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This issue of the ASEV Technical Update contains interpretive abstracts written by authors of articles published in the four issues of the 2016 American Journal of Enology and Viticulture. A link to the online Journal article appears at the end of each abstract.

Yield, Must Composition, and Wine Quality Responses to Preveraison Water Deficits in Sparkling Base Wines of Chardonnay

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A field experiment was carried out over three consecutive seasons on *Vitis vinifera* cv. Chardonnay destined for sparkling base wine Cava. Four different irrigation treatments were applied: (i) control (C), fully irrigated, in which irrigation was scheduled according to a water balance approach; (ii) RDI_m, irrigated during stage II (from berry set to the onset of veraison) when Ψ_{stem} was less than -1.0 MPa and as C during other phenological stages; (iii) RDI_s, irrigated during stage II when Ψ_{stem} was less than -1.2 MPa and as C during other phenological stages; and (iv) DI, irrigated when Ψ_{stem} was less than -1.2 MPa from flowering to harvest. Differences in yield and base wine composition were observed among years. Over the three years, reducing the quantity of water applied by 20% below that of C in the RDI_m treatment was associated with an average reduction in grape yield of 19%. The reductions in grape yield observed in the RDI_s and DI treatments were even greater at 35 and 48%, respectively. Water stress negatively affected aroma quality, titratable acidity, and malic acid and increased polyphenol concentration, which is unfavorable for oxidation issues. Therefore, C was the best irrigation strategy to maximize quality variables for sparkling base wines. However, to facilitate crop management by controlling excessive vegetative growth, it could be interesting to use the RDI_m strategy at the cost of slightly reducing some sensory attributes such as floral and tree fruit aromas and wine structure. The adoption of RDI_s or DI strategies are not recommended due to their negative effect on acidity and desirable aromas in sparkling base wines.

Am J Enol Vitic 67:1-12 (2016)

Reaction of Oxygen and Sulfite in Wine

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In an ideal situation, when a polyphenol reacts with oxygen in a model wine, hydrogen peroxide is produced and the polyphenol is oxidized to a quinone. The main function of sulfite, which is the most abundant form of sulfur dioxide in wine, is to remove both products, which in real wine would be highly damaging. Consequently, for each oxygen that reacts, two sulfites would be consumed, giving a 1:2 reaction ratio in experimental ideal conditions. Eight wines were studied and most were found to have ratios reduced down to 1:1.7. This result indicates that sulfite is not wholly effective in protecting real wine from oxidative damage. To see why this ratio was reduced, a white wine was treated with a large amount of benzesulfinic acid, which is known to react very efficiently with quinones, and so would prevent their interaction with sulfite. The reaction ratio was found to be reduced to 1:1. This result was taken to indicate that sulfite reacts fully with hydrogen peroxide and that the reduced reaction ratio is due to only partial interaction with the products of polyphenol oxidation. Two of the white wines which reacted rapidly with oxygen manifested very low reaction

Reaction of Oxygen and Sulfite in Wine *(continued)*

ratios. This was shown to be due to the presence of ascorbic acid (vitamin C), which is added to some white wines to give additional protection from oxidation. The effect of adding ascorbic acid to a white wine on the reaction of oxygen was also examined.

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Applied Water and Rootstock Affect Productivity and Anthocyanin Composition of Zinfandel in Central California

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A field study was conducted in central California to characterize the effects of rootstock genotype and applied water amounts on the productivity and anthocyanin content of Zinfandel (*Vitis vinifera* L.) grape berry in a hot climate. Zinfandel grafted on either rootstock Freedom (Fresno 1613-59 × Dog Ridge 5, 27% *V. vinifera* hybrid; high vigor, nematode resistant) or Salt Creek (*Vitis champinii;* high vigor, phylloxera and nematode resistant, and salt tolerant) was studied during two growing seasons under sustained deficit irrigation (SDI) and regulated deficit irrigation (RDI). Midday leaf water stress (Ψ_l), canopy architecture, yield, berry composition, and berry skin anthocyanin content were measured at harvest during the two growing seasons. The Ψ_l of Zinfandel was consistently higher with SDI, while rootstock genotype did not affect it. Zinfandel grafted on Freedom consistently had greater berry weight, cluster number and weight, and yield per vine compared to Salt Creek. The skin and seed mass and seed number per berry of Zinfandel were greater when grafted on Freedom compared to Salt Creek. There were few effects of applied water amounts or rootstocks on berry composition in either year. Total berry skin anthocyanin content of Zinfandel was consistently greater with SDI compared to RDI, and greater with Freedom in the second year of the study. The stable anthocyanin proportion of Zinfandel was consistently greater with Freedom rootstock. The RDI treatments reduced water footprint of Zinfandel regardless of rootstock, but the decrease in yield associated with it was commercially unacceptable. Our results suggest that SDI in combination with Freedom rootstock can enhance water productivity based on limited reductions in yield and higher anthocyanin content in berry skin in a resource-limited area.

Am J Enol Vitic 67:18-28 (2016)

Skin Particle Size Affects the Phenolic Attributes of Pinot noir Wine: Proof of Concept

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Modifying the phenolic composition of Pinot noir wines can improve their quality, overcoming familiar challenges associated with deficiencies of color, tannin, and aging potential. During fermentation, extraction of desirable components from the skin takes place primarily through the inner skin surface of the berry and from broken skin edges. Ostensibly, the extraction of phenolic compounds located in the skin may be enhanced by reducing the skin particle size. A theoretical analysis indicated that moderate fragmentation was sufficient to substantially decrease the surface area to perimeter ratio of grape skins. Three experiments showed that cutting grape skins into smaller fragments facilitated egress of color and tannin from the skin into the wine matrix. Homogenization of berry tissues resulted in a 6-fold increase in tannin, a 45% increase in stable pigment concentration, a 25% increase in wine color density, and a 20% increase in blue-purple coloration in wines at six months bottle age. Undifferentiated cutting of grapes caused a 6.5-fold increase in tannin, a 70% increase in stable pigment concentration, a 60% increase in wine color density, and a 10% increase in blue-purple coloration. Wines made using a cutting technique that reduced grape skins to 6% of their original size without damaging the seeds were 3-fold higher in tannin, 95% higher in stable pigment concentration, had 50% greater wine color density, and had a 20% increase in blue-purple coloration. The effects of reducing skin particle size on phenolic extraction were found to be much greater than those achieved using pectolytic enzymes. This innovative skin fragmentation technique has the potential to increase skin-derived red wine phenolics and is a viable alternative to maceration techniques currently used during winemaking.

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Visible-Near Infrared Reflectance Spectroscopy for Nondestructive Analysis of Red Wine Grapes

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Samples of intact grape berries were collected weekly from veraison until harvest. Each sample comprised ~400 berries selected following the preharvest sampling protocol specified by the vineyard manager. The grape cultivars and corresponding number of samples of each collected in 2009 and 2010 were as follows: Cabernet Sauvignon (43, 36), Cabernet franc (83, 80), and Syrah (38, 36). Reflectance spectra for the composite samples in a wavelength range of 350 to 850 nm were collected with a diode array spectrometer. Chemical analyses for soluble solids content (Brix), pH, titratable acidity (TA), total phenols, and total anthocyanins were carried out for all samples. Chemometric calibrations for corresponding reflectance data were developed using trained partial least squares regression (PLSR) models with several preprocessing methods (smoothing, normalization, differentiation) and subjected to variable selection by recursive feature elimination. Trained models were externally validated with data from the alternate year. Best performing models for Brix, pH, TA, phenols, and anthocyanins in 2009 had root mean square errors (RMSEP) of 0.65, 0.05, 0.59 g/L, 31.2 mg/L, and 75 mg/L, respectively, with corresponding R^2 values of 0.84, 0.58, 0.56, 0.27, and 0.65. The best 2010 models had RMSEP of 0.65, 0.05, 0.86 g/L, 27.9 mg/L, and 111 mg/L, respectively, with corresponding R^2 values of 0.89, 0.81, 0.58, 0.25, and 0.17. The 2009 calibrations were used for estimating Brix and pH from spectral data of the samples collected in the next growing season and yielded RMSEP performance of 0.87 and 0.05 with R^2 values of 0.71 and 0.56, respectively. Principal component analysis decomposition of 2009 and 2010 reflectance data showed similarities in the resultant loadings, indicating a similar underlying data structure. Larger sample size may have improved success of the models, particularly for TA, anthocyanins, and phenols. These data have significance and applicability for precision viticulture whereby fruit of different composition might be segregated during mechanical harvest.

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Amino Acid Composition of Grape (*Vitis vinifera* L.) Juice in Response to Applications of Urea to the Soil or Foliage

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High rates of nitrogen applied early in the growing season can cause grapevines to grow too large, be susceptible to disease, and produce grapes with undesirable properties. As a result, vineyard managers in the Okanagan Valley of British Columbia, Canada, tend to apply only low rates of nitrogen fertilizer. Consequently, grape juices from this region often have low levels of amino acids, which are an important source of nitrogen for the yeasts used in winemaking. Urea is a nitrogen-containing chemical that dissolves easily in water and is widely used as a nitrogen fertilizer. Some studies have found that late-season applications of urea to the soil or foliage (applied around the time when grapes begin to change color) can be used to increase the nitrogen content of grape juice and to avoid the undesirable effects sometimes associated with high nitrogen applications earlier in the year. However, it is unclear whether soil or foliar N applications are more effective at boosting grape juice N concentrations, and few studies have looked at changes in the amino acid composition of grape juice in response to these treatments. Such changes could have implications for wine quality. The effects of late-season applications of urea to the soil and to foliage on the concentration of amino acids in grape juice were compared over two growing seasons at two study sites (planted to Merlot and Pinot gris). Urea was applied three times (two weeks before veraison, at veraison, and two weeks after veraison) each year at a rate of 3.8 g urea-N/vine by either spraying 2% urea (by weight) to the foliage using a backpack sprayer (foliar N treatment) or applying granular urea to the soil below drip emitters (soil N treatment). Late-season foliar N applications were a more effective, efficient, and reliable method for boosting concentrations of amino acid in grape juice than late-season soil N applications. However, foliar N applications sometimes caused changes in grape juice amino acid profiles that did not occur when N was applied to the soil. The conditions under which such changes occur and the implications of these changes for wine quality require further investigation.

Am J Enol Vitic 67:47-55 (2016)

Comparison of Multivariate Regression Methods for the Analysis of Phenolics in Wine Made from Two *Vitis vinifera* Cultivars

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The quantification of key phenolic classes during different stages of red wine production has important industrial applications. Decisions of this nature require greater speed and economy than current bench or instrumental methodologies offer. Efforts to create rapid analysis have used models created from mathematical modeling of easily obtained spectra (UV/visible or near infrared) and reference phenolic measurements. In this work, we varied the way the sample was diluted to obtain the spectra, the reference phenolic measurement methodology, and the mathematical modeling method in an effort to find an optimal solution. One hundred samples of Washington Syrah and Cabernet Sauvignon musts from the Columbia Valley, Yakima Valley, and Horse Heaven Hills American Vineyard Areas were obtained from a commercial winery in 2011. We found that the mathematical modeling technique known as Ridge regression unanimously outperformed the other regression methods tested when calibrated with the modified assay at pH 7 and UV-visible sample dilution at 10-fold for only the Cabernet Sauvignon samples. Correlation coefficients obtained for anthocyanins, small and large polymeric pigments, tannins, and total iron reactive phenolics were 0.83, 0.78, 0.76, 0.92, and 0.90, respectively. Unfortunately, when the same multivariate regression evaluation was performed for Syrah, none of the methods tested gave accurate predictions, suggesting some cultivar specificity.

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Physiological Interaction between Rootstock-Scion: Effects on Xylem Vessels in Cabernet Sauvignon and Merlot Grapevines

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The interaction between rootstock and scion can interfere with the vegetative and productive balance of grapevines. Characteristics of the vascular connection and vascularization pattern are defined by meristematic activity and formation of new tissues, given the interaction between the genotypes of the scion and rootstock. However, little is known about the physiology of the rootstock-scion interaction and the anatomical variables associated with this process. In this context, the aim of the present research was to assess the influence of rootstock-scion interaction on the characteristics of growth and features of the xylem vessels of the *Vitis vinifera* L. cultivars Cabernet Sauvignon and Merlot. We investigated Cabernet Sauvignon and Merlot cultivars grafted on the rootstock genotypes Paulsen 1103 (*Vitis berlandieri* Planch. × *Vitis rupestris* Scheele), Mgt. 101-14 (*Vitis riparia* Michx × *V. rupestris*), and SO4 (*V. berlandieri* × *V. riparia*). We evaluated vegetative growth variables and performed an image analysis of the vascular system by quantifying the xylem and vessels (diameter, total number, density, frequency) in different portions of the scion stem. The rootstock-scion interaction caused differences in vegetative growth and was associated with differences in the vascular system. The vegetative growth of the combinations of Cabernet Sauvignon on Paulsen 1103 and Merlot on SO4 was higher than that of both varieties on Mgt. 101-14. The rootstock-scion combinations that are more vigorous showed vessels with larger mean diameter, larger xylem area, and higher frequency of vessels larger than 50 µm. The vines grafted on Mgt. 101-14 resulted in more frequency of vessels lower than 40 µm. For all combinations, the vessels' features were altered from the apex to base sections (stem morphology). The physiological interaction between rootstock-scion resulted in modifications of the vascular system in grapevines, altering the xylem vessels features according to the specific rootstock-scion combination.

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Grape Yield and Quality Response to Cover Crops and Amendments in a Vineyard in Nova Scotia, Canada

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Local waste products and cover crops have increasingly been used in vineyards to reduce the cost of synthetic fertilizers and their associated environmental impacts and yield instability. The effects of cover crop mixtures combined with organic and industrial wastes were assessed on grape yield and quality in two full growing seasons, 2011 and 2012, in Eastern Canada. The experimental treatments were arranged in a nested design with three replicates. Four cover crop mixtures: (i) oats+pea+hairy vetch (OPV), (ii) mixture of oats and red clover (ORCl), (iii) timothy+alsike+red clover (TM), and (iv) control with no cover crop (CONT) were applied to main plots, and five fertility treatments (fertilizer without N [NDEF], full synthetic fertilizer [FERT], wood ash [WA], municipal solid food waste [MSFW], and mussel sediment [MS]) to subplots. In this study, we demonstrated that grape yield for the most productive cover crop and amendment combinations were ORCl × MS (9.52 Mg/ha) > OPV × MSFW (9.49 Mg/ha) > TM × WA (8.81 Mg/ha) > ORCl × MSFW (8.28 Mg/ha). In addition, TM also resulted in the highest berry sugar concentrations among the cover crops when combined with MS (16.03 Brix) and MSFW (15.98 Brix). We concluded that a suitable combination of cover crops and soil amendments can improve yield and quality of winegrapes in the cool, humid climate of Eastern Canada.

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A New Description and the Rate of Development of Inflorescence Primordia over a Full Season in *Vitis vinifera* L. cv. Chardonnay

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The grapevine reproductive cycle occurs over two seasons, and there is much that is unknown about the formation and maturation of grapevine bunches in latent buds (the bud where bunches are first formed and then grow during season 1 before emerging as full bunches in season 2). Thus, our goal was to describe the developmental stages, time of first formation, and the fate of all developing bunches in primary latent buds in relation to the time of year and general growth stages of the whole grapevine. We also compared the size of developing bunches in the primary, secondary, and tertiary buds of the whole latent bud. Using a dissecting microscope, latent buds of Chardonnay grapevines were dissected throughout season 1, during dormancy (winter rest), and prior to budburst in season 2. At least four tiny bunches were started early in season 1, from mid-October to late November, with no other bunches started later at any time in season 1 or 2. These early bunches developed quickly, with two developing by the end of season 1 to the stages which would eventually end up as full mature bunches the next season. Growth of these developing bunches in the latent bud continued over dormancy. At least two early bunches did not grow to form full mature bunches but ended up as tendrils by budburst of season 2. Secondary buds had smaller and fewer developing bunches, and tertiary buds had none. This is the first report of grapevine bunch development in the latent bud over the entire first season and of the fate of all early bunches that were started at the beginning of season 1. These findings will assist further investigations on the grapevine latent bud.

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Determination of Energy Savings in Alcoholic Wine Fermentation According to the IPMVP Protocol

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Alcoholic fermentation in wines is a complex process that is hard to model and can vary according to many different parameters. Temperature is a key parameter throughout the fermentation process that must be controlled to avoid quality problems or even interruptions in fermentation. We sought to establish a method for conducting energy analyses of the

Determination of Energy Savings in Alcoholic Wine Fermentation According to the IPMVP Protocol *(continued)*

must fermentation process so as to learn how much energy is actually required by the process and what its cooling needs are. This enables decisions to be made with a view to keeping the process within the settings required and determining how much energy is needed for that purpose. Once these points have been determined, benchmarks can be established to which the actual energy used in the process can be compared to determine how efficient the process is. This enables the power of the cooling machinery to be optimized, which means that its maximum power use is reduced. The choice of cooling strategies also can also influence the total energy demand in the fermentation process. The model proposed provides valuable information, not just for energy processes, but for controlling the development of the product itself. The fermentation process and conditions determine the quality of the end product. The model can confirm whether a fermentation process is progressing as desired or whether there is a deviation that needs to be corrected in real time. Moreover, the information compiled can help enologists make decisions during the fermentation process and prevent unwanted developments in the product. Once fermentation is completed, this information can also help winemakers analyze the process variables applied to obtain the product, thus making it easier to reproduce the same variables in order to achieve continuous improvement of the product.

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Cover Crop and Root Pruning Effects on the Rooting Pattern of SO4 Rootstock Grafted to Cabernet Sauvignon

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Root biomass, root intercepts, and root-length density of SO4 rootstock grafted to Cabernet Sauvignon and exposed to under-trellis cover cropping (CC) and root pruning (RP) or no root pruning (NRP) were evaluated over three years. This was a long-term field study, as the cover crops had been in place from 2005 to 2014 and annual root pruning had been applied annually from 2005 to 2010. The efficacy of these management tools to limit/optimize excessive vine vigor of mature Cabernet Sauvignon vines grown in a humid environment was evaluated previously, and the current study examined the treatment effects on the vines' root systems. The CC treatments included tall fescue (*Festuca arundi nacea* Shreb.) cvs. KY-31, with and without RP, Elite II without RP, and an 0.9 m wide, under-trellis, herbicide strip with KY-31 fescue interrows, with and without RP. Approximately 70% of grapevine root biomass was observed at ≤60 cm soil depth, regardless of treatment or year. Rooting depth distributions were fitted to the model $Y = (1- \beta^d)$, originally applied to forest trees, where d is soil depth (cm), Y is the cumulative root fraction from the soil surface to depth d, and the unknown parameter β is a measure of soil vertical root distribution used as a response variable to test for treatment differences. All root distributions across treatments and years, except KY-31 fescue/NRP in 2008, generated β values greater than 0.970, similar to β values from other grapevine root distribution studies. The modest treatment impact on root biomass and distribution suggests that the mature grapevines adapted to CC and annual RP in this environment, and partially explains the minimal impact on soil water content and vine water potential previously reported from this experiment. The deep soils and humid growing conditions described in this study are common throughout the eastern U.S., and the condition of excessive vine vigor is a major challenge to the industry in the region. Although excessive vine vigor has been much studied and cover crop competition with vine roots has often been cited as the reason for decreased or reduced vine growth, few studies have investigated root growth associated with vigorous aboveground vine growth. This study contributes some initial descriptive information and insight about cover crop effects on, and competition with, the vine root system in this environment in a field setting.

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Monoterpenes in cv. Zilavka Free-Run Musts from Prefermentatively Macerated Pomace

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This research evaluated, for the first time, monoterpene potentials of the Herzegovinian autochthonous cv. Zilavka (*Vitis vinifera*). Zilavka grapes are considered aroma neutral, resulting in traditional winemaking practices with quick removal of must from skins. Based on some preliminary findings of terpenes in Zilavka grapes, three prefermentative maceration treatments on grapes from two consecutive vintages (2011, 2012) were examined as possible ways to transfer monoterpenes from grapes to musts. The vintages themselves were quite different. In 2011, the grapes were harvested on 12 Sept, the usual harvest time for Zilavka in Herzegovina, and in 2012, the harvest was on 14 Aug. According to local winegrowers, the most probable reasons for the unusually fast ripening and early harvest of grapes in 2012 were the very high temperatures and lack of rainfall during June, July, and August of that year. These differences caused more than double the concentrations of free volatile monoterpenes in grapes from 2012 in comparison with those from 2011, indicating the crucial importance of weather conditions during grape ripening for terpene synthesis and accumulation in grapes. Increasing the temperatures applied in 20-hr prefermentative maceration treatments from 6°C through 12 to 20°C did not cause significantly increased concentrations of all five of the monoterpenes examined (linalool, α-terpineol, citronellol, nerol, and geraniol; FVmT) in musts. Based on the research findings, 20-hr prefermentative maceration on temperatures up to 12°C could be an appropriate way to enrich Zilavka musts, and likely the resulting wines, with wine-odor monoterpenes.

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Genotyping of Grapevine Varieties from Garfagnana (Northern Tuscany): Evidence of a Historical Center of Diversity

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The aim of this research was to recover, characterize, and increase the value of local grapevine varieties from Garfagnana, a mountain area situated in the north of Tuscany (in central Italy). A total of 130 accessions (vines) were identified in old vineyards, characterized by OIV morphological-phenological and productive parameters, and genotyped using 14 microsatellite loci. Microsatellite analysis led to the identification of 50 genotypes. Some matched Tuscan genotypes, others corresponded to varieties cultivated in other Italian and European regions, and 18 appeared to be genotypes currently identified only in Garfagnana and presumably autochthonous of this area. The cluster and similarity analyses based on both microsatellites and morphology showed a clear grouping of the majority of the autochthonous genotypes from Garfagnana. The parentage analysis also revealed that Garfagnana autochthonous genotypes are highly first degree-related among them, suggesting that Garfagnana is a distinct historical center of diversity of cultivated varieties. All varieties have been uploaded in the Italian Vitis Database (www.vitisdb.it).

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Validation and Comparison of Two Tunable Diode Laser Absorption Spectroscopy-Based Carbon Dioxide Sensors for Bottled Wine

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The purpose of this work is an evaluation of the applicability of two different carbon dioxide sensors with respect to the wine and bottling production fields. The instruments considered both use gas-phase carbon dioxide detection through absorption spectroscopy. This research explored the applicability of this method to extract useful measurements of dissolved carbon dioxide in the liquid phase and the sample pressure. Furthermore, limitations of the measurement are pointed out.

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Review: Characterization and Role of Grape Solids during Alcoholic Fermentation under Enological Conditions

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During wine production, grape solids have a large impact on fermentation characteristics and the organoleptic qualities of the resulting wine. We reviewed the research carried out on grape solids, beginning by focusing on the origin, physical characteristics, and composition of these solids and the change in these aspects occurring during fermentation. We then considered the effect of solids on fermentation, the role of sterols, the control of solids, and the interactions between solids and other nutrients. Solids exert their effects on alcoholic fermentation mainly by modulating lipid supply. The balance between solid content and nitrogen is a key factor in fermentation control. The study of grape solids is recent and requires further development. Knowledge of the composition of these solids and of sterol uptake mechanisms by yeast should facilitate improvements in fermentation control.

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Evaluation of Primary Bud Freezing Tolerance of Twenty-three Winegrape Cultivars New to the Eastern United States

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The objectives of this study were to measure the primary bud freezing tolerance (FT) of 23 *Vitis vinifera* winegrape cultivars in Ohio and to compare three statistical methods (mode-date, piecewise regression, and annual mean LT_{50} [AFT]) for determining the minimum low temperature that will kill 50% of primary buds (LT_{50}). Minimum LT_{50} was most accurately determined using the AFT method, which distinguished a 1°C difference among cultivars in primary bud FT. The results from this study can be used to assist selection of *V. vinifera* cultivars suitable for vineyard sites where freezing temperatures limit winegrape production.

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Fe(II):Fe(III) Ratio and Redox Status of White Wines

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Wine can take up a considerable amount of oxygen, which is beneficial to a point for red wine but detrimental for white wine. Phenols are the principal reactants, but they cannot react with oxygen directly and require the intermediate assistance of iron (Fe). Iron exists in an oxidized ferric (Fe(III)) form and a reduced Ferrous (Fe(II)) form. Oxygen converts Fe(II) to Fe(III) and phenols reduce Fe(III) back to Fe(II), a process known as redox cycling, in which overall phenols are oxidized. At any time, the Fe(II):Fe(III) concentration ratio will depend on how fast Fe(II) reacts with oxygen relative to the rate at which phenols react with Fe(III) to regenerate Fe(II). Due to the speed of the Fe(II) oxidation, oxygen concentration should be the main determinant of this ratio. A simple procedure is devised to measure this ratio at any time with minimal wine disturbance by using Ferrozine. This substance binds Fe(II) selectively to give a colored product, the concentration of which may be determined with a spectrometer. The amount of Fe(III) is determined by converting all the Fe to Fe(II) with ascorbic acid and subtracting the value initially obtained for Fe(II). Screwcaps afford high protection against oxygen ingress into bottles so that little Fe(II) is oxidized, resulting in a high Fe(II):Fe(III) ratio in the bottled wine. Wines from bottles closed with natural corks and wines in boxes contained measurable amounts of oxygen, which resulted in more Fe(II) oxidation and a lower Fe(II):Fe(III) ratio. Saturation of wine with air resulted in Fe(II) oxidation and a progressive reduction in the ratio, which reaches equilibrium after several days. It is proposed that wines which oxidized most rapidly would manifest high ratios at equilibrium.

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Effects of Various Vineyard Floor Management Techniques on Weed Community Shifts and Grapevine Water Relations

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Adoption of permanent cover crops and no-till systems is considered integral to achieving the California state air quality standards regulating airborne particulate matter, as indicated in Senate Bill 656. Imposition of such management techniques in a vineyard could create competition with vines for limited water resources. We evaluated the effects of cover crops that were either tilled or just mowed on vineyard floor composition, weed populations, vine water relations and growth, and fruit composition over three years within a mature commercial Merlot vineyard subjected to deficit irrigation in Lodi, San Joaquin Valley, California. The vineyard floor in this experiment supported resident vegetation that was tilled (standard grower practice), an oat cover crop, or a legume/oat cover crop. The two planted cover crops were either tilled or mowed (i.e., no-till). Biomass of cover crops, weeds, and legumes varied by year and treatment, but consistent effects among treatments were not observed. Weed species composition and cover segregated with the presence or absence of tillage rather than cover crop type and the weed species composition of the resident vegetation was distinct from those in the cover crop treatments. Some treatments, like 'Oats/Legumes + NoTill', 'Oats + NoTill', 'Oats/Legumes + Till', and 'Resident Vegetation + Till' reduced soil water content (Θ_v) in at least one of the three shallow soil layers spanning 0 to 30 cm, 30 to 60 cm, and 60 to 100 cm in 2008, and 'Oats/Legumes + NoTill' also dried the two upper layers in 2009, but these differences had no consistent influence on plant water status. Distinctions in Θ_v between years were attributed partly to the cessation of rainfall two months earlier in 2008 than in 2009, despite similar total annual quantities. Significant reductions in Θ_v imposed by the 'Oats/Legumes + NoTill' treatments reduced vine vegetative growth in two of three years, but these effects did not manifest in yield and fruit composition. Values for the Ravaz index for two of the three years indicate that the vineyard was overcropped for all treatments, but maximizing production in this region is a common practice. Weak competitive effects of the cover crops for water were likely associated with the use of a well-established mature vineyard and demonstrated that these management strategies could be employed to improve air quality to meet California air quality regulations with limited effects on vine water status and production.

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A Condenser to Recover Organic Volatile Compounds during Vinification

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Volatile compounds are lost during grape must fermentation, which ultimately affects the wine's aroma. An innovative condensation device was designed to trap organic volatile compounds that would otherwise be lost. Trials were performed on Sangiovese and Syrah grapes and involved continuous condensation of vapor (condensed fractions, CFs) escaping from fermentation tanks. Daily measurements were taken of the ethanol content and volatile compound composition of the collected fractions. Predominant compounds were alcohols and esters of secondary origin, which have a significant impact on wine aroma. The fraction volatile profile changed as a function of fermentation time. The recovered fractions were added back to their respective wines for sensory evaluation. The re-addition of recovered fractions into the finished wine was perceivable and may have the potential to be used as a coadjutant to reinforce wine aroma. Moreover, the technique could be an effective tool for enologists to differentiate wines or characterize other alcohol-based beverages.

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Accentuated Cut Edges (ACE): Effects of Skin Fragmentation on the Composition and Sensory Attributes of Pinot noir Wines

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The phenolic composition, aroma, and sensory profiles were evaluated for Pinot noir wines made using four different maceration techniques that modified the floating pomace cap during fermentation: (1) daily plunging, (2) reduced skin particle size (accentuated cut edges = ACE), (3) submerged cap, and (4) ACE plus submerged cap. Wines were analyzed throughout vinification to assess the phenolic attributes: anthocyanin, tannin, nonbleachable pigments, color density, and hue using rapid analytical techniques. At six months bottle age (230 days postinoculation), sensory and aroma analyses were conducted on the finished wines. ACE macerated wines were found to have the highest proportion of red color, tannin, nonbleachable pigments, fruit and floral aromas, bitterness, and astringency, while submerging the pomace cap resulted in a lower concentration of phenolic components than for ACE wines but a significantly higher phenolic content and dark cherry aromas and flavor than control wine. These findings suggest that the employment of either maceration technique has the potential to make a considerable difference to the wine style produced from a given parcel of fruit and may provide an opportunity to press wines earlier in the fermentation. Linear regression analyses were conducted to compare descriptive wine parameters with instrumental phenolic measurements and demonstrated several strong correlations: red color appearance was correlated with both color density ($r^2 = 0.95$) and nonbleachable pigment ($r^2 = 0.95$); dark fruit flavor was correlated with both color density ($r^2 = 0.85$) and nonbleachable pigment ($r^2 = 0.85$); and astringency was correlated with both tannin ($r^2 = 0.97$) and nonbleachable pigment ($r^2 = 0.87$), demonstrating that techniques of rapid chemical analysis were able to provide valuable insights into the sensory properties of the wine and may become useful tools for monitoring the development of the wine during vinification. While submerged cap vinification also increased the tannin and stable pigment profiles of the wine, ACE maceration was found to be significantly more effective and is likely to be more readily adapted for application in commercial wineries.

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Analysis of Total Arsenic Content in California Wines and Comparison to Various Health Risk Criteria

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Recent media reports have discussed concerns over arsenic concentrations in California wines after some wines were found to contain arsenic concentrations greater than the U.S. Environmental Protection Agency Maximum Contaminant Level for drinking water. Arsenic occurs naturally in soil, water, and other environmental media. The concentration of arsenic in wine may be influenced by these natural sources, from the use of arsenic in agricultural and industrial practices, or from winemaking practices. The objective of this study was to characterize the total arsenic concentration in California wines, compare an average person's exposure to arsenic in wine to a total dietary exposure to arsenic, and assess the relationship between total arsenic concentrations and the type (red, white, blush) and price of wines. Total arsenic concentrations in 101 wines produced or bottled in California were measured. Of these wines, 28 were identified in media reports as containing arsenic concentrations greater than the drinking water standard. The remaining 73 wines were randomly purchased at local retailers. The group of wines cited in media reports was found to have a significantly greater average total arsenic concentration than the randomly selected wines. Additionally, blush wines were found to contain the greatest average total arsenic concentration, followed by white wines, then red wines. In this analysis, it was determined that lower-priced wines generally contained higher arsenic concentrations. Regarding dietary intake, it was determined that an average person's wine consumption accounted for a small fraction (less than 8%) of a typical adult's dietary arsenic intake. Lastly, the concentrations of total arsenic in all wines evaluated were less than the two current arsenic guidelines for wine of 100 and 200 μg/L. These results indicate that arsenic in wine does not represent a health risk for consumers.

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Impact of *Pediococcus* spp. on Pinot noir Wine Quality and Growth of *Brettanomyces*

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Pediococcus spp. have been isolated from wines all over the world and are generally associated with spoilage. Despite this, little is known concerning the occurrence of these organisms in Pacific Northwest wines and their impact, if any, on quality. In this study, species of *Pediococcus* isolated from Oregon and Washington state wines were inoculated into Pinot noir wine after alcoholic fermentation and then chemically and sensorially analyzed after 60 days. Pediococci isolates exhibited differences in production of various spoilage compounds. Despite achieving extensive populations (>10^6 CFU/mL), generally low concentrations of biogenic amines were detected (<3 mg/L total); the exception being those wines inoculated with *P. inopinatus* OW8 (>5 mg/L). For diacetyl, some wines contained low levels (<0.5 mg/L), while others contained excessive amounts (>15 mg/L). Furthermore, growth of some pediococci resulted in a loss of red color and polymeric pigment content, potentially due to acetaldehyde degradation. Sensory analyses revealed differences in aroma ("floral," "overall fruit," "red fruit," and "buttery") and flavor ("sour" and "astringency") between wines inoculated with different species and/or strains. Co-inoculation of *P. parvulus* and *B. bruxellensis* resulted in wines containing lower concentrations of 4-ethylphenol but reaching higher populations than in separate inoculations. This study demonstrated the variability that exists between *Pediococcus* species and strains in the production of various spoilage products and the potential range of sensory effects these bacteria can have on a Pinot noir wine.

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The Basis of Defoliation Effects on Reproductive Parameters in *Vitis vinifera* L. cv. Chardonnay Lies in the Latent Bud

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Loss of grapevine leaves is common, but little is known about the basic causes of its effect on the size of grape berries or size of grapevine bunches. We propose that low sugar stores in the grapevine, produced by extensive leaf loss, reduce the numbers of bunches started and limit their size during development in the latent bud (the bud where bunches are first formed and then grow during season 1 before emerging as full bunches the next season). From early in season 1 (December), Chardonnay grapevines had leaves progressively removed as new leaves appeared throughout season 1 until season end, with the bunches left on. The leaf removal resulted in low sugar stores in the grapevine at season end and consequently, smaller early embryo bunches in the latent buds by dormancy and at pre-budburst in season 2. Grapevines with leaves removed and those with none removed had similar numbers of embryo bunches at winter dormancy and by pre-budburst in season 2. However, in grapevines where leaves were removed, some post-budburst bunches died due to lack of sugar, resulting in fewer bunches in season 2. Low grapevine sugar stores during the spring of season 2 ensured that fewer bunches were started and also delayed growth, with fewer, smaller bunches at post-budburst in season 3. Thus, our study indicted that leaf removal effects were due to low sugar stores, reducing the number of bunches started and reducing their size in latent buds, and also causing death of mature bunches in the immediate post-budburst period.

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Postveraison Shoot Trimming Reduces Cluster Compactness without Compromising Fruit Quality Attributes in Organically Grown Sangiovese Grapevines

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Vine performance following preveraison shoot trimming is well documented; however, the consequences of such treatments later in the season are poorly understood. Therefore, a four-year study was conducted in a mature vineyard of Sangiovese (clone 12T) grafted onto Kober 5BB rootstock at a spacing of 1 m × 2.8 m (intra- and interrow) to analyze the influence of postveraison shoot trimming on vine growth characteristics, cluster architecture (cluster compactness), and yield from a physiological viewpoint. The treatments consisted of shoot trimming during postveraison in a randomized block design with eight replications; each replication comprised of six vines. Three treatments were imposed when the soluble solids reached 15 Brix in August (40-45 days before expected harvest): light trimming (14 nodes), severe trimming (10 nodes), and an untrimmed control. Following the treatments, various vine growth characteristics, cluster morphology, and fruit quality attributes were measured. Postveraison shoot trimming, especially severe trimming, reduced cluster weight, cluster compactness, productivity, and total yield. In terms of fruit quality attributes, these reductions were manifested as lowering of Brix and pH, with minor effects on TA, yeast assimilable nitrogen, the anthocyanin profile, and total anthocyanins. These results demonstrated that postveraison shoot trimming can be a valuable production practice in reducing cluster compactness without compromising overall fruit quality attributes in Sangiovese.

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New Stable QTLs for Berry Firmness in Table Grapes

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Berry firmness is one of the most important quality traits in table grape production and, consequently, a key aspect for table grape breeding programs. Because crops are usually harvested far from production centers, grapes have to be "good travelers," and the best travelers are varieties that have the firmest berries. In order to develop new genotypes with firm berries, breeders need to understand the genetic basis of the trait. We present the result of three years of phenotypic and genetic evaluation of a crossing of two varieties of table grapes, segregating for firmness. Results showed that even though the heritability was ~90%, season had an important effect on this trait. Quantitative trait loci (QTL; i.e., regions of the genome where the probability of finding the genes responsible for a characteristic is higher) analysis and genetic mapping showed that the determinants for this trait are located on two of the 19 chromosomes (or linkage groups) of the grapevine: linkage groups 8 and 18. This is the first time that a stable QTL for berry firmness across seasons has been identified on linkage group 8. Together these two QTLs explained ~27.6% of the phenotypic variance. Among the tens of genes found in these two QTLs, we highlighted a cation/calcium exchanger, a xylosyltransferase, a probable cellulose synthase, and a putative invertase, all related to cell wall metabolism. This study shows that berry firmness has a clear genetic basis. These results could also be useful information for table grape breeders, helping them to select new improved varieties.

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Salinity Negatively Affects Pollen Tube Growth and Fruit Set in Grapevines and Is Not Mitigated by Silicon

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In arid and semiarid vineyards, salinity causes yield losses and a decrease in wine quality. This is increasingly becoming a problem in wine regions in California and Australia and is an emerging issue elsewhere due to climate change and misuse of irrigation water or land resources. While there is a body of work on the use of rootstocks to decrease salt (sodium chloride) accumulation in fruit and decrease yield losses, little is known about how salinity actually reduces yield. The focus of this research is on how salinity affects the reproductive performance of grapevine and to see if a common treatment for reducing salt damage in other crops, the application of silicon, has any effect on mitigating salt damage in grapevine. Shiraz vines were grown in controlled conditions. Reproductive performance measures of vines were taken from control and salt-treated vines. Salt treatment was found to reduce yield by reducing fruit set through increased flower abscission and interruption of normal berry development. Pollen tube growth was tracked in flowers and was reduced under saline conditions, which correlated with a reduced number of fertilized flowers and their conversion to berries. Pollen viability and the ability of pollen to germinate on female flower parts were not affected by salinity. Silicon did not restrict sodium or chloride ion accumulation in the reproductive organs or ameliorate the deleterious effects of salinity on reproductive capacity. However, we did observe improved instantaneous water use efficiency in silicon-treated vines compared to control vines. This study suggests that fertilization is sensitive to salt accumulation and salt exposure should be avoided to minimize salinity impacts on fruit yield in the field.

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Assessment of Vineyard Canopy Porosity Using Machine Vision

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Canopy porosity is a key viticultural factor, as canopy gaps favor fruit exposure and air circulation, both benefits to fruit quality and health. Point quadrat analysis (PQA) as a standard method to assess canopy gaps is laborious and time consuming and therefore has limited utility. A new, objective, noninvasive, image-based method was developed and compared with PQA to assess the percent of canopy gaps in vineyards of different viticultural conditions and planted with diverse varieties in New Zealand, Croatia, and Spain. The regressions between the canopy porosity, expressed as percent of gaps, using both methods were very high in each site for all cultivars and for the global model. Image acquisition of grapevines can be equally carried out at any time of the day (morning, midday, or afternoon) and from any of the two sides of the canopy, as the differences in natural illumination did not significantly affect the algorithm's performance. Using this new diagnostic method, canopy management could be optimized to configure a desired amount of canopy gaps, with the aim of improving fruit quality and health. Considering the easy-to-use and fast implementation of the image-based method and the possibility of fine-tuning canopy management, it is expected that image analysis techniques will gain acceptance in viticulture, especially if they are available on smart devices.

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Impact of Frozen Storage on the Free Volatile Compound Profile of Grape Berries

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Fruits stored at temperatures above 4°C are subject to rapid deterioration due to microorganisms, enzymes, or oxidation reactions. Although freezing is not part of the usual winemaking process, freezing grape berry samples during veraison and harvest in order to postpone time-consuming analyses is common practice. In this study, the volatile composition of fresh juice from two grape varieties (Thompson and Flame) was compared with those of frozen juice and juice extracted from previously frozen grapes. Results showed that freezing the juice or extracting juice from previously frozen

Impact of Frozen Storage on the Free Volatile Compound Profile of Grape Berries *(continued)*

grapes had a significant impact on the volatile compound profile when compared to fresh samples and that these differences were cultivar-dependent. Freezing of fruit juice or the whole berries affected many compounds usually related to herbaceous, fruity, and floral notes in juices. Results suggest that care should be taken when performing free volatile compound analyses from frozen grape berries or juice, and that other preservation methods should be investigated to preserve grape berries for scientific investigations.

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Effects of Co-Inoculation on Wine-Quality Attributes of the High-Acid, Red Hybrid Variety Chambourcin

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In the present study, the results of co-inoculation (i.e., simultaneous inoculation of must with yeast and bacteria) were compared with those of traditional sequential fermentation (i.e., inoculation of bacteria after completion of the primary yeast fermentation) in the vinification of wine made from the red, high-acid French-American hybrid variety Chambourcin. Previous research has indicated that the use of co-inoculation may offer potential benefits to wine producers, including minimizing overall production time and improving wine quality. Our findings indicate that production time was decreased in co-inoculated treatments, offering an advantage to producers for improving winemaking efficiency. Additionally, minimal chemical differences were found between the sequential and co-inoculation treatments. A lack of perceived sensory differences was also noted. Therefore, this study demonstrates that co-inoculation can be used as a winemaking technique for the vinification of high-acid red varieties, such as Chambourcin, without altering wine quality, while also improving production efficiency.

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Light-Emitting Diodes as Supplemental Lighting in Viticulture Field Research

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A light emitting diode (LED) system was evaluated as a tool for field research to investigate light effects on grapevines. Preliminary laboratory trials were conducted to develop response curves for photosynthetically active radiation (PAR) and temperature in relation to distance from LED light source. LED panels were subsequently deployed in a three-year field study comprising three light exposure treatments on developing fruit clusters of *Vitis vinifera* cv. Cabernet Sauvignon: (1) clusters exposed to direct sunlight, (2) clusters shaded by canopy, and (3) canopy-shaded clusters exposed to supplemental LED light. Laboratory trials and vineyard field studies demonstrated LED panels could provide supplemental light over a broad range of PAR, up to and exceeding the photosynthetic light saturation point for exterior leaves of grapevine, by adjusting distance of LED panel to target. Although bench trials indicated significant convective heat close to the LED panel, field studies detected few temperature differences among cluster treatments. Varying results were primarily attributed to temperature measurement locations related to experimental objectives; bench trials measured target surface temperature, whereas field studies monitored whole cluster temperature. LED panels were effectively deployed to provide supplemental light to shaded grape clusters without significantly altering cluster temperature.

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Effects of Vineyard and Winemaking Practices Impacting Berry Size on Evolution of Phenolics during Winemaking

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In this study, we sought to uncover interactions between a vineyard practice that impacts berry size, such as regulated deficit irrigation (RDI), an irrigation technique whereby water is supplied at rates at or below the full evapotranspiration (ET_c), and a winemaking technique that is carried out to emulate a different berry size to that originally present in the berry population (saignée). Because extended maceration (EM) is known to alter the concentration and partitioning of wine tannins and anthocyanins, it was also included in the experimental design. Four different RDI protocols were applied to Cabernet Sauvignon grapes in the vineyard: (100% ET_c, 70% ET_c, 25/100% ET_c, and 25% ET_c). Fruit lots were then processed in the winery by applying EM, saignée, and a traditional maceration protocol. None of the four RDI treatments affected anthocyanin extraction: the amount of extracted anthocyanins in the wines was roughly proportional to the initial anthocyanin content in the fruit of each treatment. Thus, quantitative differences in anthocyanin extraction favored 25% ET_c and 25/100% ET_c wines. Likewise, there was no effect of the RDI treatments on tannin extraction. Saignée increased the anthocyanin content at day 5, but these differences subsided by day 120 irrespective of the RDI treatments, which translated into equivalent wine color saturation in saignée and control wines. Saignée also increased tannin content relative to the control wines, and these differences were long-lasting. The results also suggest that from the perspective of tannin extraction, the effect of saignée was more pronounced when applied to fruit lots having larger berry weight (100% ET_c:1.01 g/berry and 70% ET_c:0.96 g/berry). The application of EM reduced anthocyanins and wine color saturation but increased tannin extraction from seeds. On the other hand, control and saignée wines had an equivalent proportion of skin- and seed-derived tannins. Overall, the effect on phenolic and chromatic measurements of the winemaking techniques applied in the winery was more evident and long-lasting than that of the RDI treatments applied in the vineyard.

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Impact of Undervine Management on Vine Growth, Yield, Fruit Composition, and Wine Sensory Analyses in Cabernet franc

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Four undervine management treatments were established in a young Cabernet franc vineyard in Lansing, NY, in 2010, with the goal of reducing herbicide use and potentially limiting vine vigor: cultivation (CULT), native vegetation (NV), white clover (WC, *Trifolium repens* annually-seeded at 10 kg/ha), and glyphosate herbicide (GLY, the control). Vine size was reduced by the NV and WC treatments compared to vines in the GLY plots, but fruit yields were also reduced. Juice chemistry was not impacted by treatments and panelists were unable to consistently differentiate wines from treatments in any of the three vintages (2011 to 2013). The smaller vine size and yields of NV and WC vines in comparison to GLY vines suggested the potential for undervine cover crops to limit vine vigor in comparison to conventional practices, perhaps reducing the need for expensive canopy management interventions through the season. The greater yields of GLY vines, the similarity in juice chemistry among treatments, and the lack of wine sensory differences among treatments suggested that herbicide use promoted higher yields without a sacrifice in fruit and wine composition. Cost of maintaining the undervine management treatments was lowest ($84/ha) for the NV treatment and highest ($1036/ha) for the CULT treatment, but since yield was reduced in NV and WC, the GLY strategy produced up to $6891/ha more revenue than other treatments.

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Under-Trellis Cover Crop and Rootstock Affect Growth, Yield Components, and Fruit Composition of Cabernet Sauvignon

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Managing vegetative growth of grapevines is important for fruit and wine quality. We compared the use of an under-trellis cover crop (CC) with an under-trellis herbicide-treated strip (HTS) and compared three different rootstocks (101-14, 420-A, *riparia* Gloire) as a proactive means to regulate vine size and potentially improve fruit quality of Cabernet Sauvignon in a long-term study. While CC reduced vine pruning weight and increased fruit-zone exposure, it also reduced crop yield by an average of 610 kg/ha/year and offered little improvement in fruit quality when compared to HTS. Vines grafted to *riparia* occasionally had reduced vine pruning weights and increased crop yield components compared to the other two rootstocks. Rootstock 420-A consistently reduced juice pH compared to 101-14 and *riparia*. Inconsistent improvements in grape anthocyanins and phenolics were observed in *riparia* (both) and 101-14 (phenolics only) when compared to 420-A. Though more pronounced in the early years of the experiment, CC reduced vine size more consistently than did rootstock choice. As such, under-trellis cover crops offer a proactive means to regulate vine size and reduce operational costs associated with canopy management, but only if an average of 610 kg/ha reduction in crop yield is affordable. Though uncertain if similar effects will be realized with other scion varieties, *riparia* warrants consideration as a rootstock that can tandemly increase crop yield and decrease vine size. On the other hand, the reduction in juice pH conferred by 420-A rootstock could prove beneficial in situations where elevated fruit and wine pH are frequently encountered.

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Impact of the [*GAR*$^+$] Prion on Fermentation and Bacterial Community Composition with *Saccharomyces cerevisiae* UCD932

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Adoption of sound fermentation management practices greatly reduces the incidence of sluggish and stuck wine fermentations. However, there are incidences where difficulties in fermentation progression arise that are not due to the typical, known causes of yeast stress. This work demonstrates that one mechanism for reduction in yeast fermentative capacity is due to the establishment of a prion within the cell population. Prions are heritable protein conformations that can modify cell metabolic behavior. In the case of fermentation progression, establishment of the [*GAR*$^+$] prion allows the cell to circumvent glucose repression, reduce rates of glucose influx and catabolism, and maintain viability under conditions of stress. We have shown in this paper that the [*GAR*$^+$] phenotype in wine strains is indeed due to the establishment of a heritable prion state and that creation of that state is associated with a reduction of fermentation capacity and ability to dominate the broader microbial community. Comparison of [*GAR*$^+$] and [*gar*$^-$] cells showed that [*GAR*$^+$] strains failed to exclude bacteria from growing concomitantly with the yeast, reduced fermentation rates, and changed the aroma profile of the wine consistent with bacterial activity. Use of adequate levels of sulfur dioxide blocked these effects in [*GAR*$^+$] strains. We hypothesize that the bacterial induction of the [*GAR*$^+$] prion by yeast during fermentation is another possible mechanism by which stuck/sluggish fermentations may become established.

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Evaluation of Energy Saving Using a New Yeast Combined with Temperature Management in Sparkling Base Wine Fermentation

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The increasing interest in environmental sustainability will drive wine suppliers to provide quantitative information about energy-saving solutions for their processes and products and their impact on the environment. Heat removal accounts for ~90% of the total energy requirements of the winery and is mostly related to the temperature control of the wine tanks used for fermentation and maturation. The aim of this work was to evaluate the effects of a selected wine yeast, chosen to optimize sensory characteristics and minimize SO_2 production at temperatures higher than the standard for winemaking, on energy consumption during the fermentation process of the Franciacorta base wine. Fermentations using the new yeast strain were conducted at 15 and 19°C, and energy consumption was compared. Also, the sensory, chemical, and aromatic features of the sparkling base Franciacorta wines were measured. Fermentation required 21.6 $Wh/L_{grape\ must}$ at 15°C and 7.7 $Wh/L_{grape\ must}$ at 19°C, reducing energy use by ~65% at the higher temperature. Use of the tested yeast had positive effects on energy saving during fermentation without compromising sensory, chemical, and aromatic profiles of the resulting wine. This work suggests possible methods for wineries to adopt a more sustainable winemaking process that lowers energy consumption and decreases SO_2 content in wines, which may introduce eco-labeling strategies and price-premium policies.

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Effect of Postharvest Defoliation on Carbon and Nitrogen Resources of High-Yielding Sauvignon blanc Grapevines

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We quantified the importance of postharvest carbohydrate assimilation and nitrogen availability to replenish vine reserves, over and above maintaining optimal growth, productivity, and fruit quality of high-yielding, vigorous Sauvignon blanc grapevines. To create different carbohydrate (CHO) and nitrogen (N) reserve concentrations, our factorial-design trial consisted of a postharvest defoliation treatment overlaid with a pruning treatment for which 48 and 72 nodes were retained on four- and six-cane vertical shoot positioned vines, respectively. For defoliation (Defol), all the leaves of the vines were removed immediately after fruit harvest, compared to foliated vines (Fol) that went through normal senescence. From just after ectodormancy in 2008, samples of root and trunk tissue were taken throughout the years for CHO and N analyses, and results compared with annual yield data. In the seasons following the treatments, both the defoliation and node number treatments reduced vine growth and yield. Additionally, differences in CHO and N of the permanent structure were found. Depleted winter reserves in trunk and root were replenished during the next growth cycle, suggesting that grapevine N and CHO partitioning favor survival of the permanent structure over increasing vine size and yield. However, after two consecutive years of defoliation, the cumulative effects of smaller, less fruitful canes from year 1 and reduced carbohydrates from the subsequent year, did reduce both yield and vegetative growth in the third growing season. Therefore, even the short-lived postharvest canopy in cool climates contributes to the vine CHO economy. Defoliation or excessive crop loads affected carbohydrate reserves in vines, but only after a few consecutive years of low recharge was this manifested in lower yields and poorer vegetative growth.

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Impacts and Interactions of Abscisic Acid and Gibberellic Acid on Sovereign Coronation and Skookum Seedless Table Grapes

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Gibberellic acid (GA; 0, 15, 30 mg/L) and abscisic acid (ABA; 0, 150, 300 mg/L) treatments were applied alone and in combination on Sovereign Coronation and Skookum Seedless (Coronation and Skookum, respectively) table grapes in Ontario in 2013 and 2014 to assess their effects on cluster and berry size, berry composition, and sensory characteristics. The hypothesis was to produce larger and more attractive clusters using GA while accelerating fruit maturity through use of ABA. Two sites (Hipple, Lambert) were used for Coronation and one (Lambert) for Skookum. Trials were randomized complete block designs with factorialized treatment arrangements containing four blocks. GA was applied three times (prebloom, seven days postbloom, 14 days postbloom); ABA was applied twice (one and two weeks preveraison). The following data were collected: yield components (yield, cluster weight, berry weight), berry composition (Brix, titratable acidity [TA], pH, color intensity, anthocyanins), and sensory variables. GA increased yield, cluster weight, and berry weight in Coronation. GA seemed to delay ripening, with reduced Brix, color, and anthocyanins but also lower TA (both sites). ABA increased berry pH (both sites) and color intensity and anthocyanins (Hipple 2013). Yield was reduced by GA in Skookum, but cluster weight increased (2013). Brix and berry pH increased and TA decreased with increasing GA in Skookum, and ABA increased Brix and pH. In Coronation, GA enhanced several sensory variables, e.g., cluster attractiveness and color intensity (both sites), juiciness (Hipple), and *labrusca* flavor (Lambert). ABA likewise increased cluster attractiveness, color intensity, and *labrusca* flavor. In Skookum, GA increased flesh firmness, fruity flavor, and juiciness, while ABA enhanced cluster attractiveness, golden color, and visual liking. Overall, GA consistently increased yield components with minimal impacts on berry composition, while ABA increased Brix, pH, color, and anthocyanins but decreased TA.

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Climatic Niche Characterization of 13 North American *Vitis* Species

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The majority of viticulture is based on cultivation of the European grapevine species *Vitis vinifera* ssp. *vinifera*. However, in North America there are ~19 native *Vitis* species, many of which have played an important role in the generation of scions used in regions where pure *V. vinifera* doesn't do well and for rootstocks used in various regions around the globe. As changing climates present novel challenges to viticulture, scientists and breeders are looking to native North American *Vitis* species as sources of potentially valuable germplasm for scion and rootstock development. The goal of this study was to characterize the climates in which native North American *Vitis* species grow and to ask whether native populations of genetically similar *Vitis* species occur in similar climates. To do this, we compiled more than 7000 locality points for 13 North American *Vitis* species. We downloaded geographic information systems data on temperature and precipitation for each locality point and then generated environmental niche models for each species. We compared the climates in which the different species occurred and asked what components of climate (temperature, precipitation) differed among species. Our results indicate that *Vitis* species occur under a wide range of climatic conditions, including warm and wet (*V. shuttleworthii*), warm and dry (*V. mustangensis*), cold and wet (*V. labrusca*), and cold and dry (*V. riparia*) climates. Some closely related North American *Vitis* species exhibit similarities in their climatic niches, while other groups of closely related *Vitis* species exhibit notably different climatic niches. Additionally, we identified novel geographic locations where some species could potentially flourish. These data provide valuable insights into the types of climates occupied by natural populations of North American grapevines and may be useful in the development of rootstocks to suit specific climates now and in the future.

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Monitoring Volatile Aroma Compounds during Fermentation in a Chemically Defined Grape Juice Medium Deficient in Leucine

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Understanding the genetic basis of a complex attribute such as aroma compound production by yeast can benefit from a reductionist approach whereby the role of a subset of genes in this phenomenon is examined under controlled conditions. A recently reported library of yeast clones, each bearing a different set of yeast genome fragments containing about four genes each, are a new tool for such research. To ensure their genetic stability, such clones must, however, be grown in a medium devoid of leucine, an amino acid ordinarily present in grape juice and involved in formation of some relevant compounds. A chemically defined medium provides a way of ensuring leucine deficiency and controlling the formulation of the test medium in a way not normally possible with a grape juice. As a prelude to fully exploiting this medium and clone combination, this study sought to determine if the clone would grow and perform as expected in such a reduced condition and whether the aroma compounds formed reflected those seen in published reports of work undertaken with similar media. The findings confirm the appropriateness of this experimental design and open the door for further work aimed at understanding yeast aroma compound production.

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Preveraison Water Deficit Accelerates Berry Color Change in Merlot Grapevines

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The onset of berry ripening is commonly known as "veraison" and, in red varieties, is associated with the berry color change from green to red. As a first noticeable sign of ripening, veraison is considered one of the major phenological stages. The date of veraison is usually recorded in commercial vineyards and used as a phenological reference for the application of several viticultural practices, such as deficit irrigation. Deficit irrigation can accelerate the ripening process and increase the accumulation of pigments in the berry skin by enhancing the anthocyanin biosynthesis. Moreover, previous research has observed that this effect is larger when water deficit is imposed at preveraison stages. However, the impact of water deficit on the timing and progression of berry color change in the vineyard has not been much investigated. Here, we present the results of three years of observations (2011 to 2013) on the progression of color change in Merlot vines subjected to water deficit (WD) or irrigation (C) regimes. In general, water deficit did not affect the date when berries started changing color, but it did accelerate the pigmentation process in all three years. WD berries completed pigmentation five days before C on average. These results suggest that preveraison WD shortens the phase of color transition in the vineyard, potentially favoring a longer ripening time. Moreover, the shortening of the color transition might contribute to the anthocyanin/sugar uncoupling observed during ripening under water deficit.

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Review of Aroma Formation through Metabolic Pathways of *Saccharomyces cerevisiae* in Beverage Fermentations

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Fermentation has historically played an important role in the production of several commodities, such as bread and alcoholic beverages. Today fermentation can be used to produce specific flavor compounds in multiple industries. Flavor compounds are secondary metabolites produced during fermentation in addition to primary metabolites such as ethanol. Secondary metabolism is influenced by fermentable carbon, nitrogen makeup, and the fermentation environment. A better understanding of how these variables affect the physiology of yeast strains to produce flavor compounds may improve a number of industrial commodities. Systems biology is an attractive method for studying the complex dynamics of secondary metabolism. While applying a systems biology approach to winemaking or brewing is not a new concept, making direct linkages between -omics data and the production of flavor compounds is a novel approach to improving flavor production in fermentation. Thus far, the bulk of the work in which systems biology methods have been

Review of Aroma Formation through Metabolic Pathways of *Saccharomyces cerevisiae* in Beverage Fermentations *(continued)*

applied to fermentation relies heavily on laboratory strains of *Saccharomyces cerevisiae* that lack metabolism-relevant genes present in industrial yeast strains. Therefore, investigation of industrial strains using systems biology will provide a deeper understanding of secondary metabolism in the industrial setting. Ultimately, integrating multiple -omics approaches will lay the foundation for predictive models of *S. cerevisiae* fermentation and optimal flavor production.

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Scientific Opinion: Improving the Definition of Grape Phylloxera Biotypes and Standardizing Biotype Screening Protocols

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Grape phylloxera biotypes are defined by their specific performance on, or preference for, a particular host (e.g., feeding on a particular rootstock). Numerous studies have phenotyped phylloxera, particularly in regard to their performance on various hosts, but the results are difficult to compare because of the lack of a homogenous nomenclature and a standardized protocol for phenotyping. In an effort to improve communication within the scientific community, we offer a simplification of the phylloxera biotype classification to allow clear data interpretation and effective communication. We also introduce the standard techniques employed for phylloxera phenotyping and discuss their advantages and disadvantages.

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Chemistry of Manganese and Interaction with Iron and Copper in Wine

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The catalytic action of metals in wine oxidation is becoming better understood. The main reductants of wine, the polyphenols, cannot interact directly with oxygen (O_2), and metals act as a "bridge" between the two. Iron (Fe), which is present in small amounts, is able to cycle between an oxidized form, Fe(III), and a reduced form, Fe(II). As a result, Fe(II) reacts with (O_2), and the Fe(III) that is produced oxidizes polyphenols. Furthermore, copper (Cu) greatly facilitates the reaction of Fe(II) with O_2 and so accelerates wine oxidation. Some reports suggest that manganese (Mn), which is present in similar concentrations to Fe in wine, may also participate in the catalytic process. This study was therefore undertaken to examine the possibility that Mn may interact with Fe and Cu in wine to facilitate its oxidation. An initial examination showed that Mn cannot cycle between its oxidized form, Mn(III), and its reduced form, Mn(II), in the same way as Fe, as Mn(II) does not react with Fe(III) or O_2 in wine conditions. However, Mn is shown to accelerate the reaction of Fe(II) with O_2, which, it is suggested, is the result of the interaction of Mn(II) with an intermediate Fe-O_2 complex. As a result, Mn enhances the combined catalytic action of Fe and Cu in the oxidation of a polyphenol in model wine. Mn is known to be a very effective catalyst of sulfite oxidation, but it is shown that a polyphenol inhibits this process. Consequently, as with Fe, Mn cannot catalyze the direct reaction of sulfite with oxygen in wine conditions. Mn produced a modest increase in the rate of oxidation of a Sauvignon blanc wine. However, a more substantial effect was obtained by raising the Fe and Cu concentration, though still in the normal wine range.

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Impact of Mechanical Harvesting and Optical Berry Sorting on Grape and Wine Composition

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The impact of mechanical harvesting, optical berry sorting, and their possible synergistic effect on grape and wine composition was investigated. Pinot noir grapes from the Russian River Valley American Viticultural Area were harvested by hand, by a standard bow-rod mechanical harvester, or by a mechanical harvester with a Selectiv' Process on-board. For each harvest method, half of the grapes were unsorted and half were optically sorted at the winery. The grapes, wines at bottling, and wines after three months of bottle aging were analyzed by reversed-phase high-performance liquid chromatography (RP-HPLC), ultraviolet-visible spectroscopy (UV-vis), and headspace solid-phase microextraction (HS-SPME) gas chromatography mass spectrometry (GC-MS) for color expression and phenolic and aroma profiling. The machine-harvested grapes had higher levels of β-damascenone, linalool, β-myrcene, and α-terpinene, potentially caused by glycosidic hydrolysis triggered by berry damage during harvest or from induced synthesis as a wounding response. In general, differences in wine composition attributable to harvest method were diminished or eliminated by optical sorting. The machine harvester with the Selectiv' Process on-board led to wines with the most phenolics, although these differences may have been decreased or eliminated had the grapes been crushed before fermentation as the wines were produced by whole-berry fermentation. Descriptive sensory analysis conducted on wines three months after bottling determined that the wines made from hand-harvested fruit had significantly greater tropical fruit aroma, while wines made from optically sorted treatments had less hue saturation. With only two significant differences among the 18 aroma, taste, and mouthfeel attributes tested, it was concluded that all treatments led to wines of similar character.

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Arrested Sugar Accumulation and Altered Organic Acid Metabolism in Grape Berries Affected by Berry Shrivel Syndrome

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Berry shrivel (BS) and bunch-stem necrosis (BSN) are thought to be two, possibly related, physiological disorders that affect ripening grape berries. This study monitored changes in BS and BSN symptoms and fruit composition of Cabernet Sauvignon in a commercial vineyard in arid southeastern Washington over four growing seasons. The results support the idea that BS is a physiological rather than pathological disorder and is restricted to the ripening period. The vines of four adjacent rows were geolocated using GPS over three years to determine if BS was associated with specific vines or specific locations within the vineyard. Like BSN, the BS syndrome was seemingly restricted to individual clusters rather than individual vines, and it was spatially unpredictable from year to year. No consistent patterns were observed for the appearance of BS within or between vines. Vines propagated from BS-afflicted shoots only rarely displayed BS symptoms. Detailed observations on symptom development suggest that BS might be a partly asymptomatic or early form of BSN. Nevertheless, unlike the majority of BS symptoms, BSN symptoms rarely affected entire clusters. Moreover, BSN symptoms also appeared suddenly during the late ripening phase after apparently normal ripening, that is, without the early changes in berry size and fruit composition that characterized BS. Visible BS symptoms were preceded by a cessation of sugar, potassium, and oxalate accumulation in the berries, but other organic acids differed little between healthy and BS berries. This study suggests that the characteristic sour taste of BS berries is not due to high organic acid concentration but instead arises from a combination of low sugar:acid ratio due to low sugar content, low pH due to low potassium, and a concentration effect on hydrogen ions as a result of berry shrinkage.

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Impact of Crop Control Strategies on Performance of High-Yielding Sangiovese Grapevines

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Climate change will require grapegrowers to develop improved viticultural practices to control vine yield and the rate of fruit maturation. The impacts of five canopy management regimens on vegetative growth, yield, and grape quality were investigated over three years, and carryover effects on vines in the fourth year were examined. Winter pruning (*Wp*, the control), shoot thinning (*St*), shoot thinning with preanthesis defoliation (*St+Dpa*), shoot thinning with preveraison defoliation (*St+Dpv*), and shoot thinning with preveraison defoliation plus cluster thinning (*St+Dpv+Ct*) were applied to Sangiovese vines from 2011 to 2013. Neither *St* nor *St+Dpv* changed yield or grape quality compared to *Wp*. The *St+Dpa* treatment reduced leaf area and yield by 33% compared to *Wp* and *St* and led to increased sugar concentrations and a carryover effect into 2014 that reduced vine capacity. A management strategy that combines shoot thinning with preanthesis defoliation, which will increase sugar concentrations and suppress yield, offers the strongest potential for long-term regulation of vine yield and grape quality. However, in a nonirrigated vineyard of medium vigor, *Wp*, *St*, and *St+Dpv* could be used to achieve yield and fruit quality levels that meet defined thresholds while reducing costs in respect to other additional interventions such as *Dpa* or *Ct*.

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Postbudburst Spur Pruning Reduces Yield and Delays Fruit Sugar Accumulation in Sangiovese in Central Italy

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Winter pruning is a customary operation in vineyards intended to regulate vine vigor and yield and is performed during the dormant period. However, delaying winter pruning until initial vegetative growth has started might result in an overall delayed annual cycle. Such a delay might be useful in warm environments where summer heat due to climate change is endangering grape composition. Therefore, the influence of pruning date on yield control and ripening rate of spur-pruned Sangiovese grapevines was investigated over two years (2013 and 2014). Winter pruning was applied on 1 or 4 Feb (mid dormancy); 1 or 5 March (late dormancy); 2 or 7 April (bud swell); 2 or 7 May (flowers closely pressed together); and 1 or 6 June (40 to 50% of flower caps fallen), respectively. Vine yield and fruit composition at harvest were not affected by shifting from the standard pruning dates of February and March to early April. By contrast, the number of inflorescences from compound buds was significantly reduced for vines pruned in early May. No inflorescences were retained on vines pruned at the beginning of June. Early May pruning reduced fruit set and berry weight, and fruit ripening was slower when compared to the other dates. At harvest, must soluble solids and titratable acidity were 1.6 Brix lower and 1.8 g/L higher, respectively, for the May treatment as compared to the standard pruning dates. The May pruning date also achieved higher total anthocyanins and phenolic concentrations than the standard. Delay achieved by the May pruning was fully offset in the given environment. More studies are needed to better calibrate winter pruning date for managing yield and berry maturation rate.

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Deficit Irrigation Alters Grapevine Growth, Physiology, and Fruit Microclimate

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The present study evaluated the response of field-grown Cabernet Sauvignon winegrapes to different deficit irrigation regimes in arid eastern Washington. Deficit irrigation did not enhance vineyard water-use efficiency. However, replacing only 25% of the total seasonal vineyard water demand was economically unsustainable, as it led to a decline in plant capacity and yield. By contrast, the same restriction of water supply imposed early during fruit development, followed by an increase to 100% water supply during ripening, proved to be an interesting irrigation management option for Cabernet Sauvignon. This regime limited plant vigor and berry size and conserved irrigation water, while avoiding detrimental long-term effects on vine growth and yield. Water restriction led to a smaller, somewhat more open canopy, which in turn resulted in higher berry temperatures as a result of smaller berries that were more exposed to sunlight. These results suggest that potential changes in fruit composition due to water deficit may be related to alterations in canopy size and microclimate, in addition to decreases in berry size.

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Nutrient Uptake and Distribution in Young Pinot noir Grapevines over Two Seasons

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Nutrient uptake and use in four-year-old Pinot noir grapevines was determined over two years in order to quantify the amounts of nutrients required, the time that nutrients are actively taken up from soil, and how they are used within the vine. For nitrogen, maximal uptake had occurred early in the season, with most uptake occurring before bloom. Uptake of phosphorus and sulfur were also early compared to other nutrients, with similar quantities of these elements taken up between budbreak and bloom and between bloom and veraison. All other nutrients had peak uptake between bloom and veraison. Even in these young vines, ~35% of the nitrogen required by the canopy by the time fruit coloration began was remobilized from reserves in the roots and trunks. A smaller amount of potassium and sulfur were reused from stored reserves in the roots and trunks. The total quantities of different nutrients that were taken up from soil are presented and discussed.

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Sulfur Dioxide–Oxygen Consumption Ratio Reveals Differences in Bottled Wine Oxidation

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The question being addressed was how different treatments of a wine before bottling would affect its reaction to different amounts of oxygen coming through the closures during bottle aging. Specifically, we were looking at various markers for oxidation to see if particular prebottling treatments would alter the oxidative evolution of the wine. Therefore, as the wines aged, we measured dissolved and headspace oxygen, total consumed oxygen, SO_2, aldehydes, esters, and other standard wine parameters. Closures that permitted more oxygen to enter the wine did result in more wine oxidation. Wines that had been aged on lees before bottling seemed better protected from oxidation, perhaps because that aging removed some oxidation products in the wine. We did observe that when we compared the amount of oxygen versus SO_2 consumed by the wine during aging, that if much more oxygen was consumed than SO_2, the wines developed an oxidized character. We propose that analyzing this ratio could be a new way to assess wine oxidation.

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Prediction of Phenolic Composition of Shiraz Wines Using Attenuated Total Reflectance Mid-Infrared (ATR-MIR) Spectroscopy

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Phenolic compounds from red wine grapes play a major role in red wine color, flavor, and mouthfeel sensory attributes, and thus influence wine aging, stability, and consumer liking. Additionally, they are powerful antioxidants that have been linked to beneficial health effects. Wine phenolic compounds mainly originate from grapes but can be imparted during winemaking through the use of oak storage or addition of enological supplements. As such, their concentrations in wine depend on the grape variety, harvest date, viticultural management, and applied winemaking techniques, which are tailored to achieve greater wine complexity (i.e., wine with multiple layers of desirable flavors) and balance between phenolics with other wine components to meet wine consumer preferences. Such wines are often perceived as higher in quality score or grade and may command a higher retail price. Due to the importance of phenolic compounds to wine quality and style, there is interest in developing rapid methodologies for analysis of wine color and phenolic composition. Among the array of analytical approaches that can be employed, techniques based on infrared spectroscopy (analyzing how infrared light interacts with molecules) are attractive because they are fast, can be nondestructive, require minimal preparation of samples, and provide significant savings in both time and cost. This study evaluated the use of attenuated total reflection (ATR) mid-infrared (MIR) spectroscopy for the measurement of important phenolic parameters in Australian Shiraz wines of different quality levels obtained from 24 wine geographical indications. Wine quality for the wines was also assessed by an expert panel and linked to phenolic composition. The capacity of the ATR-MIR spectroscopy to predict wine color and aspects of phenolic composition of Shiraz wines was demonstrated, although the robustness, specificity, and accuracy of the MIR calibration could be improved through the analysis of a greater range of samples.

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SSR Analysis of 338 Accessions Planted in Penedès (Spain) Reveals 28 Unreported Molecular Profiles of *Vitis vinifera* L.

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A collection of 338 grapevine accessions from 24 countries planted on the estates of Bodegues Sumarroca (AOC Penedès) was genotyped with 20 microsatellite markers. A total of 294 different molecular profiles were obtained; 28 of them are presented for the first time. Twenty-six accession names are considered new synonyms and are commonly used in several regions.

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