

Story time: no grape needs heat in the ripening cycle

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Grape production dynamics

Some grapes, deemed delicate in constitution, are judged to be poor subjects for warm climates. Pinot Noir and Gewürtztraminer are good examples. Others may perhaps be more adaptable. This paper presents part of the case for the viewpoint that, if any variety is to show at its best, it needs favourable environmental circumstances during the ripening period and that this should be the first criteria for site selection where wine quality is of pre-eminent concern.

The environments supporting leaf and root activity are crucial determinants of the level of carbohydrate production in the leaves. However, an environment that maximises carbohydrate production, while it may produce the greatest fruit volume will not necessarily produce fruit of the highest quality in flavour terms. This production system can be compared to a leaky bucket. If the environment is unfavourable to flavour retention the leak is large and no matter how fast the inflow of the substrate for sugar and flavour production, sugar will accumulate, but critical flavour elements deplete. The flavours which are most adversely affected include acidity and aromatics.

What follows is a discussion of the economy of vine input/output relations in a real world situation of fluctuating temperatures. There is not much hard data with any claim to universal applicability to support this activity, so reliance must be placed to some extent upon observation and experience which is never complete, and some educated guesswork. Economics is like that, and so is farming.

Carbohydrate accumulation and disposition

Mullins et al (1992) describe an exercise where carbohydrate levels in the vine were assessed by whole vine harvest at roughly two-month intervals over the growing season. This yields information about the output of the vine at successive stages of its development. In Figure 1, prepared from their data, the two forms of carbohydrate present in the vine, starch and sugars are combined as grams of total carbohydrate. These were Chenin Blanc vines growing in Fresno, San Joachim Valley California. Necessarily irrigated in this dry climate, they continue to grow and produce new leaves throughout the season, even after harvest. Fresno is one of the warmest grape-growing climates in the world. The soils are 2.5 metres deep and fertile. Yields are high, the wine unpretentious.

Notice that ripening of the fruit is concurrent with the period of major carbohydrate output and accumulation. All vine organs continued to see an increase in their reserves in the

latest period with massive accumulation in the clusters, but not at the expense of other vine organs.

This pattern of accumulation can not be typical of locations where leaf age increases from mid season onwards and functional leaf area is static or reducing. In these conditions carbohydrate production during maturation will be truncated and, in compensation, some reduction in carbohydrate reserves in the woody parts of the plant may occur as reserves are, in part, transferred to the fruit as it matures. The speed with which massive amounts of sugar accumulate in the fruit in a short space of time suggests the significance of this process. Vines with large amounts of permanent wood in relation to crop have an advantage. Yields in following seasons may be more moderate if the vine goes into senescence with relatively low carbohydrate reserves. Budburst and crop development in the following spring will be relatively impeded. The plant is then likely to make less demand on the soil environment that supports it.

Where grape and wine quality is of pre-eminent concern, some movement away from circumstances favourable to productivity towards conditions more strictly suitable for superior flavour outcomes is obviously desirable. If very low temperatures are needed for the best flavour outcomes, leaf function and even the persistence of leaves on the vine may be at risk. This in turn may impact on the flavour spectrum in the grape with less of the vegetative compounds which originate in functioning leaves.

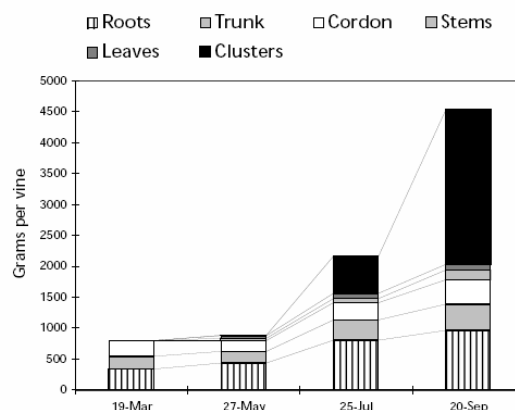


Figure 1. Accumulation of carbohydrate as sum of starch and sugar in parts of Chenin Blanc vines grown in Fresno California, as assessed by whole vine harvest at various dates. Source: Mullins et al.

Unfortunately, little is known of the pattern of carbohydrate accumulation in superior environments, its movement from woody tissues to the fruit, or indeed the environmental circumstances which favour the development of the most desirable flavours in the grape. The carbohydrate status of the vine at veraison, the crop level in relation to leaf area and the extent of leaf activity would seem to be key elements in this production system.

Leaf output at different temperatures

Figure 2 is extracted from Mullins et al (1992) originally dependent upon the work of Kriedeman published in 1968. Young but mature leaves with a high concentration of nitrogen produce more assimilate at higher temperatures than older leaves with less nitrogen. The highest rate for older leaves appears to be achieved at a temperature of 27°C, but there is little gain over the rate at 20°C.

Were temperatures in excess of 40°C to be sustained rather than intermittent, it is probable that carbohydrate production would cease and the vines expire. Figure 2, derived from field observations where high temperatures are transitory, can not therefore be taken as an indicator of performance where such temperatures are endured to a greater or lesser extent than in the site observed. It is therefore suggested that the shape of the curve at temperatures that induce stress in the vine, anything above the low twenties depending upon moisture and nutrient supply, relative humidity and wind speed, is rubbery.

Data for temperatures less than 22°C is not presented but it is known that photosynthesis is meagre at 10°C. Arguably temperatures between 15 and 20°C are highly favourable to moderate but sustained plant activity because, although the rate of photosynthesis may be appreciably lower, respiration demand and soil moisture depletion is less, and the slower work rate more sustained.

Low temperatures post veraison promote speedy maturation and acid retention

Consider Kliewer's (1968) experiment comparing the performance of potted vines, placed in a field, experiencing ambient temperatures with maxima of 41°C with other potted vines placed in a controlled atmosphere chamber where temperatures varied between 16.8 and 22.5°C. Humidity in the chamber varied between 60 and 80% and in the field was usually lower than 50%. Kliewer reported that the total number of degree days required in the chamber between veraison and maturity was from one third to one half of that required in the field. Maturity required no greater interval in terms of calendar days at the lower temperature and actually less in the case of 'White Riesling'. In addition the concentration of acid in the fruit at maturity was two to three times greater in the chamber than in the field.

Kliewer's experiment demonstrates that the movement towards maturity in vines, post veraison, is independent of temperature. It is definitely not compromised by the lack of thermal experience above 22.5°C. Critically however, fruit composition, in terms of an important flavour component, acidi-

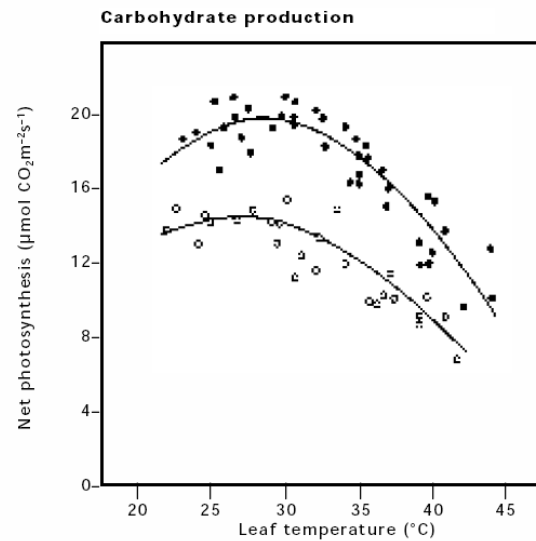


Figure 2. The temperature response curve of net photosynthesis for leaves of field-grown Thompson Seedless grapevines in the San Joaquin Valley of California. The solid circles represent mature leaves with a nitrogen concentration of approximately 32.0 mg N/g dry mass. The open circles represent older leaves with a nitrogen concentration of approximately 24.0 mg N/g dry mass. Source: Mullins et al (1992)

ty, is markedly influenced by temperature.

In Kliewer's controlled environment temperatures varied little, the air was still and relative humidity high. In some environments lower temperatures, high relative humidity and still air tend to be experienced together, whereas high temperatures tend to be accompanied by high wind speeds and low humidity (Happ 1999). Where this pattern does not prevail it is desirable that the relative contribution of these three factors should be separately assessed. To the extent that they move together it can be concluded that low temperatures in the range 16 to 22°C will favour fruit maturation and acid retention, and high temperatures can markedly interfere with vine functions and dramatically change fruit composition.

Kliewer pointed to the destructive effect of high temperatures on enzymes and chlorophyll in the leaves, which would affect the rate of carbohydrate production. Additionally, vine respiration competes with the fruit for the use of carbohydrate the more strongly as temperatures increase.

Hot sites need more degree days from bloom to maturity

Emphasising the non linear relationship between heat and grape maturity over the longer period from bloom to maturity McIntyre, Kliewer and Lider (1987) in a study of the ability of degree day measures to predict fruit maturity, found that Carignan required 1582 degree days from bloom to 20°Brix maturity at a warm (region 5) site as against 935 degree days at a cool (region 2) site. These authors point out that temperatures in excess of 30°C impair the physiological function of the vine.

Gladstones (1992) found that a summation of degree hours

between 10°C and 19°C provided a much better predictor of vine maturity dates than the simple summation above 10°C. Temperatures between 19 and 25°C are certainly not antagonistic to photosynthesis, as we have seen, and laboratory work suggests that growth is maximised at 25°C, Gladstones (1992). Thermal experience is never so tight about a mean however that periods of excess may be avoided. In a real world of fluctuating temperature, humidity and wind it appears that quite moderate temperatures, well below those where photosynthesis and growth functions are maximal, enable the vine to function with an economy of effort in terms of input utilisation (i.e. low levels of sunlight, moisture and nutrient are required at temperatures less than 20°C).

Despite the inefficiency involved in heat damage to plant function, warm sites reach a given degree Brix at an earlier calendar date than cooler sites largely because the season starts earlier and warm up is quick. Earlier maturity in moderately warm regions entails a warmer maturation cycle. In very hot regions earlier maturity can mean maturity prior to, during, or shortly after the warmest month, quite unfavourable conditions for plant function.

McIntyre et al (1987) measured degree days by digitising the area under a thermograph curve above a cut off of 10°C. This method should have the same accuracy as a degree hour calculation derived from a temperature logger measuring temperatures at frequent intervals. As these authors noted, a discrepancy of between a 6% and a 20% occurred when estimating degree hours from daily maximum and minimum temperatures. For a discussion of the critical issues involved in measuring the thermal environment accurately see Happ (1999).

The story thus far and its implications

The picture that emerges from the above is that the retention of natural acid in the grape at maturity depends upon avoiding temperatures above about 20°C. At higher temperatures the performance of the whole plant may be wound up, especially if all inputs can be supplied as required, but outputs at these higher temperatures are essentially different.

Fortunately this tension between quality and quantity can be resolved to some extent because a grape vine can do its growing and accumulate a carbohydrate surplus in summer warmth and mature its fruit in autumn when conditions are cooler. This simply requires that we choose our grapegrowing environments, and the varieties we grow, very carefully.

The speed of transition from the warmth of summer to the chill of late autumn varies with latitude and continentality and is mirrored by a similar transition in spring which affects the speed of establishment of the vines vegetative framework after bud burst. Grapegrowing environments vary in the consistency of conditions from year to year with low latitude west coastal environments having the advantage in temperate latitudes where air masses move west to east. This strongly affects the range of grape varieties that will mature under favourable conditions which in turn relates to considerations of commercial viability (Happ 1999, 2000). Grape varieties mature at different times as much as six to eight weeks apart

in a time of the year when temperatures may be rapidly falling. Varietal choice implies a choice of environmental conditions for the period of maturity; an adaptation available to all growers depending upon the range of varieties that can be reliably matured in their particular environment. This may mean, for a warm area, the choice between rather poor Pinot Noir (early ripener), and rather better Cabernet Sauvignon or Grenache (late). The Grenache can show superior flavour characteristics of the sort exhibited by Pinot Noir when it matures in an appropriately cool environment.

Most grapegrowers are happy with warm conditions for fruit maturation because warmth normally means the absence of damaging rain and freedom from disease. Unfortunately this is the hole in the bucket through which flavour escapes. The nature of this hole will now be addressed.

Aromatics are fugitive

Because we have difficulty identifying critical flavour compounds, let alone measuring them, it is very difficult to establish the relationship between all the elements of grape flavour and environmental variables. What we do know is that apart from compounds like sugar, salt, acid and phenolic bitterness the critically important flavour compounds that distinguish quality grapes are low in molecular weight, are experienced by us in the main as aromatics, are readily fugitive when the berry is crushed, rapidly oxidised to other substances on contact with the air, conditionally retained or converted to other substances during and after fermentation, and to a degree present in wines in compounds more stable than those which came from the berry itself. Aromatics are only perceived because of their fugitive, volatile nature. The grape berry intact is aromatic. Berry aroma is a functional attribute, a magnet for consumers. The grape berry is built in such a way as to enable it to continually deplete itself of its most attractive elements. This rate of depletion is temperature dependent. This is why we commonly store harvested fruits in a cool room or refrigerator. Logically a cool pre harvest environment would seem to be desirable for maximising aromatic intensity at harvest. Certainly, temperatures between 10 and 15°C should be superior in this regard to temperatures over 25°C. To the extent that temperatures are experienced in the unfavourable range, the hole in the bucket is larger.

The physics of escape strongly relate to temperature

The physics of evaporation of volatiles from grape berries are likely to relate to the following phenomena:

- Cell membrane permeability is two to five times greater for a 10°C rise in temperature according to Collander as quoted by Gladstones (1992).
- Water is continuously lost from berries at 1.7 milligram per gram per hour according to Peynaud and Riberau-Gayon (1971). This equates to a startling 25.8% of the berry mass per week. The rate of loss of lower molecular weight compounds is likely to be faster than water because the molecules are smaller.
- It is also possible that necessary compounds for flavour for-

However, cool ripening conditions are vital for success in any wine style that depends upon grape aroma and flavour for its palate impression. That qualification covers most of the field. Our first site screening should therefore be, for ripening temperatures. If we get that right, we know that our grapes will hold the flavour that they develop. The second could be perhaps for soil type and depth. The third could eliminate for frost, length of growing season, and the chance of damaging rain and so on.

Vine training influences shoot disposition and the extent of bunch shading. Fruit colour appears to vary directly with exposure but so does fruit temperature. This is a difficult situation without an answer that will be appropriate for all environments. Very hot environments demand shading to avoid premature raisining.

The proposition that no grape needs more heat in the ripening cycle than any other is difficult to test by checking flavour against temperature because we measure both flavour and temperature poorly. However it is more than satisfactorily tested by comparison of the 'Heat Load' encountered in locations producing wines of enduring reputation from a range of grape varieties. That task is pursued elsewhere (Happ 2000). While the method will bypass the task of identification and measurement of desirable flavour compounds it is nevertheless valid, and eminently useful to practical men of affairs.

A question of style, quality, palatability and price.

If strength of grape flavour, marked by fruit aroma, demands the absence of heat in the ripening cycle then its relative presence or absence will be associated with shifts in wine style. Other flavour shifts will be associated with changes in winery practice, for example the use of deliberate oxidation and surface yeast as in the Sherry process, or the use of barrels rather than tanks as fermentation vessels. Any source of flavour will influence style. There are no flavours however with quite the same ability to influence the palatability of a wine as those that arrive as well ripened grapes produced in a favourable environment. It is salutary to remember that in the long run perceptions of quality, price and palatability are strongly related.

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