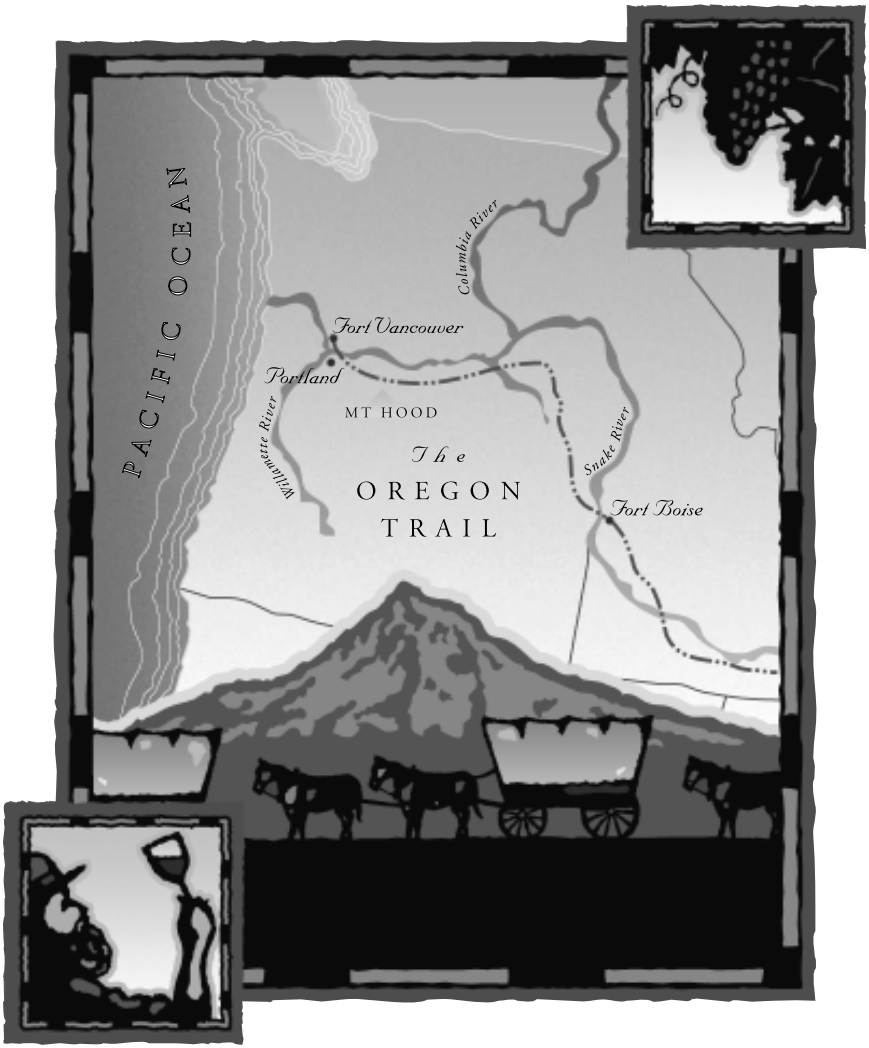
TECHNICAL ABSTRACTS



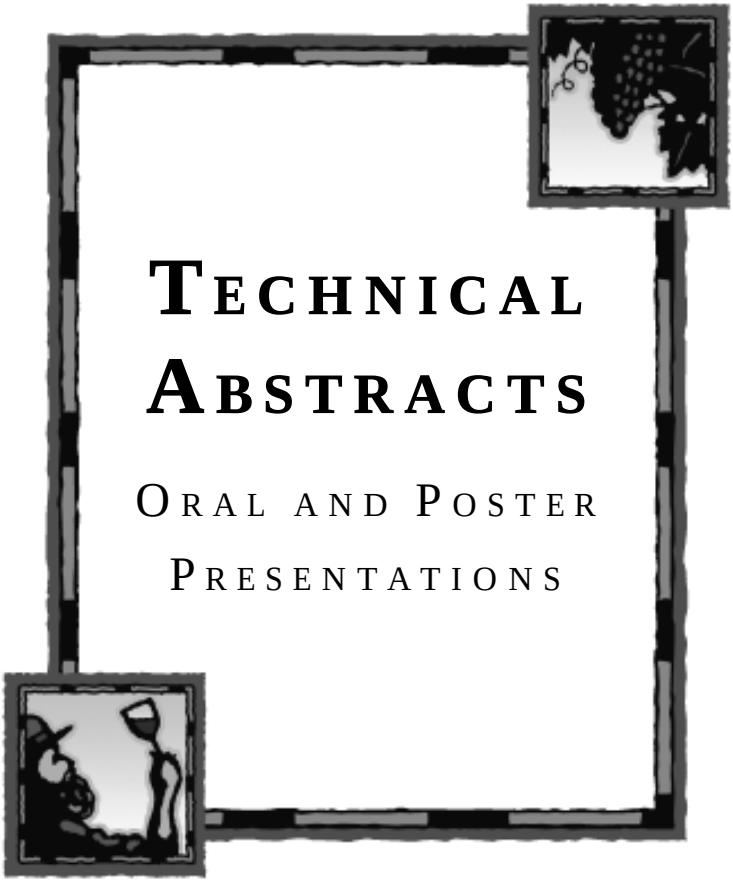
AMERICAN SOCIETY FOR ENOLOGY AND VITICULTURE

53RD ANNUAL MEETING

JUNE 26 - 28, 2002

OREGON CONVENTION CENTER, PORTLAND

53RD ANNUAL MEETING



TECHNICAL ABSTRACTS

ORAL AND POSTER PRESENTATIONS

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Alphabetical Listing of Presenting Authors

Abstracts are in the approximate order of presentation as noted in the conference program. There are no abstracts for the Experimental Design Workshop, keynote speakers, and merit and honorary research lectures.

*Indicates Poster Presentation

Genomics of Wine-related Lactic Acid Bacteria

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The Joint Genome Institute, in collaboration with the Lactic Acid Bacteria Genome Consortium, has generated draft genome sequence for 10 lactic acid bacteria. The strains, sequenced in early 2002, are *Lactococcus lactis* ssp. *cremoris, Lactobacillus gasseri, Lactobacillus brevis, Lactobacillus casei, Lactobacillus delbrueckii* ssp. *bulgaricus, Streptococcus thermophilus, Leuconostoc mesenteroides, Pediococcus pentosaceus, Oenococcus oeni,* and *Bifidobacterium longum*. Five of these strains are commonly isolated from the wine environment. Public availability of this aggregate sequence will alter the research landscape, allowing investigators to define lactic acid bacteria, in the context of wine production, in new detail. The sequence data will foster new methods for discrimination and evaluation of strains of interest to the wine industry. In general, public release of this sequence, aided by the development of novel genetic tools, will allow for expanded study of wine-related lactic acid bacteria.

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Prophylactic Use of Lysozyme to Control Indigenous Lactic Acid Bacteria during Alcoholic Fermentation

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Lysozyme has a lytic effect on lactic acid bacteria (LAB) commonly found in wine (oenococci, lactobacilli, and pediococci). In combination with SO_2, lysozyme might therefore be used as a preventive tool to control growth of unwanted LAB at an early stage of the vinification. The objectives of this study were to investigate the effect of lysozyme on indigenous LAB before alcoholic fermentation, subsequent inducement of malolactic fermentation (MLF), and different strains of *O. oeni*. In the first experiment, 200 L of a Merlot must prepared at a commercial winery in South Africa (pH 3.6) was divided into two lots; one lot had 45 mg/L SO_2 added at crush, while the other lot received 30 mg/L SO_2 and lysozyme (150 mg/L). After completion of alcoholic fermentation, MLF was induced in half of these wines using a commercial preparation of *O. oeni*. All treatments were replicated in duplicate tanks. In a second experiment, sensitivities of different *O. oeni* strains to lysozyme activity remaining after alcoholic fermentation were evaluated. Bacteria were inoculated into white wines prepared by addition of 0, 125, or 250 mg/L lysozyme prior to alcoholic fermentation. All fermentations were regularly sampled to determine bacterial populations and the concentrations of malic acid. In the Merlot wines treated with lysozyme, the populations of indigenous LAB decreased from 10^4 to 10^3 cfu/mL during alcoholic fermentation, in contrast to untreated wines where populations were $> 10^4$ cfu/mL. However, MLF was successfully induced in wines after alcoholic fermentation, indicating minimal residual enzymatic activity. In the white wines, all strains of *O. oeni* grew well and completed MLF by day 14 if lysozyme was not added at crush. Depending on bacterial strain, an increase in the concentration of enzyme added resulted in longer delays of MLF. While two strains required 28 or 42 days to complete MLF, one strain appeared to be unaffected by the enzyme and completed the fermentation in 14 days.

Acetaldehyde Metabolism in Wine from the Perspective of Lactic Acid Bacteria

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Acetaldehyde is an important sensory carbonyl compound in wine. It is volatile and may impart a green, apple-like aroma, which is usually masked by addition of SO_2. SO_2 is also an antimicrobial and antioxidant in wine, and acetaldehyde-bound SO_2 is less effective in these roles. Acetaldehyde also participates in the color development of red wines. Our aim was to study the metabolism of free and SO_2-bound acetaldehyde by malolactic bacteria (MLB) and the effect that acetaldehyde has on their growth. Strains of the genera *Lactobacillus* and *Oenococcus* were able to metabolize free and SO_2-bound acetaldehyde, whereas two *Pediococcus* did not. Acetaldehyde degradation resulted in acetic acid and ethanol production. In wine, degradation of free acetaldehyde by oenococci occurred at pH 3.6 and pH 3.3, but degradation of SO_2-bound acetaldehyde was pH dependent and caused sluggish growth. Acetaldehyde was degraded simultaneously with malic acid by oenococci, which renders it difficult to avoid acetaldehyde depletion during malolactic fermentation (MLF). Simultaneous incubations of yeasts and MLB in model systems and in grape must demonstrated the ability of MLB to degrade acetaldehyde at the moment of formation by the yeast. Results from growth experiments indicated that common acetaldehyde concentrations (< 100 mg L^{-1}) are likely to have no effect or a stimulating effect on growth of wine lactic acid bacteria. Whereas in white wines the suppression of the acetaldehyde flavor and the lesser need for SO_2 may be desirable, in the elaboration of red wines delaying MLF should be considered to encourage the participation of acetaldehyde in color development. Degradation of SO_2-bound acetaldehyde may lead to suppression of other flavors and can cause sluggish or stuck MLFs. In order to encourage MLF, the amount of total SO_2 in the wine (bound and unbound) should be considered.

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Importance of the Intracellular Redox Balance of Yeasts: Comparison of Different Enological Strains

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Reactions involved in the redox equilibrium of yeasts are important as some concern compounds that affect the organoleptic qualities of wines. To study these reactions, we investigated the consequences of adding electron acceptors, especially acetaldehyde, on the production of glycerol, acetate, succinate, butanediol, and acetoin. When addition was regular, up to 100 mM acetaldehyde could be added. Acetate, succinate, and butanediol productions were dramatically increased while glycerol synthesis was significantly reduced. The acetaldehyde concentration was also modulated by adding other aldehydes (propanal and furfural) that competitively inhibited the reduction of acetaldehyde and electron acceptors that reduced the quantity of NADH available. The various mechanisms involved are only fully functional in the stationary phase. They demonstrate (1) that in these conditions, the synthesis of glycerol serves more to eliminate a surplus of reducing power than to protect against osmotic pressure; and (2) the importance of the synthesis of acyloins, such as acetoin, followed by reduction to diols. The results also provide information concerning the synthetic pathways for succinate and acetate and the importance of the ratio NAD/NADH. Acetaldehyde perfusion also caused a significant increase of the instantaneous fermentation rate and consequently a drop in the fermentation duration. We then compared the effect of adding acetaldehyde on different enological strains and observed different effects of this addition on the by-product synthesis and the fermentation kinetics (decrease of the fermentation durations ranging from 0 to 30%). Although all mechanisms are not yet fully understood, adding electron acceptors appears to be a promising way to characterize the technological interest of enological strains, especially their aptitude to synthesize metabolites of organoleptic interest.

The Role of Juice Composition in Problem Fermentations

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Sluggish and stuck fermentations are a chronic industry problem. The purpose of this research was to determine the role of juice composition in these problem fermentations. Previous work has shown that nitrogen content is critical in determining fermentation kinetics. Thus, the objective of this research was to ascertain whether other juice components also greatly impact fermentation kinetics. Compositional analysis was performed on Chardonnay juice and wine samples provided by commercial wineries throughout California. The samples were divided into three categories based on their fermentation profiles (Brix curves): fast, medium, and slow to complete. Representative samples from each category were analyzed for organic acids, glucose, fructose, ammonia, alpha-amino nitrogen, ethanol, amino acids, vitamins, and metal ions. The data was then analyzed using decision tree analysis to determine which components were most significant in predicting problem fermentations.

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Analysis of Methylketones in Brandies Using Solid-Phase Microextraction

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Headspace solid-phase microextraction (SPME) coupled to gas chromatography-mass spectrometry was used to quantify four odd-numbered methylketones in commercial Cognac brandies. These ketones are in part responsible for the desirable and complex characteristic called *rancio charentais* or "Cognac rancio," which may only be found in grape brandies aged for decades in oak barrels. 2-Heptanone, 2-nonanone, 2-undecanone, and 2-tridecanone form through ß-oxidation and decarboxylation of long-chain fatty acids derived from yeast metabolism. Forty commercial Cognacs, ranging in age from 3 to 60 years, were analyzed. The concentrations of these ketones increased with age classification in the brandies analyzed, and 2-heptanone was present at the highest concentration in most samples. Model solution studies indicated a pH-dependent rate of ketone formation, with zero-order kinetics.

Application of the R-Index in Determining Acceptability of Natural Bark Corks for Use as Wine Closures

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Corks used in the sealing of wine bottles must be evaluated for possible negative contributions in flavor from a number of different compounds. The most well studied of these compounds is 2,4,6-trichloroanisole; however, there are several dozen compounds associated with natural bark closures that could contribute noticeable aromas to a wine. As it is not realistic to expect that a natural closure made from wood will contribute no flavor at all (despite unsubstantiated claims by some distributors), a major goal for a winemaking quality-control program is to design a sensory test that can establish whether a shipment of corks is acceptable for use in a given product. Due to production constraints and nearly impossible sampling requirements for a shipment of cork, large numbers of individual samples must be evaluated in a short time with two goals: to determine whether noticeable aromas are present and to determine whether these odors have an unacceptable impact on the final product. The R-index is normally used when two samples are compared. The tasters must decide if the samples are the same or different. We adapted the R-index for a use for which it was not originally designed in an attempt to quantify the elusive acceptability of aromas in a cork quality-control tasting. Panelists were asked to make a subjective decision about the acceptability of an aroma using this "sureness" index, which may or may not be a valid use of the R-index. However, it does provide some indication about the relative acceptability of the aromas of corks. Several unique conditions must be maintained: "blanks" (known "clean" samples) and controls (known unacceptable samples) must be used in each tasting, and, because samples are not compared to each other, an assumption must be made about the nature of response to a "clean" cork.

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Reducing Astringency Carry-over in Wine Evaluations

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In the sensory evaluation of a series of red wines, astringency builds up over successive sips. Several rinses were evaluated for their effectiveness in reducing this carry-over effect to improve the validity of evaluations of red wines. To test their effectiveness in reducing or preventing the buildup of astringency, three experiments were conducted using time-intensity methodology. Trained subjects continuously rated the intensity of an astringent red wine from initial sip, through rinsing using a sip and spit protocol, until the sensation was no longer perceptible or did not change. Wine was sipped at time 0, expectorated at 10 sec; at 20 sec, a rinse was sipped which was spit out at 30 sec. Parameters, including maximum intensity and intensity at 5, 10, 15, 20, and 25 sec after the rinse was expectorated, were extracted from the TI curves and analyzed by analysis of variance. In all three studies, pectin solutions reduced astringency most effectively. Although gelatin contains proline-rich proteins similar to those in saliva, it was no better than water at decreasing astringency. In contrast, pectin solutions from 1 to 5 g/L decreased astringency better than rinses of PVP, polycose, or water. Pectin solutions of 1 or 5 g/L were equal in effectiveness at reducing astringency with a rinse of 5 g/L critical micelle concentration (CMC), although a 1 g/L CMC rinse was no different than water. In one experiment, unsalted crackers were shown to be more effective in decreasing astringency than water, although a rinse of 5 g/L pectin was still superior to the crackers.

Tracing the Incorporation of Anthocyanins into Tannins during Wine Aging

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Anthocyanins provide red pigmentation to wine, and the chemistry of the incorporation is not well understood. Despite a large decrease of anthocyanin concentration during aging, wine maintains its color. The incorporation is affected by variables such as pH, SO_2 concentration, or temperature. One proposal is that anthocyanins react with tannins, also known as proanthocyanidins, forming red-colored polymers. This event would affect the color of the wine as well as the chemical composition of tannins. To understand and define these chemical reactions, radioactivity in the form of tritium was incorporated into one anthocyanin, malvidin-3-glucoside, which was then added to young wine. Quantification of anthocyanin incorporation into various wine components was then determined in wines subjected to different variables, such as pH, temperature, or tannin concentration.

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Effect of Arginine Addition to Must on Wine Urea, Ethyl Carbamate, and Ethyl Carbamate Potential in Cabernet Sauvignon, Syrah, Chardonnay, and Sauvignon blanc Grapes

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To establish the relationship between juice arginine concentration and wine urea, ethyl carbamate, and ethyl carbamate potential and identify the key factors for minimizing wine ethyl carbamate content, arginine was added to must of Cabernet Sauvignon, Syrah, Chardonnay, and Sauvignon blanc at 0, 200, 400, 800, 1200, 1600, and 2000 mg/L prior to fermentation at 15.6°C for whites and 18.3°C for reds. Must arginine concentration prior to arginine addition was highest in Syrah and lowest in Chardonnay. It was increased linearly by arginine addition into the must. Wine urea was 5 mg/L or less from must containing 2000 mg/L or less arginine in the must of Cabernet Sauvignon, Chardonnay, and Sauvignon blanc. There was a linear increase in wine urea content when must arginine concentration was higher than 2000 mg/L in Syrah. All wines contained 2 ng/g or less ethyl carbamate after 13 months of storage regardless of cultivars or arginine addition. Wine ethyl carbamate potential as ethyl carbamate content after heating at 71.1°C for 24 hr was 90 ng/g or lower in Cabernet Sauvignon, Chardonnay, and Sauvignon blanc and higher in Syrah. Wine ethyl carbamate potential was linearly correlated to must arginine and wine urea concentration with data combined for all the cultivars. The study demonstrated that wine ethyl carbamate formation is independent of cultivars and must arginine concentration if the fermentation and storage temperature is low. However, wine ethyl carbamate potential is dependent upon must arginine concentration which determines wine urea content. Actual wine ethyl carbamate content can be minimized by producing low arginine must to avoid high ethyl carbamate potential and utilizing low temperature for fermentation, storage, and transportation to reduce the actual ethyl carbamate formation.

Effect of Crop Load Levels and Harvest Time on Berry Quality in *Vitis coignetiae* Pulliat Grapevines

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A wild grape species, *Vitis coignetiae* Pulliat, has been domesticated for wine production in northern Okayama Prefecture, Japan. The vines, raised from hard-wood cuttings, are trained to a vertical or horizontal trellis and are neither cluster nor berry thinned. Berries are usually harvested in late September and contain high levels of acid and pigment but low level of sugar, which results in sour, bitter wine. In this work we investigated the effect of crop load levels and harvest time on juice constituents and skin pigment with 22 vines planted in commercial vineyards located in Hirzen Heights during the 2000 and 2001 seasons. The total leaf area in each vine was measured at veraison in mid-August, and berry samples were harvested at approximately two-week intervals from veraison until late October (2000) and early November (2001). Chemical analyses revealed that juice TSS (total soluble solids) and amino acids and skin anthocyanin increased and TA (titratable acidity) decreased gradually until late October. TSS levels finally reached approximately 19 Brix in each vine, but TA level was not lower than 1.4 g/100 mL even in early November. Effects of the crop load level on juice sugars, acids, amino acids, and skin anthocyanin were insignificant, although the leaf-fruit ratio was widely different, ranging from 1.16 to 3.42 m^2/kg among six vines tested in 2000. Total amino acid levels, analyzed for 16 vines in 2001, differed widely, ranging from 0.2 to 22.3 mmol/mL, independently of the leaf-fruit ratios. HPLC analyses of skin anthocyanins revealed that *V. coignetiae* berries contained two major components that were not detected in Cabernet Sauvignon berries; one has been identified as 3-0-ß-D-glucopyranosyl-5-0-ß-D-glucopyranosyl malvidin. Findings suggest that berry harvesting in *V. coignetiae* grapevines should be postponed until mid- or late October, but that the deteriorating effect of high crop loading was not significant.

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Effect of Rootstock on Pinot noir Performance

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Phylloxera was first discovered in a commercial vineyard in Oregon in 1990. It has since spread throughout the state, increasing the importance of planting on phylloxera-resistant rootstocks. Growers have little information specific to this region to use in selecting rootstock. This trial was planted in 1997 at Oregon State University's Woodhall III Vineyard in the southern Willamette Valley. Pinot noir was grown on 19 different rootstocks and as ungrafted vines in a randomized complete block design. Data collected during 2000 and 2001 consist of measurements of gas exchange, chlorophyll content, vegetative growth, and analysis of fruit yield and composition. Vines grafted to the *riparia x rupestris* rootstocks are less vigorous, and produce smaller yields and smaller berries. 101-14A Mgt is more vigorous than 3309C. Schwarzmann and 101-14A Mgt hasten ripening, while 3309C does not. Vines grafted to the *berlandieri x riparia* rootstocks are average or above average in vigor, yield, and berry size. Ripening is apparently delayed by these rootstocks. 420A Mgt and 161-49C are among the most vigorous of these rootstocks. Vines grafted to the *berlandieri x rupestris* rootstocks are, with the notable exception of 110 Richter, higher in vigor and produce greater yields with larger berries. Ripening times are average for these vines. Vines grafted to 1616C perform much like those grafted to the *berlandieri x rupestris* rootstocks. Vines grafted to Gravesac have moderate vigor and yield, average berry weight, and appear to ripen fruit early. Ungrafted vines and vines grafted to Riparia Gloire, 44-53 Malègue, and Börner are lower than average in vigor and yield and tend to produce smaller berries. The ungrafted vines and those grafted to Riparia Gloire ripened fruit early, while vines grafted to 44-53 Malègue and Börner delay ripening.

Optimizing Wood Production and Quality in Grape Nursery Blocks

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The successful production of grape nursery materials is affected by many factors, including the optimization of mothervine field culture. A 1,440 vine rootstock block in a blocked and randomized design, with six rootstocks (5C, 420A, 101-14 Mgt, 110R, St. George, and Freedom) and two training systems (trellised and matted) was completed in June 2001. The trellis system was seven feet high with a cable across the top and the vines were trained up at a 45° diagonal. Lateral shoots and tendrils were removed from the trellised vines during the growing season. Cane production was much higher on first-year vines with trellising. Freedom and 5C produced the most canes and 110R and 101-14 Mgt produced the least. The trained vines produced heavier canes and more #1 grade cuttings. The trellised vines also produced canes with more uniform diameters. Cuttings from matted vines tended to have different widths at the apical and basal ends. Canes were harvested from the treatments at two-week intervals beginning the first week of December and put in cold storage prior to bench-grafting and "direct stick" field planting in May. Sucrose, glucose, fructose, starch, and total nonstructural carbohydrates (TNC) were evaluated. The largest differences were observed in glucose content and the smallest in sucrose content. 110R and St. George had the greatest TNC and were also highest in starch. 420A had the lowest levels of all examined carbohydrates, which may be related to its lower grafting success.

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Estimates of Soil Evaporation for Furrow and Drip Irrigated Vines Grown in the San Joaquin Valley

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A large weighing lysimeter was used to estimate actual and relative amounts of soil water evaporation. Thompson Seedless grapevines were planted in the lysimeter in 1987 with vine and row spacings of 2.15 and 3.51, respectively, within the vineyard. The vines were furrow irrigated the first year. Applied water the subsequent two years was delivered via below-ground drip irrigation. Several times during the 1999 growing season the surface of the lysimeter was covered with two layers of 5-mil plastic to minimize soil water evaporation. Evaporation after a furrow irrigation event the first year was comparable to potential ET (ET_o) for 1 to 3 days when expressed on land area per vine (7.55 m^2) and decreased thereafter. When soil evaporation was expressed on the wetted area of the furrow, it was comparable to Class A pan evaporation. The initiation of irrigations the second growing season increased vine water use from 0.5 to 1.62 mm day^{-1} with an applied water amount equivalent to 2.75 mm. Later in the second growing season and during the third growing season it was determined that soil evaporation averaged approximately 0.5 to 1.0 mm per day. Covering the lysimeter's soil surface in 1999 with plastic had little effect on vine evapotranspiration (ET_c) early in the growing season, while ET_c was later reduced from 15 to 25%. For example, vine ET_c was 5.8 and 5.0 mm day^{-1} without the plastic and covered with the plastic, respectively, at midseason. Averaged across all dates during the 1999-growing season in which such measurements were made, soil evaporation accounted for 13% of ET_c. Under the conditions of this study, the results indicate that during vineyard establishment soil evaporation accounts for a large portion of vineyard ET_c, while that proportion is less for mature vines.

Bud Microclimate, Carbohydrate Availability, and Fruitfulness of *Vitis vinifera* L.

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The effects of light, temperature, and bud carbohydrate supply on the fruitfulness of Cabernet Sauvignon, Chardonnay, Thompson Seedless, and Flame Seedless were studied in the San Joaquin Valley of California. Four shoot light exposure levels were established by selective pruning before budbreak. Midday photosynthetically active radiation (PAR) on the buds was measured eight times from April to September. Diurnal PAR was measured continuously during five days at the end of April with photodiodes placed next to individual buds and connected to a data logger. Bud temperature was recorded bi-hourly on three dates. Fruitfulness was assessed at leaf fall and after budbreak. Depending upon cultivar, maximum fruitfulness occurred at midday PAR between 500 and 1,200 mol m^{-2} s^{-1}. Maximum cluster primordia per node was 7 and occurred in shoots intercepting midday PAR above 1,000 mol m^{-2} s^{-1}. Primary buds differentiated no more than 3 clusters while secondary buds no more than 2. Internode diameter, measured at leaf fall, was directly correlated to fruitfulness. A new measurement for bud fruitfulness, which includes number and size of cluster primordia, was more precise than percent fruitful buds. Thompson Seedless was 1.5 to 2.5 times less fruitful than the other cultivars under any given PAR level. The number of clusters per node emerging in the spring was lower than the number of cluster primordia counted via bud dissections in the fall for all cultivars. Bud carbohydrate supply was manipulated in Thompson Seedless through girdling, defoliation, and bud or leaf shading. Defoliation had the strongest effect in reducing fruitfulness, followed by leaf shading, while bud shading did not have any effect. Changes in fruitfulness were markedly confined to the side of the shoot receiving the treatments. Fruitfulness was positively correlated to bud total nonstructural carbohydrates.

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Rootstock Response to Potassium Fertilization

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Rootstocks selected for their resistance to soil-borne pests possess other characteristics that influence their performance under conditions not related to soil pest pressure. Vineyards on soils with less than ideal nutrient status can often benefit from rootstock selection. Merlot on nine rootstocks (5C, 5BB, 420A, 110R, 1103P, 140Ru, 101-14, 3309C, and 44-53) was studied in the Chalk Hill appellation of Sonoma County; the soil is clay, high in magnesium, and low in potassium. Potassium fertilization was accomplished with applications of 3.6 kg of K_2SO_4 per vine (1994, 1997, and 2001). Vine potassium status, measured by petiole potassium levels, was higher for fertilized vines for all rootstocks and in all years. Vines receiving potassium fertilization had a higher mean yield than did control vines, largely through an increase in cluster number arising from increased shoot number. Yield benefits of potassium fertilization increased over several years before stabilizing. While potassium fertilization never had a negative effect on yield, some rootstocks did not show a yield increase. In contrast, potassium fertilization produced significant yield increases in other rootstocks. These data suggest that rootstocks differ in either their ability to extract nutrients and/or in the way they distribute nutrients to the scion. Potassium fertilization has consistently influenced juice chemistry. The data show significant effect of potassium fertilization on pH, titratable acidity, and juice potassium. Fruit from vines receiving potassium fertilizer had lower titratable acidity and higher pH and juice potassium.

Solar Energy Trapping with Polyethylene Sleeves Advances Budbreak, Veraison, and Fruit Maturity in Three Merlot Vineyards in the Okanagan Valley

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Sleeves constructed of 2-mil polyethylene were used in the spring to trap solar energy and increase the air temperature around cordons or canes of Merlot vines in three Okanagan Valley (British Columbia) vineyards. Treatments consisted of a nontreated control and three sleeve configurations: closed at bottom, ventilated with openings at bottom, and double-layer with openings at bottom. All sleeves were perforated at the top for ventilation. The sleeves were supported by two trellis catch wires at the top and were stapled closed at the bottom under the cordon or cane. Application was the first week in April and removal was 6 to 7 weeks later, either completely at once or gradually by first opening the sleeve top then removing the sides 6 days later. Degree day accumulation inside sleeves was 1.5 to 2 times that of ambient. Budbreak was advanced by 5 days, and bloom was advanced by 1 to 2 weeks, depending on the vineyard. On the day the sleeves were removed or opened at the top, leaf stomatal conductance and photosynthesis rate were highest inside the open-top sleeves and were similar for control vines and vines with sleeves removed. Depending on the vineyard, the sleeve treatments advanced veraison by 5 to 12 days, and fruit maturity by 7 to 26 days.

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Variation in the Nematode Resistance of *Vitis champinii* and Related Species to Three Strains of Root-Knot Nematode Species

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Nematode resistance is one of the key issues for grape growers in California. Root-knot nematodes (*Meloidogyne* spp.) limit viticulture on a wide range of soils and are particularly problematic in San Joaquin Valley and Central Coast vineyards. Current sources of resistant rootstocks are often overly vigorous, may not resist the range of root-knot nematode (RKN) strains they encounter, can be difficult to root and graft, and some do not posses adequate phylloxera resistance. Most of the rootstocks used in nematode infested soils (Harmony, Freedom, Ramsey, and Dog Ridge) are derived from *Vitis champinii*, a species regarded as highly resistant to nematodes. However, aggressive strains of RKN have been identified that break resistance in Harmony and Freedom and to a lesser extent in Ramsey and Dog Ridge; resistance that is due to a single dominant gene. This research was conducted to determine if additional genes or alleles for RKN resistance exist in 29 accessions of *V. champinii* and related species; seven rootstocks were also tested. Five replicates of each selection were grown in pots and inoculated with 1500 J2 nematodes of three RKN strains (*M. incognita* R3, and C and *M. arenaria* A; the latter two are aggressive on *V. champinii* rootstocks). After eight weeks, resistance was evaluated by counting numbers of egg masses. Twenty-four of the genotypes tested resistant to R3 and 13 tested resistant to *M. arenaria* A. All the selections that tested resistant to race A were also resistant to race 3. The resistance of these 13 selections to race C is under evaluation.

Factors That Influence Tannin Extraction and Formation of Polymeric Pigments during Winemaking

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The condensed tannins of grape berries are polymeric flavan-3-ols composed of catechin, epicatechin, epigallocatechin, and epicatechin gallate. They are responsible for astringency in red wines and are extracted from the skins and seeds of berries during fermentation. Polymeric pigments are formed by reaction of anthocyanins with tannins to give red pigments that can be distinguished from the monomeric anthocyanins by their resistance to bisulfite bleaching. Using a protein precipitation assay for tannins and polymeric pigments, we can resolve the polymeric pigments of wine into small polymeric pigments (SPP) that do not precipitate with protein and large polymeric pigments (LPP) that do. We previously found that grape berries at harvest contain SPP but very little LPP. The purpose of this study was to examine factors that may influence tannin extraction and polymeric pigment formation during winemaking. In small-scale fermentations of Cabernet Sauvignon conducted at 17 or 27°C, we found that temperature had a greater effect than enzyme treatment or extended maceration. At 27°C compared to 17°C the tannin levels were increased 2.5- to 5.4-fold, LPP was increased 2- to 3-fold and SPP was increased 60%. We also studied commercial-scale fermentations of Pinot noir where the maximum fermentation temperatures were limited to 25, 30, or 33°C. We monitored the tannin and polymeric pigment composition immediately after pressing and again when the wine was racked. Tannin levels in wines from 30 and 33°C were higher than 25°C, but tannin declined up to 30% between pressing and the first racking. The LPP at pressing was higher with increased fermentation temperatures and had doubled by the time of the first racking. SPP showed a similar pattern and increased up to 75% between pressing and racking.

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Effect of Winemaking Practice and Vineyard Source on Phenolic Composition of Cabernet Sauvignon

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The influence of different enological practices on the phenolic composition in comparison to a control procedure in commercial-scale trials of Cabernet Sauvignon from four Californian vineyard sources was investigated. The practices studied included: (1) 20 days of pomace contact after fermentation; (2) addition of enzymes to enhance pigment extraction; (3) use of rotary fermentor; (4) use of thermomaceration after fermentation; and (5) addition of oak tannin. The phenolic composition of the wines was analyzed for specific monomeric and polymeric phenolic content by HPLC, for contribution to color by the Somers spectral method, and for total phenol content by the Folin-Ciocalteu procedure. The effect of maceration techniques on commercial-scale fermentations in relation to grape source was explored. In general, increasing heat and pomace contact increased the proanthocyanidin content of the resulting wine. Oak tannin addition, rotary fermentor, and enzyme addition reduced the extraction of total phenols. Overall the grape source proved more important than enological practice in determining phenolic composition.

Challenges of Producing Wine from Cynthiana/ Norton Grapes

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Cynthiana/Norton (*Vitis aestivalis*) is a premium winegrape popular in the Eastern United States. It poses a challenge to winemakers due to a typically high acidity (8.5 to 13.2 g/L) and pH (3.5 to 3.9) at harvest. This grape is unusually high in malic acid (4.3 to 6.5 g/L), and the wines often undergo malolactic fermentation. If no pH adjustments are made to the must, wine pH can be above 4.0. A comprehensive overview of two decades of Cynthiana/Norton viticulture and enological research will be presented. Winemaking begins in the vineyard and canopy management can aid in reducing malic acid content and improving color. Understanding the organic acid composition of this grape and how it changes during fermentation and cold stabilization are key to controlling acidity and pH. Timing of pH adjustments using tartaric acid or ion exchange is critical to wine quality. Extended skin contact, carbonic maceration, thermal processing, yeast selection, and oak addition have been researched and can play important roles in producing premium wines from this grape.

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Chemical and Sensory Characterization of DOC Red Wines from Marche (Italy) Related to Aging and Grape Cultivars

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The DOC red wines Lacrima di Morro d'Alba, Rosso Conero, Rosso Piceno, Rosso Piceno Superiore, and Vernaccia di Serrapetrona are produced in the region of Marche (Central Italy) and have received little research attention. The characterization of monomeric polyphenols (HPLC-DAD), copigmentation parameters and tannin fractions (spectrophotometric essays), sugars, alcohols and organic acids (HPLC-RI), and colorimetric parameters (CIE) was performed on 30 samples obtained during three different vintages ranging from 1996 to 2000 (two replications for each year). The most significant components explaining the variability of the samples were the HPLC determinations, particularly malvidin-3-glucoside, glucose, and fructose. The bitterness and astringency of the wines were determined with panel tastings and all the collected data were analysed using principle component analysis and partial least squares methodologies. The extent to which the variance in these sensory measures could be explained by the phenolic compositon was determined. The wines obtained from the cultivars Lacrima di Morro and Vernaccia di Serrapetrona were statistically different from all other wines, which were obtained with different percentages of the cultivars Sangiovese and Montepulciano. The wines made from Lacrima were found to be statistically similar to a Spanish cultivar named Tintorera. The Vernaccia wines were outliers because of the different processing of the grapes (it is a red, sweet sparkling wine). However, the influence of grape variety seemed to be more significant than wine-processing technology in distinguishing the wines by these chemical and sensory measures.

Effects of American Oak Barrels from Various Regional Sources on the Sensory Attributes of Wines

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A trained sensory panel found differences in six sets of wines that varied due to the regional sources of American oak wood in which they were fermented and/or aged. Wines fermented and/or aged in barrels made from wood sourced in Minnesota, Virginia, Missouri, and Pennsylvania, and from a control barrel made from a blend of the four woods, were significantly differentiated across all six sets of wines by use of the terms coconut, smoky, toasted, and vanilla. Wines fermented in Virginia oak barrels appeared to be lower in astringence, smokiness, toast, vanilla, and "coconut and toasted" (terms combined). Pennsylvania oak barrels produced wines lower in coconut and fruitiness and higher in smokiness. Minnesota oak yielded wines lower in smokiness, toast, and "coconut and toast." Missouri oak produced wines lower in astringence and vanilla and higher in coconut and toast. In addition, terms that were significant when individual wines were analyzed include astringent, bitter, cedar, smoky, and spicy. Industry trade tastings of these same wines, plus an additional eight sets of wines, found similar differences. The trade tastings used standardized descriptors associated with barrel trials and significantly differentiated across fourteen different sets of wines by use of the terms fruit flavor, oak aroma, vanilla, spicy, raw, roasted, smoky, and bitter. Each of our experiments consisted of between four and ten barrels per treatment; with each of the experiments there were wines that did not match the findings of the averaged results. Whether the lack of consistency reflected the natural variation expected in a barrel trial or whether it was due to a manifestation of a barrel-to-wine or a barrel-to-vintage interaction based on wine chemistry or other variation is unknown and impossible to determine from this data set.

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Effects of Commercially Available Arbuscular Mycorrhizal Fungi on Grapevine Growth

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Past research on the effects of methyl bromide fumigation on soil-borne propagules of arbuscular mycorrhizal (AM) fungi identified the importance of these beneficial microbes in the survival of grapevines planted into recently fumigated soil. Delayed colonization of young vines by AM fungi may result in stunted growth and nutrient deficiencies. Inoculation of vines with commercially available AM fungi (bio-inoculants) at the time of planting may compensate for reductions in AM fungi caused by methyl bromide. We compared the effects of two bio-inoculants, MycorMax® and Bio-Organics™ Endomycorrhizal Inoculant, on growth of three grapevine rootstocks: 101-14 Mgt, St. George, and 110R. Rootstocks were propagated from dormant cuttings in the greenhouse in nutrient-poor or nutrient-rich potting mix. Bio-inoculants were applied at recommended application rates. Noninoculated rootstocks were maintained as controls. Shoots and roots were harvested six months following inoculation and their fresh weights were recorded. Roots were examined for percentage of root length colonized by AM fungal structures. Based on the results of an analysis of variance, inoculation with either bio-inoculant resulted in significant root colonization by AM fungal structures. However, neither bio-inoculant had significant effects on growth of inoculated vines as compared to growth of noninoculated vines. Potting mix, rootstock, and block did have significant effects on percent root colonization by AM fungal structures, shoot weight, and/or root weight. Higher application rates may have resulted in higher percent root colonization and, possibly, significant growth increases of inoculated vines. Other potential benefits of bio-inoculants that we did not measure, which have been demonstrated for AM fungi on various hosts, include increased nutrient uptake, enhanced resistance to plant pathogens, and stabilization of soil structure.

Effects of Timing of Powdery Mildew Infection on Single Leaf and Whole Vine Carbon Assimilation

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Potted, two-year-old Chardonnay grapevines (*Vitis vinifera* L., Dijon clone 96 grafted to 3309 rootstock) were grown outdoors during the 2001 growing season. Plants were either: (1) inoculated with a conidial suspension of powdery mildew, *Uncinula necator* (Schw.) Burr., prior to bloom, (2) inoculated at the 5 mm berry stage, or (3) not inoculated and treated with NOVA fungicide (Myclobutanil) twice during the season. Leaf photosynthesis measurements were conducted on the most recent fully expanded leaf of a selected shoot at bloom, 5 mm berry size, 1200 growing degree days (base 10C), and postveraison using a portable infrared gas analyzer fitted with a leaf cuvette and light source. The original, most fully expanded leaf was also monitored throughout the growing season. Powdery mildew infection was determined visually and expressed as a percentage of total leaf area. Whole vine photosynthesis was measured at the 5 mm berry and 1200 degree day stages. Selected plants were destructively harvested at the 5 mm berry, 1200 degree days, and postveraison stages, and fresh and dry weights were obtained. Leaves of early inoculated plants demonstrated reduced photosynthetic rates prior to the presence of visible symptoms at all phenological stages, while late inoculated plants showed reduced photosynthetic rates after symptoms were apparent. Differences in photosynthetic rates between treatments were not observed in older leaves. Whole vine photosynthesis was negatively correlated with degree of infection at 1200 degree days. Leaves of both early and late inoculated plants senesced prematurely (compared to control plants) at comparable rates.

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Impact of Powdery Mildew Infection and Fungicide Application on Grapevine Photosynthesis

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Photosynthetic rate and associated measurements were taken on Riesling (*Vitis vinifera*) leaves of mature, bearing vines in the Lincoln University (New Zealand) vineyard using a Li-Cor 6400 IRGA system. Individual leaves of comparable age and node position on the same vine were visually estimated to be healthy, infected, or partially infected with powdery mildew (*Uncinula necator*). The selected leaves were investigated to determine the impact of this biotrophic parasite on their photosynthetic capacity. Net photosynthesis (Pn) was reduced by 41% in leaves covered in mildew and by 35% in leaves that were only partially (approximately half) infected. The measured reduction was less a response of the carbon dioxide assimilation mechanism than the result of consistently higher respiration rates experienced by infected tissues. The experiment also investigated the effect that fungicide sprays have on Pn. Initial measurements of Pn were made on selected leaves that were judged to be either heavily infected or absent of visible symptoms (control). These were then sprayed to drip with a mixture of fungicide and surfactant (Bayleton and Citowett, respectively), and Pn measured one day and one week after the spray application. The Bayleton/Citowett combination inhibited the Pn response of both healthy and infected leaves. The major cause of this inhibition was attributed to a reduction in stomatal conductance of up to 35% of that of unsprayed leaves.

Limited Effectiveness of Severe Pruning for Managing Pierce's Disease

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Pierce's disease (PD), caused by the bacterium *Xylella fastidiosa (Xf)*, is a lethal disease of *Vitis vinifera* grapes. *Xf* bacteria are spread to grapes by several xylem-feeding insects, including the blue-green and glassy-winged sharpshooters. Once inoculated into vines, *Xf* bacteria multiply and move downward toward the roots. Most infections are eliminated with routine annual pruning. However, once *Xf* moves into permanent wood, the vine becomes chronically infected and will usually die within one to three years. Management of PD usually involves removal of diseased vines followed by replanting of new vines. Four to five years may be necessary for replanted vines to reach full productivity. Severe pruning (just above the graft union) of PD vines was investigated as a way to eliminate *Xf* infections and allow for rapid re-establishment of healthy, productive vines. New vines developing from an existing root system can be back in production years earlier than newly planted vines. If severe pruning successfully eliminates *Xf* infections, this practice would greatly reduce the economic impact of PD. Six severe pruning trials were established in the Napa Valley in 1998. Vines were mapped and rated for PD in October 1998. Symptomatic vines were then severely pruned or kept as controls and pruned normally. Severely pruned vines had vigorous growth in 1999 and recovery rates after one year (October 1999) looked promising. However, by fall 2001, most severely pruned vines had PD symptoms. For vines rated in the highest PD severity category in 1998, the best results showed 58% of severely pruned vines still healthy in October 2001. All other plots had less than 10% success. Where the glassy-winged sharpshooter is causing vine-to-vine spread of PD, severe pruning should not be used to eliminate PD vines as sources of inoculum. Rather, PD vines should be completely removed.

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Transmission of Pierce's Disease by Chip-Budding and Bench-Grafting

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Pierce's disease (PD), caused by *Xylella fastidiosa* (*Xf*), is a deadly bacterial disease of grapes that exists in many regions of California. Dormant cuttings from infected vines could serve as an inoculum source, spreading PD to areas where it does not exist, and could greatly reduce propagation success at grape nurseries. Dormant canes were taken from PD infected Chardonnay grapevines growing in the Napa Valley, California in the first week of December. Canes were stored at 1°C for various lengths of time prior to grafting to healthy 101-14 Mgt. Because the level of *Xf* might vary in buds compared to nodal sections, the ability of chip-budding and bench-grafting to transmit *Xf* were evaluated by the extent of PD symptoms and ELISA. One-node sections from infected canes were also evaluated. Established potted plants of 101-14 Mgt were chip-budded with fresh PD infected canes in September. Half of the vines were moved to the greenhouse after healing; the other vines were kept outdoors to experience winter cold. PD symptoms expressed after 8 weeks of greenhouse growth. After 16 weeks the vines growing outdoors were brought into the greenhouse and buds were forced. Canes of 101-14 Mgt were bench-grafted with PD infected canes that had been cold-stored for 0, 2, 6, and 8 weeks. After healing and establishing in the greenhouse, PD symptoms were evaluated after 10 weeks. Single-node cuttings of PD infected Chardonnay canes (cold-stored 8 weeks versus fresh) were also rooted and the percent expressing PD was recorded.

In-row Spacing and Training System Interact on the Growth and Productivity of Syrah Grapevines in the San Joaquin Valley

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An experiment was conducted at the Kearney Agricultural Center in Parlier (Fresno County) to examine the interaction between in-row vine spacing and training system on the growth and productivity of Syrah grapevines. Syrah vines (UC Clone 7) grafted to 5C rootstock were planted either 4, 6, 8, 10, or 12 feet between vines within the row and trained to either bilateral or quadrilateral cordons. The experiment was planted in 1997 and designed as a 5 x 2 factorial; each treatment was replicated six times using six vine replicates. Nearly all bilateral cordon trained vines were fully trained by the beginning of the 1999 season, while the portion of fully trained quadrilateral cordon vines dropped linearly as in-row spacing was increased. The vines of all spacing and training treatments were fully extended by the spring of 2000. The trunk diameters of vines spaced 4 and 6 feet apart were significantly lower compared to the remaining spacing treatments, while cordon diameter in all treatments declined as vine spacing was increased. Leaf layer number in the fruiting zone declined, while canopy gaps, the percentage of exterior clusters and cluster sunlight exposure in the fruiting zone, increased as in-row spacing was increased. Cluster number and total yield per vine increased linearly as in-row spacing was increased in both training systems. Productivity per acre was similar among the spacing treatments for bilateral cordon trained vines, while yield per acre declined slightly as in-row spacing increased for quadrilateral cordon trained vines. No significant differences in berry size and fruit composition were observed, and wine sensory scores were generally similar among the treatments.

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Vine Irrigation and Crop Yield Effects on the Sensory Quality of Cabernet Sauvignon Wine

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The effects of vine irrigation and crop yield on sensory quality of Cabernet Sauvignon wine from the 2000 harvest were investigated using descriptive analysis with a trained panel, quality ratings by members of the wine industry, and tannin assays. In two separate trials conducted in Oakville, California vineyards, grapes received low, medium, or high irrigation treatments or were pruned and thinned to produce six yields ranging from 2.7 to 9.9 tons/acre. Wines were then made in triplicate from these grapes using standard winemaking practices, but with no oak contact before bottling. Wines differed significantly as a function of irrigation level and crop yield (MANOVA, $p < 0.0001$). Wines produced from vines with low irrigation regimes were rated highest in dried fruit/raisin, jam, and red/black berry aromas, fruity by mouth, and acidity and lowest in brown color. The high irrigation wines were rated lowest in bitterness, ethanol, body, and darkness. The medium irrigation wines were ranked highest in veggie aroma, astringency, brown, dark, body, ethanol, and bitterness and were ranked lowest in cherry aroma. Low irrigation wines received slightly higher quality ratings from members of the wine industry than high irrigation wines, but the difference was not significant, possibly because of differences among wine replicates. Lower crop yields tended to produce wines with high bell pepper and black pepper aromas, high astringency and bitterness, and high ethanol and veggie by mouth flavors, whereas the higher yields tended to result in wines with higher red/black berry, jam, and cherry aromas, red color, fruity by mouth, and acidic characters. Tannin concentration was significantly higher in the wines produced from low crop yields, consistent with the higher bitterness and astringency ratings given to those wines by descriptive analysis. We conclude that both irrigation and crop yield affect Cabernet Sauvignon wine sensory quality.

Effects of Viticultural Practices on the Aroma of 2000 Napa Valley Cabernet Sauvignon Wines

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Decisions are made during vineyard establishment and maintenance that are likely to affect the final wine sensory characteristics. However, a systematic and comprehensive study of these effects has not been completed with a single variety from the same vineyard. In the fall of 2000, thirty-two 100 lb. grape lots of Cabernet Sauvignon were harvested at 23.9 Brix (± 0.3 Brix) from the UC Davis Experimental vineyard located in Oakville, California. Various viticultural treatments were applied to each specific lot, including differences in rootstock, vine and row spacing, pruning level and method, trellis, row orientation, irrigation level, vine age, and vineyard block. The grapes were identically processed into finished wines in the UC Davis research winery. A descriptive panel of 15 trained judges was organized to the rate the intensities of eight aroma attributes, agreed on by the panel: cocoa, cherry, blackberry, dried fruit, green pepper, cooked vegetable, olive, and pepper. Using a complete block design with three repetitions per block, the panel evaluated the wine samples. The preliminary data compiled during training and practice sessions show that there are significant differences between the aroma of the wine samples. The final goal is to attempt to link aroma differences to specific viticultural treatment(s) using decision tree analysis.

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Relationship of Wine Ethyl Carbamate Potential to Vine and Fruit N Status Influenced by Rootstock, Clone, Training, Pruning, Irrigation, and Soil in Chardonnay, Sauvignon blanc, Cabernet Sauvignon, and Syrah Grapevines

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The content and relationship of wine ethyl carbamate, ethyl carbamate potential, fruit and must arginine, and other vine or fruit N measurements were evaluated under various cultural practices, including: rootstock, clone, and pruning in Chardonnay; irrigation in Sauvignon blanc; training system, pruning method, and soil type in Cabernet Sauvignon; and rootstock in Syrah grapevines. All wines had only minute amounts of ethyl carbamate under fermentation temperature of 15.6°C for white wine and 18.3°C for red wine and storage temperature of 12.8°C. Wine urea was higher in minimal pruning than hand or mechanical pruning in Chardonnay. Clone 18 of Chardonnay on rootstocks Freedom and 3309 Couderc had higher fruit and must arginine content than those on Teleki 5C. Wine urea and ethyl carbamate potential were the highest in Chardonnay with minimal pruning. High fertility soil Columbia silt loam was associated with higher contents of petiole nitrate, lamina total N, fruit total N, fruit arginine, and wine total N, compared with the low fertility soil San Joaquin loam in Cabernet Sauvignon. Syrah on rootstocks 1103 Paulsen and Freedom produced some of the highest while USDA-ARS rootstock selection 6-19B produced the lowest levels of petiole nitrate, total lamina N, fruit arginine, wine urea, and wine ethyl carbamate potential. High vine N status resulted in higher arginine content in fruit and must which, in turn, contributed to higher levels of urea, total N, and ethyl carbamate potential in wine. There were significant correlations among all the parameters measured except wine ethyl carbamate, independent of cultivars or cultural practices in most cases. Petiole nitrate content at full bloom and fruit arginine at veraison provided a simple and valuable measurement for predicting wine ethyl carbamate potential and ample time between the sampling and harvest. Temperature and possibly other factors during fermentation, storage, and transportation of wine should be considered when attempting to lower the amount of ethyl carbamate formed in wine over time.

Effects of Crop Level on Yield Components, Fruit and Wine Composition, and Wood Carbohydrate Reserves of Pinot noir Grapes

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The effect of crop thinning on yield components, fruit and wine composition, vine vigor, and wood carbohydrate reserves of Pinot noir grapevines was studied during two seasons at two locations in the northern Willamette Valley of Oregon. At both sites, crop was reduced at véraison. At site 2, on the second season, vines were thinned at bloom or at véraison in a factorial design. Wine was made from both thinning dates from the highest and lowest crop load levels. Yields ranged from 2.2 to 6.6 tonnes/ha (0.98 to 2.95 tons/acre). Yield components at both sites that were significantly affected by crop level were those expected to be strongly correlated with cluster thinning such as yield per vine, clusters per shoot, and Ravaz Index. Berries per cluster and cluster weights were significantly decreased in response to cluster thinning at site 1 in the first season. At site 2 the grape cluster weights decreased with increasing crop levels during both seasons. In the same vineyard, the number of berries per cluster decreased with increasing yields. These changes in cluster weights and the number of berries per cluster are an artifact caused by selectively removing underdeveloped clusters, thus increasing the mean cluster weight of the remaining clusters. Berry weights did not increase when clusters were thinned at véraison, indicating that yield compensation did not occur. At site 1 during the first season, juice pH decreased from 3.16 to 3.14, when yields increased from 2.8 to 6.2 tonnes/ha (1.25 to 2.77 tons/acre). During the second season at site 1, soluble solids decreased from 24 to 23.2 Brix when yields increased from 3.2 to 7.1 tonnes/ha (1.43 to 3.17 tons/acre) There was no response to cluster thinning on fruit composition at site 2. Despite the wide range of crop load, cluster thinning had no impact on vine vigor or wood carbohydrate reserves over the two-year period at both vineyards. There was an increase in total anthocyanins and color intensity in wine from fruit thinned at bloom as compared to véraison thinning. Within the cropping ranges represented by these two vineyards, which are typical of yield projections for vineyards in the northern Willamette Valley that grow Pinot noir, changes in juice and wine composition caused by cluster thinning were too modest to justify the losses in yield.

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Winegrape Crop Load Adjustment

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Crop load adjustment is widely accepted as an important vineyard management tool for premium quality wine production. However, little information is available on its effectiveness under warm, dry climatic conditions. In this study, this deficiency was addressed by altering crop loads on three winegrape cultivars grown in a mature, deficit-irrigated vineyard in the arid Yakima Valley (Washington), over a five-year period. Cabernet Sauvignon and Chenin blanc were pruned to 36 nodes per vine (42 nodes in 2001), and Riesling was pruned to 48 nodes. Node fruitfulness, expressed as number of clusters per shoot, varied considerably with cultivar and season: Cabernet Sauvignon had 2.4 clusters/shoot in 1998 and 1.2 in 2001, Chenin blanc averaged 1.6 in 1998 and 0.9 in 2001, and Riesling had 2.6 clusters in 1998 and 1.6 in 2001. Thinning consisted of removing all non-count clusters (those on shoots not arising from nodes deliberately retained at pruning) at either postfruit set or veraison. Non-count clusters on unthinned vines contributed between 30 and 45% of the total cluster number, but were 25 to 30% lighter than count clusters, resulting in a 20 to 33% potential yield reduction due to thinning. Actual yields varied from 9 to 15 t/ha for unthinned vines, and from 5 to 9 t/ha for thinned vines, depending on cultivar and season. Cluster thinning and its timing had little or no effect on shoot length and lignification, leaf area, pruning weight, berry number and weight, and fruit quality (soluble solids, titratable acidity, pH) in the thinning season and on budbreak, shoot and cluster numbers, and fruit set in the following season. Degree days during the growing season were typically about 1400°C, but ranged from 1230 (1999) to 1580 (1998). Differences in fruit quality within cultivars were mostly due to season rather than to yield.

Analysis of the Effects of Weather on California North Coast Cabernet Sauvignon Vintage Quality

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It is generally accepted that differences in weather patterns from year to year serve as the single largest contributor to variations in wine vintage quality for a given region. Using archived weather data collected from a Napa weather station and vintage quality ratings from three independent wine critics, 25 California North Coast Cabernet Sauvignon wine vintages were examined. As a preliminary exercise, the ratings of the vintages were found to vary significantly ($p < 0.001$), while no significant variation was seen among the critics. The consistency among reviewers indicates that their vintage quality scores may be used as metrics for evaluating the relative success of different vintages. With this in mind, weather variables—consisting of daily precipitation, minimum temperature, and maximum temperature, as well as composite functions of these variables—were evaluated analytically to determine which variables and time periods throughout the year are most significantly responsible for resulting vintage quality. Both the current and previous growing season were evaluated in this process. An artificial neural network was then trained using critical variable and time period data to see how well it could predict vintage quality based on this reduced set of input data. The results of this exercise could additionally serve as the basis for hypotheses for further experimentation in order to better understand the physical and biological phenomena behind the significant correlations. Application to vineyard site selection and modification of vineyard practices based on weather patterns will be discussed.

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The Effect of Polyphenol Compounds on the Headspace Volatility of Flavors

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Various nonvolatile compounds have been shown to influence the volatility of flavor compounds in solution. However, one particular class of nonvolatiles, namely polyphenols, has not been studied adequately to determine its affect on flavor solubility and volatility. Due to the relatively high concentrations of polyphenols in wine, coffee, and tea, interactions between polyphenols and flavor compounds have important implications for understanding the perceived flavor of these beverages. In this study, the effect of naringin and gallic acid on two flavor compounds, ethyl benzoate and 2-methylpyrazine, was evaluated. In addition to studies in model solutions, extracted tannins were added to red and white wine samples and sensory differences were noted. The wines were chosen because of their high fruity and floral characters. Solid-phase microextraction/gas chromatography was used to analyze the headspace volatility of the flavor compounds. This data was then correlated with sensory studies. Our results showed that both the structures of the flavor compound and polyphenol influenced the extent of the interactions. Gallic acid was found to increase the solubility, thus decreasing the volatility of 2-methylpyrazine, while naringin had no effect on the headspace volatility of this flavor. Ethyl benzoate had the weakest interactions with both polyphenols.

C_{13}-Norisoprenoid Concentrations in Grapes as Affected by Sunlight and Shading

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Volatile C_{13}-norisoprenoids are thought to be the breakdown products of neoxanthin, a xanthophyll of the carotenoid group. In grapes, norisoprenoids occur mainly as glycosidically bound precursors which when extracted into the wine can contribute considerably to the aroma. However, factors influencing the formation of C_{13}-norisoprenoids in grapes are not yet completely understood. Over a period of three years we evaluated the effect of different levels of sunlight exposures on norisoprenoid concentrations in White Riesling and Cabernet Sauvignon grapes at variable maturity levels. In addition to allowing the grapes specific amounts of sunlight using shade cloth to control levels between 4 and 97% of full sun exposure, UVA and UVB light (300 to 400nm) were also controlled in some trials. The norisoprenoid content of these trial grapes were compared to those of grapes grown under natural shade conditions, that is, grapes that were shaded by their own leaves. The amount of some of the analyzed norisoprenoids increased with sun levels above 20% of full sun exposure. At comparable sunlight levels when UVA/B light was filtered out, norisoprenoid concentrations were slightly higher than in grapes that did not have the UVA/B light filtered out. Surprisingly, norisoprenoid levels were higher in berries from naturally shaded vines compared to grapes from vines which had the applied shade cloth with a similar level of light exposure ($\sim$4%). Harvesting and analyzing grapes every two weeks during the growing season showed that detectable levels of norisoprenoids were present during the last four weeks before maturity and final harvest.

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Analysis of Riesling Wine Volatiles by a Novel Headspace Solid-Phase Microextraction Gas Chromatography Method

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A method for simultaneous extraction and analysis of higher alcohols, esters, and medium chain fatty acids was developed. The new method provides a simplified volatile extraction method to monitor flavor components important for wine quality. A polar polyacrylate coated solid-phase microextraction fiber was used to selectively extract volatile components from the headspace of a wine sample. The extract was then loaded into a gas chromatograph and separated using a Nukol™ acidic phase polyethylene glycol column. The volatile components were analyzed using a flame ionization detector. The method produced recoveries of 89 to 114% and coefficients of variation of 2 to 15%. The method was subsequently applied to the analysis of wine volatiles in a commercial yeast strain evaluation study. *Saccharomyces* strains V1116, D254, UCD 522, Bourgoblanc, EC1118, UCD 595, S6U, Wadenswil 27, 71B, and T73 were used to induce fermentations in a Washington State Riesling must. Differences were observed in the concentrations of higher alcohols, esters, and fatty acids in the wines produced by the yeast strains.

Behavior of Caftaric and Coutaric Acids in Musts of Red and White Grapes during Fermentation

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The hydroxycinnamic esters, caftaric and coutaric, were determined by HPLC in musts and wines of three white and one red grape varietals: Sauvignon blanc, Chenin blanc, Niagara, and Tannat, respectively. The experiment was performed in duplicate and was repeated for three years: 1997, 1998, and 1999. For the chemical analysis, an acid hydrolysis was made prior to the injection in the HPLC. The esters were then analyzed in the musts, during and after fermentation, and after six months in the bottle. The average total soluble solids, acidity, and pH in the musts, in the three-year period, were 15.5%, 0.63 g/100 mL as tartaric acid, and 3.5, respectively. In all the varieties studied in the three-year period, the amount of caftaric acid was always higher than the amount of coutaric acid, both in musts and wines. The average caftaric acid in the musts of the four varietals was 56.0 mg/L, while in the wines it was 29.5 mg/L, showing a substantial decrease during fermentation. Coutaric acid showed the same behavior, 22.0 mg/L in the musts against 8.3 mg/L in the wines. However, although wines in the bottle also showed a similar behavior, the decrease was in a smaller proportion.

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Effect of pH and Ethanol on the Astringent Subqualities of Red Wine

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Ethanol and pH are two major elements that have a strong influence on the perceived astringency of red wine. Decreasing pH increases the perception of astringency in red wine and model wine solutions. Ethanol, on the other hand, increases perceived wine viscosity and thereby may decrease the sensation of astringency. However, there is limited documentation describing the effects of pH and ethanol on the subqualities of astringency. Our aim was to identify appropriate sensory descriptors to assess these subqualities and quantify them together with the chemical properties of the wines. For this, two commercial red wines with differing mouth-feel characteristics were used (Cabernet Sauvignon and a red blend). The wines were analyzed chemically for anthocyanins, phenolics, ethanol, titratable acidity, and pH, as well as sensorially by a trained panel. Seventeen mouth-feel terms were identified by flavor profiling to describe the astringent subqualities: velvet, aggressive, silk/satin, dry, fleshy, unripe, pucker, viscosity, abrasive, heat, chewy, acidity, grippy/adhesive, bitter, balance, overall astringency, and mouth-coat. Ethanol had a greater effect than pH on the individual subqualities. In particular, velvet, balance, mouth-coat, grippy/adhesive, and silk/satin (Tukey's HSD, $p = 0.05$) were used to describe the high alcohol wines; these are desirable characteristics for fine red wines. In contrast, decreasing pH increased the overall wine astringency but had little impact on individual textural descriptors (Tukey's HSD, $p = 0.05$). Together, ethanol and pH influenced both the astringent subqualities and the overall astringency of the wines. These results lend support to the notion that astringency is an amalgam of sensations rather than a single overall sensation.

Volatile Terpene Constituents in Maturing Gewürztraminer Grapes from British Columbia

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Changes in several physicochemical parameters of grape composition including pH, titratable acidity, soluble solids, weight, color, and phenolic content were examined for Gewürztraminer during ripening. Free (FVT) and potentially (PVT) volatile terpenes obtained by distillation were also assessed spectrophotometrically using an acidified vanillin assay and by gas chromatography-mass spectrometry (GC-MS). The colorimetric values of PVT were estimated to account for nearly 84% of the bound terpenes, and the FVT values reflected mostly the content of unsaturated aldehydes rather than the free terpenes. A procedure using selected ions specific to terpenes was developed to accelerate the analysis time of GC-MS chromatograms. Based on selected ion chromatograms, higher correlations were found for the bound terpene concentrations in Gewürztraminer vis-à-vis total skin phenolics, skin anthocyanins, and the traditional maturity indices of soluble solids and titratable acidity as compared to free terpene content.

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Application of Electronic Tongue Sensors to American Oak Wood (*Quercus alba*) Staves Used in Cooperage

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Tasting extracts of cooperage oak is difficult due to the variety of bitter and astringent chemical compounds that they contain. Among the most abundant of these extractives are the ellagitannins, which influence the quality of wines and spirits aged in oak barrels. Assessing taste by a tasting panel is difficult because the high bitterness and astringency leads to taste saturation and quickly tires panelists. In such cases, the repeatability of human assessment is poor, leading to a need for low-cost and easily interpreted methods of wood quality-control that possess good repeatability. Extracts were made of American oak (*Quercus alba*) of known origin. These oak wood extracts were analyzed by an array of global selectivity chemical electronic tongue sensors (α-Astree Liquid Taste Analyzer). Oak extracts were analyzed by HPLC to determine ellagitannin content and were also evaluated by a tasting panel. Discrimination function analysis, principal component analysis, and partial least squares statistical methods were used to measure correlation between different analytical methods. The repeatability of the electronic tongue measurements was found to be excellent. Samples from four American states were analyzed as a single group. The electronic tongue measurements were found to be correlated with ellagitannin content (coefficient 0.79) and taste (coefficient 0.76). Prediction results, calculated from electronic tongue calibration, gave an average error for ellagitannin determination of ± 0.85 mg/g of dry oak wood (for a concentration range of 6 to 20 mg/g) and of ± 0.65 on a 10-point scale for astringency. The results showed that, despite the complexity of wood extracts, the electronic tongue approach offers a simple and rapid method of analysis suitable for cooperage.

Genetic Diversity of Commercial, Wild, and Heirloom Wine Strains of *Saccharomyces cerevisiae*

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There is a need for speedy, inexpensive, and definitive methods to distinguish strains within the species *Saccharomyces cerevisiae.* This need is especially keen in the wine industry due to the prevalence of indigenous and wild yeasts in the winery environment. A PCR-based method of strain identification could be completed in several hours rather than days. A region of the genome with significant variation between strains must be identified in order to develop this type of method. A variety of *Saccharomyces cerevisiae* strains from the Phaff Yeast Culture Collection (www.phaffcollection.org) were selected for analysis and included a broad spectrum of commercial strains from various suppliers, heirloom wine strains, and wild isolates from grapes, other fruit, and environmental sources. PCR primers were designed based on published *Saccharomyces* ribosomal sequences to amplify a 1.6 kb fragment of the intergenic sequence of the rDNA cluster, adjacent to the 5S rRNA gene. This PCR product was amplified and sequenced in over 50 *Saccharomyces cerevisiae* strains. The region from 180 to 240 nucleotides from the 5' end of the 5S rRNA gene exhibited the most significant variation between strains. Over half of the strains showed significant variation in the region sequenced. A number of the commercial wine strains, as well as several strains isolated from grapes and other fruit, were completely identical in this region. The heirloom wine yeasts analyzed were roughly as divergent as the commercial strains.

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Inhibition of Malolactic Fermentation during Alcoholic Fermentation by Different Yeasts

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The complex metabolic interactions that occur between yeast and malolactic bacteria were studied using both a Chardonnay grape juice and a synthetic grape juice medium. Different strains of *Saccharomyces* (V1116, Saint George, EC1118, and RubyFerm) were inoculated into these media. As alcoholic fermentation progressed, 100-mL samples were periodically removed, sterile filtered, and inoculated with *Oenococcus oeni*. In general, samples removed at the height of alcoholic fermentation inhibited malolactic fermentation the greatest, while this inhibition was less in samples taken before or after completion of fermentation. Total SO_2 measured during alcoholic fermentation depended on yeast strain, where Saint George produced the least (11 mg/L) and V1116 produced the most (72 mg/L). Free SO_2, as determined using capillary electrophoresis, was not detected during any alcoholic fermentation. These data may support a role of bound SO_2 produced by yeast toward inhibiting malolactic fermentation. *O. oeni* was able to complete malolactic fermentation in preliminary experiments using a synthetic grape juice. As was observed when using Chardonnay grape juice, the time taken for the bacteria to complete malolactic fermentation increased in samples taken progressively later in the alcoholic fermentation.

Oenococcus oeni Strain Differentiation by Rep-PCR

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Oenococcus oeni (formerly *Leuconostoc oenos*) is the bacterium responsible for most secondary (or malolactic) fermentations in wine. Within the species there is a substantial diversity of strains that produce different sensory qualities or are better suited for conversion of different wines and/or different growth conditions. Thus, it is important to be able to differentiate *O. oeni* strains for quality assurance and to maintain a house style from one vintage to the next. In this work, we evaluated rep-PCR as a means to differentiate *O. oeni* strains. Rep-PCR targets short repeated sequences that are dispersed throughout the bacterial genomes. While originally developed for enteric bacteria, we have modified the method for use with *O. oeni*. Two sets of primers (REP1/2 and BOX) were used to produce unique DNA "fingerprints" for a geographically diverse collection of *O. oeni* isolates, including a large number from California and New Zealand. In several cases, the pattern generated by one primer set was not sufficient to discriminate strains, however, by generating two fingerprints (REP and BOX), the resolution of the method was greatly enhanced. In general, rep-PCR offers significant advantages for rapid differentiation of *O. oeni* strains.

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Clarification of a Muscat Must Using a Flotation Technique and Wheat Gluten as Fining Agent

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Clairette de Die (French Controlled Appellation) is a sparkling sweet wine. Alcoholic fermentation begins in a tank, continues in a crown-cap bottle, and stops before the complete consumption of sugar. All particles present in the bottle have to be eliminated before corking, and it is important to have a must as clear as possible. This study concerned the clarifying of a Muscat must, treated with pectinases, using an efficient flotation technique. The must was fined with bentonite/silica/protein (gelatin or wheat gluten) to induce flocculation, and then pressurized (6 bars). After depressurization, microbubbles cling to floculates and climb to the top of the flotation tank (this flotation foam is clarified using a rotary filter). At lab scale, gluten (20 g/hL) and gelatin (10 g/hL) (each combined with bentonite and silica gel) gave turbidities equal to 50 and 35 NTU, respectively (6.5 and 4.1% of that of the nontreated must). The Muscat must was also clarified by static settling. The turbidity decreased by 86% for the gluten/bentonite fining and by 60% only for the gelatin/bentonite fining. Visually, gluten flocculation and sedimentation requires a longer time than gelatin. But the elimination of insoluble particles is more complete and turbidities are lower. At the industrial scale, gluten (20 g/hL) and gelatin (10 g/hL) (each combined with bentonite and silica gel) gave turbidities equal to 60 and 48 NTU, respectively. Turbidities measured in the tanks 14 hr after the flotation showed a better efficiency for the wheat gluten (24 NTU) compared to gelatin (28 NTU). This is explained by the static settling that completes the clarifying effect of the flotation. Comparable efficiencies for wheat gluten and lupin proteins were also shown. We propose that vegetable proteins could replace geletin.

The Effects of Microoxygenation on Red Wine Quality

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Under controlled conditions, young red wine can benefit from exposure to oxygen. The process of microoxygenation attempts to control the amount of oxygen added to a wine to enhance color stability, soften hard tannins, and decrease the perception of off-aromas. This study demonstrated that microoxygenation could influence the phenolic and sensory characteristics of red wines from different regions and varieties. The phenolic profile for each wine indicated that the treatment caused a general increase in absorbance of visible and polymeric color and color intensity compared to the controls. This supports the claim that microoxygenation can help improve color in red wines. Higher concentrations of phenolic compounds help absorb oxygen being introduced and lower the potential for oxidation of a wine due to overexposure, although the treated wines also showed tendencies toward browning and increased aging. Thus, introduction of oxygen appears to accelerate the aging process. The PCA plot shows correlated fruit, vegetative, oxidation, off-aroma, green tannin, tannin-grit, and plushness. Wines with strong off-aromas or negative sensory characteristics showed the most dramatic improvements in quality as a result of microoxygenation. Wines that had high intensities of vegetal aromas or green tannins showed decreases in these negative attributes as a result of treatment. Subsequent decreases in these underripe "green" characteristics correlated with sharp increases in fruity aromas and taste and similar positive characteristics.

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Adjusting pH of Cynthiana/Norton Wine Using an Electrochemical Cell and Resin Ion Exchange

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Wines produced from Cynthiana/Norton (*Vitis aestivalis*) grapes tend to have both high pH and titratable acidity. Organic acid additions can negatively affect quality of this wine due to high acidity. Ion exchange resins have been used to adjust acidity and pH since the 1950s but often negatively affect wine attributes. This research examined the benefit of pH reduction of Cynthiana wine using two ion exchange systems. Membranes were used in a three-cell electrochemical unit and resins were used in a column system. Wine attributes of three ion exchange membranes and two resins from different manufacturers were also compared. Wine quality was measured during storage (0, 2, 4, and 6 months) at 21 and 38°C. Ion exchange lowered wine pH from 4.1 to 3.5, resulting in an increase in titratable acidity and a decrease in potassium. Color attributes were measured on wine modified to eliminate effects of pH and sulfur dioxide. Trends for color attributes and phenolics of wine were the same for the nonadjusted control versus ion exchange treatments, indicating no overall color or phenolic loss due to the ion exchange process. The comparison of membranes and resins from different manufacturers indicated that wine adjusted with membranes was higher in color density, darkness, and phenolics than wine adjusted with resins. During storage at 21 and 38°C, both membrane and resin treatments showed similar decreases in phenolics and color attributes, but degradation was greater at the higher storage temperature. Ion exchange using membranes in an electrochemical cell and resins in columns decreased pH of Cynthiana wine. Although differences in color attributes and phenolics were small, membranes had less of an impact on wine attributes than resins. Therefore, systems using ion exchange membranes may be a better tool for reduction of wine pH than resins.

Comparison of Sweetening Cayuga White Wine by Adding Sugar or Juice or Stopping the Fermentation

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A study was conducted to determine if a dry white wine sweetened with sugar could be distinguished from wines sweetened by adding juice or stopping the fermentation. The grape variety Cayuga White was used in this experiment because of its ability to produce an appealing fruity, floral wine from grapes that have low sugar content at maturity (15 to 17 Brix). This allowed a must (15.2 Brix) to be ameliorated with sucrose to 17.3 Brix for the sugar treatment and 20.7 Brix for the juice and stopped-fermentation treatments. The intent was to have similar ethanol levels in the three wines after fermenting the sugar treatment wine to dryness, arresting the fermentation of the stopped-fermentation wine at 3.5 to 4 percent sugar, and fermenting the juice wine to dryness and adding enough juice (19.8%) to reach a similar "sweetness" level as the stopped-fermentation and sugar wines. This approach, while requiring an initial amelioration step, was preferable to harvesting grapes at different maturities to achieve the desired sugar contents. The sugar treatment wine was sweetened with glucose and fructose to match the individual sugar levels in the stopped-fermentation wine. The sugar treatment wine had the lowest levels of free monoterpenes and ethyl acetate. The stopped-fermentation wine had the highest titratable and volatile acidities and lowest pH. Wine from the juice treatment had the greatest color (absorbance at 420nm). Sensory tests (duo-trio) of aroma found a significant difference between the sugar and juice treatment wines. No sensory differences (aroma) were found between the stopped-fermentation and either the sugar or juice treatment wines.

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An Alternative Method of Producing Golden Seedless Raisins with Less Sulfur

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Sulfur has been long used to preserve the color of dried fruits, including golden seedless raisins. As consumer trends have shifted from meals prepared at home to minimally processed and convenience foods, consumers have become more cautious regarding the ingredients used in purchased foods. Fresh grapes are exposed to sulfur dioxide to preserve color after they are dipped in a caustic mix of hot water and sodium hydroxide. Dipping creates small hairline cracks to vent the fruit during dehydration. The heat used in the dipping process also contributes to discoloration of the grapes that the sulfur treatment must reverse. In place of the hot water dip, Thompson Seedless grapes were treated with a spray formulation of a 1% oleate compound and 1.5% potassium carbonate in water. The spray was applied using a filtered recirculating system mounted on the shaker/draper of the dipping line. The treated fruit was loaded onto wood trays separated into four groups and dosed with sulfur dioxide at rates of 1.55, 3.10, 4.50, and 6.01 kg per fresh tonne. The sulfur treatments were dried at 74, 63, and 57°C. Sulfur content of the golden seedless raisins ranged from 253 to 4040 mg/L across all treatments. Even though oleate treated grapes dosed with low levels of sulfur produced golden raisins with a lower sulfur content, the color rating for these golden raisins was not significantly different from hot water dipped grapes treated with higher levels of sulfur. The hot caustic dip used in this process may actually induce browning. Grapes treated with the oleate spray at ambient temperature dried at the same rate and preserved color using 25% the amount of sulfur.

Resistance in *Vitis* Species to *Meloidogyne incognita*

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Development of rootstocks with resistance to root-knot nematodes (*Meloidogyne* spp.) is a top priority in grape breeding. New sources of resistance are needed to address the challenge of root-knot nematodes that can reproduce on the rootstocks Freedom and Harmony. To identify additional nematode resistant grape rootstock germplasm, four wild grape accessions from the USDA National Clonal Germplasm Repository, Davis, California, were tested for resistance: *Vitis treleasei* DVIT 1149, *V. blancoii* DVIT 2213.8, *V. biformis* DVIT 2212.14, and *V. biformis* DVIT 2212.17. The rootstocks 41B Millardet and 1613 Couderc were used as susceptible and resistant controls, respectively. Green-growing cuttings of test accessions and controls were rooted in propagation sponges in a mist bed with bottom heat. Rooted cuttings were potted in individual NuPot 25 pots in a peat moss/vermiculite/sand mixture and grown in a greenhouse. Each seedling was inoculated with approximately 1500 second stage juveniles of Harmony avirulent *Meloidogyne incognita*. Nematode reproduction was assessed six weeks after inoculation. Roots were stained in an aqueous solution of eosin-Y (0.25 g/L for one hour), then destained. Reproduction was measured by counting the number of stained nematode egg masses visible per root system. Three of the accessions tested, *V. blancoii* DVIT 2213.8, *V. biformis* DVIT 2212.14, and *V. biformis* DVIT 2212.17, were highly resistant to *M. incognita*, allowing no nematode reproduction. These accessions may be useful for breeding nematode resistant rootstocks and should be evaluated for resistance against other root-knot nematode populations, especially nematodes virulent on Harmony and Freedom. *Vitis treleasei* DVIT 1149 was only partly resistant to *M. incognita*, with low levels of nematode reproduction compared to the susceptible 41B control.

Use of Bulked Segregant Analysis to Identify an AFLP Marker Linked to *Xylella fastidiosa* Resistance

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Xylella fastidiosa (*Xf*) is the causal agent of Pierce's Disease, a serious bacterial disease of grape. The European wine grape, *Vitis vinifera*, is not resistant to *Xf*; however, there are many other grape species that resist *Xf* and Pierce's Disease. A population of 120 seedlings, derived from a cross between the *Xf*-resistant 8909-08 (*V. rupestris* x *Muscadinia rotundifolia*) and four advanced *Xf*-susceptible USDA table grape selections (*V. vinifera*), were screened for *Xf* resistance using the pinprick inoculation technique followed by ELISA detection to verify restricted *Xf* movement. The highly resistant and highly susceptible seedlings were used for further analysis. DNA samples were taken from this set of seedlings and processed for amplified fragment length polymorphism (AFLP) analysis through the first steps of the procedure, after which they were bulked for the final PCR amplification step. Bulked samples were then amplified together, processed on silver-stained sequencing gels, and analyzed for a marker capable of distinguishing the two populations (resistant and susceptible seedlings). The bulks contain samples that are random for all traits, but *Xf* resistance or susceptibility produced specific markers, particularly for resistance. The identified marker will be used in marker-assisted selection (MAS) to expedite breeding and the screening of potentially *Xf*-resistant germplasm. Presence or absence of the marker will aid in selection and reduce the time and space needed for greenhouse screening of *Xf* resistance. Additional backcross generations will be aided by MAS so that X*f* resistance from *M. rotundifolia* and can be rapidly introgressed into high-quality *V. vinifera* traits.

Expressed Sequence Tag Databases for Stressed Chardonnay (*Vitis vinifera* L.) Leaves and Berries

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Abiotic stresses affect important aroma, flavor, and color components by altering metabolite composition and improving wine quality and human health benefits. Regulated deficit irrigation has been used successfully to grow grapes with less water, an important feature in arid regions such as Nevada. As a first step toward understanding how growth is affected and wine quality improvements might arise following abiotic stress exposure, we have initiated an expressed sequence tag (EST)-based gene discovery program focused solely on stressed plants. We constructed cDNA libraries from mRNA isolated from leaf and berry tissues of *Vitis vinifera* cv. Chardonnay, exposed to various abiotic stress conditions, including drought, cold, salt, flooding, and heat. Initial sequence analysis revealed 18% novel genes and a low redundancy of transcripts. Nine percent of ESTs have putative functions assigned to abiotic stress-related adaptations. Transcript expression data will be integrated with protein and metabolite profiles generated from the same tissue sets used for cDNA library production.

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Effect of Rootstock on Vine Growth, Yield, Fruit Quality, and Mineral Nutrients Status of Princess Table Grapevines

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Princess (tested as C45-59) is a white, seedless, midseason variety that was developed by the USDA/ARS Postharvest Quality and Genetics Unit and released to the public in March 1999. This study was designed to evaluate the effect of a broad range of rootstocks on vine growth, yield, fruit quality, and mineral nutrient status of Princess vines. Rootstocks used in this project were Harmony, Freedom, Salt Creek, 5C, SO4, 1103P, Couderc 1616, 420A, 140 RU and 039-16. Ungrafted (own-root) vines served as the control. The experimental design was a randomized complete block with 11 treatments (10 rootstocks and a control). Each treatment was replicated 6 times with 10 vines per replicate. The data showed numerical differences in yield and fruit quality between grafted vines, but the only significant differences were in vine growth and soluble solid contents of the fruit. Vines grafted on 039-16 produced the largest growth mass (pruning wt 9.45 kg/vine), which was significantly higher than vines grafted on 140 RU (5.46 kg/vine). There were significant differences among all rootstocks for the nutrients in petiole samples analyzed in the past three seasons (1999 to 2001). Differences were also noted between petiole samples collected at bloom and those collected at veraison. Nitrate-nitrogen concentration was generally higher for samples collected at veraison than those collected at bloom. Vines grafted on Salt Creek had the highest nitrate and total nitrogen concentration at bloom, which was significantly higher than the control and the vines grafted on other rootstocks.

Effect of Irrigation Amounts and Canopy Management on Vine Water Relations, Canopy Microclimate, Berry Characteristics, and Productivity of Cabernet Sauvignon

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The effects of different irrigation amounts and trellis/row spacings were evaluated in a Cabernet Sauvignon vineyard in the Napa Valley. Two trellis systems, Wye and VSP, were used. The Wye and one of the VSP trellises had a row spacing of 2.74 m (1.5 m between vines); the other VSP was planted to a 1 x 1 m spacing. The irrigation treatments were imposed once midday leaf water potential approached –1.1 MPa. The applied water amounts were 0, 25, 50, and 75% of estimated full vineyard ET_c. Midday leaf and cluster water potentials were significantly affected by trellis system/row spacing and irrigation amount. The 1 x 1 m VSP had the lowest values of leaf and cluster water potentials throughout the season at all the irrigation treatments, followed by the Wye and VSP systems on 2.74 m row spacings. Cluster water potential was linearly correlated with leaf water potential (r^2 = 0.41). Canopy temperature was negatively correlated with leaf water potential (r^2 = 0.47), while cluster temperature was positively correlated with canopy temperature (r^2 = 0.6). Cluster and/or berry temperature were not significantly affected by the irrigation treatment, but they were affected by trellis system, leaf removal, cluster exposure, and phenological stage. Photon flux density and evaporative demand within the cluster zone were influenced by the trellis system and leaf removal but not by the amount of water applied. Cluster weight and berry weight and diameter were significantly affected by irrigation treatment, trellis, and cluster exposure. The greatest yields were measured in the 1 x 1 m spaced vineyard, followed by the Wye and VSP trellises on 2.74 m rows. The results indicate that any quality enhancement induced by a trellis system may also be attributed to the impact they could have on vine water status, that is, differing degrees of vine water stress.

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Evaluation of Chardonnay Clonal Selections in the Salinas Valley

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Eleven clonal selections of Chardonnay were evaluated for viticultural performance for four years (1998 to 2001). The experiment was established in 1995 in a vineyard west of Greenfield, California in the Arroyo Seco appellation. Vines were spaced at 1.8 x 2.4 m (vine x row) and trained to bilateral cordons on a vertically shoot positioned trellis. FPMS 5 and 15 were used as standards to compare FPMS 18, 20, 22, and 23 (Rauscedo 8, Conegliano 6, 10, and 11, respectively) and CTPS 75, 76, 78, 95, and 96. During the evaluation period all vines were pruned to 20 two-bud spurs and no crop thinning was conducted on the vines. Significant differences have been observed in the yield response, with a range of 2.5 kg/vine from high to low yielding selections. Selections 5, 76, 95, and 96 tend to have higher yields. There were significant differences by year in the ranking by yield response of the selections. Higher cluster weights due to more berries per cluster was the factor most influencing crop yield. Selections 15, 22, and 23 had lower yields due to lower cluster weights as a result of more erratic fruit set that contributed to lower berry weights and fewer berries per cluster. Pruning weights were greatest for 23 and 15 and lowest for 5 and 75. Yield:pruning weight ratios were higher for the more productive selections. The lower yielding selections tended to have higher Brix. FPMS 5 had significantly lower Brix and pH and higher titratable acidity. FPMS 5 and CTPS 75, which had lower Brix, also had higher yield:pruning weight ratios.

Pinot Noir-Terroir Relationships in Northern Italy

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The cultivar Pinot noir has a wide range of clonal variation. It also reacts to different environments with large changes in cropping and fruit quality. The phenotypic stability of the main characters, such as yield, kinetics of sugar production, and quality parameters, can be used to evaluate adaptation to terroir in a ecovalence index. Data was collected from Pinot noir vineyards in three northeastern Italian areas, two located in Trentino, S. Michele all'Adige (alt. 230 m) and Faedo (alt. 650 m), and a third located in Friuli Venezia Giulia, Prata di Pordenone (alt. 50 m), during 1994 to 1998. Viticultural (number of buds, fertility, yield, and cluster weight) and enological parameters were investigated. The resulting hierarchy of the factors considered in the viticultural model (clone, site, and year) clearly showed different roles: site seemed to exercise a major influence on both yield and must quality parameters, confirming the importance of growing Pinot noir in restricted areas. Clone (genotype) had a minor role in the observed variability, with limited and consistent differences among clones grown at the different sites.

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Selected Vineyard Soil Chemical Properties Before and After Four Years of Variable Rate Fertilizer Application

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In 1997, yield-monitoring data from a Concord grape (*Vitis lambrusca* L.) vineyard in Central Washington showed a high degree of spatial variability. The following spring, the vineyard was intensively soil sampled to assess inherent variability in selected soil chemical properties, specifically, organic matter, cation exchange capacity, pH, nitrate nitrogen, and extractable phosphorus and potassium. Soil textural analysis was also conducted on the soil samples. Since the soil test results showed variability, pre-budbreak fertilizer applications were made using variable rate application (VRA) equipment. This procedure was conducted for four successive years (1998 to 2001). Between 1998 and 2001, soil pH, nitrate nitrogen, and extractable potassium in the subsurface (30 to 75 cm) depth changed. Over time, soil pH in the surface soil (0 to 30 cm) decreased, while nitrate nitrogen and extractable potassium in the soil surface increased. In the subsurface soil the most notable change was a decrease in extractable potassium, likely reflecting plant nutrient uptake.

Effect of Berry and Juice Storage under Cooling or Freezing Conditions on Measurements of Fruit Composition in Cabernet Sauvignon, Syrah, Sauvignon blanc, and Thompson Seedless Grapes

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Effect of berry and juice storage under cooling or freezing conditions on measurements of fruit Brix, pH, and TA was examined in Cabernet Sauvignon, Syrah, Sauvignon blanc, and Thompson Seedless grapes. To evaluate the effect of berry storage under cooling or freezing, samples were either analyzed immediately after sampling at room temperature, stored at 4°C in a refrigerator for two days, or stored at –20 or –50°C in freezers for seven days. To further investigate the feasibility of juice freezing under research conditions, Brix, pH, and TA were analyzed prior to and after juice sample storage at –50°C for seven days for berry samples collected at harvest from experimental vineyards of all the cultivars. Even widely accepted storage protocol in a refrigerator at 4°C for two days resulted in false fruit composition measurements. Berry freezing at –20 or –50°C caused even greater change in fruit composition compared to that analyzed at room temperature immediately after sampling, including potentially higher or lower Brix, higher pH, and lower TA. The pH and TA measurements are more of a concern when berries are stored under either cooling or freezing conditions, with differences as much as 10% for pH and 24% for TA. On the other hand, juice storage under freezing conditions only affected some of the composition measurements with minimal impact. When time is critical, berry samples should be extracted and juice stored under freezing conditions to ease the time constraint during the harvest season. Analysis of the frozen juice at a later date will correctly estimate fruit maturity and the effect of experimental treatments.

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Effect of Partial Rootzone Drying on Leaf Water Relation and Chlorophyll Fluorescence Characteristics in Sauvignon blanc Grapevines

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Effect of partial rootzone drying (PRD) on water relation and chlorophyll fluorescence characteristics of recently matured leaf was studied in bilateral cordon-trained Sauvignon blanc grapevines on Freedom in the San Joaquin Valley of California. Treatment factors included PRD and conventional drip irrigation at 0.4 and 0.8 crop evapotranspiration. The vines were irrigated daily during the growing season and the treatments were applied between fruit set and harvest. The wetting and drying sides of PRD treated vines were alternated at an interval of 7 to 20 days. The response of mature leaf stomatal conductance (g) and transpiration (E) to irrigation treatments depended on the time of the season. The earlier the time of the season, the longer it was from PRD switch to the day when significant differences of g and E were detected among the treatments. Among 24, 29, and 21 measurements in 1999, 2000, and 2001, there were 11, 10, and 7 times when g and E was affected by irrigation rate, respectively. Irrigation methods only affected g and E once later during the season in 2000 when the air temperature was very high. During a given day from 6:00 to 19:00, g and E increased to its daily maximum around 10:00 and then decreased gradually. Significant differences were detected between 10:00 and 16:00, mainly caused by irrigation rates, with only a few exceptions. Quantum efficiency of photosystem II was the only chlorophyll fluorescence characteristic affected, which was higher on PRD treated vines than that of conventional drip irrigation-treated vines at the end of third PRD cycle on 1 August 2000. The study demonstrated that the effect of irigation treatments on vine water relation is mainly from reduced irrigation rate rather than switching of rootzone drying.

Effect of Clone, Rootstock, and Pruning on Vine Performance of Chardonnay Grapevines in the San Joaquin Valley of California

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Effect and interaction of clone, rootstock, and pruning system on vine performance were investigated in Chardonnay grapevines for two years in 1999 and 2000. The experiment was designed as a randomized complete block with 3 clones (4, 6, and 18), 3 rootstocks (3309 Couderc, Teleki 5C, and Freedom), and 3 pruning systems (hand-spur, mechanical, and minimal) with 4 replications. Clone interacted with rootstock and pruning to affect fruit composition when fruit was harvested at the same time while clone interacted with pruning to affect berry weight and pruning weight in 1999. Rootstock interacted with pruning to affect number of shoots, number of clusters, fruit Brix, and fruit TA in 1999 and number and weight of clusters in 2000. Two-factor interactions on other parameters and three-factor interaction on all parameters were insignificant. Clone 4 produced largest clusters and highest yield while clone 6 produced smallest clusters and lowest yield. Rootstock 3309 Couderc produced more smaller clusters, compared to Teleki 5C and Freedom. Hand-spur pruning produced least shoots, least clusters, largest clusters and berries, while minimal pruning produced most shoots, most clusters, smallest clusters and berries. Yield of mechanically pruned vines was lower than that of hand-pruned vines and comparable to that of minimally pruned vines. Fruit maturity was delayed for 7 days by mechanical pruning and 34 days by minimal pruning in 2000 when fruit was harvested at comparable composition, compared to hand pruning. Clones 6 and 18 had greater pruning weight than clone 4 in both years, while rootstock Teleki 5C had greater pruning weight than rootstock 3309 Couderc and Freedom. Pruning weight of hand-spur pruned vines was greater than that of mechanically pruned vines.

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Skin Flavonoid Profile of Cabernet Sauvignon: Effect of Cluster Exposure, Applied Water, and N Fertilizer Amounts

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Flavonoids are the main molecules responsible for color and astringency of finished wines. Flavonoids accumulate during berry development, and the total amount present at harvest depends upon the genetic makeup of the grape cultivar, environmental factors, and cultural practices. Others have shown that cluster exposure, nutrient availability, and vine water status can influence the quality and quantity of flavonoids present in the fruit at harvest. In an attempt to elucidate the interactions of the above-mentioned cultural practices and environmental factors on flavonoid composition, two experiments were conducted in two commercial vineyards near Oakville, California. Cabernet Sauvignon vines grafted onto the rootstock 110R using a VSP trellis system and planted to either north/south or east/west row directions were used. Vines were irrigated at different fractions (0.25, 0.5, and 1.0 for the 1999 season and 0 and 1.0 for the 2001 season) of estimated vineyard water use and received different N fertilizer amounts (0 or 37 kg N/ha for the 1999 season and 0 and 109 kg N/ha in the 2001 season). Diurnal and seasonal changes in the light environment, evaporative demand, and berry temperature were measured. Berries from fully exposed clusters were collected from both sides of the canopy throughout the season until harvest. Postveraison berry temperature in clusters exposed to full sunlight on the west side of north/south rows was 8°C greater than the ambient temperature. The greatest evaporative demand was also measured on the west side of north/south canopies. Berry size was significantly affected by both row orientation and irrigation treatments. Results indicate significant differences in the total amount of flavonoids per berry at harvest, particularly anthocyanins, with minor changes in the relative content of specific pigments. The greatest flavonoid contents were found in berries exposed to lower temperatures independently of light availability and vine water and N status.

Conversion of Mature Chardonnay in the Northern San Joaquin Valley to Mechanical Pruning

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A three-year replicated commercial field trial was set up in the northern San Joaquin Valley to observe the response of converting mature Chardonnay to two mechanical pruning systems. The control was traditional bilateral cordon trained and spur pruned. The second treatment was a mechanically hedged box approximately 20 cm wide and 40 cm high beginning at the cordon. The third treatment was a "V" shape similar to the machine-pruned cordon-trained system with the cut beginning at the cordon and extending 45° upward and outward. Midspring low-hanging fruit was trimmed off as soon as it became pendulous. The first harvest after conversion produced no difference in sugar accumulation; the plots were not harvested because of a lack of funding. The next two years the plots were harvested. The second year the box treatment produced significantly more fruit/vine with no significant reduction in sugar. In the third year, the V treatment produced significantly more fruit with a 3 Brix reduction in sugar. Titratable acidity and pH were not significantly different either year. Clusters/vine, cluster weight, berries/cluster, and grams/berry were all affected. Percent rot was 16.1 for spur, 9.8 for box, and 5.1 for V the second year. There was no rot in any treatment the third year.

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Influence of Chemical Treatments at Veraison on the Pigment Content and Composition of Table Grapes

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Inadequate color development is often a problem for table grapes grown in the San Joaquin Valley, especially for the two major red seedless cultivars Flame Seedless and Crimson Seedless. The objectives of this experiment were to examine the anthocyanin composition of these cultivars, as well as to determine how plant growth regulators (ethephon) and key flavonoid pathway intermediates (caffeic acid and taxifolin) influence their pigment accumulation and composition. Ethephon (0 or 250 mg/L), caffeic acid (0, 1, 10, 100, or 1000 mg/L) and taxifolin (0, 1, 10, or 100 mg/L) were applied at veraison (20% berry color) by immersing individual clusters in treatment solutions for 5 sec. A similar set of experiments examined the interaction between ethephon (0, 200, or 400 mg/L) and ethanol (0, 2.5, 5.0, or 7.5% v/v) on berry color development. The experiments were designed as a randomized complete block using 12 single-cluster replicates per treatment. Berries from all experiments were harvested at commercial maturity and frozen prior to pigment analysis. Total anthocyanins were measured through spectrometry, and pigment composition was determined by reverse-phase HPLC. Ethephon significantly increased pigment accumulation compared to the untreated control in both cultivars, while caffeic acid and taxifolin had no significant influence on color development. Ethanol stimulated pigment accumulation when applied in conjunction with ethephon, but negatively affected wax deposition on the berry surface and fruit appearance. Treatment effects on pigment composition will be presented.

Chamber for Measuring Whole Vine Photosynthesis in the Vineyard

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Photosynthesis contributes directly to the yield and quality of wine grapes. Environmental variables like radiation, temperature, humidity, nutrition, and water affect photosynthesis at the vine level. Measurements of whole-vine photosynthesis reflect the integrated response of the vine to its environment and are important to understand the effects of management practices imposed on the vineyard. With this in mind, an open-top chamber (8 m^3 volume) was built for the measurement of gas exchange (CO_2 and H_2O) from a whole vine. The design criteria and materials used were selected to minimize any artifact caused by the chamber itself and to accommodate the trellis of a mature field-grown vine. Considering no transpiration, a maximum internal temperature increase of 2.5°C was expected according to a radiation balance based on the size, shape, and ventilation rate of the chamber. Temperature profiles of vines inside and outside the chamber were measured. Solar radiation inside the chamber was approximately 90% of ambient. Several chambers will be used to measure net photosynthesis in a vineyard under regulated deficit irrigation (*Vitis vinifera* L. cv. Cabernet Sauvignon) in Washington State. This type of chamber could be used for other studies where an understanding of the whole vine responses is needed.

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The Effect of Rootstock on the Performance of Chardonnay, Merlot, Pinot noir, and Pinot gris

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The importance of grafting to phylloxera-resistant rootstocks in Oregon has increased as phylloxera has spread throughout the state during the past 20 years. Because Oregon growers have little information specific to this region to use in rootstock selection, this trial was initiated in 1997. The varieties Chardonnay, Merlot, Pinot noir, and Pinot gris were planted on nine different rootstocks and as ungrafted vines in a randomized split-plot design. Data collected during 2000 and 2001 consisted of measurements of gas exchange, chlorophyll content, vegetative growth, and analysis of fruit yield and composition. Vines grafted to the *berlandieri x riparia* rootstocks 420A Mgt, 5BB, and SO4 had high vigor and higher-than-average yields and berry weights relative to other vines in the trial. Ripening was average to later-than-average for these vines. Of the *riparia x rupestris* rootstocks, 101-14 Mgt imparted higher vigor and earlier ripening than 3309C. Yields and berry weights were average for vines grafted to these rootstocks. The *berlandieri x rupestris* rootstock, 110R, imparted only moderate vigor and yield. Berry weight and ripening time were average for vines grafted to this rootstock. Vines grafted to Gravesac had moderate vigor and yields and average to lower-than-average berry weights. These vines ripen fruit earlier than average. Vines grafted to 44-53 Malègue had lower-than-average pruning and berry weights and slightly lower-than-average yields. Ripening appeared to be delayed by this rootstock. Riparia Gloire imparted the lowest vigor of rootstocks evaluated in this trial. Yield and berry weight were also low. Ripening was earliest for vines grafted to this rootstock.

Effect of Canopy Management Practices on Growth, Yield, and Fruit Composition of Cabernet Sauvignon Grapevines in Arkansas

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Grapevine canopies are managed to manipulate vegetative growth and optimize vine physiology, improve vine productivity, reduce disease incidence, improve fruit composition, and increase wine quality. This experiment examined the response of Cabernet Sauvignon grapevines to selected canopy management practices applied individually or in combination. The experiment was conducted in a commercial vineyard that was established in 1996. Vines were grafted to Kober 5 BB rootstock and planted in a Linkers fine sandy loam soil. The vineyard was drip-irrigated and vineyard spacing was 2.4 m x 3.4 m (vine x row). Vines were trained to a bilateral cordon and spur pruned. A vertical shoot-positioned trellis system with movable catch wires was used, and row orientation was east to west. Canopy management treatments were shoot thinning, flower cluster thinning, and leaf removal. Treatments were imposed during the 2000 season. Initial results from the 2001 season are reported. Shoot thinning had little effect on canopy characteristics, yield or fruit composition. However, shoot thinning significantly reduced shoots per vine and shoot density. Cluster thinning had a greater impact than shoot thinning. Cluster thinning significantly reduced clusters per vine and yield. In addition, vines that were cluster-thinned had higher berry weight, cluster weight, berries per cluster, and pruning weight. Leaf removal reduced canopy density as indicated by point quadrat analysis. However, yield and fruit composition were not improved. The data presented are preliminary and further study is needed before equilibrium results are obtained.

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California's Tightening Winery Wastewater Requirements

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California's recent tightening of winery wastewater treatment and disposal requirements and third party concerns are driving changes to past practices. Historical winery practices, in particular land-based wastewater treatment and disposal systems, are being forced to change due to development and environmental concerns associated with organic, salt, nitrogen and hydraulic loadings, as well as odors. This study describes the regulatory framework driving these changes. Using case studies from several wineries, different approaches, the results of studies required to address concerns, and the collection of environmental data are presented.

Use of Roundup® Tolerant Aurora Gold Hard Fescue (*Festuca trachyphylla*) in a Weed Management Program in Vineyards

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Studies have shown that weed growth in vineyards, especially during dry periods in the summer, can limit productivity. Weeds compete for water, nutrients, and sunlight. Rotary or cultivating machines are available, but the risk of trunk and root injury is high. Although many options are available, most vineyards are using herbicides because of their low cost and reduced traffic through the vineyard. Without a cover crop, erosion is also a concern between the trellises. The results of cover crop experiments indicate that any actively growing cover crop in the immediate post-bloom period can limit vine size, berry size, and yield. To avoid reduced shoot growth, early defoliation, and reduced yield, fine fescue sod must be used only in the alleys between the trellises and not planted under the vines. It would be advantageous to have a cover crop that could be kept weed and damage free when weeds are sprayed under and in between the vines. Roundup® is a broad spectrum herbicide that breaks down over time into natural materials and will not move in the ground to affect nearby, untreated plants. Aurora Gold Hard Fescue is a cool-season turf grass that has been selected for natural Roundup® tolerance. It is a low maintenance turf with good drought and shade performance. Aurora Gold will tolerate 4 to 16 oz per acre of Roundup®, making it ideal for weed control in vineyards. Aurora Gold can provide erosion control, with adequate control of most grassy weeds and small broadleaf weeds.

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Efficacy of Lysozyme Against Spoilage of Lactic Acid Bacteria during Alcoholic Fermentation

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Lysozyme from hen egg white was used for the inhibition of indigenous lactic acid bacteria (LAB) and four inoculated spoilage LAB cultures in a lab-scale winemaking process. The spoilage LAB cultures included *Lactobacillus kunkeei*, *Lactobacillus brevis*, *Pediococcus parvulus*, and *Pediococcus damnosus*. Three levels of lysozyme were used: 0, 125, and 250 mg/L. The alcoholic fermentation of the 2001 Chardonnay grape juice was carried out at 20°C using *Saccharomyces cerevisiae* (ICV D47). No negative impact on the yeast growth and sugar reduction was observed from the addition of lysozyme. Lysozyme was found to be highly effective in inhibiting the growth of the indigenous LAB flora and the four inoculated LAB cultures. For some of the inoculated LAB cultures, as high as an 8 log cell reduction was achieved with the addition of 250 mg/L lysozyme. Lysozyme addition as low as 125 mg/L significantly reduced the production of acetic acid by *L. brevis* and *L. kunkeei* ($p < 0.01$). The effect of lysozyme on the cells of *L. brevis* and *P. damnosus* was examined under a scanning electron microscope. It is evident that lysozyme had a detrimental impact on the cells of the two cultures. Based on these observations, it is concluded that lysozyme can be used to control the growth of spoilage LAB and to reduce the production of acetic acid. The addition of lysozyme also prevents the increase of volatile acidity and reduce the chance of stuck/sluggish alcoholic fermentation. This tool is particularly useful in high pH wines where SO_2 is less effective.

Applications of ICP-MS in the Enology and Viticulture Industry

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Inductively coupled plasma-mass spectrometry (ICP-MS) provides the analyst with the ability to rapidly fully characterize soils, waters, and the final products in the enology and viticulture industry. Due to its wide dynamic concentration range capabilities matrix, minor and trace elements can be easily determined. Full elemental analysis allows the user to possibly determine country of origin from elemental ratios as well as to ensure that no toxic elements are present at harmful levels. The study describes the routine application of ICP-MS in the industry.

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Effects of Row Direction and Trellising on Direct Sun Exposure on Grapes

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Direct sunlight exposure of grapes affects fruit ripening and has other physiological influences on wine quality. This research project used hemispherical photography with digital image analysis to quantify potential direct solar radiation in the fruiting zone. Photographs of six trellis systems in east-west rows were taken in the Lodi, California appellation. Specialized solar analysis software was used to quantify the direct insolation (INcident SOLAr radiaTION) over the growing season and to simulate other row directions for the same trellis types. The software overlays sunpaths on the photos, which were taken at the fruiting zone, and calculates potential sun exposure on the grapes for the growing season (estimated as April 21 to September 21). The potential direct insolation over the growing season for the south side of the east-west rows varied by a factor of 10 by trellis type from 3950 Mj/m^2 for a clean vertical shoot position trellis to 315 Mj/m^2 for a vigorous sprawl. The clean vertical shoot position trellis was simulated in a north-south row direction and a northeast-southwest row direction. The ratio of potential direct insolation over the growing season for each side of the trellis was calculated to evaluate side-to-side variability and overall variability for each row direction. The east-west row had the highest side-to-side ratio of 4.2:1. As expected, the north-south row had a side-to-side ratio of approximately 1:1, but the potential insolation was reduced by 30% when compared to the south side of the east-west row direction. Using hemispherical photography, this study evaluated two key vineyard-level decisions, trellis selection and row direction, to quantify their effects on sunlight exposure of the grapes throughout the growing season.

Investigations of Vineyard Light Environments Using Hemispherical Photography

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The vineyard light environment is driven by a complex combination of factors, including latitude, slope, aspect, row direction, trellis type, and canopy management. The amount of insolation (INcident SOLAr radiaTION) striking grape clusters is a key determinant of grape quality, and quantitative understanding of daily and seasonal variability of insolation may provide guidelines for vineyard layout and canopy management. Hemispherical photography provides a tested and reliable method for characterizing plant canopies. Digital overlays of sunpaths and sky geometry on a 180° "fisheye" image pointed straight up from underneath a vineyard canopy provides fine temporal resolution of direct sun exposure and produces "insolation profiles" that describe hourly and monthly variations in insolation. This study provides an overview of the technique, from acquisition of hemispherical photos, the mechanics of digital image processing, to the interpretation of results. Two examples illustrate vineyard applications. Leaf removal from north-facing cordons increases diffuse and direct insolation levels by 100 to 200%, depending on trellis type. Sunburn potential in a vertical shoot position trellis depends strongly on row direction, with southwest-facing cordons at the highest risk.

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