Temperature variations in the Walla Walla valley American Viticultural Area

Variations des températures de la Région Viticole Américaine de la vallée de Walla Walla

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Summary

Variations in average growing season and ripening season temperatures within the Walla Walla Valley American Viticultural Area are related to elevation and regional and local topography. Downstream narrowing of the Walla Walla Valley creates a nocturnal cold air pool that is more pronounced during the August to October ripening season. Average growing season temperatures are generally higher and growing degree-days greater at lower elevations. Average temperatures increase with elevation to 450 m during the ripening season as temperature inversions become more pronounced and persistent. Cool air descending from the Blue Mountains lowers average growing and ripening season temperatures at sites near major streams. Adiabatic warming of down-sloping prevailing winds increases average growing season and ripening season temperatures near the base of Vansycle Ridge. Grapevines planted below 300 m have a much greater risk of damage from frosts and freezes. Variations in vineyard ground surface materials have no apparent effect on ambient air temperatures as measured by radiation shielded data loggers at a height of 1.5 m.

Keywords: Walla Walla Valley, temperature, elevation, topography, growing degree-day

Introduction

The Walla Walla Valley American Viticultural Area (AVA) straddles the eastern part of the border between the states of Oregon and Washington in the northwestern United States (figure 1). The AVA contains 122,822 hectares of which approximately 500 hectares are currently planted with wine grapes (Gregutt, 2007). Viticulture within the AVA is rapidly expanding and tens of hectares of new vineyards are planted each year. As the name implies, the AVA is centered on a broad valley drained by the Walla Walla River and it's tributaries, which arise in the Blue Mountains and flow generally westward toward the Columbia River. The southern edge of the valley is bounded by Vansycle Ridge, a linear 300 m-high escarpment. The AVA boundary follows the 450 m topographic contour line along the face of this escarpment. The eastern boundary of the AVA follows the 610 m (2000 ft.) topographic contour line in the foothills of the Blue Mountains. In contrast to the steep escarpment forming the southern side of the valley, the northern side slopes gradually, and the AVA boundary in this region consists of straight-line segments that encompass the rolling hills that lie within 15 km of the Walla Walla River and Mill Creek, a major tributary. The western boundary of the AVA consists of straight-line segments that cross the Walla Walla River at a point near where the valley is constricted between Vansycle Ridge and a ridge known as Nine Mile Hill.

Elevations in the Walla Walla Valley AVA range from 610 m on the eastern boundary in the foothills of the Blue Mountains to 100 m where the Walla Walla River crosses the western boundary. This relief produces a large variation in growing season temperatures that enables the cultivation of a wide range of cultivars of `Vitis vinifera` including grenache, sangiovese, cabernet sauvignon, syrah, pinot noir, and gewürztraminer. Meinert and Busacca (2000), using seven years of climate data from a single vineyard located at an elevation of 240 m near the center of the AVA, reported growing degree-day (GDD) (10°C) values ranging from 1480 to 1830 for the April to October growing season. Jones et al. (2003) reported long-term average GDD values ranging from 1370 to 1676 from seven weather stations. Jones et al. (2003) noted that temperatures and growing degree-days in the Walla Walla Valley AVA are strongly influenced by downstream narrowing of the valley, which creates nocturnal cold air pools. Although temperature inversions related to cold air pooling have been recognized as an important influence on viticulture in the Walla Walla Valley AVA, the details of these and other topography-related effects have not been well documented. As viticulture expands in the Walla Walla AVA, it is critical that the selection of new sites and appropriate cultivars be guided by knowledge of variations in parameters such as GDD, average growing season temperature, average ripening season temperature, and relative susceptibility to frosts and freezes.

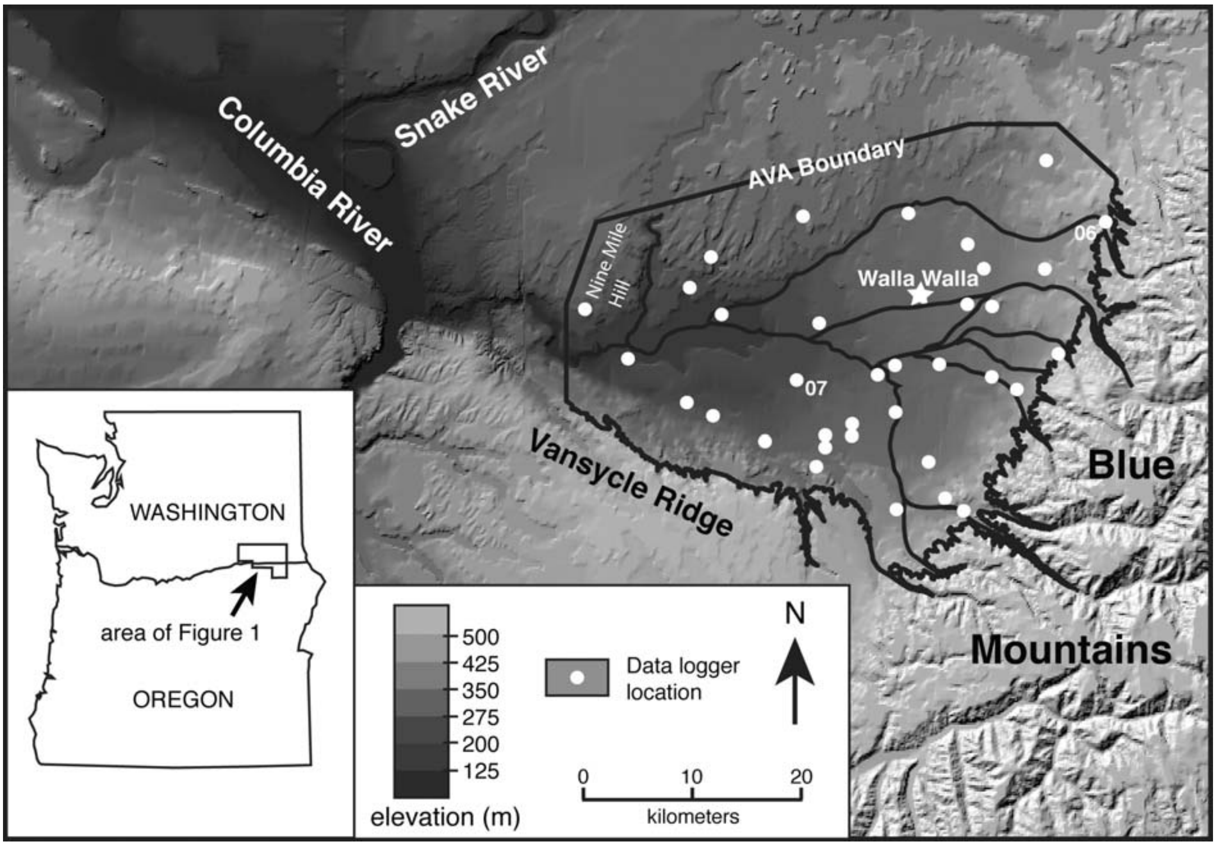

Figure 1 Digital elevation model of the Walla Walla American Viticultural Area showing locations of temperature data loggers used in this study.

Materials and Methods

To quantify temperature variations and map their distribution within the Walla Walla Valley AVA, we installed a network of 35 temperature data loggers in widely distributed locations during the summer of 2006. All but two of the data-logging stations were located in vineyards. Each station consisted of an Onset Computer Corporation HOBO© Pendant temperature data logger suspended inside an Onset RS-1 solar radiation shield. The data loggers were programmed to record the temperature every hour. Each sheltered data logger was mounted at a height of 1.5 m and, where possible, on the north side of the end post of a vineyard row. The location and elevation of each station were measured with a Global Positioning System receiver and altimeter. Information was gathered regarding the slope, aspect, and ground cover material at each site as well as its proximity to major streams.

The network of data loggers was in place by August 3, which coincided with the onset of véraison in 2006. Data were downloaded from the loggers in early November, at the conclusion of the grape harvest. In March of 2007, the batteries in the loggers were replaced and their memories reset in order to obtain a full growing season (April to October) of hourly temperature data. One new site (elev. 205 m, 07 on figure 1) was added at this time. Data from the loggers was downloaded in the field to a Macintosh laptop computer using HOBOware Pro© software which was also used to compute GDD using the high/low average method. Average temperatures were computed by dividing the sum of all hourly readings at each site by the total number of readings. One of the data loggers (elev. 614 m, 06 on figure 1) installed in 2006 malfunctioned in 2007 and its data was lost.

Results and Discussion

A graph of 2007 growing season GDD vs. site elevation (figure 2) shows no direct correlation between elevation and GDD. However, the sites where GDD were below 1800 tended to be above 400 m and sites where GDD exceeded 1900 tended to be below 300 m. A graph of July average temperature vs. GDD (figure 3) shows a distinct linear trend with approximately 100 GDD accumulated for each 1°C increase in average July temperature.

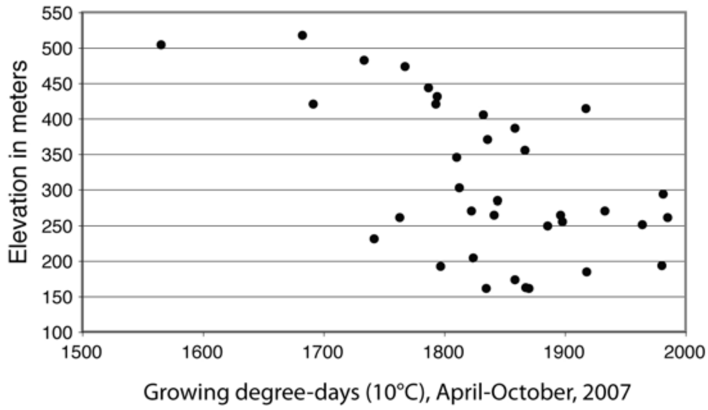

Figure 2 Graph of total growing degree-days for 2007 vs. elevation.

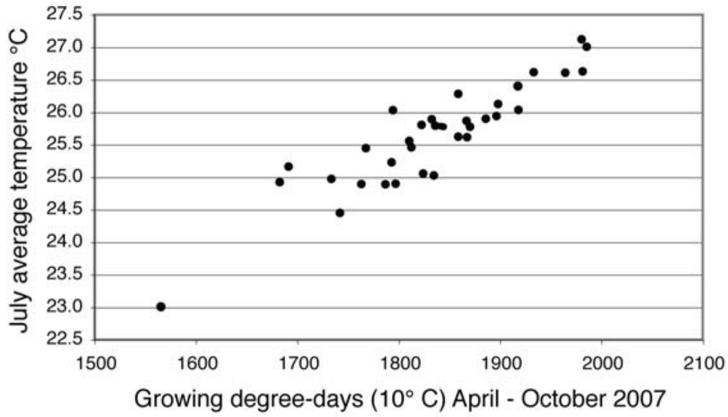

Figure 3 Graph of total growing degree-days for 2007 vs. July average temperature.

Comparisons of growing season average temperatures and GDD to ripening season (August to October) values of these parameters reveals some important relationships. A graph of the average 2006 ripening season temperature vs. elevation for each site (figure 4) can be divided into 5 fields. Most of the sites fall within field A, where average ripening season temperatures increase with elevation at a rate of approximately 0.7°C per 100 m up to an elevation of approximately 450 m. Above this level, average temperatures in field A decrease with elevation at a rate of approximately 1°C per 100 m. Fields B, C, and D contain sites that lie within 500 m of major streams. Average temperatures at these sites were 0.5°C to 2.0°C colder than sites at similar elevations in field A. Field E contains sites located along the base of Vansycle Ridge and one site on an isolated hilltop. Average temperatures at field E sites were 0.5°C to 1.0°C warmer than sites at similar elevations in field A.

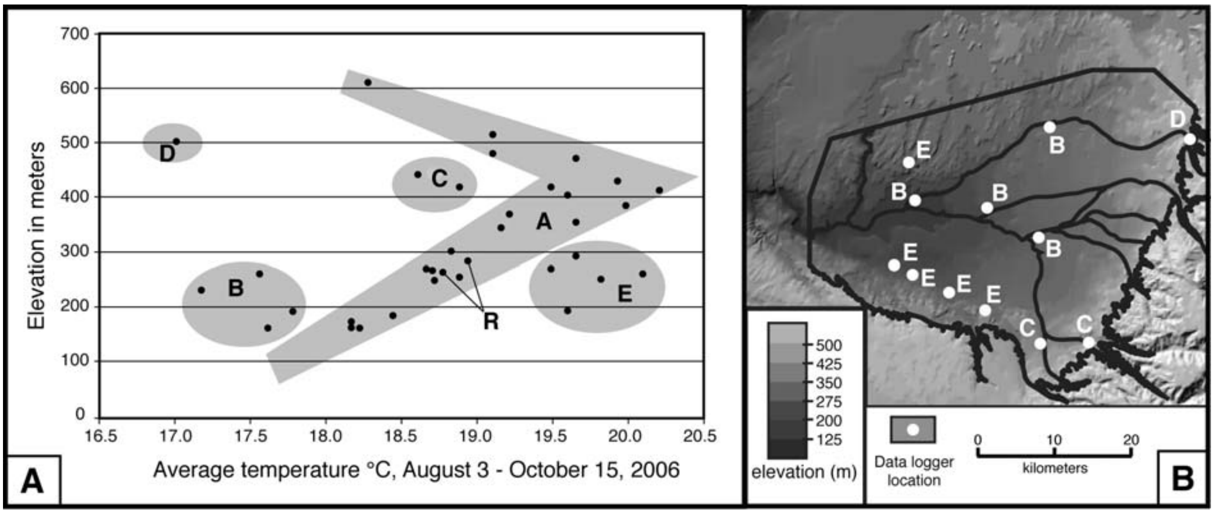

Figure 4 (A) Graph of average ripening season temperature for 2006 vs. elevation and (B) map showing locations within fields B, C, D, and E.

A graph of the difference between average 2007 growing season and ripening season temperatures vs. elevation for each site (figure 5) shows that average ripening season temperatures decrease relative to average growing season temperatures at a rate of approximately 0.25°C with each drop of 100 m in elevation. Growing degree-day values show a similar trend (figure 6) with sites at higher elevations accumulating a higher percentage of total growing season GDD after July.

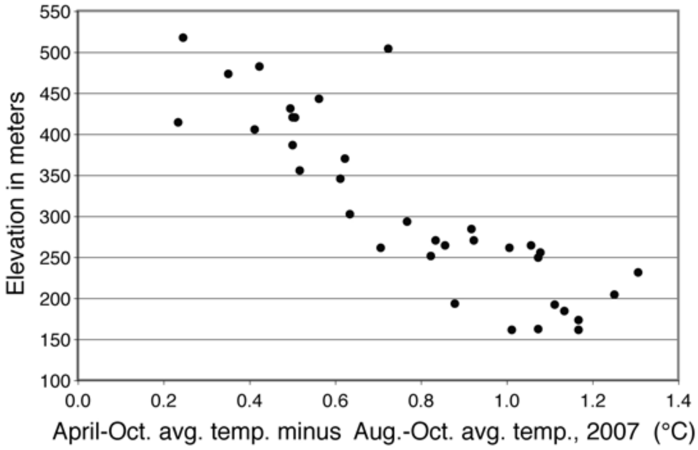

Figure 5 Graph of 2007 growing season average temperature minus ripening season average temperature vs. elevation.

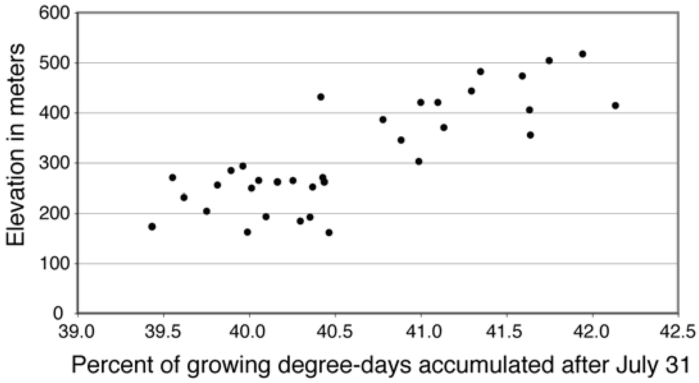

Figure 6 Graph of percent of total 2007 growing season growing degree-days accumulated after July 31 vs. elevation.

Freezing temperatures were first recorded at all sites on one of four dates in October of 2006 (figure 7). In general, sites at lower elevations experienced freezing temperatures earlier in the month.

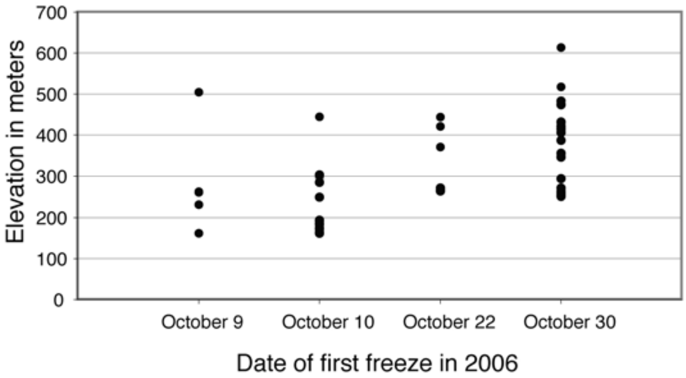

Figure 7 Graph of date of 2006 first freeze vs. elevation.

The graphs in figures 2 through 7 indicate that elevation is the most important control on temperature variation in the Walla Walla Valley AVA. The highest growing season GDD correspond with sites at low elevations and the lowest GDD values were recorded at the highest sites. However, the wide range in elevations with GDD between 1800 and 1900 reflects the importance of local topography and the fact that cooler late season temperatures partially offset very warm mid-summer temperatures at lower elevations. The points that lie to the left of the main cluster in figure 3 are mostly sites at higher elevations where a higher percentage of the total GDD are accumulated after July (figure 6). During the ripening season, average temperatures increase with elevation up to an elevation of approximately 450 m. Cold air draining from the Blue Mountains reduces average ripening season temperatures near major streams by at least 0.5°C, regardless of elevation. The anomalously warm ripening season temperatures recoded at sites near the base of Vansycle Ridge most likely result from adiabatic warming of the prevailing south-southwesterly winds as they descend the escarpment. These sites also recorded 4 of the 5 highest GDD values for the 2007 growing season.
During the ripening season, as daylight and sun angle decrease, the nocturnal cold air pool in the central Walla Walla Valley becomes cooler, deeper, and more persistent. The seasonal decline in average temperatures at sites below 300 m is thus more pronounced than at higher sites that are less affected by this phenomenon. Sites below 300 m also have an enhanced risk of damage from early frosts and mid-winter freezes. In 2006, many sites below 300 m were much more likely to have experienced freezing temperatures on earlier dates (figure 7). An invasion of arctic air in the winter of 2004 caused severe damage to many vineyards in the Walla Walla Valley AVA. In that year, only vineyards above 300 m yielded fruit. The thermal conductivity of surface materials is often mentioned as an important influence on vineyard temperatures. In particular, the ability of stony soils to store daytime heat and reradiate it during the night is often cited (White, 2003; Gladstones, 1992). In our study, however, no relationship was observed between ground cover material and the ambient vineyard air temperatures. For example, two of the sites (labeled “R” in figure 4) were in vineyards where the surface material is composed of dark-colored cobbles derived from the local basalt bedrock (Pogue and Dering, 2007). We had anticipated that these rocky sites would have average temperatures that were anomalously high for their elevations. However, in figure 4 they plot near the center of field A, with values typical for their elevation. We suspect that the data loggers might have been mounted too high to observe the effect and that infrared energy radiated by the rocks after sunset is blocked by the solar radiation shields that house the data loggers.

Conclusions

Gladstones (1992) noted that growing degree-days summed over an entire growing season are generally only useful as a first approximation of vineyard climate. This observation is certainly relevant to site selection within the Walla Walla Valley AVA. Many of the sites below 300 m with relatively high growing season GDD are potentially less suitable for warm climate or late-ripening varieties due to lower average ripening season temperatures and an enhanced risk of frost and freeze damage. Gladstones (1992) postulated that the optimal average ripening season temperature for wine grapes is approximately 20° C. In 2006, average ripening season temperatures above 19.5° C were recorded only at elevations between 350 m and 500 m or near the base of Vansycle Ridge, where descending air is adiabatically warmed. At all elevations, cool air draining from the Blue Mountains reduces average temperatures and increases diurnal variation at sites near major streams. Differences in the thermal conductivity of ground surface materials had no obvious effect on ambient vineyard air temperature at a height of 1.5 m.

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