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Row Direction--Which End is Up?

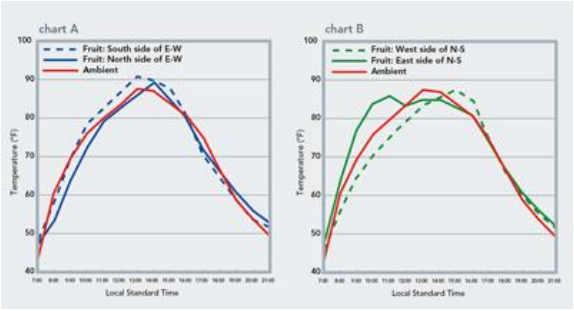
Some considerations regarding which way to lay out vine rows

by Mark Greenspan

In a vineyard installation, probably no decision is more permanent and costly to modify than row direction. Wrong variety? Grafting is relatively easy. Wrong rootstock? Digging up the old vines and replanting sure is costly. But row direction involves infrastructure: Stakes, endposts, wire, underground and above-ground irrigation components, drainage, etc. Changing row direction usually requires a total tear-out and new installation of a vineyard. So, getting it right the first time is essential.

It seems that most flat-ground vineyard installations done in the '70s and '80s were planted with an east-west row orientation. Research and experience tell us that there is almost no good reason to plant E-W unless the topography dictates it. The reason for this is that fruit on the north side of the canopy experiences a very different microclimate (light and heat) than fruit on the south side of the canopy. It makes intuitive sense: fruit on the south side is exposed to sunshine nearly all day long while fruit on the north side is shaded (reversed in the southern hemisphere, of course).

My colleagues and I from The Winegrowing Consortium[1] ran a brief experiment where we monitored fruit temperature on both sides of VSP canopies for E-W rows and for N-S rows in two adjacent blocks. The south-side fruit tended to be about 5°F warmer than the north-side fruit for most of the day (see chart A). While 5 degrees may not sound extreme, consider that the fruit experiences this difference day-in and day-out. In an experiment conducted in a California Central Valley vineyard, Bergqvist et al. found that about every measureable component of fruit composition differed between fruit on each side of an E-W canopy[2].



That said, there are three general considerations when considering row direction: parcel geometry, topography and microclimate. The latter is the primary viticultural component of the decision, and that is what I will expound upon here. But in practicality, parcel shape and topography are often overriding or modifying factors. A viticulturally-optimum row direction that creates short "point" rows in the corners may create an excessive number of endposts and too many turn-arounds for operations. Likewise, topography may be limiting for hillside installations--rows usually need to be oriented up and down a slope to avoid side-slopes, which present hazards or must be dealt with by terracing. Creating new terraces is becoming frowned-upon (or not allowed) because of the great soil disturbance that it creates, opening up potential for erosion or land-slips.

The microclimatic considerations that influence the row direction decision depend upon the general "macroclimate" of the site. And the primary determinant for this is whether the climate features hot days or not. Heat-prone climates necessitate that fruit are protected from sunlight (i.e., are shaded) during the hottest time of the day. Cooler climates, free from that restraint, are driven by the more viticulturally-eloquent influence of thermal balance between the two sides of the canopy.

Row Direction in Heat-Prone Climates

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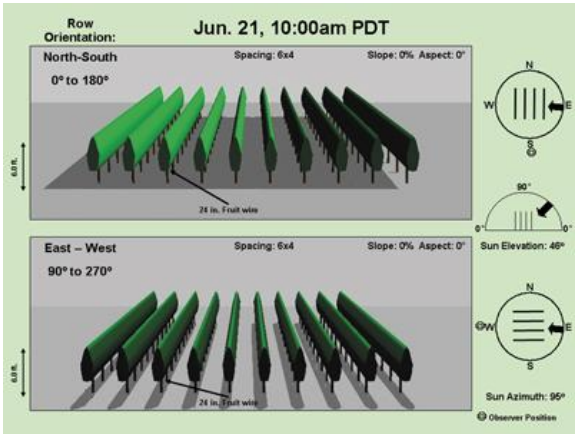

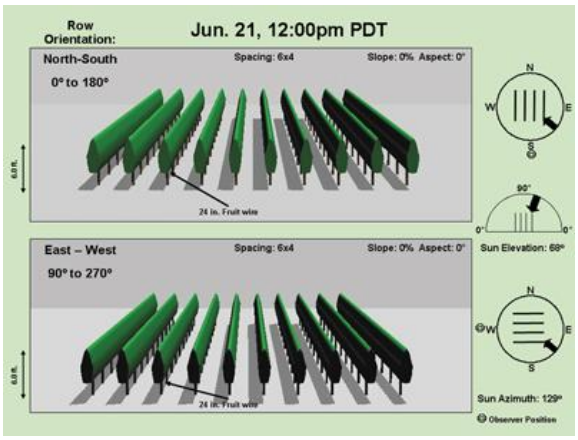

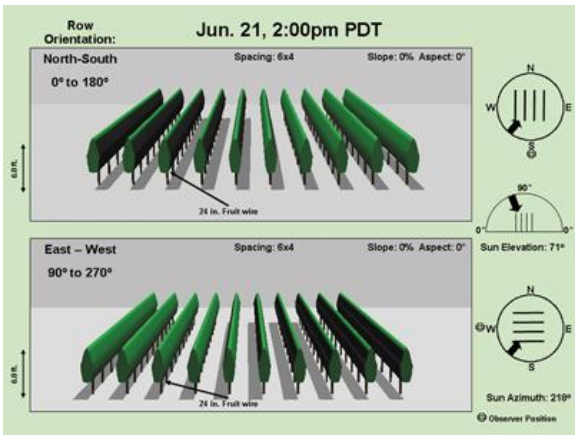

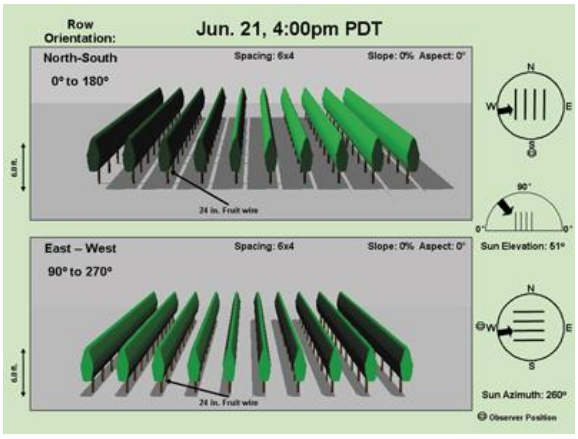

What defines a "hot" day? Grape composition can be degraded at 95°F (35°C), where anthocyanin accumulation is reduced relative to lower temperature regimes[3]. It was found that the anthocyanin loss under high temperatures (95°F) resulted from both degradation of anthocyanin and from the inhibition, at the gene transcription level, of the anthocyanin biosynthetic enzymes[3]. However, when concerned with high temperatures and row direction, I am more concerned about short-term, high temperature events, like those that occur during heat waves, which may cause visible sunburn on grapes or may cause more subtle damage that is not visible until the fruit matures further. So-called heat shock proteins are formed at 95°F in grape leaves but are produced most prolifically at 104°F[5]. I generally think of 100°F (38°C) as a usable threshold for heat damage of ripening fruit. Keep in mind that dark-skinned fruit can be at least 10°F warmer than ambient when exposed to sunshine. On the other hand, green, pre-veraison berries will not rise that high above ambient temperature because they absorb less radiant energy. Therefore, a higher temperature threshold might be more appropriate for fruit in that stage--for instance, 105°F. I analyze climatic data over as long a period that is available, and I look for the average and typical range of the number of days per month above those given thresholds. If there are, on average, more than two days per season above a very high threshold (say 105°F) or more than five days above a less extreme threshold (say 100°F), I consider it to be a "heat-prone" climate. I generally only consider months where fruit is developing on the vine.

As I said, vineyards planted in heat-prone climates need to have rows oriented such that fruit is shaded in the hottest part of the day. I analyze climatic data to determine what time, typically, has the highest diurnal temperature. I look at the month of August, which is a hot month in California and the month when veraison frequently occurs. Typically, this tends to occur between 2 and 3 p.m. (local standard time). But I feel that the fruit needs to become shaded about an hour before this temperature peak so that fruit can remain shaded after the peak (fruit temperature lags ambient temperature in time due to heat capacity of the fruit, which I'll discuss shortly). I consult astronomical tables to find out what the solar azimuth angle (compass direction) will be at that time of day at that location and at that time of the year. This gives me the optimum row orientation for the hotter climates. Nominally, the row direction tends to be about 30°.

My colleague, Mike Bobbitt, a GIS specialist with Mike Bobbitt and Associates, goes many steps further. He has developed a canopy shading model that takes into account the geographic location of the site at any point on the globe and has been used for vineyard developments internationally. Not only does it consider latitude and longitude, but also the site's slope and aspect. His model can, therefore, be very valuable for hillside locations. Additionally, his model can incorporate row spacing and other trellis dimensions, so it could even be used as an aid for vineyard design. Take a look at a few of the simulation outputs, run for east-west rows and for north-south rows. It is clear to see that the north-south rows have a more equitable amount of sunshine hours on each side of the canopy than the east-west rows. For rows that are oriented about 30° to avoid heat damage, the two sides of the canopy will not receive the same amount of sunshine. However, that is the sacrifice that must be made for heat-prone vineyard locations.

Row Direction in Cooler Climates

With the restriction of midday sun exposure lifted, row orientation may be chosen to maximize viticultural characteristics. Fruit temperature is a key (perhaps the key) factor in the ripening process. For highest wine quality, our goal is to have fruit achieve ripeness (flavor, not just sugar) at the same time. Therefore, we want to promote uniformity of fruit ripening processes for both sides of the canopy. That means that fruit on each side should experience similar temperature cycles each day. At first blush, one would think that the best way to achieve this is with a north-south row orientation. After all, they both will receive the same amount of sunshine. Indeed, a north-south row orientation will come close to this ideal. But, take a look at the fruit temperature measurements made for the north-south row in Chart B. The east side fruit, exposed to the sun's rays in the morning, heats up and reaches peak temperature well before noon. The west side fruit, shaded until after solar noon, peaks in temperature in the mid-afternoon. But notice that the temperature curves are not symmetrical. If we did a heat summation on the two curves, the east-facing side would have been seen to have received more "degree-hours." In other words, the north-south row orientation does not achieve the ideal goal of equitable heat exposure of the two sides of the canopy.

The reason for this discrepancy is that grape berries are mostly water and water has a high heat capacity. In other words, it takes a lot of energy to raise berry temperature to a given level, and by the same token, berry temperature tends to resist changes, including cooling. This can be thought of as akin to "thermal momentum." Because of this thermal momentum, the east-side fruit that warms up under the direct morning sunshine remains relatively warm during the afternoon, even though it is no longer in the sun. This is because the ambient temperature continues to increase, and fruit temperature will not fall until the ambient temperature falls below fruit temperature.

On the other hand, the west-facing fruit does not experience sunshine until after noon, at which time its temperature rises above ambient. But because of thermal momentum, its temperature does not peak until an hour or two later than the ambient temperature peak. Once the west-facing fruit temperature peaks, the ambient air temperature is well past its peak and its temperature does not remain elevated like that of the east-facing fruit. Therefore, to account for this small, but significant, discrepancy, row direction should be oriented about 10 to 15 degrees west of north (i.e., 345-350°) in cool climates. This is just an educated guess, and I have not determined the ideal row orientation as it would require some advanced modeling or some additional field research. Nevertheless, I will assume that most situations in cool climates can get away with a north-south orientation, especially since many parcel boundaries are laid out in that direction. But the slight jog towards the west should be a consideration for vineyard installations attempting to maximize uniformity of ripeness in their vineyards.

Wind

I have not mentioned that wind, another climatic characteristic, may be influential in the row direction decision process. Wind induces stomatal closure in grapevine leaves, and this effect has been measured at wind speeds as low as 8 miles per hour[6] of sustained wind speed. The effect had a residual one (even with wind exposure removed) at higher wind speed (24 mph). The effect is not a water stress; it is a response motivated by the rapid leaf movement. Wind is a significant consideration in many growing regions. In California, high afternoon winds are an everyday occurrence in the Salinas Valley, the Petaluma Gap and in the Santa Rita Hills.

What this means for row direction depends upon where the vineyard is to be developed. With rows oriented perpendicularly to the prevailing wind direction, the rows will "self-shelter" one another and wind speed will be reduced in the lower portion of the canopy, compared to rows oriented parallel to the wind direction. This has a measurable effect on the stomatal conductance and, probably, photosynthesis of each situation. Wind-perpendicular rows will have higher stomatal conductance and, thus, will be able to continue to produce sugar. In very cool regions where sugar accumulation is difficult, this may be the preferred row orientation. On the other hand, in more mild climates, the afternoon "shut down" of photosynthesis may actually be welcome as it will slow down the sugar accumulation process, allowing flavor maturation to proceed without the accompanying rapid Brix increases.

A downside to cross-wind row orientation is that the vines act as "sails," and there can be problems with vine rows leaning over from the constant wind force. Shoot breakage is also a hazard with the cross-wind row orientation, and meticulous shoot positioning must be made so that shoots don't flap in the wind.

To Summarize

Heat-prone climates: Rows oriented about 30-40° (northern hemisphere)

Cooler climates: Rows oriented north-south to 15° west of north (northern hemisphere)

Windy climates: Plant cross-wind if sugar accumulation is a challenge or parallel to the wind if sugar accumulation is not an issue.

Other concerns: Topography may override all of the above, and property boundary geometry may necessitate modifications of the ideal direction. wbm

Author's Note: Ideas expressed here come from thinking arising from numerous fruitful discussions with colleagues, including Dr. Daniel Roberts (of Integrated Winegrowing), Mr. Theo Csavas (now with Jackson Family Farms), Mr. Mike Bobbitt (Mike Bobbitt and Associates) and other consultants participating in the Winegrowing Consortium (www.winegrowingconsortium.com).