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Exploring High Altitude Viticulture

Part One

Story by Ted Rieger › *senior feature editor*

The Elevation of Wine, the first international high altitude viticulture and winemaking symposium, was held at the 2,200-foot-elevation Snow's Lake Vineyard in the Red Hills American Viticultural Area (AVA) of Lake County which has one of the largest concentrations of higher altitude vineyards in California's North Coast, with 8,800 acres of vineyards ranging in elevation from 900' to more than 3,000'.

The conference was organized by a committee of the Lake County Winegrape Commission led by **Peter Molnar**, co-owner of Obsidian Ridge Vineyards in the Red Hills AVA that ranges in elevation from 2,350' to 2,640'. Molnar served as moderator, and in opening comments provided reasons for the symposium and suggestions for future direction. He said, "Everyone who grows fruit in the mountains realizes something is different. We know that light, air, and temperatures can be different. Let's find out what the differences really are. We're here out of curiosity."

One issue highlighted by the symposium was that the term and concept of "high altitude" viticulture and wines have not been clearly defined. Attendees represented vineyards ranging in elevation from 1,000' or less for hillside vineyards in California up to 9,800' elevation vineyards in Argentina. As some speakers indicated, elevation alone is not always the main factor that creates characteristics associated with higher altitude vineyards. Other factors include the latitude, degree and distance of hillside slope, proximity to the coast, and other localized topographical and climatic factors.

Symposium organizers provided grants to UC Davis and CSU Fresno to conduct literature searches on published research related to high altitude, mountain, and hillside viticulture. CSUF undergraduate students **Willow Corson** and **Jeremy Timm**, under the direction of **Dr. Robert Wample**, compiled one bibliography of relevant research. At UC Davis, graduate student **Sallie Hess**, working with **Dr. David Smart** of the Department of Viticulture and Enology, compiled another bibliography.

Files of these bibliographies were placed on a CD, with copies provided to each symposium attendee. Hess provided a summary of signifi-

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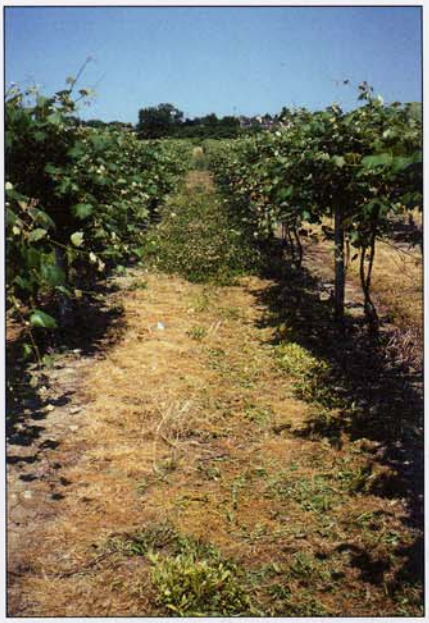
At a Glance

- Factors associated with high altitude viticulture (that change with elevation gain) are lower temperatures, higher UV radiation and light intensity, and lower percentages of atmospheric components such as oxygen and carbon dioxide. High elevation vines generally have a shorter growing season, but can have higher rates of photosynthesis due to higher UV radiation.
- One of the most important and beneficial factors in high elevation grapegrowing is a wide swing in diurnal temperature differences distinguished by lower nighttime (cooling) temperatures.
- Grapes grown at higher altitudes can develop a more favorable phenolic profile with higher levels of tannins and anthocyanins, and a more rounded tannin structure due to lower levels of monomeric tannins.
- Potential challenges associated with high elevation and mountain vineyard development and management include: increased risk of frost; extreme weather events such as heavy rains, hail, and high winds that can damage crops; higher costs for vineyard development and management; soil erosion; uneven soil types and variable soil fertility; variable grape maturation rates from bottom to top of slope; and lower overall yields.
- More research is needed to understand and quantify the effects of altitude on grapes and wine. One area of particular interest is the relationship between increased UV radiation intensity at higher altitude and its effect on phenolic development and content in grapes.



From Lakso's study, a July photo of a part of the cover crop trial that shows the conservative Roundup at bloom treatment in the foreground and a more water-competitive cover crop in the background.

tion is needed on the response of premium wine grapes to imposed irrigation deficits and to soils of low moisture-holding capacity."

Reynolds and colleagues conducted a series of experiments on Vitis labruscana (concord and niagara), table grapes (sovereign, coronation), French-American hybrids (baco noir), and several V. vinifera (chardonnay, sauvignon blanc, cabernet sauvignon) to investigate the impact of different durations of putative water stress upon vine performance, fruit composition, and water relations. This study is of particular interest in contrasting the perceived grape and wine quality benefits of non-irrigation prevalent in the AC regions of France with the study results on wine the grape and wine quality benefits of irrigation.

In chardonnay, treatments were: non-irrigated control; early deficit irrigation (reduced irrigation post fruit set); midseason deficit irrigation (reduced irrigation at lag phase of berry growth); late season deficit irrigation (reduced irrigation at veraison); full season irrigation. The full season irrigation treatment increased yield by 18% (2001) and 19% (2002) over the non-irrigated control due primarily to increased berry weight. Soluble solids (Brix) were increased by irrigation, and the full season irrigation treatment showed similar or higher Brix than all other treatments in two of four years. Wines from irrigated treatments had greater intensities of apple, citrus, and floral aromas and flavors, as well as lower levels of earthy aroma and flavor.

Chien gives full credit for the development of the symposium program, which he described as "one of the best I have attended in eight years here," to incoming chair of Eastern Section, Terry Bates. The 2008 annual ASEV/ES symposium will take place mid-July in Ontario.

cant points from the papers, in which she stated that altitude has been linked to differences in the following three categories:

- Differences in Plant Physiology/Anatomy: higher foliar N, higher leaf water content, lower leaf cell sap concentration, higher photosynthetic rate, higher net CO_2 assimilation, lower stomatal conductance, lower CO_2 diffusion, early ripening, late phenological development, smaller leaves, shorter canes, and low yield tied to smaller berries, fewer clusters, and smaller clusters.
- Differences in Berry Composition/Wine: higher anthocyanins, lower proanthocyanidins, lower monoterpenes and norisoprenoids, higher "phenolic maturity," higher carotenoids, higher titratable acidity, higher malic acid, lower color intensity in wines, lower/slower sugar accumulation.
- All Linked to Differences in: interception of solar radiation, diurnal temperature differences, lower relative humidity, lower or higher plant available water (depending on site).

It should be pointed out that characteristics associated with high altitude grapes and wines are sometimes in conflict with one another, specifically regarding fruit maturation and wine intensity. Higher altitudes have been associated with earlier fruit development and ripening, as well as delayed fruit maturation and later ripening due to site specific characteristics.

Depending on orientation and localized conditions, with a vineyard planted on a sloping hillside, the grapes at the top of the hill may mature and ripen earlier because they receive more solar exposure and higher temperatures, as compared to grapes near the bottom of the hill that receive fewer hours of direct sunlight, or may be below the fog line on some days. This can occur in milder climate regions such as California hillside vineyards up to about 2,500' in elevation.

In contrast, mountain and higher elevation vineyards in some areas of the world are associated with cool climate viticulture, with average temperatures decreasing with higher altitudes. In these locations, fruit development and ripening are later, the higher the altitude. Some speakers discussed wines produced with greater "intensity" due to the stress of hillside and altitude growing conditions. Other speakers described wines with more "finesse" and "balance" that are sometimes associated with cooler climate viticulture. This stylistic contrast can be due to site specific conditions, as well as winemaking styles based on harvesting decisions and grape sugar levels.

ELEVATION AND CLIMATE

Climatologist **Dr. Greg Jones** of Southern Oregon University, whose parents own Abacela Vineyards near Roseburg, OR, discussed the importance of climatic factors and differences that can be associated with higher elevation vineyard sites. He first listed some potential climate-related

hazards associated with high elevation vineyards: extreme winter temperatures including spring frosts that can kill early-season growth and fall frosts that can cause early leaf drop to end photosynthesis; moisture and precipitation that can cause bloom disruption, split berries, and ripening disruption; and extreme weather events such as hail, wind, and heavy rain that cause crop damage.

The four main factors that influence weather and climate are latitude, continentality, altitude, and topography, and these are all tied together to create specific weather patterns at specific sites. As part of understanding and defining "high elevation," Jones discussed the concepts of "relative relief"—the difference in elevation between the low point and high point on a hillside or slope, vs. "absolute relief"—the difference in elevation from sea level (0' elevation).

Jones summarized, "In most vineyard areas, relative relief is the most important aspect of elevation difference producing local topographical effects on weather and climate.

"However, very high absolute relief can drive significant differences in weather and climate compared to lower elevations at similar latitudes." A general rule of thumb for topographical influence on temperature in mid-latitudes, is that temperature decreases an average of 1 degree F. per 275' in elevation gain, or 3.6 degrees F. per 1,000'. Other influences of local relief are the effects of slope on air movement which can vary based on aspect/orientation creating diurnal winds (upslope winds and downslope winds at different times of the day), temperature inversions, and different thermal zones. Slope and aspect also affect heat loading and retention of air and soil temperatures. Proximity of a local site to bodies of water will influence heat retention, or buffer temperatures from extremes.

Absolute relief influences several factors that can affect vineyards and vine growth at increasing altitudes.

1. Temperature differences are the same, on average, decreasing 1 degree F./275' at higher altitudes, however, there is a greater diurnal temperature range and lower overnight temperatures at higher altitude.

2. Pressure and density differences are amplified at altitude, due to the effects of gravity, with lower percentages of oxygen (O_2) and carbon dioxide (CO_2) as atmospheric components. O_2 is 89% of the atmosphere at 3,000' compared with sea level, 78% at 6,000', and 60% at 9,000'. CO_2 levels, along with water and nitrogen, are some of the major limitations to plant growth. The percentage of CO_2 in the air at 2 miles is about the same as at sea level (0.03%), but the relative abundance of CO_2 compared to O_2 decreases. Jones said, "CO_2 uptake by plants is typically less at higher altitudes and limits photosynthesis and productivity." In addition, the CO_2 gradient from the atmosphere into leaves is less, and plants physiologically adapt to this by increasing stomata size and number.

3. Radiative differences: At higher elevations. surfaces gain and give off heat quickly (sun/shade effect), and there is higher intensity and more ultraviolet (UV) radiation. The principle of rarefaction occurs at high altitude as the thinner atmosphere filters less UV light, thus there is an increase in UV radiation of 3% to 4% per 1,000' elevation gain. "Theoretically, UV exposure should increase phenolic and color levels in grapes, but other factors may lessen these influences," Jones said. He said recent research indicates some grape diseases occur due to a combination of water stress and UV-B radiation, and he noted that chlorophyll degradation in leaves and berry skins can occur more rapidly at high UV radiation environments.

Jones noted that UV radiation levels are mostly stable around the world, but some areas are showing an increasing trend (southern hemisphere, Europe) and some areas indicate a declining trend due to clouds and pollution.

4. Moisture patterns are greatly influenced by mountain terrain, including orographic rainfall and valley and upslope fog. Drying winds and lower humidity can cause more rapid dehydration in some locations, but potential ET rates can be less in other locations.

5. Wind characteristics are influenced by the direction of the wind toward mountains and this influences how air flows over them. Jones showed diagrams of several common wind flow patterns over mountains, and said, "The greatest vertical motion is created with winds that move perpendicular to the mountain range."

JONES' IMPORTANT CONCLUSIONS

- Elevated climates can be characterized by a distinctive combination of temperature, radiation, wind and rainfall patterns, and by larger climate variability, over both spatial and temporal scales, compared with lowlands at the same latitude.
- Many complex interactions and effects are hard to isolate.
- While growing seasons are shorter at higher elevations, plant growth can be intense because of a favorable radiation climate, and a marked contrast between daytime and nighttime temperatures (resulting in reduced plant respiratory loss).
- Radiative and CO_2 effects are likely the most important factors.
- More research into how the various weather and climate parameters at higher elevations influence vine growth, fruit composition, and wine quality is needed.

SIERRA FOOTHILLS SYRAH

Bill Easton, co-owner/winemaker for Easton and Domaine De La Terre Rouge Wines in Amador County discussed his experience with syrah from different elevation vineyards in the Sierra Foothills. He began his presentation by admitting, "I'm not really a scientist, I'm a seat-of-the-pants winemaker." Sixty percent of Terre Rouge's total production is syrah, and it bottles five different syrahs from vineyards ranging in elevation from 800' to 3,200'.

He presented two wines from the 2003 vintage for comparison. The Sentinel Oak Syrah is from a 1,400' vineyard in Amador County's Shenandoah Valley AVA. The "High Slopes" Syrah is made from grapes sourced from two vineyard sites in the Sierra Foothills, each over 3,000'. Both wines were processed almost identically, and each was aged in one-third new French oak. But the Sentinel Oak spent 18 months in oak, whereas High Slopes was aged for 24 months. Sentinel Oak is a more powerful wine with bigger fruit, and the High Slopes is a more elegant wine.

Sentinel Oak fruit usually ripens about one month earlier than the High Slopes. One technique used with these sites is to prune the vineyard as late as possible, "to push the growing season and ripening curve more toward the fall to get more hang time and cooler season fruit ripening," Easton said. "Wines reach maturity with a little more finesse at higher elevations," Easton believes. Terre Rouge also produces a limited bottling luxury wine called "Ascent" made from the eight best barrels of syrah from each vintage, priced at $80/bottle.

Easton is very positive about the Sierra Foothills terroir, its climate, soils, and its history of winemaking dating to the Gold Rush era. "I think that some of the best spots for vineyards in the Foothills are yet to be found," Easton said.