The impact of differences in soil texture within a vineyard on vine development and wine quality

Impact des différences de la texture du sol dans un vignoble sur le développement de la vigne et la qualité du vin

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Abstract: Marlborough Sauvignon Blanc has rapidly gained an international reputation for style and quality. The extent to which this can be attributed to the climate, soils or vineyard management is at present unclear. However, the young alluvial soils of the Wairau Plains are considered to play an important role in determining this unique wine style. Marked changes in soil texture occur on the Wairau Plains over short distances. These changes reflect the historical braided nature of the Wairau River, and often run at right angles (east-west) to the north-south orientation of vineyard rows. Trunk circumferences were measured on whole rows of vines in a vineyard on the Wairau Plains to identify vines exhibiting different vigour levels. Vine vigour as reflected by trunk circumference and pruning weight was increased with the depth to gravel, while fine root density was greater in the gravelly phases of the soil profile. Vine phenology was more advanced where vines were growing on gravelly soils, in particular time of flowering (by 3 days), veraison (by 7 days), soluble sugars at harvest (by 11 days) and the onset of leaf senescence (by 60 days). We conclude that within a vineyard, the higher the proportion of gravelly soils, the more advanced the vine phenology and the riper the fruit and ultimately wine style will be on a particular date.

Key words : terroir, Sauvignon Blanc, soil texture, fruit development, vine phenology

Introduction

Achieving the optimal fruit composition at harvest to produce the perfect wine is the aim of most grape growers. However, there may be 8 to 10-fold differences in vine to vine yield within a single vineyard which in turn may impact on fruit composition (Bramley, 2005). Where the variation in maturity at harvest is large, it is likely that overripe and unripe flavours will be present in the fruit. Carroll *et al.* (1978) demonstrated how this may influence wine style by making wines from different maturity classes from a single population of grapes. The wines made from berries of optimum ripeness were considered to be superior to those from under-ripe or over-ripe fruit.

Soils of the Wariau Valley in Marlborough, are typical of the East Coast of the South Island of New Zealand. The soils are derived from greywacke alluvial deposits that generally consist of variable thicknesses of sandy to silty loams that overly gravels. Former river channels produce marked variation in soil texture, on average every 50 metres on a north-south transect across the valley (Rae and Tozer 1990). As the vine rows are generally planted north-south, these differences in texture can result in marked variation in vine development along a single row (Trought, 1996), which in turn impacts on fruit composition. When harvesting a vineyard, the differences in fruit compositions from individual vines are typically amalgamated into a single vineyard composition. Understanding the contribution of individual vines to this composition will help to manage vineyards to achieve optimum fruit style.

The advent of precision agriculture technologies in the vineyard such as global positioning systems (GPS), yield monitors on harvesters, electromagnetic soil surveys (e.g. EM38) and airborne remote sensing have identified the magnitude and extent of spatial variability (e.g. Bramley and Proffitt, 1999). However, the impact of this variability on the overall properties of the fruit composition from a vineyard is seldom considered (Vaudour, 2002). More work is needed to determine the consequence of variation in fruit composition on wine quality.

This paper summarises experiments that were conducted to measure and understand the impact of soil variation on vine development and fruit composition and to relate the field measurements to those obtained by remote sensing an EM38 soil survey. Our primary objective is to develop methods that allow us to predict the impact of soil variability and vine management on fruit composition and ultimately wine style.

Materials and methods

The trial site consisted of a 5.7 ha commercial vineyard on the north side of the Wairau Plains (173°53.35'E, 41°29'S). Grapevines (cv. Sauvignon Blanc, clone MS UCD1) grafted onto SO4 rootstock were planted in 1994**.** The rows were planted approximately north-south, with 2.4 m between the rows and vines planted 1.8 m apart within the rows. Trial plots consisted of four vines planted in bays between intermediate posts. The vines were trickle irrigated, trained to a 4-cane vertical shoot positioned system using foliage wires to maintain a narrow canopy approximately 0.4 m wide and 1.6 m tall. Normal commercial practice consisted of trimming the canopy to maintain these dimensions 3 times during the season and leaf plucking in the fruiting zone to expose fruit shortly after bunch closure.
Pest and disease management was achieved following NZ Sustainable Winegrowing practice (http://www.nzwine.com/swnz/). The under-vine area is kept weed free using herbicides while the inter-row is a closely mown sward of mixed herbaceous species.
The trunk circumference of all vines in eight rows of the vineyard was determined by taking the average of the circumferences 10 cm above the graft union and 10 cm below the head of the vine. We calculated the average circumference of vines in each four vine bay, excluding any bay that showed significant internal variability, which effectively removed any bays with replanted vines. We then chose six bays in each row to give a range of vine trunk circumferences (165mm XS-extra small; 176mm S-small; 187mm M-medium (2 bays); 202mm L-large; 220mm XL-extra large). Vine phenology and fruit development was monitored on the bays in each row. Four shoots in the canopy were tagged on one of the canes shortly after bud break, one at the base of the cane, two in the mid-cane area and one at the end of the cane. Percent cap fall was visually assessed every three days during flowering. The progression of veraison was measured on the same bunches by gently squeezing, to assess softness, four berries on each bunch at weekly intervals from the start of February until all fruit had completed veraison. A sample of 32 berries was also collected weekly from just prior to veraison to harvest, to monitor changes in fruit composition. Berries were weighed, gently crushed and free run juice extracted through a coarse filter. Soluble solids was measured by using an Atago, pocket PAL-l refractometer, titratable acidity using a Mettler Toledo DL50 autotitrator and pH electrode to an endpoint of pH 8.2 and the pH determined using a Metrohm 744 pH meter and electrode. Leaf senescence was measured using a Konica-Minolta SPAD-502 chlorophyll meter. At harvest, berries from four bunches were carefully removed from the rachis, by cutting through the pedicel of each berry. The berries were separated into 1 °Brix categories by floating the fruit in solutions containing a range of sugar concentrations from 14 to 27 °Brix. The number of berries in each category was recorded.
Shoot numbers were recorded after leaf fall and vines in the bay were pruned, with current and previous seasons fresh weights recorded separately. Average shoot weight was determined from the weight of the current seasons growth and shoot number.
An electromagnetic sensor (EM38, Geonics Ltd., Mississauga, Canada) in conjunction with a real time kinematics global positioning system (RTK-GPS) was used to measure and map the soil conductivity of the vineyard. The soil profiles were described in pits that were approximately 1.5m deep in the inter-row, one row away from the measured bays (to prevent root pruning of the measured vines). Soil temperature was measured every 2 seconds at a depth of 30cm, and averaged hourly.

Results and discussion

Vine trunk circumferences in the eight rows varied from approximately 130 to 250 mm. The trunk circumferences are not randomly distributed in the vineyard (figure 1) but correlate with EM38 values (Figure 2), which in turn reflect changes in soil characteristics determined by both aerial photographs and soil pits. Vines with extra small trunk circumferences grow in soils where the gravels reached the surface, while vines with extra large circumferences grow in silty loams. Vines with intermediate trunk circumference grow where silty loam overlies gravel. The number of fine roots and root density was greatest in the gravely soils. Higher soil temperatures (at 30cm) were recorded where gravels came to the surface of the soil profile (Figure 3). As the rows were planted approximately north-south and the historical river channels ran east-west, the variation in vines size was observed along single rows of vines within the vineyard.

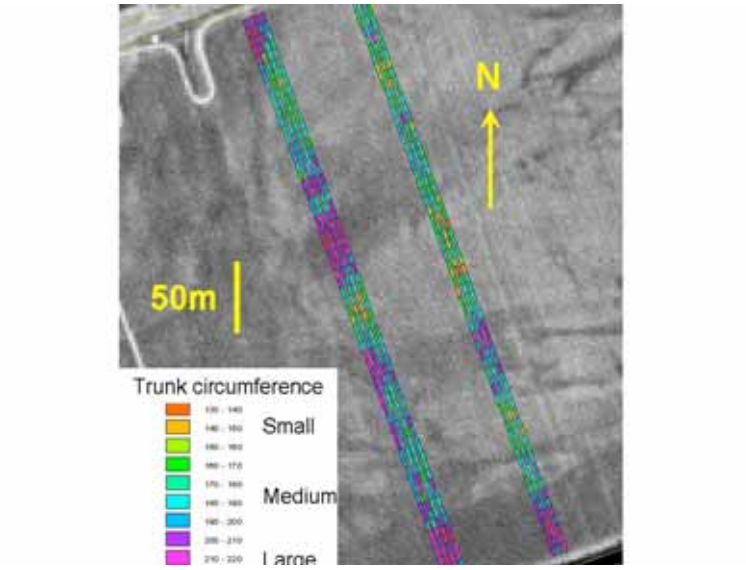

Figure 1 - Trunk circumference of vines superimposed on an aerial photograph of the vineyard (173°53.35'E, 41°29'S).

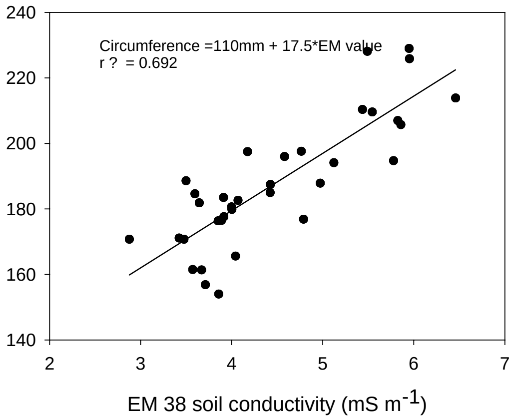

Figure 2 - Relationship between EM38 and trunk circumference

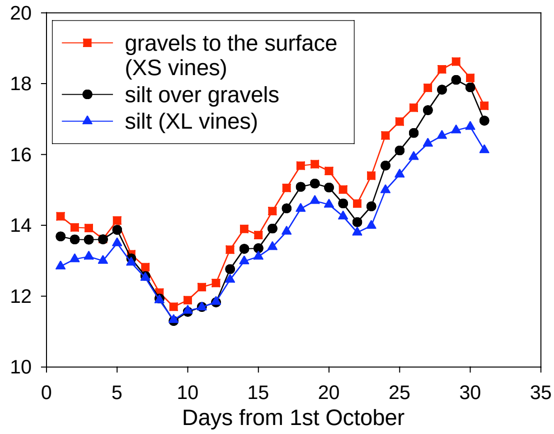

Figure 3 - Influence of depth to gravel on 30 cm soil temperature

Differences in vine phenology correlate with trunk circumference: When compared to the XL vines, vines with the smallest trunks (XS) flowered earlier (by about 3 days) (figure 4), and progressed through veraison earlier (by 7 days) (figure 5). Additionally, at harvest, on 19th April, XS vine fruit was riper with a higher soluble solids and pH and lower titratable acidity (table 1) and had achieved a target soluble solids 11 days earlier (figure 5). The density distribution of the fruit was also influenced by trunk circumference (figure 6). The distribution of berry density of the XL vines was approximately normal with a mean of 21.6 °Brix, while that of the XS vines was skewed to the left with a mean of 24.0 °Brix. Leaves in the fruiting zone on XS vines started to senesce 60 days earlier and chlorophyll concentrations were lower at harvest than those on XL vines (table 1). Likewise the XS vines had lower pruning weight, and lower average shoot weights, but slightly higher fruit yield (table 1).

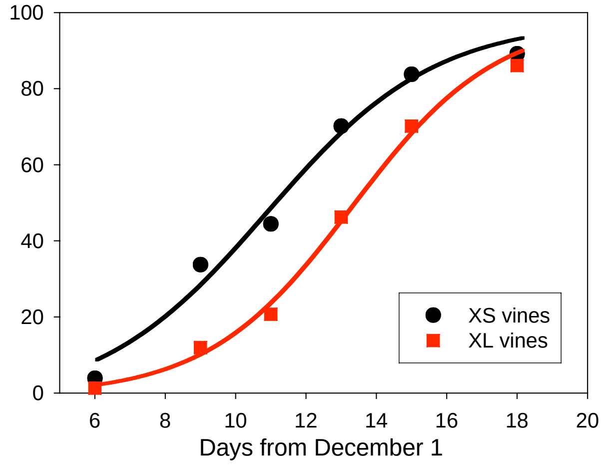

Figure 4 - Influence of trunk circumference on flowering progression

The differences in fruit composition at harvest had already been established by veraison (figure 5) and probably as early as flowering. While lower crop loads may advance vine phenology, the differences in phenology observed here can not be explained by vine yield, and were possibly more related to the differences in soil temperature that were observed in the vineyard. It is interesting to note that the rate of change in soluble solids post-veraison was similar across all trunk circumferences.

Using the berry density distribution data, and an understanding of the impact of soil texture on vine phenology and in particular fruit development, it is possible to evaluate the impact of differences in the proportions of soil texture on the soluble solids distribution of vineyards. This information may be used in a number of ways: For example, a vineyard that has 25% of XS vines, would have fruit density ranging from 18 to 27 °Brix, with a mean of about 21.8 °Brix. In contrast, a vineyard with 75% XS vines would have fruit density from 19 to 27 and a mean of 23.8 °Brix (figure 7), suggesting that there would be a riper style of wine from this vineyard. In some cases, vineyard areas may be managed differently (through irrigation, leaf removal, fertilization and/or harvesting) to minimize variation. Alternatively, understanding the different responses of various parts of the vineyard to factors such as water stress and the impact on fruit composition overall, will provide an opportunity to describe the consequences of different seasons on fruit composition and wine style from a particular vineyard.

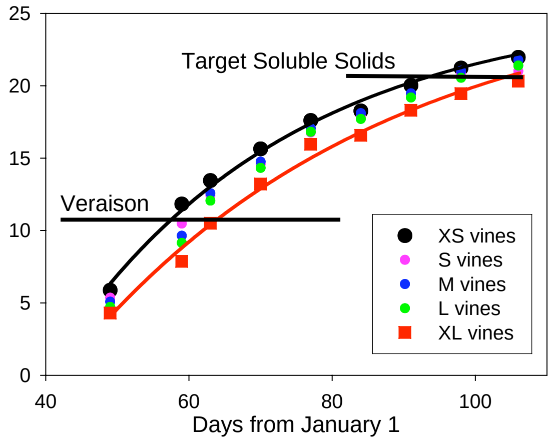

Figure 5 - Influence of trunk circumference on fruit soluble solids

Table 1 - Influence of trunk circumference on fruit composition, leaf senescence and pruning weights

	XS vines	XL vines
Fruit yield (kg/vine)	7.1	6.1
Harvest composition (19th April)		
Soluble solids (^{o}Brix)	22.0	20.3
Titratable Acidity (g tartaric acid/L)	8.55	10.41
pH	3.08	3.00
Pruning weight (kg/vine)	8.47	12.97
Average shoot weight (g)	64.6	107.9
Leaf chlorophyll levels at harvest (SPAD units)	28.8	41.9

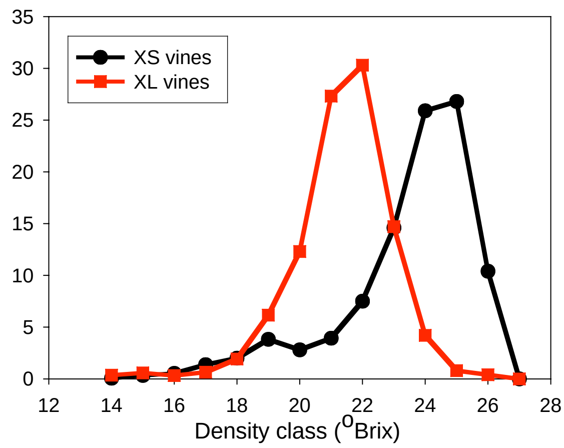

Figure 6 - Influence of trunk circumference on berry density distribution determined by floatation

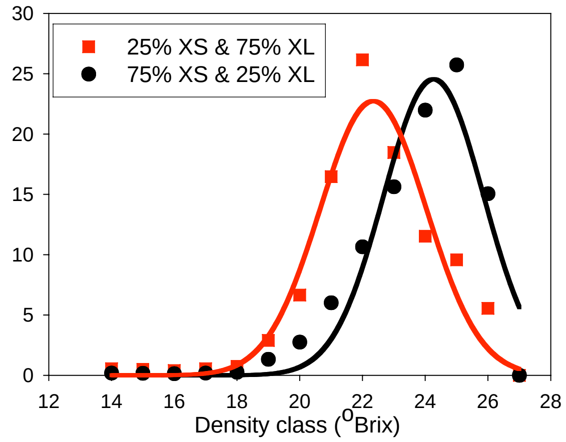

Figure 7 - Influence of different proportions of XS and XL vines on soluble solids distribution in the vineyard

Conclusion

Changes in soil conductivity mapped in a single vineyard using an EM38 electro-magnetic ground conductivity meter correlate with differences in the depth to gravels observed in soil pits using conventional soil mapping techniques, the vine trunk circumference and pruning weights of 12 year old Sauvignon Blanc vines. In the 2005 harvest year, the phenology of vines with small trunk circumferences growing in soils where gravels came to the surface (the XS vines) were more advanced from flowering onwards and that resulted in fruit having a higher soluble solids and lower titratable acidity at harvest than vines growing on silt soils with large trunk circumferences. The differences in phenology may reflect higher soil temperatures early in the growing season.

Identifying the differences in soil texture within a vineyard and the proportion of XS and XL vines in the vineyard impacted on the mean and density distribution of the berries. This can potentially reflect differences in overall fruit composition at harvest. The higher the proportion of gravelly soils in the vineyard and hence the proportion of XS vines in the vineyard, the riper fruit and the style of wine it will produce by a particular date.

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