

Drought Stress Effects on Vine Growth, Function, Ripening and Implications for Wine Quality

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In wine production the role of water stress has been debated for many years. It has become clear that neither end of the spectrum of water stress is optimal for desired balances of yields and wine quality (Seguin, 1983). We will discuss how the range of water status affects vines and wines in this section. Following sections address the fundamentals of water balance in vineyards and how irrigation may fit, and the effects of drought stresses as seen in 1999 on vine performance and management options.

Excessive water. The “wet” end tends to induce excessive vegetative growth that often leads to dense canopies, large dilute berries and compact clusters, poor fruit exposure and disease problems. All of these lead to poor fruit and wine quality. Since in temperate climates like ours we may have years of very low stress due to rain and cool temperatures, approaches have been developed to try to overcome these limitations. Canopy management to control the canopy form and to keep the canopy open via shoot positioning, topping, and leaf pulling has been very effective in many cases. Also, canopy division was first proposed for juice grapes by Nelson Shaulis in the Geneva Double Curtain, and later adapted to the Open Lyre by Alain Carbonneau for upright varieties. Canopy division spreads the canopy out to reduce canopy density and improve fruit exposure and utilize vigor rather than fight it. But it also increases light interception by the vine, which causes more water use and therefore somewhat more water stress. Additional approaches of encouraging competitive cover crops to use up the excess water have been successful in some cases, but the success depends on how wet it is and how deep the soil is (if the soil is deep the grape roots may not be competing with the cover crops). In addition to the growing season, excessively large vigorous vines in wet sites grow too late into the fall and often do not ripen the canes adequately. This can lead to significant losses to winter cold.

Experience in many wine-growing regions suggests that vineyards on well-drained soils will have fewer problems in wetter years although canopy management is especially critical for avoiding the problems of cool wet seasons.

Excessive drought stress. On the dry end of the spectrum, vine growth is inhibited and fruit ripening may be delayed or suppressed. Optimum wine quality requires some stress but does not come from stunted vines with non-functional leaves. Too much early stress will not allow the development of the desired leaf-to-fruit ratio of roughly 12-15 leaves per cluster (this will vary with cultivars, but is a reasonable average). This means the vine will not have the capacity to properly ripen fruit. Mid- to late-season stress, however, will shut down the leaf photosynthetic function and suppress ripening also (why produce a canopy if it can't function?). It may appear that fruit ripen due to increases in Brix, but that is often a result of simple dehydration, not actual import of sugar. Flavors in the fruit tend to develop in the last few weeks, so late stress also affects flavor development.

Although difficult to control stress and quantify all the effects of excessive stress, our observations have been that although small berries might suggest good extract and concentration, excessively stressed vines tend to produce wines of dull or little fruit, less complexity, relatively short life. The “untypical or atypical aging (UTA or ATA) appears due to a stress syndrome, of which water stress is a key factor (also low nitrogen stress seems to be important too). We have seen more of the UTA symptoms in the Finger Lakes following dry years, so we are concerned about the aging of wines in drought-affected locations in 1999.

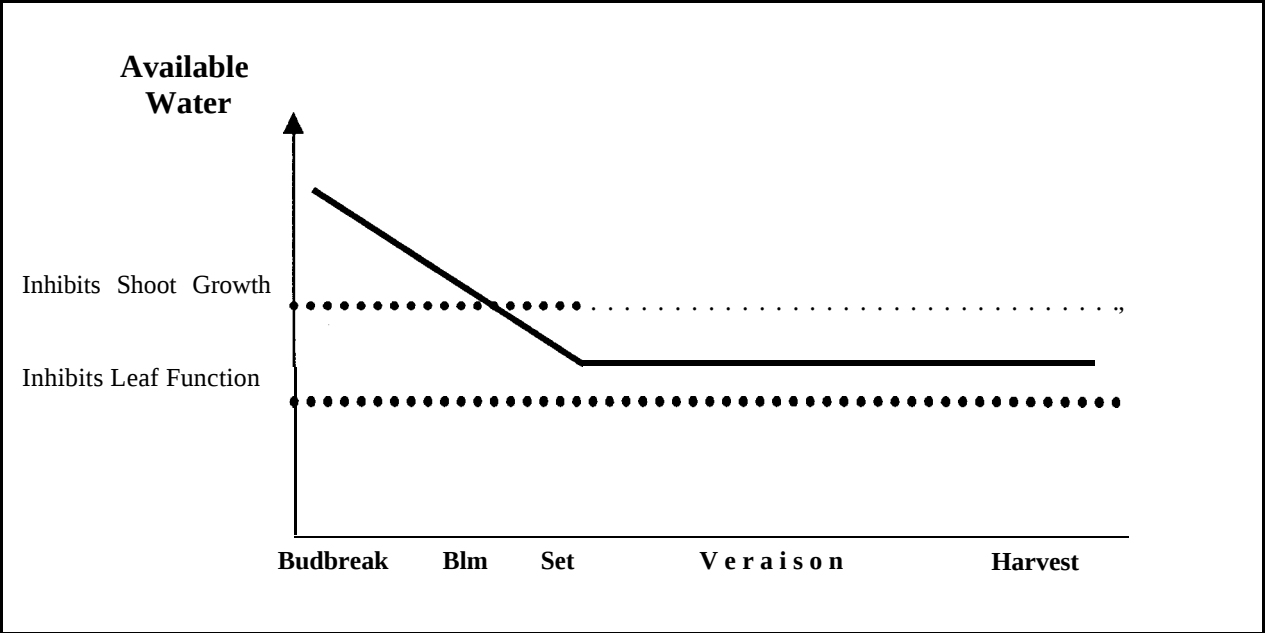
What is optimal stress for wine quality? Different processes in the vine respond differently to water stress. Growth processes like shoot growth and early berry growth are very sensitive to water stress, leaf photosynthetic function is less sensitive, and post veraison berry growth is quite resistant to water stress. So there is a degree of water stress that allows good leaf function but reduces shoot growth. It appears that in general optimal fruit flavor and complexity development requires the intermediate stress that leads to a full, but open, canopy with good fruit exposure, but healthy, functional leaves. Based on experience and visits to top wine producers in many areas suggest that the optimal stress scenario over a season is:

- Adequate water early in the season to have good, but not overly-vigorous, canopy and cluster development through bloom. This normally occurs as the early growth period is normally cool and there is little leaf area on the vine.
- Mild stress should gradually develop after bloom so that good fruit set can occur, but the growth of the berries and shoots are slowed somewhat.
- After fruit set, and initial berry growth, the canopy should be filling the trellis, At this time, the stress should increase so that the shoots slow growth markedly, the berries stop growth at a somewhat reduced size and yet the leaves are still fully functional.
- Mid-season to harvest the vines should be maintained at the intermediate stress to reduce vegetative growth, but keep the leaves healthy through harvest, There should be some, but not a lot of basal leaf yellowing before harvest if the canopy is kept open. In NY this period is most commonly the time that water stress develops to be too severe. Maintaining vines in a healthy state is the most likely value of irrigation in NY

This scenario (see Figure) could be seen in practice at Chateau Cheval Blanc in Bordeaux where the vineyard manager explained that they have very gravelly, stony soil that is extremely well drained, but also apparently has water available deep under the gravel. A few of the roots probably always tap into the water supply, but not enough to overstimulate the vines. In the wet years the gravel does not hold excessive water. In the dry years the vines are stressed moderately, but develop an adequate canopy, and have enough water to maintain healthy leaves. At the time of the visit, the topsoil was extremely dry, yet the leaves were not overly stressed, Combined with meticulous canopy management and careful cluster and berry thinning to balance the crop, some of the greatest wines in the world are made.

Another example with more controlled conditions is from a research trial in Washington State at Columbia Crest with Sauvignon Blanc (Wample, 1996) in which they used either a high irrigation or a low irrigation regime all season (HH, LL) or alternated during the period either before or after canopy fill (HL, LH). The full irrigation all season, HH, or full only in the first half, HL, gave somewhat higher yields

and similar Brix, but the wines were "leafier and more austere, higher acidity and more tart" (Irvin and Clore, 1999). The wines from the L irrigation regime early or full season were both fruitier, but "It (LH wine) was fruitier in the aroma, highlighting melonlike fruit aromas with just a bit of the grassy character of this grape. On the palate the wine was rounder and fruitier. The LL wine had a tarter, more austere finish," (Irvin and Clore, 1999). These results support the need to have some stress-induced slowing of early growth and to maintain canopy health in the last half of the season. It also suggests that if the stress level is correct early in the season, the amount of water received or applied later is less critical.



General diagram of a proposed “optimal” water stress scenario for wine grape production and quality.

Summary. Optimizing vine productivity and wine quality is a complex task, but water management is an important component. High wine quality appears to require adequate, but not excessive, water supply early in the season to establish a good canopy to support the crop, followed by moderate stress that limits further growth, but allows healthy leaves to fully ripen the fruit. Canopy management interacts strongly, so water management and canopy management must be well integrated, Although the water status cannot be controlled in NY conditions, an

understanding of the principles will allow an evaluation of each vineyard to determine if there are opportunities to more often reach the desired scenario,

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