61
SIXTYFIRST NATIONAL CONFERENCE

SCIENCE

a platform for PROGRESS

61st ASEV National Conference

June 20–24, 2010

Washington State Convention Center
Seattle, Washington USA

TECHNICAL ABSTRACTS

AMERICAN SOCIETY FOR ENOLOGY AND VITICULTURE

Oral Abstracts (Research Reports)

Wednesday, June 23

Thursday, June 24

Poster Abstracts (Research Reports)

Wednesday, June 23 and Thursday, June 24

NOTE: pp. 1-38 constituted the program section of the original printed *Program and Technical Abstracts* booklet.

Abstracts are listed in the approximate presentation order as noted in the conference program. Abstracts are those submitted and accepted through the 2010 Call for Abstracts.

Alphabetical Listing of All Presenting Authors

Abstracts are those submitted and accepted through the 2010 Call for Abstracts.

Wine Microbiology Session

Impact of Malolactic Fermentation on Biogenic Amines and Sensory Perception in German Pinot noir

Pascal Herr,* Stephan Sommer, Michael Wacker, and Ulrich Fischer
*State Education and Research Center for Viticulture & Horticulture (DLR – Rheinpfalz), Department of Viticulture and Enology, 67435 Neustadt/Weinstraße, Germany (pascal.herr@dlr.rlp.de)

The effects of different malolactic fermentation (MLF) strategies in regard to biogenic amine content and sensory properties on Pinot noir wines (Pfalz region) were studied in 2008. The aim was to evaluate MLF strategies concerning composition and amount of different biogenic amines and resulting sensory properties of the wines. Biogenic amines were determined by HPLC using fluorescence detection after precolumn derivatization with o-phthaldialdehyde. Sensory analysis was carried out with a panel of 26 trained judges in two repetitions. Data acquisition was realized with FIZZ software, V.2.40. Fermentation was carried out in simple repetition either by thermovinification or by skin fermentation with punchdown at pH 3.4 and 3.6 with a commercial yeast strain or by spontaneous fermentation. The effect of several MLF strategies on biogenic amine formation was investigated by using commercial lactic acid bacteria (LAB) at different inocculation times or spontaneous MLF. Multifactorial analysis demonstrated statistically significant differences between fermentation process and MLF modalities concerning sensory analysis. Principal component analysis and agglomerative hierarchical clustering explained differences between fermentation and MLF trial modalities. A negative correlation between thermovinification and biogenic amines and a differentiation between both spontaneous alcoholic or malolactic fermentation and inoculation with commercial yeast and LAB strains could be demonstrated. Partial least squares analysis showed good correlation between the biogenic amines histamine, isoamylamine, and phenylethylamine and highly significant sensory descriptions of in-mouth-modalities like tannin perception, bitterness, astringency, and a coated/anesthetic mouthfeel.

Metabolic Basis of Differing Ethanol Yields in *Saccharomyces*

Yeun Hong and Linda F. Bisson*
*Department of Viticulture and Enology, University of California, Davis, CA 95616 (lfbisson@ucdavis.edu)

Ten commercial wine yeast strains with a range of ethanol yields were selected to identify the differences in intermediary metabolites produced during fermentation that may be responsible for the biochemical variation in ethanol production. Each strain was genetically marked by insertion of the kanamycin (G418) resistance marker into the HO (homothallism) gene to document that Chardonnay juice fermentations were conducted by the inoculated strain. The 10 modified strains were evaluated for fermentation performance and yield of ethanol in minimal must medium (MMM) to determine if they were equivalent to their parental strains. All of the marked strains were identical to their parental strains with respect to fermentation properties and ethanol production. The weight losses as CO_2 ranged from 91.8 to 96.7% of the theoretical maximum for parental and 90.7 to 96.9% for the marked strains in MMM.

Wine Microbiology Session – CONTINUED

The range of ethanol concentrations in Chardonnay wines was 11.1 to 13.8%. The plating data in the presence and absence of G418 indicated that the marked strains were dominant with less than 5% contamination by day 4 of the fermentation. Metabolomic analysis of six experimental replicate Chardonnay fermentations for each strain and of uninoculated juice was performed. Data was normalized to cell dry weight and Chardonnay juice data. Levels of metabolites in day 2 samples were generally higher than in day 4 samples. Statistical analysis for individual metabolites was also performed to investigate their contribution to the different metabolite profile among strains. PCA analysis of the complete metabolite profiles identified three strains that were consistently grouped separately.

Funding support: American Vineyard Foundation and California Competitive Grant Program for Research in Viticulture and Enology.

Yeast Population Dynamics during Spontaneous Wine Fermentation of Cabernet Sauvignon from Ningxia, China

Erhu Li, Aiguo Liu, and Yanlin Liu*
*College of Enology, Northwest A&F University, Yangling, Shaanxi 712100, China (lylsun@yahoo.com.cn)

The eastern foot of the Helan Mountain in Ningxia is a premium viticulture area and a newly developing district for wine production in China. The indigenous yeast species diversity and population dynamics during spontaneous fermentation of grape musts from this area were investigated. This was a first step toward a long-term goal of selecting strains with valuable enological properties typical of the region. A total of 400 wine-related yeast colonies were isolated from Cabernet Sauvignon musts in three vineyards at the beginning, middle, and final stages of fermentation using YPD agar plates. Yeast species were first classified according to colony morphologies on Wallerstein Laboratory Nutrient Agar (WL agar) and confirmed by sequencing of the D1/D2 domain of the 26S rRNA gene. Nine unique colony morphology types were profiled on WL agar and new types of *C. zemplinina, H. occidentalis,* and *H. vineae* were found and described. Sequence analysis indicated that the yeasts belonged to nine species; *H. uvarum, H. occidentalis, M. pulcherrima, C. zemplinina, H. vineae, I. orientalis, Z. bailii, P. kluyver,* and *S. cerevisiae*. The non-*Saccharomyces* yeasts, mainly *H. uvarum, M. pulcherrima,* and *C. zemplinina,* dominated the early stage of the fermentation, while *S. cerevisiae* took over the later stages. The dominant species during must fermentation from all vineyards were *S. cerevisiae, I. orientali,* and *H. uvarum*. However, significant differences on yeast diversity and population were found among three vineyards and other international wine regions. This work illustrates the considerable role of non-*Saccharomyces* yeasts during spontaneous fermentation and demonstrates the diversity of wine-related yeasts in Ningxia.

Funding support: China National Science Foundation.

Wine Microbiology Session – CONTINUED

The Search for 2,4,6-Tricholoranisole Genes in *Streptomyces coelicolor* A3(2)

Paula A. Mara and Linda F. Bisson*
*Department of Viticulture and Enology, University of California, Davis, CA 95616 (lfbisson@ucdavis.edu)

The filamentous bacterium, *Streptomyces*, has been shown to produce 2,4,6-trichloroanisole (TCA). This actinomycete is a normal member of winery flora and can contribute to the appearance of TCA in wineries. The purpose of this research was to identify genes in *Streptomyces* that encode enzymes responsible for the O-methylation of 2,4,6-trichlorophenol (TCP). Many *Streptomyces* species have been shown to produce TCA from TCP in intracellular reactions requiring the cofactor S-adenosylmethionine (SAM). Using bioinformatics, the genome of the TCA-forming sequenced strain *Streptomyces coelicolor* A3(2) was searched for genes encoding proteins with both O-methyltransferase and SAM-binding motifs. Twelve genes matching these criteria were identified. Three are unlikely candidates due to their physical localization within the cell. The remaining genes were chosen for amplification, cloning, and protein expression in *E. coli* to test the encoded enzymes for O-methyltransferase activity capable of converting TCP to TCA. This set included two genes previously shown to encode proteins capable of O-methylation of compounds similar in chemical structure to TCP. These proteins have also been shown to have activity in cell culture and cell extracts. It was hypothesized that one or both may be responsible for O-methylation of TCP. These two genes were successfully expressed in *E. coli*. However, TCA from TCP was not detected in either live cell culture or cell extracts. Two additional O-methyltransferase genes were also tested but likewise were not shown to produce TCA from TCP. The remaining five genes are in the process of being screened.

Cultural Practices Session

Evidence for Degradation of Alkylmethoxypyrazines to Alkylpyrazinones during Grape Ripening

Imelda Ryona and **Gavin L. Sacks***
*Department of Food Science and Technology, Cornell University, Geneva, NY 14456 (gls9@cornell.edu)

The herbaceous smelling alkylmethoxypyrazines (MPs) are well known to decrease in winegrapes during maturation. However, the biochemical fate of MPs in grapes or in any other fruit following degradation is not established. We hypothesized that MPs would be demethylated during maturation to form their corresponding alkylpyrazinones (PZs). We analyzed bell peppers over five stages of ripeness and determined that isobutylpyrazinone (IBPZ) increases proportionally to the decrease in isobutylmethoxypyrazine (IBMP) during maturation. A method for quantifying IBPZ in grapes at low ng/L levels was developed utilizing solid-phase extraction followed by two-dimensional comprehensive gas-chromatography mass spectrometry (GCxGC-TOF-MS). IBPZ was measured at veraison and at maturity in three cultivars with high (Cabernet franc), medium (Riesling), and low (Pinot noir) potential for producing MPs. No cultivars had detectable IBPZ at veraison. In mature Cabernet franc, 95 ± 12 ng/L IBPZ was detectable. When the initial extract was submitted to acid hydrolysis and re-extracted, 143 ± 10 ng/L IBPZ was detected, indicating that IBPZ in grapes may exist at least partially in a "bound" form such as a glycoside. No IBPZ was detected in the Riesling or Pinot noir samples. These results suggest that MPs in grapes are demethylated following veraison to their corresponding PZs, and that PZ concentration at harvest may be useful as a marker of maximum MP concentration preveraison.

Funding support: New York Wine and Grape Foundation and Viticulture Consortium East.

Grapevine Growth Management with Root Pruning and Perennial Cover Crops

Gill Giese,* Tony Wolf, Molly Kelly, Ciro Velasco, and Lucas Roberts
*Surry Community College, Dobson, NC 27017 (gieseg@surry.edu)

Root pruning and cover crops which reduce vine vigor and improve canopy characteristics have not been substantially investigated under warm, humid field conditions. Annual root pruning and five complete vineyard floor cover crops were investigated with field-grown Cabernet Sauvignon (SO4 rootstock) over five growing seasons at Dobson, North Carolina. Mean pruning weights of root-pruned vines were reduced 13% compared to non-root-pruned vines. Fescue K-31, perennial ryegrass, and orchardgrass were all effective in reducing annual cane pruning weights to a more desirable weight per unit length of canopy. Rate of shoot growth in vines grown with Fescue KY-31 or orchardgrass treatments was reduced 23% compared to control vines managed with an herbicide strip under the trellis. Root-pruned vines had significantly lower petiole total N% at bloom compared to control vines in 2007 (0.80 versus 0.89).

Cultural Practices Session – CONTINUED

Fescue KY-31 produced the greatest amount of cover-crop biomass and resulted in 49% more soil moisture loss than that which occurred from herbicide strip plots over a 45-day period (bloom to veraison) in 2006. Berry skin color density (2008) was greatest for vines grown with orchardgrass and least from vines grown with perennial ryegrass, but only in one year. Nematode (Dagger, *Xiphimena americanum*) populations were significantly greater in perennial ryegrass plots compared to other cover-crop treatments (2009). Root-pruning and cover crops generally improved canopy characteristics (PQA) and, in some years, slightly improved berry composition compared to control vines.

Funding support: North Carolina Wine and Grape Council and Virginia Wine Board.

Crop Forcing by Complete Removal of Shoot Tips, Clusters, and Leaves in Warm Regions to Produce Cool-Climate Quality Fruit

Sanliang Gu* and Sean Jacobs
*Viticulture and Enology Research Center, California State University, Fresno, CA 93740 (sanliang@csufresno.edu)

Experiments were conducted in commercial vineyards of Cabernet Sauvignon, Zinfandel, Chardonnay, and Sauvignon blanc in the San Joaquin Valley of California in 2009 to determine if crop forcing (CF) can be used in warm regions to shift fruit ripening to the cooler portion of the growing season to produce fruit of similar composition of cooler regions. CF treatments were conducted between 2 to 10 weeks postanthesis (June and July) when primary shoots were hedged to six nodes while all clusters, laterals, and leaves were removed. All CF treatments were effective in inducing new shoots and clusters in all varieties. CF applied 4 to 6 weeks postanthesis shifted fruit ripening from the hot portion (July and August) to the cooler portion (October through early November) of the growing season and produced fruit of criteria desirable for harvesting and winemaking. Fruit ripened either too early (in September) when CF was applied 2 weeks or did not ripen when CF was applied 8 to 10 weeks postanthesis. Fruit of forced crop had smaller berries, lower pH, higher TA, and higher anthocyanin content when compared to normal fruit at the same Brix level. CF vines were less vigorous and had more or fewer clusters depending on cultivar and CF timing. Leaves on CF vines were more active photosynthetically later during the season. The research demonstrated the potential of CF through complete removal of shoot tips, clusters, and leaves to shift fruit ripening in warm regions and to produce better quality fruit for winegrapes.

Cultural Practices Session – CONTINUED

Cover Crop, Rootstock, and Root Manipulation as Tools to Alter Vegetative Growth and Affect Potential Wine Quality

Tremain A. Hatch, Tony K. Wolf,* and Bruce W. Zoecklein
*AHS Jr. Agricultural Research and Extension Center, Virginia Tech, Winchester, VA 22602 (vitis@vt.edu)

Cover crops, rootstocks, and rootzone restriction were evaluated for their effect on vegetative and reproductive growth on Cabernet Sauvignon. Treatments were arranged in a strip-split-split plot arrangement with undertrellis cover crops (UTCC) compared to row-middle only cover crop combined with 1-m weed-free strips in the vine row as main plots. Rootstocks Riparia Gloire, 420-A, and 101-14 were subplots, while sub-subplots comprised two treatments: vines were either planted in root-restrictive (RR) fabric bags (0.16 m3) at vineyard establishment (2006) or were planted without root restriction. Canopies of vines with UTCC and RR had reduced leaf layer values by ~21% and 23% compared to conventional controls. The principal effect of the UTCC and the RR treatments was a sustained reduction in stem (xylem) water potential. Vine fruitfulness was significantly decreased (20%) by UTCC as compared to weed-free strips. UTCC and RR caused significant 7 and 10% reductions in berry weight, compared to herbicide UTGC and NRR. Berry weights of vines grafted to Riparia were greater than those of vines grafted to other rootstocks. Wine made from UTCC and RR treatments had increased color density by 21% and 10% compared to herbicide UTGC and NRR, respectively. Vines with UTCC had 18% lower petiole nitrogen concentrations at bloom than vines with weed-free strips, yet the difference in yeast assimilable nitrogen (7%) in must was insignificant. This study identified treatments that improve vine balance while simultaneously improving grape composition and wine composition.

General Enology Session

Anthocyanin Metabolites Inhibit Viability of Caco-2 Cells

Sarah C. Forester, Andrew L. Waterhouse,* and Patricia I. Oteiza
*Department of Viticulture and Enology, University of California, Davis, CA 95616
(alwaterhouse@ucdavis.edu)

Anthocyanins are a class of polyphenols in the skins of red grapes. Gut microflora metabolize anthocyanins to phenolic acids and aldehydes. These metabolites may explain the relationship between anthocyanin consumption and reduced incidence of colon cancer. Previously, gallic acid, 3-*O*-methylgallic acid, and 2,4,6-trihydroxybenzaldehyde were found to decrease Caco-2 cell viability more than other anthocyanin metabolites. We have now investigated the mechanisms behind the effects of these three metabolites. Caco-2 cells were incubated for 24 to 72 hr in the presence of 10 to 100 µM gallic acid, 3-*O*-methylgallic acid, and 2,4,6-trihydroxybenzaldehyde. The aldehyde reduced cell viability at the highest treatment concentration (100 µM). Both gallic acid and 3-*O*-methylgallic acid induced a time-dependent decrease in cell viability. After 72 hr incubation, the three metabolites caused an arrest in the G0/G1 phase of the cell cycle. Apoptosis was monitored as caspase-3 activation and DNA fragmentation. The three metabolites, at a concentration of 50 µM, activated caspase-3 (evaluated as PARP cleavage and enzyme activity). However, only gallic acid and 3-*O*-methylgallic acid increased the levels of mono- and oligonucleosomes within the cytoplasm and caused apoptotic nuclear morphologic changes (Hoechst staining). Both 3-*O*-methylgallic acid and gallic acid led to a decrease (67.8% and 47.0%, respectively) in NF-κB-DNA binding. In conclusion, the decreased Caco-2 cell viability caused by 3-*O*-methylgallic acid and gallic acid can occur as a consequence of both the induction of apoptosis and the inhibition of cell proliferation. The inhibition of transcription factor NF-κB, which promotes cell proliferation and survival, can underlie the observed effects.

Funding support: The Wine Spectator Scholarship Foundation and the John E. Kinsella Endowed Chair in Food, Nutrition and Health.

General Enology Session – CONTINUED

Comprehensive Analysis of Winery Wastewaters Using SPME-GC-MS

Kim P. Mosse,* T. Vincent Verheyen, Alicia Cruickshank, Timothy R. Cavagnaro, Evan W. Christen, and Antonio F. Patti
*School of Applied Sciences and Engineering, Monash University, Churchill, Australia (kim.mosse@sci.monash.edu.au)

Winery wastewater arises mostly from spillage and cleaning operations within a winery and is potentially able to be reused as an irrigation water source, although the long-term impacts of such a practice are unknown. A major gap in all studies pertaining to winery wastewater is the fact that a detailed chemical composition is usually not determined. While wastewaters are inherently variable, there are still significant similarities among wastewaters, which may help to inform management and reuse options. In this study, 15 wastewaters at various stages of different treatment processes ranging from simple ponding systems to aerobic digestion were collected from two Australian wine-producing regions (Griffith, New South Wales, and Yarra Valley, Victoria). The water soluble fraction of these wastewaters was subjected to analysis using solid-phase microextraction (SPME) coupled with gas chromatography-mass spectrometry (GC-MS), with on-fiber derivatization. Using this method, it was possible to semi-quantitatively detect organic acids, esters, sugars, and phenolic compounds. The yield and structure of these compounds varied markedly under the impact of biological treatment and aerobic conditions. The change in structural composition of these soluble organic compounds is discussed in terms of their impact on water reuse and recycle options.

Funding support: Grape and Wine Research and Development Corporation and Co-operative Research Centre for Irrigation Futures.

Irrigation/Soils/Nutrition Session

Influence of Soil Type on Sauvignon blanc Growth and Fruit Composition

Melissa Sutherland, **Glen L. Creasy**,* and Michael C.T. Trought
*Centre for Viticulture and Oenology, Lincoln University, Christchurch 7645, New Zealand (creasyg@lincoln.ac.nz)

Soil variation is a major management concern in many New Zealand vineyards as it has an influence over vine growth and fruit composition. A trial investigating the effects of different soil types on Sauvignon blanc was established in a commercial vineyard in the Wairau Plains. Eight-year-old vines on SO4 rootstock growing in soil types classified as Heavy Silt, Light Silt, Stony, and Very Stony were identified and monitored. Vine trunk diameter varied with soil type, with the vines on the stony soils having thinner trunks than those in the silt soils. Root measured in soil pits showed 2.5 times more fine roots (<5 mm diam) in the stony soils than in the silt ones. There were also slightly more larger roots in the stony soils compared to the silt soils. Pruning weights and canopy density measurements showed that vines on stony soils were less vigorous and had better exposed fruit. Shoot diameters were smaller on the stony soils, with the proportion of large (>13 mm diam) shoots being higher in the silt soils. Harvest data indicated that crop loads were higher for vines on the stony soils, due to both increased cluster number and cluster weight. Given the canopy density differences, fruit composition differences were as expected, with soluble solids being higher in the better exposed fruit from the stony soils and both total acidity and malic acid concentrations being lower in fruit from the stony soils. 2-Methoxy-3-isobutylpyrazine concentration was higher in the fruit from the silt soils.

Effect of Deficit-Irrigation Timing on the Tannin and Anthocyanin Concentration of Cabernet Sauvignon Grapes and Wines from Washington State

James F. Harbertson,* Kerry Ringer, William R. Riley, and Russell Smithyman
*School of Food Science, IAREC, Washington State University, Prosser, WA 99350 (jfharbertson@wsu.edu)

Regulated deficit irrigation was applied to a 27-year-old own-rooted Cabernet Sauvignon vineyard in Mattawa, Washington, in an attempt to evaluate the effect of altering the timing and duration of the deficit on grape and wine phenolic composition during the 2008 and 2009 vintages. Evapotranspiration (ET) was used to estimate full vine ET and manage the irrigation applications. Four experimental deficits were applied: early, veraison, full season, and none (control). The control received 0.7 of ET whereas all of the treatments were 0.35 of ET during the deficit period but were given the same amount of water as the control otherwise. The experiment was carried out in a randomized complete block using north-south row orientation with four repetitions of each treatment. Wines were made in duplicate by combining two of the vineyard replicates at a commercial winery (1,542 kg). At harvest, early and full season deficits consistently reduced berry size by 15 to 20% and enhanced skin tannins and anthocyanins but not seed tannins. However, the results indicate that the full season

deficit skin tannin was significantly greater than that of the early season deficit. The experimental wines generally mirrored the results found in the vineyard, with anthocyanins and tannins statistically greater in the full and early season deficits, but the early season deficit having the significantly greatest amount of tannins and anthocyanins. Polymeric pigments formed during the winemaking process were significantly greater in the full and early deficit wines.

Funding support: Washington Wine Grape Funds.

SAD Affected Fruit Has Elevated Levels of Norisoprenoids Which May Be Desirable for Winemaking

Mark Krasnow,* Mark Matthews, and Ken Shackel
*Department of Viticulture and Enology, University of California, Davis, CA 95616 (mnkrasnow@ucdavis.edu)

Sugar accumulation disorder (SAD, formerly known as berry shrivel) is a ripening disorder of unknown cause. Affected Cabernet Sauvignon fruit does not accumulate sugar or anthocyanins to the same degree as normally developing fruit and prematurely shrivels on the vine. SAD appearance is variable from year to year, but generally affects only a small proportion (0 to 10%) of the fruit in a vineyard. Affected fruit is generally removed from the processing stream either in the vineyard or at the sorting table. To investigate the effect of not removing the fruit prior to crushing, wines were made with 0%, 5%, and 10% (by weight) SAD fruit added to the fermentation. Descriptive analysis of the wines demonstrated that the wines with SAD fruit added were significantly more fruity and less vegetal than control wines. The wines with SAD fruit added had elevated levels of β-damascenone, a volatile norisoprenoid compound that has been shown to enhance fruity aromas and suppress vegetal aromas. When SAD affected fruit in a subsequent year was analyzed for norisoprenoid content, marked increases in these compounds compared to normally developing fruit were found. These data suggest that including SAD affected fruit in a Cabernet Sauvignon fermentation may actually be beneficial, depending on the style of wine.

Irrigation/Soils/Nutrition Session – CONTINUED

Compositional and Morpho-Anatomical Examination of Ripening Disorders of Grape Berries

Bhaskar Bondada*
*Department of Horticulture and Landscape Architecture, Washington State University Tri-Cities, Richland, WA 99354 (bbondada@wsu.edu)

The objective of this study was to examine morpho-anatomical and compositional characteristics of different berry shrivel types so that each can be distinguished clearly from the other to avoid losses in yield and fruit quality. Four types of shrivel were identified, each type was caused by a different factor. Shrivel associated with sunburn lost the bloom, mesocarp cells close to the periphery showed increased water loss leading to raisinlike characteristics with reduced color. Brix, pH, TA (g/100 mL), and malic acid (g/L) were 27.6, 3.79, 0.29, and 0.63, respectively. Shrivel due to dehydration developed dimples on the surface resembling a golf ball. Brix, pH, TA, and malic acid were 33.3, 3.97, 0.40, and 1.27, respectively. Shriveled berries caused by bunch-stem necrosis involved development of darkened lesions either on the rachis or on the peduncle after veraison; consequently, the berries on the affected portions of the cluster dried up. The affected areas on rachis developed tylosis. Brix, pH, TA, and malic acid were 43.5, 3.85, 0.54, and 1.06, respectively. Finally, clusters afflicted with berry shrivel were flabby, resembling a deflated soccer ball. Moreover, berries developed less color, the juice was watery and very sour with no perceptible sugar, and very often the berries developed an off-flavor. Brix, pH, TA, and malic acid were 18.1, 3.14, 0.63, and 0.40, respectively. The study clearly showed that a failure to follow the normal processes of ripening caused deviations in berry composition and morphology, which are not desirable for making wine.

Phenolics Session

Hydroxycinnamate α,β–Unsaturated Sidechain Moieties Are Potent Antioxidants

Nick Gislason and Andrew L. Waterhouse*
*Department of Enology and Viticulture, University of California, Davis, CA 95616 (alwaterhouse@ucdavis.edu)

The antioxidant activity of phenolic compounds in wine was previously attributed solely to their phenolic hydroxyl moieties, but it has been discovered that the α,β–unsaturated sidechains of hydroxycinnamates are also involved in wine oxidation reactions. During the oxidation of wine, the unsaturated sidechains of caffeic, ferulic, coumaric, and even non-hydroxylated cinnamic acid were found to be involved in a radical trapping reaction resulting in decreased acetaldehyde production and the simultaneous formation of an allylic alcohol from the parent hydroxycinnamic acid. The purified allylic alcohol product was characterized by ^{1}H and ^{13}C NMR in conjunction with HPLC-MS. The involvement of hydroxycinnamic α,β–unsaturated sidechains in wine oxidation reactions represents a newly discovered mode of antioxidant activity conferred by these ubiquitous compounds originating from the juice and pulp of winegrapes.

Funding support: UC Davis, ASEV, American Wine Society, American Society of Brewing Chemists, Adolf and Richie Heck Scholarship, Master Brewer Association of the Americas, Horace O. Lanza Scholarship, Orange County Wine Society, and the Rhone Rangers.

Phenolics Session – CONTINUED

Phenolic Contributions of Wood and Influence on the Organoleptic Perception of Red Wine

Julien Michel, Michaël Jourdes, Thomas Giordanengo, Nicolas Mourey, and Pierre-Louis Teissedre*
*UMR 1219 INRA Œnologie, Laboratoire de Chimie Appliquée, Faculté d'Oenologie ISVV, 33882 Villenave d'Ornon, France
(pierrelouis.teissedre@u-bordeaux2.fr)

Some wood substances such as ellagitannins can be extracted during wine aging in oak barrels. The level of these hydrolyzable tannins in wine depends on the species and origin of oak wood as well as its treatment during barrel realization. The impact of ellagitannin concentration on the sensory perception of red wine is poorly known and still unclear. In our research, we classified staves according to their ellagitannins level using a NIRS online procedure (Oakscan) and were able to correlate the NIRS classification with the level of ellagitannins estimated by HPLC-UV. The different types of staves were added to red wine during its aging and the extraction and evolution of the main ellagitannins was monitored by HPLC-UV. The influence of ellagitannins levels on wine perception was estimated by a trained panel of judges. It appears that the staves classification estimated by NIRS procedure on wood was in good agreement with the total level of ellagitannins extracted by organic solvents as well as the level of ellagitannins quantified in red wines aged for 4 months with the classified staves. The level of ellagitannins was estimated by quantification of ellagic acid released during hydrolysis as well as by quantification of each specific ellagitannin: vescalagin, castalagin, grandinin, and roburins (A, B, C, D, E) by HPLC-UV-MS. Furthermore, the level of ellagitannins in red wine seems to have an impact on the roundness of the wines. Moreover, it appears that astringency and bitterness were not negatively impacted by the level of ellagitannins in wine.

Phenolics Session – CONTINUED

Investigation of Condensed Tannin Protein-Binding Capacity by Spectrophotometric Measurement of Remazol Brilliant Blue R Stained Bovine Serum Albumin

Christopher W. Beaver and James F. Harbertson*
*School of Food Science, IAREC, Washington State University, Prosser, WA 99350 (jfharbertson@wsu.edu)

A method of protein staining has been adapted to measure the protein precipitating capacity of condensed tannins found in *Vitis vinifera* berries. A common textile dye, Remazol Brilliant Blue R (RBB), was covalently bound to bovine serum albumin (BSA) to create a dyed protein. This allows for the quantification of precipitated protein in a spectrophotometer. Along with an independent spectrophotometric method for tannin quantification, the two methods combined allow for the evaluation of tannin-protein interactions that have well-documented connections to sensorial evaluations of astringency. Different ratios of dye to protein were explored, and it was found that a 5:1 and 1:1 (RBB:BSA) ratio mimics the tannin precipitation function of unaltered BSA, but the 5:1 (RBB:BSA) offers more sensitivity for the quantification of precipitated protein. Simultaneous evaluation of protein-binding kinetics demonstrated that precipitated tannin and protein compared to the amount of protein added follows independent parabolic curves where both precipitated tannins and proteins continue to increase until the slope of the function approaches zero. However, the amount of bound protein continues to increase after the amount of tannin precipitation is constant. As much as double the amount of added protein was necessary to achieve the maximum precipitated protein value. This demonstrates that determining the protein-binding capacity of condensed tannins requires simultaneous and independent evaluations of both precipitants.

Funding support: Washington Wine Grape Funds.

Vine Composition and Environmental Viticulture Session

Cell Viability during Berry Ripening of *Vitis vinifera* L. Cabernet Sauvignon: Effects on Fruit Composition

Martin Mendez-Costabel,* Chandra Kilburn, and Nick Dokoozlian
*E&J Gallo Winery, Modesto, CA 95358 (martin.mendez@ejgallo.com)

A study was conducted during the 2010 season to look at the changes on cell viability in grape berries during ripening and to correlate attributes such as berry sugar content, berry color, or berry mouthfeel compounds with percentage of viable cells during the latter stages of ripening. A commercial vineyard of *Vitis vinifera* L. Cabernet Sauvignon located in Lodi was used for the experiment. Twenty clusters were randomly selected each week after 22 Brix, placed in zip-lock bags, and bags were located in refrigerated coolers, then sent to the lab for fruit composition assessment. Four 50-berry samples were taken to the lab immediately for cell viability assessment using fluorescein diacetate (FDA). High percentages of dead tissue were recorded during the ripening period, with more than 90% of the berry tissue showing no response to the FDA staining after 24 Brix. The center portion of the berry suffered losses of cell viability earlier compared to other regions within the grape berry. This might be linked to the loss of hydraulic conductivity in the fruit's vascular system after veraison. Brix, fruit moisture content, malic acid, and IBMP showed a strong correlation with cell death, but aroma precursors, fruit color, and mouthfeel compounds did not. Degradation of IBMP and malic acid continued even when the majority of the cells were dead. This would suggest that the amount of live tissue in grape berries is not tightly associated with the changes in metabolites that occur during extended ripening.

Altering Pinot noir Vine Crop Load to Leaf Area Ratio Affects Fruit Composition

Michelle Pan, **Glen L. Creasy**,* and Gilbert Wells
*Centre for Viticulture and Oenology, Lincoln University, Christchurch 7645, New Zealand (creasyg@lincoln.ac.nz)

A grapevine's leaf area to crop load ratio could have significant effects on fruit composition. To this end, a trial was established to alter both the leaf area and crop load on Pinot noir vines. Leaves and/or crop were removed from VSP trained vines in a factorial design with full, half, and quarter treatments for leaf and crop. Shoots were cut above the 14th node and two of the basal four leaves were removed in all cases, and either all, four, or one leaf retained above this to give the appropriate leaf numbers. Fruit was removed randomly by cluster thinning, with all treatments being imposed by three weeks after fruit set. Reducing leaf area reduced vine crop weight except for the one-quarter crop, where no definite trend was apparent. Yield compensation was noted with the crop-load treatment, with cluster weight increasing relative to the control by almost two times in the case of one-quarter crop and less so in the other treatments. Decreasing leaf area resulted in smaller cluster weights in the one-quarter crop load treatment, but the trend was not so clear at higher crop loads. Fruit Brix tended to decrease with increasing crop load, but increase as leaf area decreased. Treatments also had an effect on vegetative growth measured at pruning, with greater leaf removal resulting in significantly lower average cane weights. The results suggest that vines with one-to-one ratios (i.e., 0.25:0.25, 0.5:0.5, and 1:1) do not perform in the same way.

Vine Composition and Environmental Viticulture Session – CONTINUED

A Snapshot of Vineyard Carbon: Using a New Technique to Facilitate Low-Impact Organic Carbon Measurement in a California Vineyard

Keir Keightley*
*Geography Graduate Group, University of California, Davis, CA 95616 (keight@ucdavis.edu)

California viticulture accounts for 10 to 12% of agricultural land use. As a factor in agricultural carbon flux, viticulture represents the largest allocation of land use for a perennial crop sequestering carbon in California. Methods for the nondestructive assessment of vineyard carbon storage through accurate wood volume estimation at the vine level and soil sampling to one meter depth are presented in this research. This approach represents a carbon estimate using oblique, close-range remote sensing. As such, it is an in vivo technique that does not require destructive harvest. A total of 36 vines were identified for aboveground wood volume data collection using a tripod mounted laser scanner in 2007 in a single vineyard in southern Sacramento County. Likewise, 24 locations in the vineyard were identified for composite organic soil carbon sampling in two horizons occurring between the surface and 1 meter depth. Aboveground wood volume was calculated using combinations of several high-resolution laser scans, then processed to carbon mass based on empirical measures of wood density, carbon content, and root-scion biomass ratio. Soil carbon was measured as the difference between the total carbon, minus carbonate content and expressed as kg/m^2 based on parallel measures of soil bulk density. The vine and soil point data were spatialized to provide total carbon content in the vineyard using interpolation techniques. Vine carbon content analysis yielded a vineyard total of 58.0 Mg organic carbon. Soil carbon content analysis yielded a total of 3,072.5 Mg organic carbon. These results along with additional application of these methods to California's common vineyard configurations will provide a better characterization of carbon sequestration in this form of perennial agriculture.

Vine Composition and Environmental Viticulture Session – CONTINUED

Using Cloud Imagery and Distance to Water to Improve Spatial Climate Estimates for Coastal Winegrowing Sites in California

Kimberly Nicholas Cahill,* Sam Iacobellis, Dan Cayan, Mark Greenspan, and Mike Bobbitt
*Fruit Fly Wine Sciences, Sonoma, CA 95476 (kncahill@ucdavis.edu)

Accurate estimations of maximum and minimum temperatures are important to aid in vineyard site and variety selection. However, the network of public climate stations is limited, and the heterogeneous topography of the North Coast limits the applicability of available stations outside the immediate locale. The performance of the PRISM model, which interpolates monthly temperatures to a 400 m^2 grid, was tested against a dataset of nine public and private weather stations in Napa and Sonoma. PRISM performed well for estimating maximum August temperatures (R^2 = 0.75), but not for estimating minimum temperatures (R^2 = 0.02). As a result, growing degree-day calculations performed using PRISM are likely inaccurate. Toward improved estimates of the PRISM temperatures in Napa/Sonoma, two additional statistical modeling factors were evaluated: low cloud cover and distance to water. An algorithm was developed to classify the hours of summer low cloud cover using hourly GOES satellite images from 1996-2008 with 1 km^2 pixels. A geographic information system (GIS) was used to estimate the closest distance to the Pacific Ocean or to the San Francisco Bay as a measure of marine influence upon a given inland site. Incorporating hours of low cloud cover and distance to water dramatically improved the estimation of August Tmin (R^2 = 0.84). Validating this model on nine additional vineyard weather stations, not included in our model development, yielded good agreement (R^2 = 0.73). This improved model promises to provide more accurate mapping of the fine-scale temperature patterns in the North Coast, especially with regard to nighttime temperatures, so important for fruit maturation. Such improvements will increase our knowledge about the diverse meso-climates in the region.

Wine Aroma/Sensory Session

Projective Mapping and Descriptive Analysis of the Perception of Minerality in White Wines

Dwayne Bershaw* and Hildegarde Heymann
*Department of Viticulture and Enology, University of California, Davis, CA 95616 (dmbershaw@gmail.com)

Projective mapping is gaining popularity as a technique to quickly perform sensory analysis on foods and beverages. Projective mapping eliminates the long training and product repetition of a conventional descriptive panel, and thus is an excellent sensory tool for panelists unable to participate in a conventional panel due to time or logistical constraints. Recently interest has also increased in the use and meaning of the term *minerality* as a wine descriptor. This study used a group of white wines, some of which were described by professional critics as having minerality, to compare a projective mapping analysis performed by wine industry professionals to a standard sensory descriptive analysis. The sensory data obtained from the panels are similar, but a specific difference occurred with respect to minerality and acid taste that may relate to how the panels were performed. The projective mapping panel found minerality to be positively correlated with acid taste and citrus, fresh, wet stone, and chemical aromas and negatively correlated to butter, butterscotch, vanilla, and oak aromas. The descriptive analysis panel found mineral aroma (mineral taste was not chosen as an attribute through consensus) to be positively correlated with reduced, chalky, bitter, and grassy aromas and negatively correlated with barrel, caramel, honey, juicy fruit, musty, and cat urine aromas. Panel results were also compared to standard chemical analysis of the wines. These data indicate that minerality may be related either to a group of aromatic compounds perceptible orthonasally or to the wine acids or to both sets of compounds.

Funding support: John Ferrington Award, Haskell F. Norman Wine and Food Scholarship, Rusty Staub Fellowship, Mario P. Tribuno Memorial Scholarship, Brad Webb Memorial Scholarship, and Wine Spectator Scholarship.

Assessing the Influence of Site on Wine Composition and Sensory Characteristics of Cabernet Sauvignon

Anthony Robinson,* Paul Boss, Hildegarde Heymann, Peter Solomon, and Robert Trengove
*Separation Science Laboratory, Murdoch University, Murdoch, WA 6150, Australia (t.robinson@iinet.net.au)

This study investigates the role of site in defining the sensory and compositional characteristics of commercial Cabernet Sauvignon wines from Australia. Volatile compositional analysis was conducted using a new analytical method (HS-SPME GCxGC-TOF-MS) which was developed as a sensitive and comprehensive method for analyzing volatile and semivolatile compounds found in the wine headspace. This study demonstrates an important advancement in wine volatile analysis as the method allows for the simultaneous analysis of a significantly larger number of compounds found in the wine headspace compared to other current single-dimensional GC-MS

Wine Aroma/Sensory Session – CONTINUED

methodologies. Descriptive sensory analysis was undertaken to understand the relationship between the aroma profile of the wines and the volatile composition. Application of multivariate statistical techniques including two-dimensional hierarchal clustering, canonical variate analysis, and partial least squares regression was used to relate compositional and sensory results with reference to the geographic origin of the wine. Wine products were clearly differentiated using both compositional and sensory analysis. A number of candidate compounds were identified as being distinctive of wines from particular geographic regions. This study uses modern analytical techniques coupled to sensory analysis to better understand the traditional theory that the character of a wine reflects the site where it was grown.

Funding support: Australia's grapegrowers and winemakers through their investment body, the Grape and Wine Research and Development Corporation, with matching funding from the Australian Federal Government. The GCxGC TOF-MS was purchased through an Australian Research Council (ARC) Large Equipment Infrastructure and Facilities (LEIF) grant.

Adaptive Evolution of Commercial Wine Yeast Strains for Reduced Ethanol Production

Vidhya Ramakrishnan and Linda F. Bisson*
*Department of Viticulture and Enology, University of California, Davis, CA 95616 (lfbisson@ucdavis.edu)

Extended berry ripening often results in high sugar levels at harvest leading to high ethanol concentrations in wine that can be undesirable. Analysis of use of *Saccharomyces* for the production of biofuels identified two inhibitors, furfural and hydroxymethyl furfural (HMF), that block formation of ethanol. The sensitivity of wine strains to these inhibitors was evaluated as furfural can be found during aging in oak. Our goal was to use these aldehydes to develop commercial *Saccharomyces* wine strains with reduced yields of ethanol via the process of adaptive evolution. Thirty strains, 27 commercial strains plus three lab strains, were screened for adaptation abilities in the presence of furfural and HMF. These strains defined four different groups: those that adapted to both the inhibitors to varying levels, those that adapted to furfural but not HMF, those that were resistant to HMF and adapted to furfural, and, finally, those that were unable to adapt to either inhibitor. These findings indicate that the mechanisms of adapting to these two inhibitors are not the same, in contrast to previously reported work. Sixteen strains were chosen for further analysis from the first three groups. Cluster analysis based on the growth patterns under varying conditions grouped them into six clusters. The two strains that showed weak adaptation on HMF were also low ethanol producers (determined using GC-FID), suggesting a link between aldehyde tolerance and ethanol yield. Strains representing each cluster are being evaluated for the production of ethanol under constant pressure of the inhibitor.

Funding Support: American Vineyard Foundation and California Competitive Grant Program for Research in Viticulture and Enology.

General Viticulture Session

Progress toward the Breeding of *Rotundifolia*-Based Rootstocks

M. Andrew Walker,* Cecilia Agüero, Chin-Feng Hwang, Liang Zheng, Howard Ferris, and Daniel Ng
*Department of Viticulture and Enology, University of California, Davis, CA 95616 (awalker@ucdavis.edu)

The most widely used *Muscadinia rotundifolia*-based grape rootstock is O39-16. This *Vitis vinifera* x *M. rotundifolia* (VR) rootstock is used to control fanleaf degeneration, a serious disease caused by grapevine fanleaf virus (GFLV) and vectored by the root-feeding dagger nematode, *Xiphinema index*. Although O39-16 has high levels of resistance to *X. index*, the test probing of this nematode allows GFLV to get into the root where it moves upward, infecting the scion. There are other rootstocks with strong resistance to *X. index* feeding, but they too allow uptake of GFLV; only O39-16 induces tolerance to fanleaf disease. The *rotundifolia* parentage of O39-16 also allows it to resist the ring nematode. However, O39-16 is a high-vigor rootstock, with a late growth cycle, and it is susceptible to root-knot nematode feeding. We have been evaluating progeny from a cross of 101-14 Mgt x *M. rotundifolia* Trayshed as replacements for O39-16. They have been evaluated for rooting ability, resistance to *X. index*, ring and aggressive strains of root-knot nematode, and for their ability to induce fanleaf tolerance. This population of about 50 progeny is being expanded with the addition of seedlings from 200 seeds produced in 2009. Tests on a subset of the population have shown great promise. Progress on these tests and on efforts to better elucidate the ability of *rotundifolia* to induce fanleaf tolerance will be reported.

Funding support: California Grape Rootstock Improvement Commission, American Vineyard Foundation, CDFA Fruit Tree, Nut Tree and Grapevine Improvement Advisory Board, California Table Grape Commission, Louis P. Martini Endowed Chair funds, and Mark Lyons.

A Root-Knot Nematode Resistance Allele from *Vitis cordifolia* Is Not Allelic to the N Nematode Resistance Allele

Peter Cousins*
*Grape Genetics Research Unit, USDA-ARS, Geneva, NY 14456 (peter.cousins@ars.usda.gov)

Root-knot nematodes, *Meloidogyne* spp., are major pests of grapes worldwide. Populations of *Meloidogyne* have been isolated that can feed and reproduce on grapevine rootstocks with the N allele, a main source of genetic resistance to root-knot nematodes in grape (found in rootstocks Harmony and Freedom). DVIT 1280, an accession of *Vitis cordifolia* in the USDA ARS National Clonal Germplasm Repository (Davis, California), was shown through progeny testing to be heterozygous for a single dominant resistance allele with specificity different from that of N. The hypothesis is that the new allele is found at a distinct resistance locus and is not an allele of the N gene. The relationship of the novel allele, tentatively R_c, to N was determined using progeny testing. The resistant accession (putative genotype nnR_cr) was crossed with the rootstock Freedom, homozygous for the N allele (NNrr). Progeny from the Freedom x *V. cordifolia* cross were screened with N-virulent nematodes and seedlings resistant to

General Viticulture Session – CONTINUED

N-virulent nematodes (genotype NnR_cr) were selected. A staminate flowered seedling was tested crossed to a nematode-susceptible female, the rootstock 161-49C (nnrr). Test cross progeny (NnR_cr x nnrr) were screened with N-avirulent nematodes. Segregation for resistance in the population was consistent with a 3:1 ratio by chi-square test, indicating that N and R_c are nonallelic and represent two distinct resistance loci. This knowledge will facilitate the use of the resistant accession to breed cultivars resistant to N-virulent nematodes.

Funding support: USDA ARS, American Vineyard Foundation, California Table Grape Commission, and California Raisin Marketing Board.

Measuring the Effect of Falcon Presence in Vineyards as a Biocontrol to Prevent Bird Damage to Grapes

Valerie Saxton*
*Faculty of Agriculture and Life Sciences, Lincoln University, Christchurch 7647, New Zealand (Valerie.saxton@lincoln.ac.nz)

This project measured the economic value of native New Zealand falcons (*Falco novaseelandiae*) as a biocontrol for pest birds in vineyards. In 2005 a project was launched in Marlborough, New Zealand, with a two-fold aim of conservation of an endangered species and protection of grapes from bird damage. Young falcon nestlings were translocated from nearby mountains to artificial nests in vineyards and fed regularly. The falcons were free to fly and some consorted with falcons in the surrounding hills. They also successfully bred in the vineyards. An economically viable, statistically robust, and repeatable grape damage survey method was developed. Results from grape damage surveys in 2008 and 2009 showed a highly significant reduction in bird damage to grapes within 300 m of the falcon feeding trays compared to distances greater than 600 m. Overall damage was higher in 2009 than in 2008, as was the case also in the control vineyard where no falcons were present. Damage was higher in Pinot noir and Pinot gris than in Sauvignon blanc in both years. Results suggested that for Sauvignon blanc, savings in bird control costs can be reliably made over 23 hectares even in a year with high bird pressure. For Pinot noir and Pinot gris, falcon presence in conjunction with other methods could reduce bird management expenses. Further research is now measuring the deterrent effect of the numerous and available Australasian harriers (*Circus approximans*), which have been trained as adults to feed in vineyards, as a biocontrol for grapes from bird damage.

Funding support: New Zealand Ministry of Agriculture and Fisheries Sustainable Farming Fund.

Enology

Quantifying Dissolved Carbon Dioxide Concentrations in Fermenting Red Musts

David M. Goldfarb, Steven D. Colomé, Marci Norkin, and Geraldine S.P. Ritchie*
*Food Science & Nutrition, Cal Poly State University, San Luis Obispo, CA 93405 (gsritchi@calpoly.edu)

The concentration of dissolved carbon dioxide (DCO_2) is recognized as being high during alcoholic fermentation, but there is little data to indicate the actual concentrations and how they vary with extent of the fermentation or winemaking operations. The presence of the inert gas is important in protecting the juice or must from oxidation. In addition, carbon dioxide (CO_2) is a recognized greenhouse gas, and the contribution of fermenting juice and musts to atmospheric CO_2 cannot be put in perspective or modeled unless one has a better idea of DCO_2 and whether supersaturation is occurring throughout fermentation or for part of the time. This study monitored DCO_2 concentrations on a daily basis in four red musts during alcoholic fermentation in a commercial winery. Dissolved carbon dioxide concentrations generally peaked at around 2000 mg/L, but the maximum was not associated with a particular stage of fermentation. Musts tended to be supersaturated with DCO_2 when the rate of fermentation was high and/or the temperature increased rapidly and after a rack and return. Upon completion of alcoholic fermentation, DCO_2 concentrations generally decreased to between 400 and 1000 mg/L. During malolactic fermentation, DCO_2 concentrations varied between 1000 and 1500 mg/L.

Genome-wide Identification of Genes Important for Ethanol Tolerance in *Saccharomyces cerevisiae*

Michael J. Anderson, Sarah Barker,* Charlie Boone, and Vivien Measday
*Donnelly Centre for Cellular and Biochemical Research, University of Toronto, Toronto, ON M5S 3E1, Canada (sahara.barker@gmail.com)

The *Saccharomyces cerevisiae* lab strain S288C and (*S. cerevisiae*) industrial wine yeast strains have highly similar gene order and sequence content, thus the genomic resources created from S288C can be used to understand and improve wine yeast fermentation. Recently, a systematic, high-throughput method to clone all *S. cerevisiae* genes with their endogenous promoters into uniquely bar-coded vectors has been developed in order to obtain a genome-wide library of high-copy plasmids, enabling all genes to be screened for a particular phenotype. In this study we have transformed the high-copy yeast gene library into both an industrial wine yeast strain, M2, and an S288C strain and used the bar-code methodology to identify genes that when overproduced enhance the ability of M2 to survive high ethanol stress, a common problem during alcoholic fermentation. Both M2 and S288C genome pools were grown for 60 hours in 12% ethanol, and plasmid DNA was extracted for PCR amplification of bar codes and hybridization to an oligonucleotide array carrying tag complements. To determine the abundance of cells over expressing each gene, we quantified their associated molecular

Enology – CONTINUED

bar codes and have identified a putative subset of 24 genes important for ethanol tolerance. To a large extent, the exact role of these genes in ethanol tolerance is currently unknown because the conditions in which the majority of yeast research takes place is far different than the extreme conditions that occur during fermentation. We are in the process of confirming their phenotypes of enhanced ethanol tolerance in both M2 and S288C strains.

Funding support: ASEV, American Wine Society, Canadian Vintners Association, and UBC Graduate Fellowship Scholarships.

Behavior of "Foxy" Methyl Anthranilate in Interspecific Variety Muscat Bailey A (Muscat Hamburg × Bailey) Fortified Wine during Thermal Maturation

Chien-Hao Chen, Ming-Hsu Chang, Ming-Kwei Shih, Chii-Ming Jiang, and Ming-Chang Wu*
*Department of Tropical Agriculture and International Cooperation, National Pingtung University of Science and Technology, Pingtung 912, Taiwan (globalizationwu@yahoo.com.tw)

A general aversion has persisted against using interspecific hybrids for winemaking due to the undesirable foxy methyl anthranilate (MA) inherited from the American *Vitis* species. Taiwan is situated in between subtropical and tropical zones. As the climate is not naturally suited to viticulture, the use of resistant interspecific varieties is inevitable. Muscat Bailey A (Muscat Hamburg × Bailey) is the most important interspecific hybrid variety developed in Japan and cultivated in Taiwan since 1945 for red wine production. Thermal maturation (TM) is a fortified wine aging tradition from the subtropical island of Madeira. Some chemical compounds in Madeira wine were degraded by TM and produced diverse characteristic flavors. This technique may be an option to improve quality of wines. Therefore, the objectives of this study were to observe the behavior of "foxy" MA in Muscat Bailey A fortified wine during TM and to determine its influence on the sensory quality. Grape must was obtained from Golden Muscat harvested during the 2009 summer in Ho-Li district. The fermentation was stopped by fortification of grape spirit and alcohol content was adjusted to 19% (v/v). The temperature of the TM was controlled at 50°C. Samples were analyzed after 30 d, 60 d, and 90 d of TM. Control wine was made without TM. In summary, the MA content decreased significantly ($p < 0.05$) in all thermally treated wines. Panelists indicated that the TM wines have stronger ($p < 0.05$) intensity in fruity and spicy aroma/flavor sensory characteristics. Control wine showed foxy flavors.

Enology – CONTINUED

Using Solar Thermal Energy to Produce Golden Muscat (*Vitis vinifera* × *Vitis labrusca*) Fortified Wine in Taiwan

Chien-Hao Chen, Ming-Hsu Chang, Ming-Kwei Shih, Chii-Ming Jiang, and Ming-Chang Wu*
*Department of Tropical Agriculture and International Cooperation, National Pingtung University of Science and Technology, Pingtung 912, Taiwan (globalizationwu@yahoo.com.tw)

Taiwan is situated between subtropical and tropical zones. The location is ideal to develop solar thermal energy. Thermal treatment (TT) is a fortified wine aging tradition from the subtropical island of Madeira. Some chemical compounds in Madeira wine were degraded by TT and produced diverse characteristic flavors. Despite the importance of TT as a special fortified wine-aging technique, no previous studies have considered the use of solar thermal energy for the TT. Therefore, the objectives of this study were to develop a solar TT system to produce fortified wine made by local variety Golden Muscat (*Vitis vinifera* × *Vitis labrusca*) and to evaluate its efficiency and the effects on the chemical composition and sensory quality of wines. A typical pumped-circulation solar water heater was used for the TT. The TT chamber was built by the low thermal conductivity high temperature insulation board to prevent heat loss. Hot water was sent into serpentine pipe installed on the floor of TT chamber for heat exchange. When the TT chamber's temperature achieved 50°C, the temperature sensor triggered the pump. The experiments were carried out at Ho-Li district from 2 Aug to 2 Nov 2009. The average temperature of the TT chamber was maintained at 48.8 ± 2.5°C. Samples were analyzed after 30 d, 60 d, and 90 d of TT. Control wine was made without TT. Increased brown (absorbance at 420 nm) color and red, green (absorbance at 520 nm) color in all TT samples were detected. Panelists indicated that the TT wines have stronger ($p < 0.05$) intensity in Madeira style sensory characteristics. Based on results of this study, this system could assist local winemakers to produce fortified wine with acceptable quality.

Enology – CONTINUED

Effect of Grain Orientation on Extraction of Flavor Compounds from Oak

Kevin Crawford,* Almon Benton, Alfred Grigg, and David Plumb
*Department of Chemistry, University of Wisconsin, Oshkosh, WI 54901
(crawfork@uwosh.edu)

The extraction of flavor compounds from oak into wine is a time-dependent process. In the practice of winemaking, the oak of a traditional barrel is only exposed to the wine along the radial (parallel) axis of the staves on only one side of the stave. When barrel alternatives are used, the entire piece of wood is exposed to the wine, allowing penetration and extraction along the two longitudinal (cross-cut) axes as well as all four radial axes. In order to determine the relative extraction rates of oak flavor compounds based on grain orientation, we prepared blocks of wood with epoxy coating preventing wine exposure on either the longitudinal or radial axis. These blocks were soaked in a model wine solution which was sampled weekly for SPME-GC-MS quantification of furfural, oak lactones, and vanillin. Results indicate that furfural is rapidly extracted from the longitudinal axis relative to the radial axis and that vanillin extraction was only measurable in the longitudinal axis exposed wood during the 12-week exposure. The lactones were detected in both solutions but only after the fourth week. These results demonstrate that maximal exposure of the longitudinal axis of oak pieces will result in a much more rapid extraction of flavor compounds into wine products.

Enology – CONTINUED

Polyphenol Content in Merlot Wines from Brazil

Carlos Eugenio Daudt* and Aline de O. Fogaça
*Departamento de Tecnologia e Ciência dos Alimentos, Federal University of Santa Maria, 97105-910 Santa Maria, RS, Brazil (ced.voy@gmail.com)

The southwest of Rio Grande do Sul, Brazil (latitude 31° south, bordering with Uruguay) is a new viticultural area. It has been observed that the technological maturity is achieved before the phenolic maturity of the grapes in this area; climate plays an important related role. Merlot grapes from two different vineyards (same region and different altitudes) were fermented using two techniques. The first was the classic vinification: destemming, crushed, and fermented, with three maceration times (4, 8, and 15 days). The second technique was whole-berry fermentation: destemming, light crushed, and fermented with whole berries for four days, then completely crushed, staying on the skins for 8 and 15 days. Wines were then analyzed for total phenolics (Folin-Ciocalteau), anthocyanins (pH shift), tannins (acid hydrolysis), and phenolic index (OD 280 value). For the total phenol index, total phenolics, and tannins, the 15-day skin maceration seems to be the best for the classic vinification. Anthocyanins, however, showed contradictory results between the two wines. The altitude likely had some effect here, explained by the presence of complex molecules formed by tannin and anthocyanin condensation. By the analysis of these results it is very difficult to point out the best number of days for maceration. The results also show no significative differences between the two techniques used. Whole-berry fermentation is a technique suggested by many, even though it does not seem worthwhile.

Enology – CONTINUED

Effects of Phytic Acid on Protein Stability in a Commercial White Wine

Rachel Fanning and Brent Trela*
*Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409 (brent.trela@ttu.edu)

Protein hazes are a common instability in white wines and occasionally in blush wines. The most common fining treatment used in wineries to prevent protein hazes is the addition of bentonite. This study attempts to provide an alternative protein stabilizing treatment method using phytic acid compared to bentonite treatments. Prior work has shown that phytic acid can act as a strong metal chelator in wines and as a protein stabilizer. Grapes are reported to contain phytic acid. A commercially produced and unfined Riesling wine was treated with increasing concentrations of phytic acid under constant pH and subsequently tested for heat stability. Heat stability was significantly improved with some phytic acid treatments compared with the control and bentonite treatments.

Accurate Oxygen Management in Bottling Phase

Roberto Ferrarini,* Enrico M. Casarotti, Gianmaria Zanella, and Sergio Ciocchetta
*DiSTeMeV, Università di Verona, San Floriano, VR, Italy (roberto.ferrarini@univr.it)

The management of oxygen is one of the most critical factors for wine quality. Notably, it is the bottling phase that can compromise all the work to obtain a quality product because of an excessive oxygen introduction. This work determined the optimal conditions to allow an appropriate inertization (in order to protect from oxidations) of different kinds of bottles with different fillings. In addition, a measurement method was developed that can be applicable on all the bottling machines and permits the determination of the oxygen increasing in the bottle, allowing the testing of machine performance. The variables that can influence the oxygen content in this phase of the process have been evaluated: inertization with inert gas before filling and set up of the machine for bottling with different bottles. The data have been elaborated with a model, determining the best filling conditions and the correct setup in order to obtain an oxygen increase less than 0.2 ppm.

Enology – CONTINUED

Yeast Strain and Its Chemical and Sensory Impact on Red Wine Phenolics

Roy J. Thornton,* Susan Rodriguez, Kenneth Fugelsang, and **John Giannini**
*Department of Viticulture and Enology, California State University, Fresno, CA 93740 (rthornto@csufresno.edu)

Cabernet Sauvignon grapes were fermented during a two-year study using several different strains of *Saccharomyces cerevisiae* to determine if differences in wine phenolic profile (anthocyanin, tannin, and total phenolics) can be attributed to yeast strain. Nine *S. cerevisiae* strains were evaluated the first year in 65-lb lots. Three of the strains, CSM, Noble Ferm, and Fermichamp, from the first year were selected for further evaluation on the basis of the parameters of the wines they produced. In the second year, the three yeasts were used to ferment 2-ton lots of Cabernet Sauvignon grapes. Phenolic profile differences for the resulting wines, through chemical and sensory analyses, appeared greater during the first year (statistical data not available) than for the second year. For second-year wines, tannin levels were the only statistically different phenolic compound, according to the Adams-Harbertson assay. Sensory evaluation of the wines was performed for color only the first year, and for color, aroma, and flavor for the second-year wines. The data demonstrated that all the first-year wines differed significantly in color. Only the CSM and Fermichamp wines from the second year were significantly different from each other in color, aroma, and flavor.

Funding support: American Vineyard Foundation and The Agricultural Research Initiative administered by the California Technology Institute of California State University, Fresno.

HPLC Profiles of Wine and Brandy from Muscadine Grapes (*Vitis rotundifolia*)

Yong D. Hang* and Edward E. Woodams
*Department of Food Science and Technology, Cornell University, Geneva, NY 14456 (YDH1@cornell.edu)

Muscadine grapes (*Vitis rotundifolia*) are widely grown in southeastern United States for commercial production of juice, wine, and other value-added products. The current investigation was undertaken to determine the composition of major volatile compounds in wine and brandy made with three muscadine grape cultivars (Carlos, Fry, and Noble) grown in Raleigh, North Carolina. The grapes were mashed and fermented with a Red Star wine yeast, *Saccharomyces cerevisiae* Montrachet. Brandy samples were prepared by double distillation of the wines under controlled conditions. All wine and brandy samples were analyzed by HPLC with a Bio-Rad Aminex HPX 87H column and a refractive index detector. Volatile acid (acetic acid), methanol, ethanol, n-propanol, isobutanol, and amyl alcohol were identified as the major volatile compounds. The ethanol concentrations in the wine and brandy samples were 7.0 to 9.0% v/v and 42.0 to 58.0% v/v, respectively, depending on the muscadine grape cultivars used in the fermentation. The concentrations of methanol in the wines and brandies were less than 0.06% v/v and 0.24% v/v 40% alcohol, respectively. Volatile

Enology – CONTINUED

acid (acetic acid), n-propanol, isobutanol, and amyl alcohol were present in significantly lower concentrations. The results of the current study indicate that the methanol concentrations in the wine and brandy samples produced with the muscadine grape cultivars are well below the United States FDA guidelines.

Funding support: Multistate project NY 6236315 and N.Y. State Agricultural Experiment Station. Dr. Leon Boyd, North Carolina State University, provided the muscadine grapes.

Wine Quality Optimization Using Decision Tree Analysis and Random Forest Classification Techniques

Zhiyu He, Yang Yu, and Brent Trela*
*Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409 (brent.trela@ttu.edu)

The use of statistical classification methods are being applied to wine production data for the purpose of predicting desirable wine quality. Titratable acidity, tannin and total phenolic concentration, glycerol concentration, and alcohol concentration will be used as parameters to quantify wine quality compared to published wine reviews. The initial data will be generated through historical records and industry surveys which contain basic measurement during the winemaking process, such as initial Brix, initial pH, and fermentation temperature. This research uses decision tree analysis and random forest classification to analyze the data. Decision tree analysis performs binary splits based on the values of the variables in the data set. A random forest is a collection of tree classifiers. To grow one tree in the forest, N vineyards are randomly sampled with replacement from the original sample and then a classification tree is constructed without pruning the data set. These techniques are statistically compared to find the principal factors that determine wine quality and provide a reasonable forecast of the wine's quality.

Changes in Proanthocyanidin Concentration during Fermentation of Muscat Bailey A Wines

Marie Ichikawa, Keiko Ono, Masashi Hisamoto, Toshihide Matsudo, and Tohru Okuda*
*Laboratory of Biofunctional Science, The Institute of Enology and Viticulture, University of Yamanashi, Kofu, Yamanashi 400-0005, Japan (okuda@yamanashi.ac.jp)

Proanthocyanidins (PAs) are believed to be important contributors to the taste, quality, and beneficial effects of red wine. We analyzed the concentrations of PAs in Japanese red wines using the bovine serume albumin (BSA) precipitation method. Muscat Bailey A (Muscat Hamburg × Bailey; MBA) wines had extremely low concentrations of PAs (65 mg/L) compared to other varieties, such as Cabernet Sauvignon (312 mg/L) and Merlot (356 mg/L). MBA is native to Japan and the wine is very popular in Japan. Small-scale fermentation tests were conducted and changes in total phenol and PA concentrations were compared during winemaking. Total phenol concentration during fermentation of red wine increased with increasing alcohol concentration and became

Enology – CONTINUED

constant after reaching a maximum. This tendency was similarly observed for all grape varieties. In contrast, differences in PA concentration were noted among the grape varieties. In MBA, PA concentration decreased rapidly after reaching a maximum. For the other varieties, PA concentration remained stable even after reaching a maximum. This unique phenomenon of PAs in MBA wine was also noted in relatively large-scale commercial wines.

Metabolomics of *Brettanomyces bruxellensis* Strains in Wine

C.M. Lucy Joseph* and Linda F. Bisson
*Department of Viticulture and Enology, University of California, Davis, CA 95616 (cmjoseph@ucdavis.edu)

Brettanomyces bruxellensis is a major spoilage yeast in finished wines and produces many "off" aromas and flavors. Studying the metabolism of *Brettanomyces* in wines is difficult due to the complex nature of this growth substrate. A global analysis, such as a metabolomics analysis using gas chromatography-mass spectrometry time-of-flight (GC-MS TOF) to identify large numbers of the metabolites found in the cells, may be the most efficient way to identify important metabolic systems at play in the organism when it is growing in wine. To this end, a comparison of different *Brettanomyces* strains grown in both wine and a defined medium was undertaken. A time course during growth yields information about how the metabolism of the cells changes over time in the wine. Preliminary results indicate significant differences between the cells grown in defined medium and those grown in wine, as well as between the different *Brettanomyces* strains. The cells grown in medium showed a normal metabolic profile, while in wine, metabolism was repressed, possibly due to ethanol. The two strains were significantly different in both the wine and the defined medium. Differences may reflect the availability of carbon and nitrogen sources for growth under the different conditions as well as the inherent metabolic differences between the strains studied.

Effect of Bentonite Additions Prior to Fermentation on Protein Stability in Edna Valley Sauvignon blanc

Tymari LoRe, Matthew Brain, and Geraldine S.P. Ritchie*
*Food Science & Nutrition, Cal Poly State University, San Luis Obispo, CA 93405 (gsritchi@calpoly.edu)

Sauvignon blanc often requires large amounts of bentonite in order to remove haze proteins and make the wine heat stable. However, large bentonite additions can affect the sensory perception of the wine. We studied the effect of adding small amounts of bentonite before fermentation on the subsequent amount required after fermentation to heat stabilize the wine. Protein stability was evaluated in two lots of Sauvignon blanc juice from two blocks of the same Edna Valley vineyard. Bentonite (Volclay KWK, American Colloid Co.), 4.6 g suspended in 200 mL water, was added to 19 L of juice prior to fermentation. The control had 200 mL water added only. Juice treated with bentonite before fermentation required the lowest amounts of postfermentation bentonite to achieve protein stability, as determined by heat

Enology – CONTINUED

stability tests using a nephelometer. A correlation was observed between the turbidity of heated juices treated with different amounts of bentonite and protein measured by the Bradford Protein method. Sensory studies were conducted to ascertain if the effect of different bentonite additions and timing of additions changed the sensory perception of the resulting wine.

Common Faults in Washington State Cabernet Sauvignon Wines

Holly Pinkart,* Anne Johansen, Sara Rybka, Celia Faiola, and Amy Mumma
*Department of Biological Sciences, Central Washington University, Ellensburg, WA 98926 (pinkarth@cwu.edu)

The Washington Wine Quality Initiative was designed to facilitate improvement of wines produced by small-scale wineries in Washington State. Its first objective was to determine the most common faults exhibited by Washington Cabernet Sauvignons and then identify those physical, chemical, or biological attributes which were significant predictors of wine quality. A total of 180 bottled wines representing seven vintages (and the majority of Washington AVAs) was evaluated. Assessment included sensory analysis of 11 visual, aroma, and palate characteristics and analytical measurement of 28 chemical compounds and 12 microbial species known to influence wine quality. All data were initially analyzed with standard descriptive statistics. A "wine quality score" was generated from sensory data. Correlation analyses and linear and multiple regressions were employed to identify the factors that exhibited the greatest influence on wine score. The average wine quality score was $3.08 \pm 1.5_{SD}$, with 35.42% scoring in the 1-2 range (high quality) and 13.79% scoring as 6 (extremely faulty). Washington Cabernets tested in this study demonstrated a trend of high pH, high ethanol, high populations of *Lactobacillus* species, and high volatile acidity. Combined with low average molecular SO_2 values, the data suggest these wines are at great risk for oxidation-related faults and microbial spoilage and provide an explanation for the atypical aging associated with Washington red wines. Lowering must pH prior to alcoholic fermentation could minimize these risks and increase the effectiveness of added SO_2.

Funding support: U.S. Department of Education FIPSE grant P116Z080267.

Sensory Analysis of within-Region Variation for Pinot noir from New Zealand

Elizabeth Tomasino, Roland Harrison,* Richard Sedcole, and Andrew Frost
*Centre for Viticulture and Oenology, Lincoln University, Canterbury 7647, New Zealand (roland.harrison@lincoln.ac.nz)

This paper reports results of variability in the intensity of 27 aroma, in-mouth flavor and mouthfeel attributes determined by untrained but experienced tasters from the Marlborough wine industry. Pinot noir wines were from the four main regions: Central Otago, Marlborough, Martinborough, and Waipara. Canonical variate analysis was used to identify the attributes that were most useful in separating the wines by region. To uncover the within-region variability, canonical variate analysis was used grouped by wines. Four variate factors were found to attribute to 70% of the variance within

Enology – CONTINUED

regions, with the 1st factor containing balance, fruit density, and raspberries; 2nd factor, bitterness, oak, strawberries, and barnyard; 3rd factor, chocolate, graininess, herbal, oak tannins, and spice flavor; and 4th factor, jam, red cherry, and smokey. The amount of within-region variance can be displayed using the intergroup distance, or how far apart the wines separate from each other. The greater the intergroup distance, the more variance within the region. The average intergroup distances for the regions were Central Otago, 0.70085; Marlborough, 0.5103; Martinborough, 0.6222; and Waipara, 1.048. Waipara wines had the greatest variance due to the fact that one wine was found to be completely different from all other wines used in the study and Marlborough wines were found to be the most similar across all factors. Central Otago wines varied on the 1st and 4th factor, Marlborough wines varied on the 4th factor, Martinborough wines varied on the 1st and 3rd factors, and Waipara wines varied on the 1st, 3rd, and 4th factors. While all of the regions displayed within-region differences, there also were factors that contained little to no variance displaying on overall region style to this regional wine.

Funding support: Foundation for Research, Science & Technology, New Zealand, Lincoln University, and Pernod Ricard, New Zealand.

Comparison of Phytic Acid Analysis Methods for Use on Grapes and Wines

Christopher Sheppard and **Brent Trela***
*Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409 (brent.trela@ttu.edu)

Previous research has shown that phytic acid can act as a protein stabilizer and strong metal chelator in wines. Grapes are reported to produce and contain phytic acid, but the concentrations have not been quantified. Further, there are no published methods to quantify phytic acid concentrations in grapes and wines. This limits the scope of experimentation using phytic acid as a wine treatment. The focus of this research was to develop a reproducible method for measuring concentrations of phytic acid in grapes and wines. Several techniques, including NMR, ion exchange, colorimetric, HPLC, ICP, and atomic absorption have been used to measure phytate concentrations in other matrices such as plant tissue extracts and urine. This research has shown that some methods, such as NMR, may not be sensitive enough to adequately identify and differentiate between P species at concentrations present in wines. The goal of this research is to utilize a combination of published methods used for other matrices to provide an accurate and reproducible method for quantifying phytic acid concentration in grapes and wines.

Viticulture

Effects of Training System on Sunlight Penetration, Yield, and Fruit Quality of Frontenac (*Vitis* spp.)

Christina M. Bavougian,* Paul E. Read, and Elizabeth Walter-Shea
*Department of Agronomy and Horticulture, University of Nebraska, Lincoln, NE 68583 (christina.huck@huskers.unl.edu)

This study investigated the effects of five trellis styles on the fruit-zone light environment, fruit chemical composition, and yield of Frontenac grapes grown on a fertile site near Crete, Nebraska over two growing seasons. Photosynthetically active radiation (PAR) was measured above the canopy and within the fruiting zone at berry set, veraison, and harvest. Point quadrat canopy analysis was performed at veraison. Fruit was collected at harvest for chemical analysis (pH, % soluble solids, titratable acidity). At all sampling dates in 2008, vines grown on Geneva double curtain (GDC) and high cordon (HC) trellises had significantly higher midday transmittances than vines grown on Smart-Dyson (SD) and vertical shoot-positioned (VSP) training systems. In 2009, transmittance relationships between trellises were similar. In both years, leaf layer number was lower for GDC and HC than for SD and VSP. In 2008, GDC vines had higher fruit yield than VSP, SD, HC, and Scott Henry. In 2009, GDC yielded significantly more than VSP and HC. In 2008, trellises with higher transmittances produced higher-quality fruit: GDC had higher pH and Brix than other trellises; titratable acidity (TA) was lower in GDC and HC than in SD and VSP. In 2009, fruit-quality results were not related to transmittance. GDC and HC canopies had the highest transmittances on most sampling dates, but GDC vines had significantly higher yield and may produce higher-quality fruit. These results suggest GDC is the best training system for Frontenac on high-vigor sites in southeastern Nebraska.

Evaluation of Syrah Clonal Selections in the Salinas Valley

Larry Bettiga*
*University of California Cooperative Extension, Salinas, CA 93901 (lbettiga@ucdavis.edu)

Seven clonal selections of Syrah were evaluated for viticultural performance for six years (2004-2009). Syrah FPS 7 (reported to be 877); ENTAV selections 174, 383, 470, and 525; 99 (Tablas Creek A); and Shiraz FPS 7 were field budded onto SO4 rootstock planted in 2001 at a vineyard site southwest of Soledad (Arroyo Seco American Viticultural Area). Vines were planted at a row and vine spacing of 2.4 x 1.5 m, trained as unilateral cordons, and spur-pruned on a vertical shoot-positioned trellis. Significant differences have been observed in the yield response, with a range of 1.5 kg/vine from high to low yielding selections. Syrah selections separated into three groups: 99 being the highest yielding and ENTAV 383 and 525 similar; ENTAV 174 and FPS 7; and ENTAV 470 and Shiraz FPS 7 the lowest yielding. Higher cluster weights were the factor most influencing crop yield. Either more berries per cluster or greater berry weight increased cluster weight. Pruning

Viticulture – CONTINUED

weights had a range of 0.52 kg/vine from high to low weights. Shiraz FPS 7 and ENTAV 470 had higher pruning weight and ENTAV 525 had the lowest; the remaining selections were intermediate between the high and low groups. Yield:pruning weight ratios were higher for the more productive selections, ranging from 3.5 (99) to 1.7 (Shiraz FPS 7). The lower yielding selections tended to have higher Brix. Tasting panels were not able to significantly separate the wines made in 2005 and 2006; in 2007 there was a preference for wine made from Syrah 7 (877).

Driftwatch Pesticide-Sensitive Crops and Habitats Registry

Bruce P. Bordelon,* Leighanne Hahn, Lawrence Theller, and Bernard Engel
*Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907 (bordelon@purdue.edu)

A web-based technology has been created to facilitate communication between pesticide applicators and potential victims of pesticide drift, such as producers of pesticide-sensitive crops (tomatoes, grapes, melons, organic crops, greenhouse, nursery, etc.) and managers of sensitive habitats (sensitive watersheds, endangered species habitats). This communication tool allows applicators to take precautions to reduce potential drift to these areas, thereby protecting sensitive natural resources and reducing economic losses. A communication and outreach effort has been undertaken in Indiana by Purdue University and the Office of the Indiana State Chemist to educate producers and applicators. In 2009 more than 500 sensitive crops producers, 2,000 managed habitat areas, and 42 drinking water watersheds were registered on the site. EPA funding will expand the site to surrounding states of Michigan, Illinois, Minnesota, and Wisconsin. The sensitive crops producers, commercial pesticide applicators, and agricultural chemical industry are all supportive of the program.

UV Screening Affects Leaf Greenness in Müller Thurgau

Cindy Bizet and **Glen L. Creasy***
*Centre for Viticulture and Oenology, Lincoln University, Christchurch 7645, New Zealand (creasyg@lincoln.ac.nz)

Early season grapevine leaf yellowing had been observed over several years in New Zealand vineyards. It was thought that UV radiation may be the cause of this temporary change to leaf color, so an experiment was set up to determine if screening the grapevines from UV resulted in a decrease in the effect. Own-rooted and mature Müller Thurgau vines growing in Canterbury on a four-cane VSP trellis were sheltered from UV starting near budbreak (19 Oct) using tentlike wooden frames and Mylar polyester film. There were seven replications (one vine each) of each treatment, with the control vines having no frame or film. Canopy temperatures were measured in both control and UV-screened treatments. Leaf greenness was measured using a Minolta SPAD-502 meter on three dates, 14 Nov, 25 Nov, and 1 Dec. Leaf gas exchange was measured with a Li-Cor 6400 on one date. SPAD values were significantly higher (~3 units) in UV-screened vines on all three dates. Differences in leaf photosynthetic rates were not significant, though there was a tendency for the rate to be higher under the

Viticulture – CONTINUED

UV screens. Daytime temperatures were slightly higher under the screens compared to vines in the open, and the average temperature difference over the duration of the trial was 0.9°C. Despite the temperature difference caused by the film structure, it appears that screening UV radiation from the vines resulted in a lessening of leaf yellowing, with a possible concomitant increase in vine productivity.

Rootstock Effects on Mendoza Chardonnay in a Cool Climate

Glen L. Creasy* and Gilbert Wells
*Centre for Viticulture and Oenology, Lincoln University, Christchurch 7645, New Zealand (creasyg@lincoln.ac.nz)

Rootstocks have varying effects on scion growth depending on scion cultivar, environment, and soil characteristics. Because rootstock behavior is so dependent on location, in 2002 a trial including six rootstocks with varying parentage was established using Chardonnay (Mendoza clone) as the scion. The control was Chardonnay grafted onto itself, as the grafting process may influence vine growth. Each treatment was replicated six times in a randomized complete block design (4 vines per replicate). Rootstocks used were 3309, Riparia Gloire, 420A, Ramsey, K51-32, 1103 Paulsen (1103P), plus the own-grafted scion as control. Data reported here are from the 2006-2007 and the 2007-2008 seasons. Under the conditions of this trial, K51-32 resulted in the lowest pruning weights and 1103P and Ramsey the highest. The ratio of scion:rootstock diameter was lowest for own roots and K51-32 and highest for 3309 and Riparia Gloire. Vine yield tended to be lower for K51-32, 1103P, and own roots, and higher for 3309 and 420A. Cluster weights were higher for 3309 and Riparia Gloire, but lower for 1103P, own roots, and K51-32. Cluster number per vine was also affected, with K51-32 being lower and 3309 higher, generally. Berries per cluster was lower for 1103P and own roots and higher for 3309 and Riparia Gloire. Average berry weight was lower for K51-32 and higher for Ramsey. Fruit ripeness in the two seasons was almost identically ranked among the rootstocks, with Riparia Gloire and K51-32 reaching the highest Brix and 420 and own roots the lowest.

Quantification of Grape Rot by FTIR and Chemometrics

Susan Rodriguez,* **Hatice Durgun**, Jorge Ramirez-Perez, Seth Wood, and Roy Thornton
*Department of Viticulture and Enology, California State University, Fresno, CA 93740 (susanr@csufresno.edu)

Determining the degree of rot in harvested grapes is important to winemakers and grapegrowers alike. Currently in California, a subjective method involving the visual identification of rotten berries is used. In an attempt to obtain a method that is both accurate and simple, Fourier-transform infrared (FTIR) spectra of Chardonnay and Zinfandel grape samples containing 0 to 5% rot were evaluated using multivariate statistics. Both fresh grapes and vacuum-packed chilled grapes were used to assemble preparations composed of differing concentrations of moldy grapes. Rotten grapes were

Viticulture – CONTINUED

obtained by inoculating individual trays of grapes with *Aspergillus niger*, *Penicillium italicum*, and *Rhizopus stolonifer*. The resulting rotten grapes were mixed together and homogenized. The rot homogenate was mixed with sound grapes at 1 to 5% w/w, homogenized, filtered, and run on the FT 120 Winescan. The resulting spectra were imported into Unscrambler 9.8 for evaluation. Partial least squares (PLS) regression with full cross-validation of selected ranges of the full spectrum resulted in R^2 values greater than 0.9. These results indicate that an FTIR spectral method is a good candidate for an objective, simple method for rot quantification on the sugar stand.

Funding support: American Vineyard Foundation and the Agricultural Research Initiative administered by the California Technology Institute of California State University, Fresno.

A Rapid Assay for Chloride Exclusion That Aligns with Field Observations

Kevin Fort and M. Andrew Walker*
*Department of Viticulture and Enology, University of California, Davis, CA 95616 (awalker@ucdavis.edu)

Saline soil is a widespread problem that often occurs when salts accumulate from irrigation water and fertilization practices. Grapevine rootstocks can partially mitigate salt uptake by excluding chloride in the root. To efficiently improve this trait, a reliable and high-throughput screen is needed; however, many published trials have yielded inconsistent genotype rankings that do not correlate with documented field performance. We tested a variety of systems in different environments using variable genotypes, graft status, growth stage, assay period, pruning regime, watering frequency, salt concentration, container volume, and geometry and rooting media. We found that a simple 14 day assay using herbaceous cuttings in a fritted clay media effectively replicated field performance of chloride uptake for the subset of genotypes tested. Factors which may be critical to the success of this assay are: (1) a lack of any pruning, (2) non-use of woody plant material, (3) initiation of the salt treatment no later than 7 weeks after field cuttings are collected, (4) a short period of salt exposure, on the order of two weeks, using 25 mM NaCl and no ramp-up period, (5) a highly homogeneous greenhouse environment, and (6) a post-hoc assessment of leaf area to root length ratio, with normalization for variable total root length in some cases. We are currently streamlining this assay, testing populations that segregate for chloride exclusion and testing diverse *Vitis* germplasm whose ability to exclude chloride is unknown.

Funding support: California Grape Rootstock Improvement Commission, scholarship funds provided by ASEV, UC Davis-Jastro/Shields, C.O. Foerster, Jr., Knights of the Vine, Nathan Fay, the Wine Spectator, and the American Wine Society Educational Foundation. Plant material was provided by Sunridge, Vintage, and NovaVine Nurseries.

Viticulture – CONTINUED

Effect of Temperature and ABA on Skin Anthocyanin, Tannin, and Phenolics in Cabernet Sauvignon Berries

Sanliang Gu,* Erik Mallea, and Yulin Fang
*Viticulture and Enology Research Center, California State University, Fresno, CA 93740 (sanliang@csufresno.edu)

An experiment was conducted to investigate the effect of and interaction between temperature and abscisic acid (ABA) on skin anthocyanin, tannin, and phenolics in Cabernet Sauvignon grapes in 2008. Berries detached from rachis but with pedicels intact were submerged for 10 m in ABA solution at 600 ppm for pink and red berries at veraison and purple berries two weeks prior to harvest. Berries were then placed in plastic bags with small holes, incubated at 10, 20, 30, and 40°C for 4 days, and analyzed for anthocyanin, tannin, and phenolics. Temperature interacted with ABA to affect skin content of anthocyanin, but not tannin or phenolics. Skin anthocyanin content was higher at 20-40°C than 10°C in untreated pink and red berries, while it decreased linearly with increasing temperatures in dark berries. ABA enhanced anthocyanin accumulation at 20-40°C and induced greater anthocyanin accumulation at higher temperatures in pink and red berries. Anthocyanin content was higher when purple berries were treated with ABA only at 30°C. It is assumed that the greater increase in ABA treated berries at 30 or 40°C is mainly due to the much-increased ABA penetration into skin tissues under higher humidity. It appears that skin anthocyanin development was more sensitive to ABA at veraison, while its degradation predominated the accumulation at higher temperature prior to harvest. The research demonstrated a fast and effective protocol for evaluating skin anthocyanin accumulation with detached berries. It also illustrates the importance and potential of ABA penetration into the skin tissues when applied for fruit color enhancement.

Funding support: California State University–Agricultural Research Initiative Grants Program, Constellation Wine US, and Valent BioSciences Corporation.

Efficacy of ABA Application to Enhance Fruit and Wine Color in Warm-Region Syrah and Merlot Grapes

Sanliang Gu,* Sean Jacobs, Erik Mallea, and Yulin Fang
*Viticulture and Enology Research Center, California State University, Fresno, CA 93740 (sanliang@csufresno.edu)

Abscisic acid (ABA) applied to clusters was recently reported to significantly increase fruit and wine color in some winegrape varieties. Experiments were conducted over two years to evaluate the efficacy of ABA applications to enhance fruit and wine color in Syrah and Merlot grapes in Fresno, California. To identify the most effective ABA concentration and timing, clusters of mature Syrah and Merlot were sprayed with ABA until runoff at 300, 600, or 1200 ppm in 2008 and at 600 ppm in 2009. ABA was applied either once or twice during berry coloring. All ABA treatments were effective in enhancing skin anthocyanin content and wine color. ABA at various concentrations

Viticulture – CONTINUED

resulted in similar increases in fruit and wine pigments. ABA application at 300 ppm was only occasionally less effective. When applied only once, ABA at 80-100% berry coloring was the most effective in both years. Double ABA applications were more effective for Syrah in 2008 and Merlot in 2009. ABA could be applied during 80-100% berry coloring for significant color enhancement for Syrah or Merlot in warm growing regions. Another application one week before or after 80-100% berry coloring may also offer additional benefit.

Funding support: California State University–Agricultural Research Initiative Grants Program, Constellation Wine US, and Valent BioSciences Corporation.

Effect of Heavy Hedging on Vine Vigor, Yield Components, and Fruit Composition in Warmer Region Cabernet Sauvignon Grapevines

Sanliang Gu* and Sean Jacobs
*Viticulture and Enology Research Center, California State University, Fresno, CA 93740 (sanliang@csufresno.edu)

An experiment was conducted in a commercial Cabernet Sauvignon vineyard in Fresno, California in 2009 to determine if heavy hedging (HH) would stimulate new growth, delay fruit ripening, and improve fruit quality in a warm region. Mature vines were hedged to one leaf above primary cluster at prebloom or to the top wire at pea-size and veraison on a T-trellis of a California sprawl canopy. Only HH at prebloom stimulated large numbers of new shoots and secondary-forced clusters. HH at pea-size and veraison reduced canopy size and pruning weight due to the partial removal of the primary shoots and the lack of new growth. Berry size of primary fruit was reduced by HH at prebloom but increased by HH at veraison. Yield was higher on vines with HH at prebloom or at veraison due to the secondary-forced fruit or increased berry size, respectively. Fruit composition was affected by HH by only small magnitudes: lower Brix by HH at pea-size and veraison, slightly lower pH by HH at prebloom and pea-size, higher TA by HH at prebloom and pea-size, and lower anthocyanins by all HH treatments. Tannin and phenolics of primary fruit were not affected by HH at any time. Secondary-forced fruit resulting from HH at prebloom were smaller in berry size but ripened faster, resulting in similar Brix and TA but only slightly lower pH when compared to the primary fruit. HH does not improve and may reduce fruit quality in warmer regions, even when conducted at prebloom producing secondary-forced fruit.

Viticulture – CONTINUED

An Emerging Agenda for Wine Industry Research: Vulnerability to Climate Change

Tara Holland* and Barry Smit
*Global Environmental Change Group, Department of Geography, University of Guelph, Guelph, ON N1G 2W1, Canada (hollandt@uoguelph.ca)

Research on climate change and the wine industry has been characterized by several themes. Studies to date have addressed the impacts of climate change on wine quality, impacts of climate change and variability on grapevine yield and phenology, and vineyard site suitability in the context of terroir. We review the state of knowledge on the implications of climate change for viticulture and viniculture and propose the vulnerability approach as a direction for future research. A particular strength of this research approach is that it recognizes that nonclimatic forces also contribute to vulnerability. This is extremely relevant in the wine industry, where the production and successful marketing of wine constitutes a complex interaction of the forces of climate, physical geography, economics, appellation regulations, science, creativity, cultural knowledge, and regional identity. The vulnerability approach will increase understanding of the adaptive capacity of the wine sector, with the ultimate goal of reducing the vulnerability of the industry to climate change. In both Canada and the United States, there are documented risks and opportunities to a changing climate. We conclude with a conceptual framework for the assessment of the vulnerability of the Canadian wine industry to climate change that will enable comparisons with case studies done in other viticultural regions.

Effect of Rootstock and Water Stress on Gas Exchange, Water Relations, and Water-Use Efficiency in Petite Sirah Grapevines

Sean D. Jacobs,* Yulin Fang, and Sanliang Gu
*Viticulture and Enology Research Center, California State University, Fresno, CA 93740 (sjacobs4@gmail.com)

Two-year-old potted Petite Sirah grapevines on 101-14 Mgt, 3309 Couderc (3309C), 1103 Paulsen, St. George, or its own roots (OR) were examined under well-watered (WW) or water-stressed (WS) conditions in Fresno, California to determine if rootstocks alter vine water use without affecting photosynthetic performance. Gas exchange, water relations, and water-use efficiency (WUE) were measured twice daily during the first and seventh 5-to-7 day cycles of water withholding followed by rewatering. Rootstock and water stress did not interact to influence most parameters. Rootstock did not affect gas exchange or WUE except when plant available water was <35%, at which point net photosynthesis (P_N) of vines on 3309C and OR declined, or at extremely high temperatures (40.4°C avg, 44.9°C max) where most of the gas exchange parameters were different among rootstocks. P_N, stomatal conductance (G_S), instantaneous transpiration (E), and WUE declined while substomatal CO_2 concentrations (C_i) increased as plant available water reduced to <50% or <40% for WS cycle 1 and 7, respectively. Approximately 36 hours post-rewatering during WS cycle 7, morning P_N, G_S, and carboxylation efficiencies spiked in WS vines and their values

Viticulture – CONTINUED

exceeded WW vines, but WUE, E, and C_i were unaffected. WS vines were smaller, had shorter shoots, fewer laterals, smaller leaf areas, and less vine biomass than WW vines. Similar daily water loss, lower daily transpiration rates, and larger average leaf area of vines on 3309C suggest greater whole plant WUE under WS than vines on OR or other rootstocks.

Funding support: Bayer and Fleming's Graduate Assistantships.

Can Late Season Foliar Nitrogen Application Reduce Winegrape Nitrogen Nutrition Stress?

Catherine Jones* and Joan Davenport
*Department of Soil Science, IAREC, Washington State University, Prosser, WA 99350 (catiejones@gmail.com)

Nitrogen (N) management is critical to successful grape production. When nitrogen is added to a vine with low nitrogen nutrition, nitrogen metabolism is stimulated, causing an increase in protein synthesis. Based on recent whole plant nutritional analysis of grapevines in the Pacific Northwest, N is less available at a time when it is essential for fruit growth and development and to build storage reserves for the following growing season. Research has also indicated that soil applications of N at veraison do not move to the appropriate organs for fruit development, thus these applications increase the risk of N leaching throughout the wet winter months. This field experiment was conducted using own-rooted Merlot and Riesling grapevines (*Vitis vinifera* L.). Twelve plots were designed in a four block pattern with each row serving as a block. Plots were replicated at each site. A 6% solution of liquid urea was applied at weekly intervals beginning at veraison, for five total applications (total of 6.8 kg N/ha). For the organic source, a single rate of Biolink Vegan Nitrogen (6-0-0) was applied at the same rate for the same duration of time. Our objective was to determine the effects of late season foliar N applications with both conventional and organic N sources on yield, yield components, and vegetative growth in irrigated vineyards of eastern Washington.

Identification and Characterization of *S*-3-(Hexan-1-ol)-Glutathione and *S*-3-(Hexan-1-ol)-L-Cysteine in *Vitis vinifera*

Hironori Kobayashi,* Hideki Takase, Yumiko Suzuki, Fumiko Tanzawa, Ryoji Takata, Shunji Suzuki, and Tomonori Konno
*Laboratory of Fruit Genetic Engineering, The Institute of Enology and Viticulture, University of Yamanashi, Kofu, Yamanashi 400-0005, Japan (kobayashi-hr@mercian.co.jp)

We reported the identification and characterization of *S*-3-(hexan-1-ol)-glutathione (3MH-*S*-glut) and *S*-3-(hexan-l-ol)-L-cysteine (3MH-*S*-cys) in *Vitis vinifera* grapevine using liquid chromatography-tandem mass spectrometry. 3MH-*S*-glut and 3MH-*S*-cys hardly accumulated in stem and seed, but accumulated in leaf and berry. Leaf had the highest 3MH-*S*-glut and 3MH-*S*-cys contents among the grapevine tissues tested throughout development. Commercial yeast strains converted 3MH-*S*-glut and 3MH-*S*-cys into 3-mercaptohexan-1-ol (3MH) and 3-mercaptohexyl acetate (3MHA),

suggesting that both 3MH-*S*-glut and 3MH-*S*-cys are the flavor precursors of 3MH. Cultivation conditions and berry maturity stage affected 3MH-*S*-glut and 3MH-*S*-cys contents in grape berry. Moreover, various environmental stress conditions induced the biosynthesis of 3MH-*S*-glut and 3MH-*S*-cys in grapevine. Ultraviolet-C irradiation, water deficit, and biological stimulation increased 3MH-*S*-glut and 3MH-*S*-cys contents in grape leaf and berry irrespective of grape cultivar (Sauvignon blanc, Chardonnay, Merlot, and Koshu). On the other hand, the glutathione content in grape berry was decreased under environmental stress, while the expression levels of *V. vinifera* glutathione *S*-transferases (*VvGST1*, *VvGST3*, and *VvGST4*) were high under the stress conditions compared with the control. On the basis of these findings, the biosynthetic pathway of 3MH-*S*-glut and 3MH-*S*-cys in grapevine was suggested. Further studies elucidating the relationship among stress conditions created by various cultivation conditions in vineyards, and the biosynthesis of various flavor precursors in grape berry, might be able to explain terroir in the vineyards.

Development of Tannin and Phenolics in Skins and Seeds of Syrah Berries in a Warm Region

Erik B. Mallea,* Yulin Fang, and Sanliang Gu
*Viticulture and Enology Research Center, California State University, Fresno, CA 93740 (erikmallea@csufresno.edu)

Development and accumulation of tannin and phenolics in skins and seeds of Syrah berries (*Vitis vinifera* L.) were determined in a commercial vineyard in Fresno, California, in 2008. Skin tannin was maximal 2 weeks postanthesis while seed tannin was maximal 4 weeks postanthesis. Skin tannin decreased rapidly over the next four weeks and seed tannin decreased slowly until veraison. A second period of skin tannin accumulation commenced near veraison, with tannin increasing 56% during berry ripening. At harvest, skin and seed tannin was 0.63 and 1.02 mg CE/g fwt, respectively. Seed lignification was observed to begin one week before veraison but did not correspond to a decrease in seed tannin content. Skin phenolics reached a maximum concentration of 6.65 mg/g fwt 2 weeks postanthesis, decreasing sharply to 1.34 mg/g fwt over the next four weeks, and reaching 1.46 mg/g fwt at harvest. The observed development and accumulation patterns of tannin and phenolics are similar to those previously published for warmer regions elsewhere but different from those for cooler regions. Initial concentrations of tannin and phenolics are similar in all published research. However, in warmer regions, the research suggests that tannin and phenolics tend to decrease through development due to reduction in extractability, cessation of synthesis, or likely both.

Funding support: California State University-Agricultural Research Initiative and Valent Biosciences Corporation.

Viticulture – CONTINUED

Effect of ABA on Tannin and Phenolics in Skins and Seeds of Syrah Berries

Erik B. Mallea,* Yulin Fang, and Sanliang Gu
*Viticulture and Enology Research Center, California State University, Fresno, CA 93740 (erikmallea@csufresno.edu)

The effect of abscisic acid (ABA) on the accumulation of tannin and phenolics in skins and seeds of Syrah grape berry (*Vitis vinifera* L.) was assessed in a commercial vineyard in Fresno, California, in 2008. Development of seeds and berries as well as vine vigor were also evaluated. ABA was sprayed onto clusters at 1000 ppm at anthesis, 2, 4, and 9 weeks postanthesis (veraison). Detached berries were also treated by soaking in ABA at the same concentration and incubating at room temperature for four days at 3, 5, and 9 weeks postanthesis. ABA application did not influence the accumulation of tannin or phenolics in either skins or seeds. However, vines had more seeds per berry when treated with ABA at anthesis and higher yield when treated with ABA at 4 weeks postanthesis in comparison to untreated vines or the other ABA treatments. ABA application did not affect berry weight, pruning weight, or shoot and cluster number in the following year. The research demonstrated that ABA application onto clusters does not enhance fruit content of tannin or phenolics in Syrah in warmer regions.

Funding support: California State University-Agricultural Research Initiative and Valent Biosciences Corporation.

Effect of Potassium and Calcium on Quality and Yield of *Vitis vinifera* L. cv. Flame Seedless

Gerardo Martínez,* José Miranda, and Humberto Núñez
*INIFAP-CECH, Hermosillo, Sonora, México (germadz@hotmail.com)

Viticulture is one of the most important agricultural activities in La Costa de Hermosillo, Sonora, where grapes should fulfill requirements of good quality to be exported. Among these traits are acceptable levels of soluble solids, good color, and berries without cracking. The objective of this experiment was to determine the effect of potassium and calcium applied to the foliage on the accumulation of soluble solids, color, berry cracking, and yield of the grape Flame Seedless. The treatments were 0.7 and 1.4 kg ha^{-1} of potassium oxide, 0.1 and 0.2 kg ha^{-1} of calcium oxide, and control. The treatments were distributed in a completely randomized block design with three replications, and the experimental unit was one row with 160 grapevines. Each rate of the nutrient was applied four times, from berry set to veraison. Potassium at 1.4 kg ha^{-1} showed 15.2 and 16.1 Brix in the evaluations carried out on 15 May and 21 May, respectively, values that were significantly different than the controls, which showed 14.4 and 15.5 Brix ($p < 0.05$). Berry color and cracking were not affected by potassium applications. Calcium did not affect accumulation of soluble solids, berry color, and berry cracking. The treatments did not affect yield of the grape Flame Seedless.

Viticulture – CONTINUED

Improving Efficiency of Research and Vineyard Operations via Spatially-Explicit Sampling Protocols

James M. Meyers,* Harold M. van Es, Gavin L. Sacks, and Justine E. Vanden Heuvel
*Department of Horticulture, Cornell University, Ithaca, NY 14853
(jmm533@cornell.edu)

Environmental parameters within a vineyard are spatially correlated, which impacts the economic efficiency of cultural practices and the accuracy of viticultural studies that use random sampling. We have tested the performance of nonrandom sampling protocols that account for spatial correlation ("spatially-explicit protocols") to reduce sampling requirements versus random sampling and decrease the negative impacts of spatial unbalance. Data from fruit exposure studies from multiple sites/seasons/training systems were evaluated using a series of computational optimization models. The models were designed to balance minimal sample sizes against maximal fit to key population parameters of fruit exposure; specifically, the population probability distribution of cluster exposure flux availability as determined by enhanced point quadrat analysis and calibrated exposure mapping. The simulations indicated that globally optimized (i.e., block level) spatially-explicit sampling reduced fruit cluster sample size requirements versus random sampling by as much as 49% when tested in sample sizes ranging from 3% to 80% of population cluster number. Locally optimized vine sampling templates, in which sampling patterns were derived from canopy biomass geometry and applied consistently to all vines in a block, reduced sampling requirements by as much as 5%. Results suggest that block-scale variability (due to soil conditions, for example) influenced spatial patterns in cluster exposure more than canopy geometry (training system and vine morphology) within the studied vineyards.

Viticulture – CONTINUED

Update on Physiological Differences of Cool, Warm, and Hot Climate Grapevine Varieties Grown on the Texas High Plains

Thayne Montague,* Edward Hellman, and Keith Jenkins
*Texas AgriLife Research and Extension Center and Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409 (thayne.montague@ttu.edu)

On the Texas High Plains grapevines are subjected to climatic extremes. Therefore, to assist growers when selecting adapted varieties, evaluations are being conducted in a research vineyard (planted in 2006) on varieties which may be adapted to the climatic conditions found in the region. Research presented is from an ongoing study (initial data was collected during the 2008 growing season). We collected gas exchange data on *Vitis vinifera* cool climate (Pinot noir), warm climate (Cabernet Sauvignon and Merlot), and hot climate (Grenache and Mourvedre) varieties grafted to 110R rootstocks. On 15 dates during the 2009 growing season, midday photosynthetic rate, stomatal conductance, transpiration, water use efficiency, and leaf-to-air vapor pressure deficit were measured with a Li-Cor 6400 over a range of leaf temperatures (24, 27, 32, 34, 37, and 40°C). Inside the leaf chamber, light levels were maintained near 2,000 PAR. Unlike 2008 data, second-year data over the range of leaf temperatures examined indicate few differences in gas exchange rates between each variety. Despite increased leaf temperatures, each species was able to maintain gas exchange rates at levels which would likely maintain sufficient productivity. Because this is a young vineyard, additional research (gas exchange, fruit quality, shoot growth) through upcoming growing seasons will give further insight to adaptability of these varieties to the climate on the Texas High Plains.

Influence of Water Availability on Maturation and Quality of Grape for Winemaking

Gustavo Marques Mostaço, Graciete Mary dos Santos, Luiz Augusto Barbosa Cortez, Ivanira José Bechara, and Claudio Luiz Messias*
*Faculdade de Engenharia Agrícola-Feagri, Universidade Estadual de Campinas-Unicamp, Campinas, SP, Brazil (cmessias@feagri.unicamp.br)

The state of São Paulo/Brazil is known nationally for its table grape production. The winegrapes *Vitis vinifera* and the European/American hybrids for wine suffer with the hot and wet climate and with the harvest in rainy season, influencing grape sanitation and ripening, and resulting in grapes with poor sugar and total phenolic concentrations. In order to study this effect on water availability, and consequently the moisture at the root levels, studies conducted during 2008 and 2009 in a red grape vineyard planted with the hybrid (Syrah and Seibel 11342) Máximo, IAC-138-22, evaluated a group of plants at two different treatments by using a plastic film, keeping areas at the surface of the soil of each group of plants covered and the other uncovered. The maturation of the winegrape cycle based on sugar and total phenolic concentration was studied for both treatments. Results showed a positive influence

Viticulture – CONTINUED

given by the moisture reduction during maturation on sugar, Brix, and total phenolic concentration. The study showed the potential of this agronomic management to increase grape and must quality considering the balance among the gains in sugar and total phenolic concentration, as well as the cycle of maturation was shortened in relation to the plants in the uncovered areas. This management also allowed for earlier harvest, thus avoiding heavy fungicide use and potentiating sensory attributes for the resulting wine.

Dry Matter Accumulation and Partitioning in Response to Leaf Removal in Pinot noir Grapevines

William R. Nail*
*The Connecticut Agricultural Experiment Station, New Haven, CT 06504 (William.Nail@ct.gov)

Grapevines frequently lose functional leaf area due to a variety of factors, including deliberate leaf removal in the fruit zone, predation by arthropods, fungi, and wildlife, and other causes such as hail. Excessive loss of this functional leaf area can damage plants by reducing their photosynthetic capacity, with possible long-term effects. The effects of leaf removal on dry matter partitioning were examined over two consecutive years. Established cane-pruned Pinot noir grapevines were exposed to three levels of leaf removal (0, 1/3, and 2/3) in midseason. After leaf fall, vines were carefully excavated, divided into component parts, and dried. Over two years, leaf removal resulted in differences in accumulated dry matter for most plant parts. The greatest effects of leaf removal were on 1-year-old canes and total dry weight, which were significantly higher in control vines. The increased weight of the 1-year-old canes accounted for most of the increased biomass of these vines. Defoliated vines had slightly greater proportional thin and fine roots and 2-year-old wood compared to control vines. Fresh cane pruning weights increased on the control vines but decreased on the defoliated vines compared to the previous season. There were few differences in dry matter partitioning between the two defoliation levels. The long-term impacts of reduced carbon assimilation within a growing season were not apparent except in 1-year-old canes, most of which would be removed during subsequent spring pruning.

Chilling Affects Ionic Composition and Budbreak of Flame Seedless Table Grape Buds

Humberto Núñez,* Eduardo Corvera, Gerardo Martínez, Arnulfo Márquez, and José Miranda
*INIFAP-CECH, Hermosillo, Sonora, México (nunez.humberto@inifap.gob.mx)

Studies in laboratory and field were conducted to determine the effect of chilling on ionic composition of Flame Seedless table grape buds and budbreak. In one study, canes were collected on 8 Oct and exposed to 0, 70, 140, 210, 280, 350, and 420 hours at 5°C. Another study was conducted collecting canes from the field every week from 8 Nov through 8 Dec. In each treatment of low temperature exposure and time of cane collection from the field, bud water content, weight, ionic composition, and budbreak

Viticulture – CONTINUED

percent were determined. Buds were cut off from canes at each period of exposure and field collection dates and bud water content and bud weight were determined by fresh and dry weight. To determine ionic composition, 1 g buds and 2 mL deionized water were mashed using a mortar and pestle, then the solution was used to determine pH, electrical conductivity, nitrates, ion sodium, and ion potassium with Cardy plant nutrient meters. Ten canes exposed to the temperatures and collected field canes containing two buds were placed in 0.5-L plastic cans with distilled water and were placed in an incubator at 20°C to determine budbreak percent. Three replications were conducted in each determination. As the period to low temperature exposure was increased, bud electrical conductivity (2.83 ± 0.09 to 1.72 ± 0.05 $dS \cdot m^{-1}$), nitrates (237 ± 11.6 to 22 ± 3.2 ppm), and ion potassium (700 ± 20 to 453 ± 75 ppm) decreased. Buds collected from the field had the same trend, as winter advanced, bud electrical conductivity (2.83 ± 0.09 to 2.07 ± 0.06 $dS \cdot m^{-1}$), nitrates (237 ± 11.6 to 19 ± 0.6 ppm), and ion potassium (700 ± 20 to 423 ± 32 ppm) also decreased. As the exposure to low temperatures increased, the days to initial budbreak were reduced. No exposure and 70 hours of exposure showed a late and low budbreak percent; with 140 hour days initial budbreak required 24 days, while for 420 hours it was 12 days. Ionic composition and budbreak was affected by low temperature exposure and may be related to dormancy intensity.

Use of Raman Spectroscopy in the Quality Evaluation of Winegrapes

Susan Rodriguez, **Jorge Ramirez-Perez**, Hatice Durgun, Seth Wood, and Roy Thornton*
*Department of Viticulture and Enology, California State University, Fresno, CA 93740 (rthornto@csufresno.edu)

A major point of friction between winemakers and grapegrowers is the quality of the harvested grapes when they reach the sugar stand. One parameter that has defied objective analysis for over 40 years is the degree of microbial rot. The current method requires an inspector to clip off rotten berries from a sample of grapes and express the weight as a percentage. Grape rot is the result of a complex interaction of yeast, bacteria, and molds growing on the berries. Thus, a single parameter analysis is unlikely to satisfy all scenarios. Raman spectroscopy has been used in an attempt to satisfy this challenge. Fresh Chardonnay grapes were used to create samples with differing concentrations of rotting grapes. Individual batches of clean grapes were inoculated with *Aspergillus niger*, *Penicillium italicum*, and *Rhizopus stolonifer* and incubated. The grapes were harvested when moldy and homogenized. Microscopic observation of the homogenate revealed a complex mixture of yeast, bacteria, and mold. The homogenate was mixed with sound grape homogenate at 0 to 5% w/w, filtered, and run on an Advantage 532 Raman spectrometer. The spectra from nine 0-5% rot sets were imported into Unscrambler 9.8 to evaluate by partial least squares (PLS) regression. A calibration R^2 of 0.996 using only six principal components is a strong indication that Raman spectroscopy may be a valuable tool in the estimation of microbial rot of winegrapes.

Funding support: American Vineyard Foundation and the Agricultural Research Initiative administered by the California Technology Institute of California State University, Fresno.

Viticulture – CONTINUED

Twelve Years of Cold-Climate Cultivar Evaluation: Budbreak, Hardiness, and More

Paul E. Read* and Stephen Gamet
*Viticulture Program, University of Nebraska, Lincoln, NE 68583 (pread@unl.edu)

Winegrape cultivation in Nebraska is challenged by diverse geophysical conditions, a continental climate, and extremes of precipitation. In order to determine genotypes appropriate for production of grapes suitable for quality wine production in Nebraska, over 75 cultivars and selections were established on four test vineyard sites, three in eastern Nebraska and one in western Nebraska. Observations of time of spring budbreak (and resulting freeze damage in certain years), winter survival, disease and henoxy herbicide tolerance, harvest parameters, and production were recorded. Based upon data acquired from 1998 to 2010, genotypes have been placed into five categories: consistently early budbreak, early midseason budbreak, midseason budbreak, late midseason budbreak, and late season budbreak. When data on winter survival, tolerance to stresses, and fruit characteristics are combined with budbreak information, a map of the diverse zones of the state was constructed in which recommendations can be found for choice of cultivars to consider when establishing a new vineyard or to serve as an advisory when considering changing cultivars in existing vineyards. Those cultivars listed for the specific hardiness categories and the map of appropriate cultivar selections will be presented, along with observations of wine quality resulting from such winegrape cultivar selections.

Funding support: Richard and Lurine Kimmel Charitable Foundation, the Nebraska Grape and Wine Board, and the University of Nebraska Institute of Agriculture and Natural Resources.

Behaviors of Koshu Grape Constituents during Ripening and Appropriate Harvest Timing for Winemaking

Michikatsu Sato,* Taiyo Furuya, Masashi Hisamoto, and Tohru Okuda
*The Institute of Enology and Viticulture, University of Yamanashi, Kofu, Yamanashi 400-0005, Japan (msatoh@yamanashi.ac.jp)

Koshu is a traditional, Japan-specific *Vitis vinifera* grape, and the wine is collecting attention because of its good compatibility with Japanese cuisine. However, Koshu wine has a high level of nonflavonoid phenolics and a relatively flat taste. Koshu wine may exhibit phenolic off-flavors because of the phenolics. We examined the behaviors of grape constituents such as Brix, acids, phenolics, and α-amino nitrogen during grape ripening and selected appropriate harvest timing for making Koshu wine without phenolic defects. The phenolic level of Koshu grapes was higher than that of white grapes such as Chardonnay, Semillon, and Riesling. The cinnamate content in Koshu grape was higher than that of the white grapes by 20 to 30% at harvest. As Koshu grapes accumulate sugars relatively slowly, the harvest timing tends to be late. The time course of cinnamate peaked at veraison and decreased during ripening at a sugar level of

Viticulture – CONTINUED

~15-16 Brix, but it began to increase thereafter. The grapes contained high phenolics by the conventional harvest timing at 18-20 Brix. α-Amino nitrogen during grape ripening also decreased after veraison. The content of α-amino nitrogen in Koshu grapes tends to be as low as 50 to 80 mg/L. The appropriate harvest timing of Koshu grape will be proposed and the nutrient additions related to the fermentation rate and aroma formation will be presented.

Insecticide Control of Vine Mealybug

Rhonda J. Smith* and Lucia G. Varela
*University of California Cooperative Extension, Sonoma County, Santa Rosa, CA 95403 (rhsmith@ucdavis.edu)

High populations of vine mealybug, *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae), pose potential economic loss in winegrapes. Postharvest transport of vine mealybug-infested clusters and subsequent winery pomace disposal provide opportunities for the spread of vine mealybug to previously noninfested areas. Population suppression in clusters at harvest is a primary goal of a control program both to reduce crop damage and loss and to decrease the likelihood of geographic spread. In 2009, an insecticide control trial was conducted in a 14-year-old Pinot noir vineyard infested with vine mealybug in the Carneros District of Sonoma County. Twelve treatments were replicated four times in a randomized complete block design. Blocks were selected to account for the gradient of changes in soils down the vineyard slope. The following insecticides were tested alone or in combination: acetamiprid, buprofezin, clothianidin, dinotefuran, imidacloprid, spirotetrament, and thiamethoxam. Acetamiprid, buprofezin, dinotefuran, clothianidin, and spirotetramat were applied to the foliage. Dinotefuran, imidacloprid, and thiamethoxam were applied to the soil via chemigation. Vine mealybug populations were assessed with in-season timed counts by vine and by insect counts within clusters at harvest. Of all products and combinations tested, buprofezin and spirotetramat provided the most effective vine mealybug control with two and one application per season, respectively. Thiamethoxam when combined with spirotetramat did not provide more effective control than spirotetramat alone. No single neonicotinoid provided control similar to buprofezin or spirotetramat. Of the neonicotinoids tested, acetamiprid appeared to provide the most effective vine mealybug control.

Viticulture – CONTINUED

On-Site Measurements to Assess Vine Balance of Mechanically Managed Shiraz Grapevine Canopies in the San Joaquin Valley

Dave B. Terry and S. Kaan Kurtural*
*Department of Viticulture and Enology, California State University, Fresno, CA 93740 (kkurtural@csufresno.edu)

Canopy microclimate and crop load of Shiraz/1103P grapevines were altered through dormant pruning and shoot and cluster thinning in a commercial vineyard in the San Joaquin Valley of California. Four canopy levels were imposed by dormant pruning the vines to 21 spurs (control), mechanically pruning to 10 cm hedges, and mechanically thinning shoot and cluster density to 16 shoots/m, 20 clusters/m (CLL); 23 shoots/m, 30 clusters/m (CLM); and 49 shoots/m, 36 clusters/m (CLH), respectively. The yield per vine ($p < 0.0001$), Ravaz index ($p < 0.0001$), leaf layer number ($p < 0.0001$), and vine leaf area ($p < 0.0001$) increased linearly with the increase in the number of shoots exposed per hectare. As the leaf layer number increased, the Ravaz index ($p < 0.0001$), leaf area to fruit ratio (m^2/kg) ($p < 0.0001$), and leafiness index (cm^2/cm) ($p < 0.0001$) also increased linearly. The number of shoots exposed per hectare, the distance between shoots per linear length of cordon, and the leaf layer number of the Shiraz canopy were better predictors of total iron reactive phenolics ($p < 0.0356$), anthocyanins ($p < 0.0285$), and tannins ($p < 0.0457$) 3 months postbottling when compared to the Ravaz index ($p < 0.6548$) and leaf area to fruit ratio ($p < 0.9568$). The most preferable wine, 3 months postbottling, was achieved with 67,000 shoots exposed per hectare, positioned 5.0 cm apart along the cordon, with 3.5 leaf layers resulting in 25 tons per hectare yield when harvested at 23% total soluble solids. This study provides information for growers who aim to balance vine growth with fruit and quality through on-site measurements for mechanically managed vineyards in the San Joaquin Valley.

Interactive Effects of Mechanical Canopy Management and Reduced Deficit Irrigation on Shiraz Grapevines in the San Joaquin Valley

Dave B. Terry, Geoffrey Dervishian, and S. Kaan Kurtural*
*Department of Viticulture and Enology, California State University, Fresno, CA 93740 (kkurtural@csufresno.edu)

Canopy microclimate of Shiraz/1103P was altered and exposed to reduced deficit irrigation (RDI) varying in severity and timing. Four canopy levels were imposed by dormant pruning the vines to 21 spurs (control), mechanically pruning to 10 cm hedges, and mechanically thinning shoot and cluster density to 16 shoots/m, 20 clusters/m (CLL); 23 shoots/m, 30 clusters/m (CLM); and 49 shoots/m, 36 clusters/m (CLH), respectively. Control vines were irrigated to 70% ET until harvest (RDIC). Other vines either received 70% of full vine ET up to veraison, after which rate was cut to 50% of ET (RDIL) or had their irrigation cut to 50% of ET before veraison (RDIE), but not thereafter. At veraison, the shoots exposed per hectare were 53% and 39% lower for the CLL and CLM; but 43% higher for the CLH when compared to the control. The distance between shoots was 137% and 81% higher for the CLL and CLM, but 29% lower for the CLH compared to control. Compared to control, leaf layer number was 55% and 50% lower for the CLL and CLM, but 20% higher for the CLH.

Viticulture – CONTINUED

The RDIE and RDIL lowered the leaf layer number by 22% and 10%, respectively, compared to RDIC. Berry weight was lowered 2%, 5%, and 11% by the CLL, CLM, and CLH, respectively. RDIE also reduced berry weight by 16% at harvest compared to RDIC and RDIL. Yield was reduced by 33% and 29% by the CLL and RDIE, but increased by 5% and 17% for the CLM and CLH, respectively. The CLL and CLM reduced the leaf area:fruit by 33% and 54%, respectively, whereas the RDI treatments did not affect the leaf area:fruit. There was an interaction of canopy management and RDI stress on wine total phenolics, tannins, and anthocyanins where the CLM with RDIL had the highest tannins and total phenolics. The highest wine anthocyanins were seen with the CLM with the RDIE. This study provides important information for growers considering mechanizing canopy management operations while scheduling reduced deficit irrigation where best results were achieved with the CLM and RDIE treatments.

Funding support: American Vineyard Foundation, Bronco Wine Company, Oxbo-Korvan International, West Coast Farming, Viticulture and Enology Research Center.

Survey of Texas Vineyard Nutrient Status and Its Effects on Grape and Wine Constituents

Yanmei Zhang, Zach Edgerton, Christopher Sheppard, and Brent Trela*
*Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409 (brent.trela@ttu.edu)

There are few published reports analyzing soil and vine nutrient status in Texas. Soil nutrition among Texas vineyards is suspected to be a contributing factor causing instability, particularly with respect to calcium tartrate, high pH, and reduced quality in finished wines. Six grape varieties were compared among 10 vineyards in western Texas, the main growing region in the state. The potential effects of soil and grape mineral nutrient status on subsequent constituents in finished wines were investigated. Soil, blade, petiole, and grape samples were collected during the 2008 and 2009 growing seasons. The soil nutrient concentrations were regressed with blade, petiole, and grape must nutrient concentrations from each respective vineyard, paying specific attention to mineral nutrients, including Ca, Fe, and K. The grape samples were fermented to dryness using a microvinification method. The finished wines were evaluated for nutrient status, stability, anthocyanin, tannin, and total phenolics. There were no significant differences between the two years within the specific vineyard blocks studied. There were significant differences among varieties grown in the same soils for some grape and wine constituents. Wines made from Merlot grapes under different soil conditions had relatively stable K and Ca concentrations compared with wine made from Cabernet Sauvignon. Numerous wine samples showed high pH and high calcium concentrations with potential calcium tartrate stability issues. The results showed differences between soil nutrient levels and finished wine constituents produced from vineyards in the major Texas growing areas.

Funding support: Texas Department of Agriculture.

Industry

Using Soil Water Potential to Monitor Irrigation in an Idaho Vineyard

Lauren Bissey,* Karl Umiker, Jeff L. Smith, and Doug R. Cobos
*Decagon Devices, Inc., Pullman, WA 99163 (lauren@decagon.com)

The maximum benefits of deficit irrigation are not often reached because of the inability to quantify the effects of the irrigation schedule on the actual water potential in the soils. This study was conducted to determine if in situ soil volumetric water content sensors and soil water potential sensors could improve deficit-irrigation techniques. During the growing season of 2009, effects of a traditional deficit-irrigation schedule (70% of vine transpiration) were monitored with volumetric water content and soil water potential sensors at 0.6 and 1.2 meters depth at Umiker Vineyards in Lewiston, Idaho. Sensor data suggest that the deficit-irrigation schedule held the soil water potential at -250 kPa at both 0.6 and 1.2 meters depth. When the grower deviated from the traditional irrigation schedule, the water potential responded accordingly, often to levels greater than field capacity. Daily sensor data also showed clear patterns of diurnal redistribution of water in the root zone. Additional soil water content and water potential sensors will be installed in March 2010 in different locations to monitor the effect of sensor placement on data interpretation as well as horizontal and vertical distribution of drip-irrigation water in the soil during and after irrigation events. Data from 2009 suggests that soil water potential sensors can be valuable in confirming that a particular irrigation schedule is maintaining a certain water potential level or for monitoring when a grower wishes to deviate from a planned irrigation schedule.

Industry – CONTINUED

Empirical Study of Carbon Dioxide Released to the Atmosphere during Commercial Red Grape Fermentation

Steven D. Colome,* David M. Goldfarb, Marci Norkin, and Geraldine S.P. Ritchie
*EcoPAS, LLC, Irvine, CA 92612 (sdcolome@eco-pas.com)

Carbon dioxide (CO_2) is a pollutant (greenhouse gas) that is emitted during winemaking but not currently regulated by the Environmental Protection Agency. While winery CO_2 emissions have been modeled, they have never been measured continuously or confirmed during a commercial fermentation. As international interest increases in greenhouse gases, it is important to know the amount of CO_2 release and the determining factors; yeast strain, temperature, and dissolved CO_2 are potentially important parameters. The study was designed to quantify emissions and test a theoretical model for atmospheric release of CO_2 during alcoholic fermentation in a commercial winery. Gas release was channeled through a manifold system with an in-line mass flow meter calibrated for CO_2, providing real-time and integrated measurement of atmospheric emission. Intermittent use of a hot-wire anemometer was used as a check on the mass-flow measurements. Initial results indicate that integrated mass of CO_2 release is dependent on total Brix decrease and not duration of fermentation, consistent with the Williams and Boulton model. However, the time course of release and the shape of the release curves differed substantially among ferments and were primarily dependent on the length of active fermentation.

Disclaimers

Endorsement & Opinions

ASEV provides a forum for the presentation, discussion and publication of research and technological developments for the promotion of education in enology and viticulture. ASEV does not endorse the products or services of its members or other delegates. The mention of products or services in the published abstracts does not imply endorsement of these or other products. No endorsement of any kind should be inferred.

The ASEV is not responsible for statements or opinions printed in its publications; they represent the views of the authors or the persons to whom they are credited and are not binding on the ASEV as a whole.

Errors and Omissions

ASEV is not responsible for incorrect listings or typographical errors that may occur in any of ASEV publications, abstracts, materials and/or its website.

Copyrights