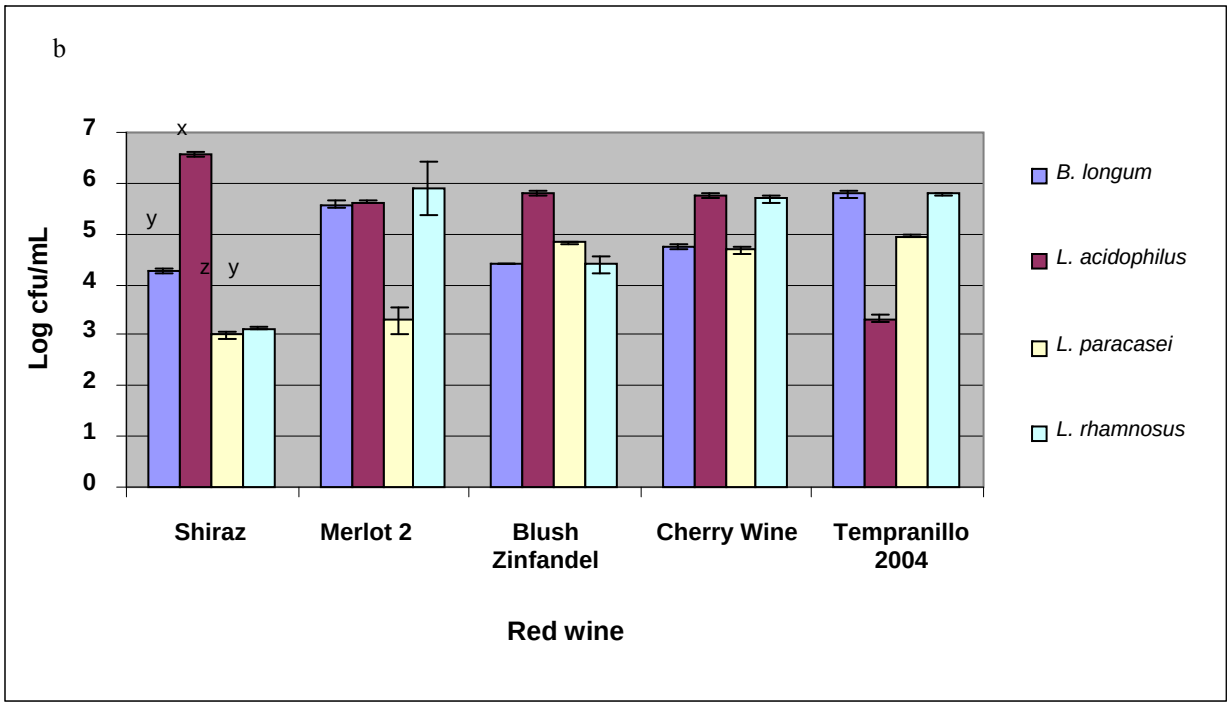


Figure 2. Red wine activity against probiotics when tested at 80% concentration. The initial number of each probiotic was 10^7 CFU/mL. Means with the same letters are not significantly different at $P \leq 0.05$.

Chambourcin. However, there was a significant difference in inhibition among *S. boydii*, *L. monocytogenes* and *S.* Typhimurium ($P \leq 0.05$). The inhibitory action of Merlot 2, Chambourcin, Pinot Noir and Shiraz was extremely rapid compared to that of the Zinfandels and Cherry wine. Cabernet Sauvignon and Merlot 2 were more potent than the Zinfandels and Cherry wine even though the pH of the former was 3.8 and 3.6, respectively, while that of the latter, ranged from 2.86 to 3.58. This fact can again be attributed, in part, to the lower levels of polyphenols present in the latter wines in comparison to the former.

On the other hand, all four probiotic strains tested survived exposure to up to 80% of each red wine, even though the decrease in numbers was prominent from the initial 10^7 CFU/mL. *L. acidophilus* even survived in the presence of 100% Pinot Noir, albeit the number was reduced by 6 log CFU/mL. Figure 2 shows the antibacterial activity of 80% (v/v) red wines against the probiotics tested via the pour plate technique. The inhibitory action of Cabernet, Pinot Noir and Merlot was approximately similar against the four probiotics tested. The degree of inhibition of *B. longum* was not significantly different from that of *L. rhamnosus*, while the inhibition of the other two lactobacilli were significantly different from one another ($P \leq 0.05$) when tested against the red wines. *B. longum* and *L. rhamnosus* were more resistant than the other two lactobacilli against Chambourcin and Zinfandel & Carignane 2000. *L. acidophilus,* among the probiotics tested, was most resistant to Shiraz followed by Zinfandel & Carignane 2000, Merlot 2 and Blush Zinfandel. Overall, *L. paracasei* appeared to be the least resistant to the red wines among all the probiotics tested.

When the alcohol was evaporated and the total polyphenols tested against the pathogens and probiotics, complete inhibition of all five pathogens were observed. On the other hand, the probiotic numbers decreased by about 4 log CFU/ml upon exposure to the red wine polyphenols. This result support the fact that the alcohol in red wines is not the only responsible antimicrobial agent, but that the polyphenols present also exhibit antimicrobial properties. Interestingly, the probiotics were more resistant to the polyphenols than the pathogens, again supporting their higher tolerance to the beverage in general.

Conclusions

Our work showed, via in vitro tests, the antimicrobial activity of various red wines against multiple foodborne pathogens. It also demonstrated that health beneficial probiotic cultures were not as drastically affected by red wines as the pathogens. The probiotics could withstand red wines up to 80% whereas the pathogens were completely killed at red wine concentrations of above 40-50%. The determination of *t*-resveratrol in various red wines indicate that the drier the red wine, the higher the polyphenol content and the greater the antimicrobial activity, while the opposite was true with the sweeter red wine varieties and white wine. Our study

clearly showed that the Zinfandels and sweet table wines were not as potent as the other counterparts in bringing about bactericidal properties against the pathogens. Since the percentage of alcohol was almost the same in all the red wines tested, the inhibitory effects can be attributed not just to the alcohol, but the polyphenols, including *t*-resveratrol, along with the acidic pH and organic acids that synergistically resulted in the bactericidal property of red wines against the foodborne pathogens tested.

References

Bellido-Blasco, J.B., Arnedo-Pena, A., Cordero-Cutillas, E., Canos-Cabedo, M., Herrero-Carot, C., Safont-Adsuara, L. 2002. The protective effect of alcoholic beverages on the occurrence of a *Salmonella* food-borne outbreak. Epidemiol. 13:228-30.

Bresee, J.S., Dietz, V., Griffin, P.M., McCaig, L.F., Mead, P.S., Shapiro, C., Slutsker, L., and Tauxe, R.V. 2000. Food-related illness and death in the United States. J. Environ. Health. 62:607-625.

Burns, J., Crozier, A., and Lean, M.E. 2001. Alcohol consumption and mortality: Is wine different from other alcoholic beverages? Nutr. Metab. Cardiovasc. Dis. 11:249-258.

CDC. 2005. Preliminary Food Net data on the incidence of infection with pathogens transmitted commonly through food - 10 States, United States. MMWR 55:392-395.

Desenclos, J.C.A., Klontz, K.C., Wilder, M.H., and Gunn, R.A. 1992. The protective effect of alcohol on the occurrence of epidemic oyster-borne Hepatitis A. Epidemiol. 3:371-374.

Dunn, B.E., Cohen, H., and Blaser, M.J. 1997. *Helicobacter pylori.* Clin. Microbiol. Rev. 10(4):720-741.

Friedman, M., Henika, P.R. Levin, C.E., and Mandrell. R.E. 2006. Antimicrobial wine formulations active against the foodborne pathogens, *E. coli* O157:H7 and *Salmonella enterica.* J. Food Sci. 71(7): 45-251.

Moretro, T. and Daeschel, M.A. 2004. Wine is bactericidal to foodborne pathogens. J. Food Sci. 10:1365-2621.

Murray, L.J., Lane, A.J., Harvey, I.M., Donovan, J.L., Nair, P., and Harvey, R.F. 2002. Inverse relationship between alcohol consumption and active *Helicobacter pylori* infection: The Bristol *Helicobacter* project. Am. J. Gastroenterol. 97 (11):2750-2755.

Sanders, M.E. 1999. Probiotics. Food Technol. 53 (11):67-77.

Rodriguez Vaquero, M.J., Alberto, M.R. and Manca de Nadra, M.C. 2007. Antibacterial effect of phenolic compounds from different wines. Food Control 18: 93-101.

The use of fining agents and their effects on wine composition

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Abstract

Wine clarity, brilliance and a supple rounded palate can be achieved within a shorter time than waiting for spontaneous natural settling and aged integration if fining agents are used. Fining can insure that soluble proteins will not denature in less favorable storage conditions causing haze and sediment. In addition, some quality issues caused by oxidation such as browning and cooked aromas can be reduced by fining. The most common fining agents used in wine production include bentonite, casein, gelatin, isinglass, albumen and PVPP (polyvinylpolypyrolidone). Modes of action employed by fining agents for compound removal are electrostatic charge, hydrogen bonding, adsorption and absorption. Unfortunately, fining not only removes compounds that have a negative effect on wine quality but beneficial compounds to some degree as well. Quality wine is denoted by its sensory attributes namely, flavor, color and aroma, all of which are impacted by fining. The negative impacts of fining include reduction in wine structure, loss of varietal and fermentation aroma, and loss of color. To avoid the pitfalls of fining it is crucial the winemaker is familiar with different fining agents and employs the correct methods for preparation, fining trials and the right agent for the task.

Important fining agents used in wine clarification and protein stability

Fining agents have an important role in the production of quality wine. The uses of fining agents include tannin removal, wine flavor or mouth feel modification, color removal, clarification and haze removal [1]. The most common fining agents include bentonite, casein, albumen, gelatin, isinglass and PVPP and can be divided into two broad categories, organic and inorganic agents. Organic

agents include casein, albumen, gelatin, and isinglass and inorganic – bentonite and PVPP. The aforementioned organic fining agents are all protein based and are used primarily for the modification of wine tannin profiles. PVPP, a synthetic polymer, is also used for phenolic removal. Bentonite is utilized mainly for protein removal and the prevention of protein haze.

As a winemaking aid, bentonite dominates in the removal of unstable proteins. It is a useful tool in reducing browning [2] and pesticide concentrations [3]. In addition, when added pre-ferment as an insoluble solid, bentonite acts to promote yeast growth encouraging ferment completion, quicker ferments and slightly increases fusel oil concentrations [4].

Unfortunately, bentonite is the most likely fining agent to have a negative effect on wine quality [1]. Some researchers have found that the excessive addition of bentonite (>0.5 g/L) can cause stripping of wine body, flavor and in some red wines, color [1]. This is supported by those in the industry with some winemakers reporting that bentonite fining has a greater impact on a wine's overall structure and mouth-feel rather that its aromatic profile (Dave Johnson 2007, personal communication).

Protein based fining agents include casein, albumen, gelatin and isinglass. With all protein fining agents it is necessary to choose the best product available free of undesirable off odors and flavors [1]. The mode of action for these agents is that of hydrogen bonding between the carbonyl oxygen of the peptide bond and the phenolic hydroxyl [1].

Casein is the most important protein in milk [1]. The different forms of casein used include whole milk, skim milk, lactic casein and potassium caseinate [5]. The skim milk form is the most gentle of the casein products and can be used up to 2L/1000L wine [1]. Potassium caseinate is the most commonly used form as it is water soluble [6]. When added to an acid solution such as wine, casein, the positive charged molecule flocculates, adsorbing and mechanically removing suspended proteins as it falls [6]. Casein is used to remove unwanted or oxidized aromas, take out color and clarify white wines [1, 6]. Addition rates for casein are in the range of 1.25 to 24g/hL [1]. Casein is the least likely fining agent to over-fine wine due to high addition rates [5].

Albumen derived from egg whites is routinely used in red winemaking for phenolic removal to soften wine by reducing astringency [1]. Fresh, opposed to frozen, egg whites appear to have greater capacity for phenol removal [1] and are prepared as a 10% solution with water and 0.5% non iodized NaCl [5]. Albumen addition rates are normally one to three eggs, (each egg yielding 3-4g of protein) per 200L wine [5] but can be up to eight egg whites per 225L barrel [1].

Gelatin is collagen based and is used to reduce wine color and wine phenolic concentration. It is often added with silicon dioxide or flavorless tannins to avoid induced protein haze [1, 7]. The use of silicon dioxide as a counter fining measure is thought to reduce the impact of gelatin fining on wine flavor [1]. Addition rates range from 0.75g/L in white wine up to 48g/L in heavy pressings suffering from astringency and oxidized color [1].

Isinglass is a collagen derived from fish and is thought by some to be the best protein fining agent producing wines that are brilliantly clear and with a rounded palate [5]. Isinglass is employed using low fining rates between 0.02-0.1g/L and is often added with bentonite, which is added first [5]. Temperature is of concern when preparing isinglass which begins to denature at around 50°F (10°C) therefore isinglass preparation needs to be at cool temperatures ≤15°C (60°F) [1].

PVPP or polyvinyl-polypyrrolidone is a synthetic substance that specifically removes phenolic compounds responsible for excessive astringency and browning [5 175]. In addition PVPP has been found useful for the removal of pinking [5]. It is thought to be one of the least aggressive fining agents as it does not impact the aroma profile of wine and is commonly added at rates between 0.2 to 0.5g/L [5].

Fining trials

Post-ferment fining tests are undertaken to determine the least amount needed to give the desired change to wine composition and/or appearance. A bentonite test is done by making up a stock solution, 5% is common, then adding given amounts of bentonite solution to a wine to give a range of concentrations (e.g. 0, 0.2, 0.4, 0.6 g/L). The wine is then filtered or centrifuged, decanted and then heated to 80 °C for 6 hours. Samples are then checked for clarity to find the appropriate dosage level [5].

Proteinaceous fining agents are trialed in a similar fashion using addition rates within the ranges described earlier. However, assessment of wines would be according to sensory evaluation, e.g. correct astringency balance and level of color reduction. It is essential that the same method of fining agent preparation be used when preparing for addition to wine.

Influence of fining agents on browning, pesticide removal and protein stability

Casein, gelatin, isinglass, PVPP and bentonite addition are effective in reducing browning [2, 5]. Bentonite is more useful for pesticide removal than PVPP [3] but is most commonly used in white wines for protein stability.

When added to Seyval blanc at the juice phase and/or during fermentation, bentonite at rates of 950mg/L (950ppm) was found to successfully reduce browning, its efficacy equivalent to that of SO_2 additions at rates of 100ppm [2]. PVPP was less effective than bentonite in reducing color in juice and did not inhibit or reduce the activity of catecholase, the enzyme responsible for browning [2]. The influence of bentonite was attributed to the removal of phenolic compounds which act as a base for browning through oxidation [2]. It is the process of oxidation that causes browning during white wine aging and the shift from blue/purple to brick red in red wines. However, after aging it was found that SO_2 was the only treatment effective in preventing browning in the bottle [2]. This study highlights the importance of adequate SO_2 for wine protection [2].

Pesticide residues in wine are an important consideration for winemakers. In recent times there has been a growing demand for sustainable, organic and even biodynamic wines. An Australian study [3] looked into the influence of fining on pesticide removal. It was found that bentonite addition at rates of 2500mg/L were highly effective at pesticide removal in white wine with almost total removal (91-100%) of two fungicides, carbenzidazim and chlorothanolil. Bentonite removed around half of the aforementioned fungicides from red wine [3] while PVPP showed no significant removal. However, at low concentrations (0.1mg/L) the insecticide chloropyrifos was partially removed by PVPP around 55% and 86% at low and high fining addition rates of 0.05 and 0.3 grams per liter respectively [3]. In the case of the fungicides carbenzidazim and chlorothanolil, bentonite was most effective at lower pesticide concentrations, 0.1 vs. 3.0 ppm and 0.1 vs. 1.0 ppm respectively [3]. Insecticides chloropyrifos and dicofol were significantly reduced (albeit by a lesser degree than the aforementioned fungicides) by bentonite and removal was greater at higher concentrations, 1.0 vs. 0.1ppm and 2.0 vs. 5.0 respectively [3]. Of the four filtering and fining agents used in the Australian trial (DE, bentonite, PVPP and activated charcoal) activated charcoal was the most effective, followed by bentonite [3]. In general pesticide removal was more successful in white wine than red wine [3].

In a study by Puig-Deu et al. [8] wines fined with bentonite (0.5 g/L) had 45% less protein than control wines. However additions at 0.18 g/L showed no reduction in protein content. Important studies [4, 9] on unstable proteins in wines found that the most important proteins contributing to protein instability in wines were of a low MW (molecular weight) of 12,600 and 20,000-30,000 of a low pl (polarity) and included glycoproteins which contribute a large proportion of grape proteins. Sauvignon blanc and both Riesling and Gewürztraminer wines are high in MW proteins of 25,000 and 28,000 respectively [9]. Such MW values fall outside the parameters of those most readily removed by bentonite e.g. intermediate MW 32 000- 45 000. The Hsu & Heatherbell [10] study gives insight into why some white wines have a predilection to protein instability (Dr. D. Heatherbell, personal communication 2005). Other anecdotal evidence supports varietal protein instability. Traminette, the French-American hybrid suffers protein instability and high rates of bentonite addition are needed to ensure wine stability (Dave Johnson, 2007, personal communication), as does its close relative Gewürztraminer [9].

Low rates of bentonite addition (30ppm) at *tirage* negatively impacts sparkling wine quality by significantly reducing wine effervescence in regard to foam production: reducing surface area covered by foam and increasing bubble size [11]. A significant reduction of protein and peptide concentrations were noted in wines fined with bentonite but no such trend was found in amino acid concentrations [11].

Fining agent impact on flavor and aroma compounds in wine

Regional variation and cultural wine making practices are commonly known to influence wine composition and quality. Winegrowing regions develop a notoriety and demand higher price points for wines that display these regional characteristics, e.g. Marlborough Sauvignon blanc, Alsatian Riesling and Missouri Norton.

Timing of addition is a contentious issue with some believing that bentonite added pre-ferment has less impact on wine quality compared to post-fermentation addition [12]. Others have found that bentonite added pre-fermentation leads to the greatest loss of wine volatiles [8]. When used as a settling agent, bentonite was found to produce wines that were lower in concentrations of volatile compounds compared with other fining agents such as potassium caseinate [8].

Compounds that are important in contributing to a wines sensory profile include organic acids, sugars, methoxypyrazines, thiols, esters, oak derived compounds and alcohol.

Organic Acids & Sugars

As a group acids are almost as important to wines as alcohols [7]. Acids are responsible for giving wine its structure and longevity in addition to flavor. Must fining with bentonite, potassium caseinate and a combination of bentonite and gelatin showed no impact on wine pH or titratable acidity in Parellada wine [8].
Must fining with bentonite, potassium caseinate and a combination of bentonite and gelatin showed no impact on wine residual sugars in Parellada wine [8].

Methoxypyrazines & Thiols

IBMP (2-Methoxy-3-isobutylpyrazine) is regarded as the most important contributor of the grassy, green pepper, asparagus, herbaceous aroma of Sauvignon blanc wines [13]. About half the IBMP and IPMP in grapes is lost during wine processing [14, 15]. IBMP is easily extracted during grape processing with free run juice concentrations very similar to those from pressed juice fractions [14]. The addition of bentonite to wine appears to have little influence on methoxypyrazine concentrations [15], however, settling, an important part of clarification, causes the loss of approximately half of the methoxypyrazines in wine [14].

An important group of aroma compounds that add to the perception of fruitiness in wines are thiols. The addition of bentonite at 700ppm has little influence on thiol concentrations in Sauvignon blanc wine [15].

Esters

Created during fermentation esters are known to produce a large proportion of the aromatic profiles of young white wines [7]. Overall wine ester concentrations are reduced by bentonite addition at a rate of 600ppm (0.6g/L) [16]. Findings show hexyl acetate and ethyl ocatanoate increased by about 1 mg/L from about 4.7 to 5.7mg/L, and 5mg/L from 44 to 49mg/L [16]. The same study showed a decrease in ethyl hexanoate by 4mg/L from approx 26 mg to 22 mg/L. Voilley [17] found an ester reduction of around 20%, namely ethyl hexanoate and isoamyl acetate in model wines when fined with bentonite. Sodium caseinate showed similar influence on ester concentrations binding 24% ethylhexanoate and isoamyl acetate [17].

Hexyl acetate described as perfume and ethyl octanoate as sweet soap are considered to be the key aroma compounds indicating high quality red wine [18]. Due to the low sensory thresholds of wine esters; increasing or reducing ester concentrations by around 1 to5 mg/L as found by some researchers [16, 17] could impact wine sensory profiles and therefore quality perception in consumers.

Terpenes

Terpenes are varietal aroma compounds that are important in the expression of aromatic wines such as Gewürztraminer and Riesling [19]. Terpenes give floral fruity nuances to wine and in addition terpene profiles can be used to denote the wine geographical origin [19]. Sodium caseinate reduces terpene concentrations by binding 50% β-ionone in white wine [17]. β-ionone is characterized by nuances of violet [20] Bentonite addition was found to reduce total terpene content in Albarino wines by 13% [16]. Whereas silica gel in the same study produced a 20% increase in terpenoids. The increase in terpenes may be due to the removal pre-ferment of other compounds that mask or interfere with terpene expression [16]. In contrast, a study by Puig-Deu et al.[8]found that potassium caseinate had no impact on terpenes, namely linalool, the Chardonnay terpene [21], α-terpinol and nerol.

Phenolic compounds

Bentonite is not as effective as potassium caseinate in removing phenolics from white wine [8]. Potassium caseinate can remove around 20% polyphenolics from wine whereas bentonite reduced polyphenols by around 6% [8]. In white muscadine wines both PVPP and casein reduced total phenolic and flavonoid phenolics [22].In red wine PVPP and casein significantly reduce color and phenolics content [22]. Compared with the control (1150 mg/L) PVPP addition of 0.5 g/L and 1g/L reduced total phenols by approximately 100mg/L and 150mg/L [22]. Casein at 0.5g/L and 1g/L removed about 50mg/L total phenols from wine [22]. Red wines fined with casein and PVPP in this study also showed significant color loss.

Alcohol

Ethanol is the most important by product of fermentation [7] that influences wine quality appreciably. The affect of ethanol on the metabolic rates of yeasts influences the types and amounts of aromatic compounds produced. In addition, its action as a solvent acts to reduce the release of aromatic compounds from wine with carbon dioxide while fermentation is taking place [7]. Must fining with bentonite, potassium caseinate and a combination of bentonite and gelatin showed no impact on ethanol concentration in Parellada wine [8]. However, when added as a fermentation aid bentonite increases fusel alcohols, namely isoamyl alcohol and n-proyl alcohol by 4 mg/L and 1mg/L respectively [4].

Conclusion

Wine consumers expect brilliant clarity and the expression of variety and regionality in a quality wine. Winemakers strive to produce wine that has powerful varietal and regional character that communicates to the consumer individuality and value for money. Varietal and regional characteristics of a wine are a product of the flavor and aroma compound concentrations. Clarity and stability in wine can come at the expense of compounds that are indicators of wine quality. Some compounds that are significantly influenced by fining are phenolics and esters whereas methoxypyrazines, organic acids and alcohols appear not as susceptible. The expected impact of fining on a wines sensory profile includes reduction in wine structure and astringency from phenolic removal and reduced aromatic intensity from reduced terpene and ester content.

References

1. Zoecklein, B.W., et al., *Wine analysis and production.* 1999, New York: Kluwer Academic.
2. Main, G.L. and J.R. Morris, *Colour of Seyval blanc*

juice and wine as affected by juice fining and bentonite fining during fermentation. American Journal of Enology and Viticulture, 1994. **45**(4): p. 417-422.
3. Ruediger, G.A., et al., *Removal of pesticides from red and white wine by the use of fining and filter agents.* Australian Journal of Grape and Wine Research, 2004. **10**: p. 8-16.
4. Groat, M. and C.S. Ough, *Effects of insoluble solids added to clarified musts on fermentation rate, wine composition and wine quality.* American Journal of Enology and Viticulture, 1978. **29**(2): p. 112-119.
5. Rankine, B., *Making good wine: a manual of winemaking practice for Australia and New Zealand.* 2004, Sydney: Pan Macmillan Australia Ltd.
6. Morris, J.R. and G.L. Main. *Fining agents for wine.* in *14th New Mexico Grape Growers and Wine Makers Conference*. 1995. Albuquerque, New Mexico.
7. Jackson, R.S., *Wine Science: Principles, Practice, Perception*. 2nd ed, ed. S.L. Taylor. 2000, San Deigo: Academic Press. 648.
8. Puig-Deu, M., et al., *Influence of must racking and fining procedures on the composition of white wine.* Vitis, 1996. **35**(3): p. 141-145.
9. Hsu, J.-C. and D.A. Heatherbell, *Heat-Unstable Proteins in Wine. I. Characterization and Removal by Bentonite Fining and Heat Treatment.* Am. J. Enol. Vitic., 1987. **38**(1): p. 11-16.
10. Hsu, J. and D. Heatherbell, A., *Heat-unstable proteins in wine. I. Characterisation and removal by bentonite fining and heat treatment.* Am. J. Enol. Vitic., 1987. **38**(1): p. 11-16.
11. Martinez-Rodriguez, A.J. and M.C. Polo, *Effect of the addition of bentonite to the tirage solution on the nitrogen composition and sensory quality of sparkling wines.* Food Chemistry, 2003. **81**(3): p. 383-388.
12. Wehrung, F., *Els productes enologics adaptats a la vinificacio del tipus 'champenoise'*. 1996, Station oenotechnique de Champagne Martin Vialatte: Reims.
13. Marais, J., *Sauvignon blanc cultivar aroma-a review.* South African Journal of Enology and Viticulture., 1994. **15**(2): p. 41-45.
14. Roujou de Boubee, D., *Research on 3-methoxy-3-isobutylpyrazine in grapes and wines.* 2003, Academie Amorim: Bordeaux.
15. Ford, R.J., *The effect of shading and crop load on flavour and aroma compounds in Sauvignon blanc grapes and wine*, in *Viticulture and Oenology*. 2007, Lincoln University: Lincoln, Canterbury.
16. Armada, L. and E. Falque, *Repercussion of the clarification treatment agents before the alcoholic fermentation on volatile composition of white wines.* European Food Research and Technology, 2007. **225**: p. 553-558.
17. Voilley, A., et al., *Influence of macromolecules and treatments on the behavior of aroma compounds in a model wine.* J. Agric. Food Chem., 1990. **38**(1): p. 248-251.
18. Marais, J. and F.C. van Rooyen, *Objective quality rating of Pinotage wines.* Vitis, 1979. **18**: p. 31-39
19. Rapp, A., *Volatile flavour of wine: correlation between instrumental analysis and sensory perception.* Nahrung, 1998. **42**(6): p. 351-363.
20. Fretz, C., et al., *Analysis of volatile components of Petite Arvine wine.* European Food Research and Technology, 2005. **221**(3-4): p. 504-510.
21. McCloskey, L.P., M. Sylvan, and S.P. Arrhenius, *Descriptive analysis for wine quality experts determining appellations by Chardonnay wine aroma* Journal of Sensory Studies, 1996. **11**(1): p. 49-67.
22. Sims, C.A., J.S. Eastridge, and R.P. Bates, *Changes in Phenols, Color, and Sensory Characteristics of Muscadine Wines by Pre- and Post-Fermentation Additions of PVPP, Casein, and Gelatin.* Am. J. Enol. Vitic., 1995. **46**(2): p. 155-158.

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Grape phylloxera, Daktulosphaira vitifoliae Fitch,in the Ozark Mountain Region

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In the last decade, the North American grape phylloxera has reached pest status in the Ozark Mountain Region as growers plant more acres of own-rooted phylloxera-susceptible wine grapes (*Vitis vinifera* and *V. labrusca* parentage). This tiny yellow aphid-like insect is considered the most serious grape pest worldwide because the root form may cause vine death of susceptible cultivars. We are conducting studies to identify which of the major grape cultivars and rootstocks grown in the Ozark Region are seriously damaged by either grape phylloxera leaf galling or root attack and how best to manage this pest.

History: The grape phylloxera was the reason that 16th century French colonists in Florida and colonists elsewhere in North America and Mexico were unsuccessful in growing the European grapevine, *V. vinifera.* It was thought that eastern North American soils and climate were unsuitable for growing *V. vinifera*, whereas these vines grew well in California until the grape phylloxera was introduced during the 1870s. Between 1858 and 1862, the grape phylloxera was also introduced to Europe on imported American vines. For 15 years after introduction, this pest spread and destroyed 40% of French grape vines

and put at risk every vine in Europe (Montague 1986).

What causes vine death? In 1868, Professor Planchon dug up healthy, dying, and dead vines and noticed that all the dying vines had small yellow insects on their roots (grape phylloxera). In 1870, the American entomologist Charles Valentine Riley confirmed that grape phylloxera was causing root infestations of European vines and leaf galls on American vines (Montague 1986). Granett (2004) noted that grape phylloxera does not harm native American grapevines, although it causes galls on expanding grape leaves and swells small roots into nodosities. Feeding by root phylloxera on vines of *V. vinifera* and some hybrid cultivars causes them to become infected with secondary fungal pathogens that kill the vines.

Solution: Two French wine growers suggested grafting *V. vinifera* scion wood to American roots known to resist damage by grape phylloxera. In the late 1870s and 1880s, French growers began to replant preferred *V. vinifera* scion wood grafted on phylloxera-resistant American rootstock (Montague 1986). To date, phylloxera-resistant rootstocks have been optimized for vineyard locations and soil types and grafted to phylloxera-susceptible cultivars grown throughout the world (Granett 2004).

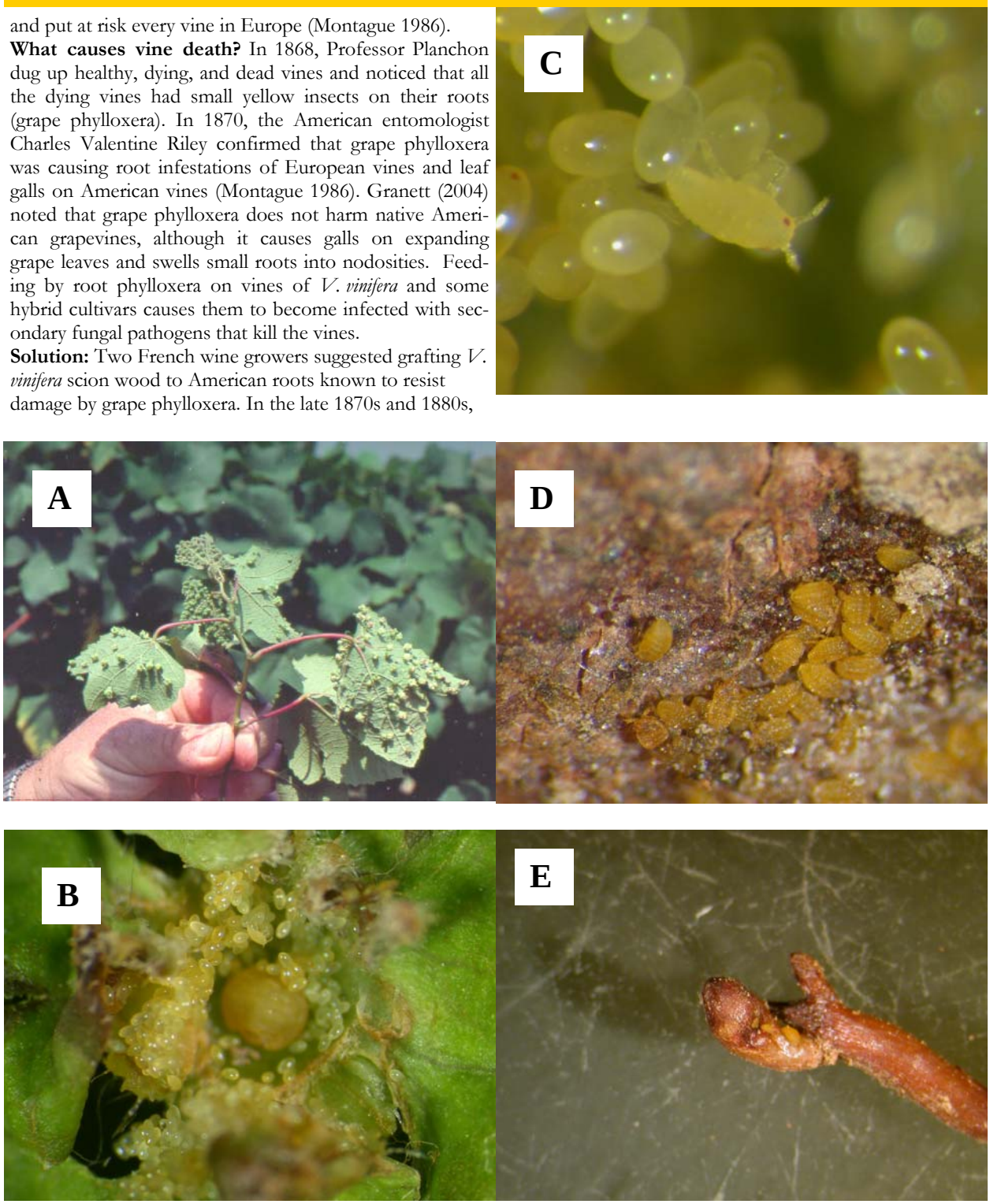

Figure 1. A) Galls on grape leaf in June, B) gall containing a grape phylloxera female with eggs, C) legged crawler on eggs inside a gall, D) phylloxera feeding on a large root and E) phylloxera feeding on a small root tip causing it to swell into a nodositie

Damage: Root infestation first causes grape leaves to yellow, turn red, then dry up and eventually drop off which produces fruit of poor quality. Typically, infested vines die within three years of initial attack. Dying or dead vines have roots that appear black and rotting. Grape phylloxera feeding injects a toxin into roots that causes yellow swollen galls on root hairs called nodosities and swellings of larger roots called tuberosities. Root feeding wounds serve as entry points for fungal infection which kills roots and leads to vine vigor decline or death. The foliar form causes leaf galls and premature defoliation which can reduce yield and fruit quality. This pest spreads to neighboring vines. In comparison, large roots of all North American *Vitis* species are not very affected by the insect. However, the small roots of some more northern species such as *V. labrusca* ('Concord') are eventually killed by the grape phylloxera, while the small roots of the more southern species of *V. riparia* and *V. rotundifolia* are resistant to root attack.

Description: The immature or crawler stage of the foliar form of grape phylloxera feeds on leaves and the leaf grows a gall around the crawler **(Fig. 1. A)**. The crawler matures into a fundatrix female called a stem mother (1st generation). In May, the stem mothers produce yellow, oval eggs **(Fig. 1. B)** that hatch into yellow, oval crawlers with six legs **(Fig. 1. C)**. Throughout the summer and fall, the root form of phylloxera increase in number on susceptible roots (**Fig. 1 D**) causing root tips to swell into nodosities (**Fig. 1 E**) and larger roots to swell into tuberosities.

Biology: A study was begun to determine the seasonal biology of grape phylloxera on grapes, relate crawler and winged adult emergence to cumulative degree-days (DD, base 50° F after 21 March), and determine when winter eggs are laid on grape trunks in October and hatch in April (**Fig. 2**). In the humid climate in the Ozarks, there are 5-7 generations per year of the foliar form. The first generation crawler walks on new shoots and feeds on the 1st to 5th expanding leaf. The grape phylloxera leaf gall counts per leaf and per vine increase with each generation. From 1 May on, 20 galled leaves were collected weekly from 'Norton' and from 1 June on from 'Vignoles'. Number of galls per leaf peaked for 2nd and 3rd generation crawlers on 11 May and 30 June in both cultivars (**Figure 2**). A small number of root phylloxera overwinter on roots.

In 2006, second generation crawler emergence peaked on 11 May (528 DD) and third generation peaked on 30 June (1658 DD). The April 8 freeze in 2007 removed foliage until early May so there were no detectable first or second generation crawlers. On 1 May 2007, double-sided sticky tape traps were wrapped on the trunk and on canes to capture crawlers moving from the soil up the trunk and on the canes to expanding foliage. Aerial sticky traps captured winged adults. In Altus, AR and Purdy, MO, third generation crawlers began emerging by 13 June 2007 from 1416 to 1600 DD. Aerial sticky traps detected first winged adult flight from 2526 to 2620 DD (**Fig. 3**). Larger numbers of winged adults and crawlers emerged in late September and early October which may be the overwintering egg laying period.

Susceptible cultivars and resistant rootstocks: Various scientists reported that several grape cultivars from crosses of *V. vinifera* and various American *Vitis* species when

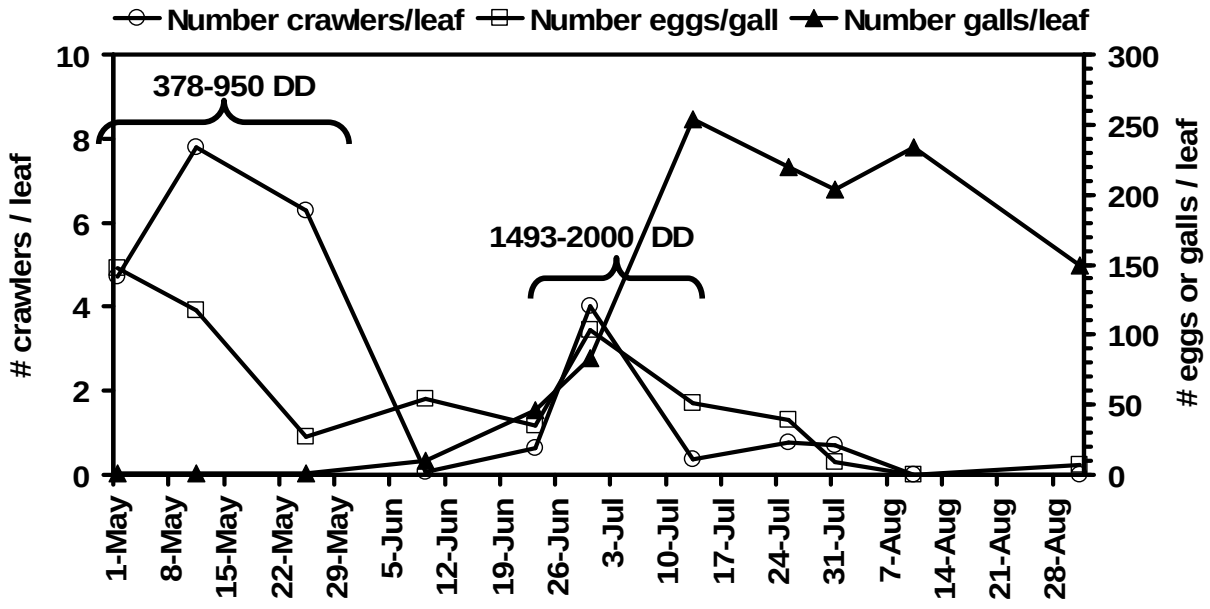

Figure 2. Cumulative number of degree-days (DD, base 50° F) versus number of 2nd and 3rd generation grape phylloxera eggs or crawlers per leaf in 'Norton' vineyard in Purdy, MO (2006)

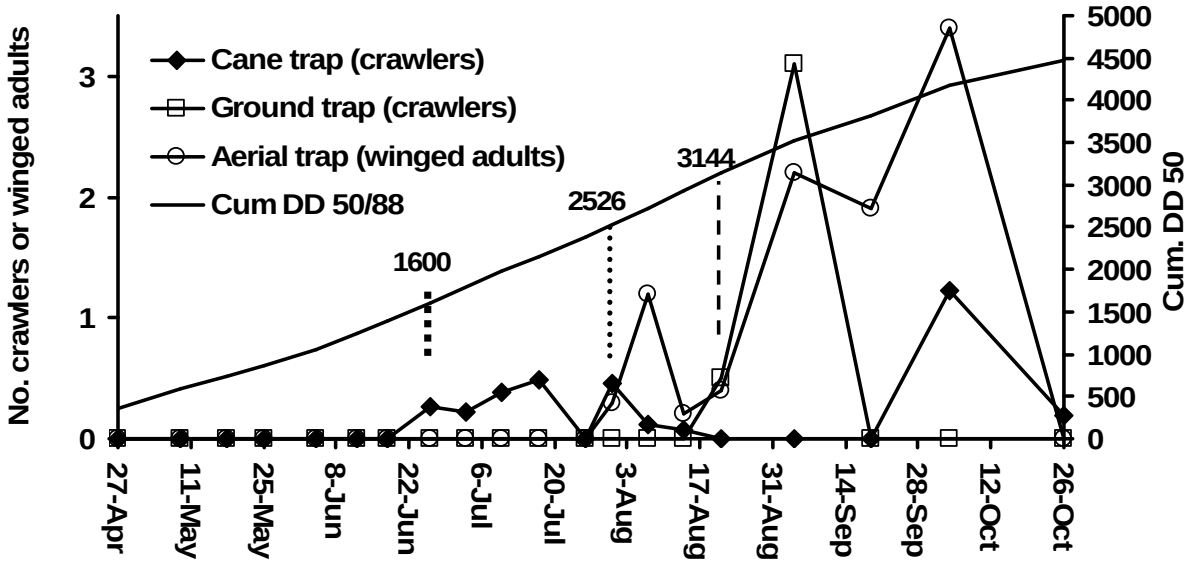

Figure 3. Cumulative number of degree-days (DD, base 50° F) versus number of 3rd and later generations of grape phylloxera crawlers and winged adults per trap in 'Vignoles' vineyard in Purdy, MO (2007)

Table 1. Mean number of grape phylloxera nodosities on roots of six grape cultivars at the University of Arkansas Farm in Fayetteville, AR, at Crown Valley Vineyard near Ste. Genevieve, MO (September 2006), and at St. James, MO (29 August 2007)

Site/Cultivar	**No. vines**	**No. root nodosities**
UA Farm-Fayetteville, AR		
3309C	4	1.5 ± 1.5b
Geneva Red	6	31.0 ± 14.7b
St. Vincent	6	75.7 ± 64.2b
Chambourcin	6	80.2 ± 19.3b
NY70.0834.05	7	696.3 ± 302.1a
NY73.0136.17	7	586.9 ± 177.0a
Crown Valley, MO		
Frontenac	4	1.0b
Traminette	4	39.3ab
Concord	4	66.5ab
Chardonel	4	74.0ab
Vignoles	4	127.7ab
Norton (2006)	4	219.8a
Norton (2007)	4	163.5 ± 227.0
St. James, MO		
Rougeon	4	49.8 ± 28.6
Cayuga White	4	395.5 ± 183.9
Catawba	4	353.0 ± 213.5
Norton	4	611.0 ± 377.5

[a] Mean values in a given column by site followed by the same letter are significantly different ($P < 0.05$), where the Least Significant Differences were 459.3 (UA) and 211.4 (Crown) (Waller-Duncan K-ratio t Test)

grown in the Ozarks were highly susceptible to leaf galling including: Aurora, Cascade, Cayuga White, Chambourcin, Chancellor, Chelois, DeChaunac, Delaware, Himrod, Humbert, Lakemont, Norton/Cynthiana, Rayon D'Or, Reliance (table grape), Rougeon, Seibel, Seyval, Vidal Blanc and Vignoles. In 2006, the 3309C rootstock was confirmed to be resistant to root phylloxera (< 2 nodosities) and there were several cultivars with < 81 nodosities on own-rooted vines (in ascending order of nodosities): Frontenac, Geneva Red, Traminette, Rougeon, Concord, Chardonel, St. Vincent and Chambourcin. Between 100 to 400 nodosities were recorded from Vignoles, Cayuga White, Catawba and Norton and > 500 nodosities occurred on NY70.0834.05 and NY73.0136.17 (**Table 1**). Other phylloxera-resistant rootstocks being evaluated in the Ozarks include: 101-14, 110-R, 1103P, 44-53, 5BB, Freedom, and SO4.

Monitoring: Restrict monitoring to moderately to highly foliar-susceptible cultivars. Begin examining the foliage weekly for new galls on expanding leaves after 3rd expanded terminal leaf. The 2nd generation crawlers emerge near bloom from 400-800 DD.

Control of root phylloxera: Root phylloxera damage is best prevented by grafting susceptible cultivars to resistant rootstocks like 3309, 110-R, 1103P, 44-53, 5BB, and Freedom, and SO4.

Control of foliar phylloxera: The leaf gall has a small opening on the upper surface of the leaf that minimizes phylloxera exposure to predators and insecticide. Thus, it is recommended to apply insecticide to foliage of susceptible cultivars near bloom during the 2nd generation crawler emergence period. Each crawler is exposed to insecticide as it walks from a parental gall along canes to expanding terminal leaves to feed. Repeat spray in 10 to 14 days if crawlers are still seen inside leaf galls. The following chemicals are labeled for foliar phylloxera control: Admire Pro, Assail, Danitol and Endosulfan (caution – Endosulfan is phytotoxic to several grape cultivars). In 2006, foliar sprays of Danitol applied either once (11 May) or Assail applied twice (11 and 25 May) during the second generation crawler period allowed significantly fewer galled shoots per vine (< 3) than did Admire Pro (8.8) which was significantly less than the untreated vines (> 15) (**Table 2**). We found that recommended rates of Danitol and Assail were effective against foliar phylloxera. Applying Admire Pro as a soil drench by bud break is expected to perform better than the soil application at time of crawler activity on 11 May 2006 (**Table 2**). The active ingredient of Admire Pro needs a couple weeks to systemically move from the roots to the leaves.

References:

Granett, J. 2004. Rooting out the wine plague. Books and Arts: Phylloxera: how wine was saved for the world. By C. Campbell. HarperCollins: 2004. 314pp. Nature 428(6978): 20.

Montague, J. 1986. The great French wine blight. Wine Tidings 96 (July/August).

Ordish, G. 1987. The great wine blight. J. M. Dent & Sons Ltd., London.

Table 2. Insecticide control of foliar grape phylloxera in Norton grapes in Purdy, MO (2006)

Treatment	No. Sprays [a]	# galled shoots/vine on 16 June [b]	# galled shoots/vine on 24 July [b]
Check	-	10.8a	15.7a
Admire Pro[a]	1	10.03a	8.8b
Assail	1	1.8c	7.3b
Assail	2	0.3c	2.0d
Danitol	1	0.2c	2.9cd
Danitol	2	0.08c	1.3d

[a] 1 = sprayed on 11 May; 2 = sprayed on 11 and 25 May

[b] Mean values in a given column followed by the same letter are not significantly different ($P > 0.05$), where the Least Significant Differences were 2.6 and 4.1 for 16 June and 24 July, respectively (Waller-Duncan K-ratio t Test)

What We Learned from the 2006 and 2007 Grape Crop Loss Surveys

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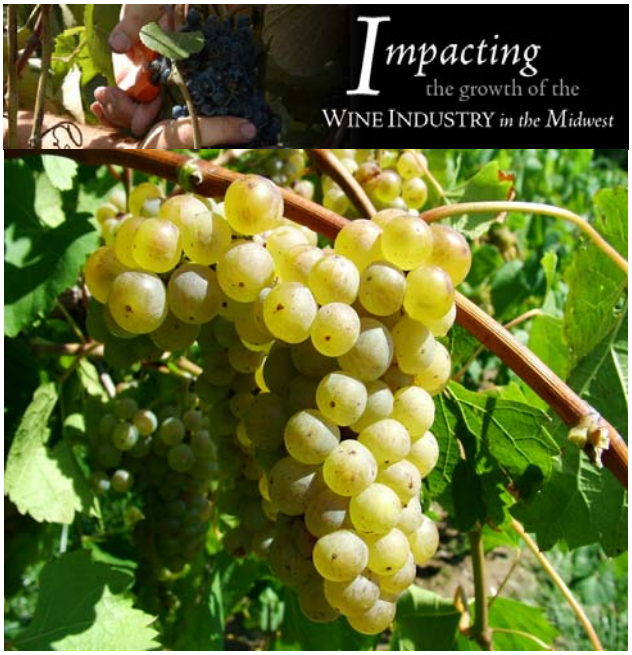
The Missouri Wine and Grape Board (MWGB) requested that the Institute for Continental Climate Viticulture and Enology (ICCVE) survey Missouri growers to determine the extent and causes of crop loss during the 2006 and 2007 seasons. Draft survey documents were developed each season by ICCVE staff and revised based on input received from MWGB and MWGB Research Committee members. Surveys were mailed to members of the Missouri Grape Growers Association, Missouri wineries, and Missouri grape growers on the ICCVE grape grower mailing list. The response rate was high representing 60-70% of Missouri grape acreage. The entire Crop Loss Surveys for 2006 and 2007 are available on the ICCVE website http://iccve.missouri.edu.

The 2006 and 2007 seasons had distinct climatic conditions which likely contributed to the results obtained in the surveys. The 2006 season was characterized by low precipitation and higher than normal temperatures in many growing regions of Missouri, especially during the April to July period. The 2007 season is still fresh in the minds of most Missouri grape growers due to the severity of events in early spring. Record warm conditions in March were followed by a record breaking freeze event during April 4-7, 2007. Growers experienced early bud burst and shoot development that was extremely susceptible to the following freeze events. In addition, the 2007 summer was hot with the majority of Missouri receiving below normal precipitation during the June to October period.

A very high percentage of growers reported crop loss in each season – 83% in 2006 and 100% in 2007. Crop loss was estimated to be 15% in 2006 and 61% in 2007. The major factor causing crop loss in each season was related to climatic extremes that occurred during the season, principally heat and drought in 2006 and the April freeze in 2007. It is important to note that vertebrate pests (birds, deer, raccoons, etc.) were reported to be the second most important cause of crop loss in both seasons. This indicates that this problem deserves greater attention from growers and the ICCVE viticulture program. Another important item revealed by the survey was the high percentage of vineyards reporting the use of irrigation (approximately 70% in both seasons).

We have and will continue to use the information from these and future Crop Loss Surveys to provide direction for our research and extension programs. An irrigation management workshop was held at the 2007 Midwest Grape and Wine Conference based on heat/drought crop losses in 2006 and the increasing use of drip irrigation by growers. The April 2007 freeze and resulting crop losses were the impetus for the "Understanding and Preventing Freeze Damage in Vineyards" workshop held in Columbia, MO in early December 2007.

What does the future hold? Based on the reported crop loss due to vertebrate pests, we plan to conduct research and demonstrate the latest technology on netting of vineyards for exclusion in 2008. More information on this will be provided in future issues of the Midwest Winegrower, viticulture electronic advisories and on the ICCVE website.



ICCVE Activities

Cross-flow Filtration Workshop
On February 6th 2008 a cross flow filtration workshop was held at Les Bourgeois Winery, Rocheport. It was sponsored by the ICCVE, Pall Filtration and Enpro. The workshop covered important aspects of filtration including filtration principles, mechanisms and ratings, cartridge filtration, sheet and module filtration and cross flow filtration. There was also a demonstration of cross flow filtration.

Rebecca Ford

2008 Grape Production Short Course Begins
The ICCVE 2008 Grape Production Short Course started Thursday February 21st. Despite near-full registration for the course, turnout for the first class meeting was small due to an ice storm that prevented many from attending. The short course is full of new and potential viticulturists eager to learn about grape production in the Midwest. Also among the attendees this year are several regional extension specialists seeking more in-depth information on grape production. The course follows the annual cycle of the vineyard and covers topics before or as they are happening in the vineyard. An important aspect of the Short Course is the practical component—time spent in the vineyard as well as in the classroom.

Andy Allen

Vineyard Best Management Practices Tailgate Meetings Begin
The first round of monthly tailgate meetings for the Ozark Mountain Region Vineyard Best Management Practices Project was held March 31st in Northwest Arkansas and April 1-3 at four locations in Missouri. Speakers included Dr. Donn Johnson, fruit research entomologist at the University of Arkansas, and Andy Allen and Jackie Harris of the ICCVE. The next round of tailgate meetings will take place May 19-22. Speakers will include Johnson, Allen, Harris, and Dr. Reid Smeda, weed research scientist with the University of Missouri. Beginning in May, all tailgate meetings will run from 1:00 to 4:00. For dates, locations, and directions to the tailgate meeting nearest you, check the ICCVE website at http://iccve.missouri.edu.

Andy Allen

Upcoming Events

Missouri Viticultural Field Day—June 3
The ICCVE and MGGA (Missouri Grape Growers Association) will hold the Missouri Viticultural Field Day at Crown Valley Winery in Ste Genevieve. Speakers include Dr Keith Striegler (ICCVE), Dr. Wayne Wilcox (Cornell University), Dr. Turner Sutton (North Carolina State University) and Mr. Jim Anderson (Missouri Grape and Wine Board). Dr. Wilcox will speak on the biology and control of powdery and downy mildews and Dr. Sutton will speak on the control of summer bunch rot diseases.

ASEV 59th Annual Meeting—June 17-20
The American Society for Enology and Viticulture will hold their annual meeting at the Oregon Convention Centre in Portland, Oregon. Highlights include the 5th Joint California-Burgundy-Oregon Winemaking Symposium, an honorary research lecture by Dr Peter Winterhalter on the Application Of Countercurrent Chromatography in Wine Research and Wine Analysis, and a Sensory Symposium. For more information visit the following website: http://asev.org/annual-meeting/.

Establishing and Operating a Small Winery Laboratory Workshop—July 8-10
Held at the University of Missouri ICCVE laboratory between 8:30am—5:00pm. This is a single day workshop repeated over three days to enable small group sizes for an intensive, hands-on, practical learning for participants. It will cover basic laboratory equipment needed for a small winery and associated costs, undertaking basic analysis on participants own wines and supplier demonstrations of winery laboratory equipment. No previous laboratory experience required. For more information please contact Rebecca Ford fordrj@missouri.edu or phone (573) 884 2950.

ASEV Eastern Section Annual Meeting—July 14-16
The ASEV Eastern Section will hold its annual meeting at the Four Points by Sheraton St. Catharines Niagara Suites in Ontario. Features of the annual meeting include a tour of Ontario vineyards and wineries in Niagara-on-the-Lake and Vineland on the 14th, student and contributed papers on the 15th, and a daylong "Anything But Riesling!" aromatic white wine symposium on the 16th. Information and registration will be available at the following website in May: http://www.nysaes.cornell.edu/fst/asev/conference.php.

Multi-state Viticulture Field Day—July 28
A Multi-state Viticultural Field Day will be held from 9:00am to 4:00pm. Registration at 8:30am with the morning and lunch sessions are to be held at Linwood Lawn, Lexington MO and the afternoon sessions at Baltimore Bend Winery, Waverly MO. For more information please contact Paul Read pread@unlnotes.unl.edu or phone (573) 289-6719.