Case study of vigour-based zonal vineyard management and phenolic variation in wine

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Precision viticulture technology (such as EM38 and plant cell density imagery) represents a sound approach to understanding spatial variation within vineyards and providing targetted management of these areas. This case study shows that using spatial mapping technology to guide differential harvesting can result in wines with different phenolic characteristics and might also provide insights into vineyard terroir.

Spatial variation within a vineyard is common because vines, like any plant, generally integrate the effects of their local environment (Proffitt and Winter 2008). Subtle variations in vineyard geology, geo-morphology, aspect, elevation and other meso-climatic influences are all components that can influence vine growth, fruit composition and terroir. According to Bramley (2005), "understanding and predicting the variability is important if vineyards are to be managed appropriately and fruit harvested at a ripeness to make a target wine style". Precision viticulture can effectively geo-reference and isolate areas of variation within a vineyard, which assists viticulturists and winemakers to consider how these differences might influence ripening and fruit composition.

The 2010-11 vintage in the Yarra Valley was notable for high rainfall. Figure 1 demonstrates the 2010-11 season rainfall compared with the lowest and highest recorded at the Bureau of Meteorology's Coldstream site (1994 and 2011, respectively). Of the seven growing season months listed, four were the highest recorded at the site. Consequently, the high seasonal precipitation had impacts for viticulture, as soil moisture content was generally at field capacity when ripening was under way. Therefore, management of vine vigour and phenolic ripeness were two areas we thought were particularly important to consider for viticulture.

The vineyard considered in this case study was a high quality Shiraz block located in Coldstream, which produces Yering Station's reserve fruit (PT-23 planted in 1996). Precision viticulture programs, such as EM-38 (with ground core truthing) and plant cell density (PCD) imagery, have been applied to the vineyard to provide management with potential insights into areas of uniqueness.

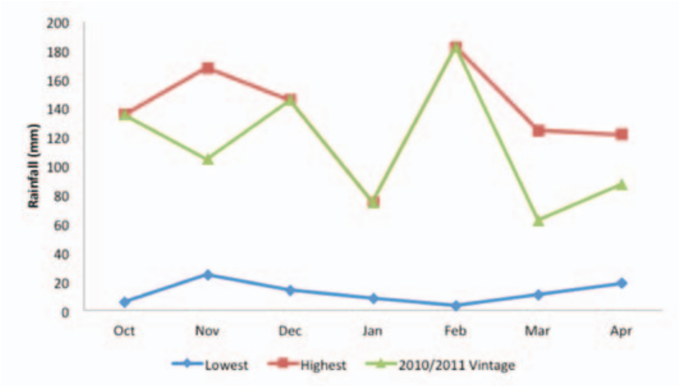

Figure 1. This representation of the 2011 vintage shows the 2010-11 seasonal rainfall from the Bureau of Meteorology, at Coldstream (number 86383), compared with the lowest and highest on record (1994 and 2011, respectively). October 2010, December 2010, January 2011 and February 2011 were all the highest months recorded at the station.

In support of this view, Trought and Bramley (2011) discuss the empowerment of viticulturists and winemakers to apply vineyard spatial variation knowledge to selectively harvest (and manage) with greater accuracy.

During the growing season there were obvious vigour differences in the block, which are identified in Figure 2 (see page 42). The EM38 and PCD images were reviewed and there was a putative association between electrical conductivity and vine vigour.

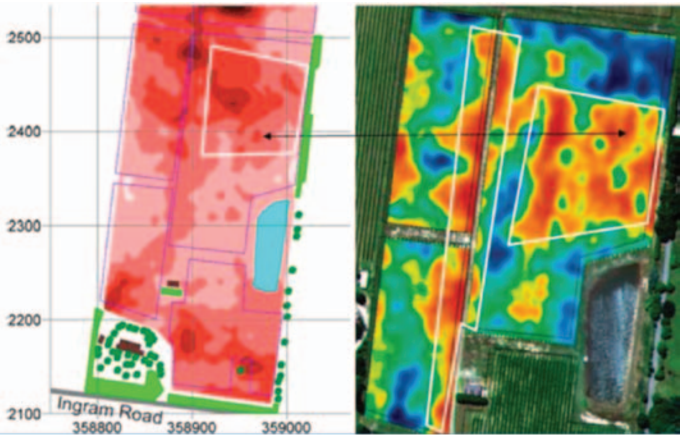

Figure 2. EM-38 (left), and PCD imagery.

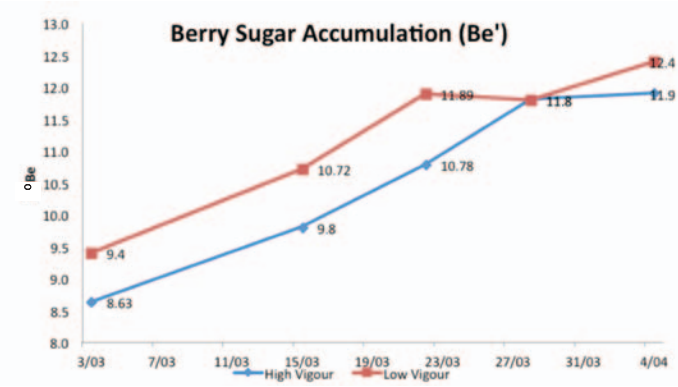

Figure 3. Ripening profile differences (°Be) between high- and low-vigour areas in Yering Station's Carr C Block.

Considering the high seasonal rainfall (Figure 1), areas of low vigour were deemed to be desirable, as there seemed to be higher levels of shoot-tip termination (with corresponding lowered vegetative growth), fruit exposure and opportunity for phenolic development. These images were loaded onto a GPS (Trimble Juno) and the block divided into two zones: high- and low-vigour (Figure 2). The zones were considered by Yering Station's winemaker (Willy Lunn) and viticulturist (John Evans) as two entities and assessed individually through the ripening process to determine whether there was sufficient difference in fruit composition and flavour to warrant differential harvesting.

During the ripening period, strategic maturity sampling of the zones showed variation in sugar accumulation (Figure 3). The 'low-vigour' areas started accumulating sugar earlier and the trend, over time, showed this zone to be consistently advanced in sugar ripeness. Following standard winery practice of regular laboratory analysis, in combination with vineyard-based berry tasting, there were sufficient differences in flavour and sugar ripeness between the two zones observed. Consequently, the zones were differentially harvested on the same day and wine was made under the same standard commercial protocols.

Upon sensory assessment of the wines from the two zones during maturation in oak, there were differences in the wines identified by the winemakers. Therefore, samples were sent to The Australian Wine Research Institute for phenolic analysis by its Commercial Services and Tannin Research teams.

PHENOLIC COMPOSITION OF LOW- AND HIGH-VIGOUR WINES

A broad look at phenolic composition showed two key responses as a result of the differential harvesting. Wines made from the low-vigour fruit had higher tannin and colour density

Table 1. General phenolic content and wine colour parameters for low- and high-vigour treatments in the 2011 vintage. The difference is that from high-vigour to low-vigour as a percentage.

Wine Colour	Low Vigour	High Vigour	% Difference
Tannin (g/L)	2.1	1.5	29
Anthocyanin (mg/L)	598	478	20
Non-bleachable pigment (a.u.)	2.4	2.1	15
Colour Density (a.u.)	13.5	10.3	24
Hue	0.57	0.59	-4
Total phenolics (a.u.)	68	55	19
Total red pigment (a.u.)	34	27	19

Table 2. Tannin composition from low- and high-vigour treatments in the 2011 vintage.

Tannin Component	Low Vigour	High Vigour
Mass conversion (%)[a]	62	59
mDP[b]	11	8
Molecular mass (subunit)[c]	3301	2360
Molecular mass (GPC 50%)[d]	1926	1615
Trihydroxylation (%)[e]	30	25
Galloylation (%)[f]	4.1	3.8

[a]Mass conversion based on the percentage recovery of tannin by phloroglucinolysis based on its concentration in wine using the methyl cellulose assay. [b]Mean degree of polymerisation in epicatechin units. [c]Molecular mass as determined by phloroglucinolysis. [d]Molecular mass as determined by GPC at 50% proanthocyanidin elution. [e]Per cent trihydroxylation of tannin as the percentage of epigallocatechin extension units, [f]Per cent galloylation of tannin as the percentage of epicatechin-gallate extension and terminal units.

(Table 1). The higher wine colour was found to be driven by the higher anthocyanin and non-bleachable pigments in the low-vigour wines. Since non-bleachable pigments contribute significantly to the visual perception of colour at wine pH, this will make a greater contribution than anthocyanins. It is likely that the higher tannin in the wines from low-vigour vines enabled enhanced development of non-bleachable pigment formation as polymeric pigment (tannin-anthocyanin complexes). This might show that there is a greater ageing potential in the wines from low-vigour vines.

Tannins are polymers, consisting of linked flavan-3-ol sub-units; the greater the number of sub-units, the larger the molecule, which is termed its molecular mass. The average length of the tannin chain also gives us an idea of the size of the tannin, which is its mean degree of polymerisation (mDP). This can be measured by breaking the tannin apart into its sub-units (Table 2). The analysis revealed that the tannin in the wines from the low-vigour vines was not only higher in concentration, but also had a higher mDP and molecular mass. The tannins in the wines from the low-vigour grapevines are, therefore, potentially more astringent. Another way to confirm this is by observing the rate at which tannin moves through a gel using a method called gel permeation chromatography (GPC) (Figure 4, Table 2). The material that easily flows through the gel (12 minutes) is of a larger molecular mass, and that eluting later is of a lower molecular mass (18 minutes). Note that there was a greater amount of tannin in the wines from the low-vigour grapevines, as represented by the size under the curve, but it is also skewed toward 12 minutes, meaning the tannin is of a generally larger-size distribution than that from the wines from high-vigour grapevines.

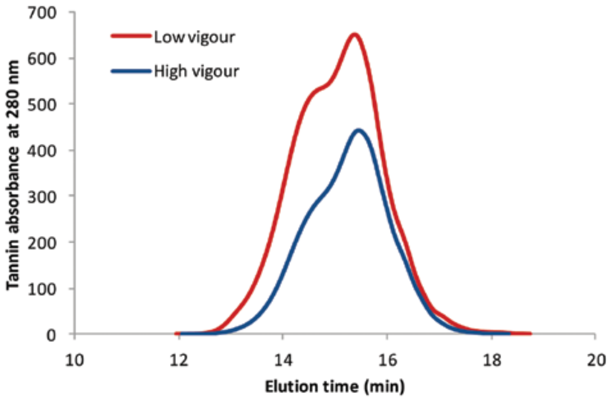

Figure 4. Gel permeation chromatogram of tannins isolated from wines from low- and high-vigour vines.

This finding begs the question, why? Tannin that ends up in wine is the net product of two processes during winemaking: extraction and loss (Bindon *et al*. 2010). Extraction is dependent upon what is available in the grape source and how easily it moves from the grape solids into the wine solution. Tannin is also potentially lost due to its ability to react with suspended solids in the ferment, which are derived from the grape pulp (Bindon *et al*. 2010). To provide clues as to where within the grape the wine tannin is derived, one can look at the sub-unit composition of the tannins. For the wines from low-vigour vines, there was a higher percentage of trihydroxylation (Table 2), which reflects a greater extraction of tannin from the skin. Interestingly, the percentage of galloylation was slightly higher as well, but a closer analysis revealed that this was due to the polymers being larger (results not shown). As such, this does not necessarily indicate increased tannin extraction from seeds in the wines from low-vigour grapevines. This finding for a low- and high-vigour study is not new, and similar work on Pinot Noir in Oregon has shown that increases in wine tannin in response to a reduction in vigour is a result of higher skin tannin extraction (Cortell *et al*. 2005). There has been found to be a positive correlation with enhanced skin tannin concentration in wines under low-vigour and the perception of wine astringency (Cortell *et al*. 2008).

CONCLUSION

Precision viticulture identified two distinct zones within a vineyard block (within rows), which were assessed through the ripening period of a high rainfall season. Results identified advanced ripening on the low-vigour zone, with phenolic analysis showing that a higher concentration of desirable phenolics occurred in wine, primarily driven by increases in skin tannin and anthocyanin. This might lead to the enhancement of the stabilisation of wine colour in a wet, 'low colour' vintage like 2011, with greater long-term ageing potential, a phenomenon to which enhanced skin tannin extraction might contribute. The results show that knowledge of vineyard vigour distribution derived from precision viticulture, enabling differential harvesting, is a management tool that might overcome difficulties under challenging climatic conditions.

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