THE IMPACT OF DIFFERENCES IN SOIL TEXTURE WITHIN A VINEYARD ON VINE VIGOUR, VINE EARLINESS AND JUICE COMPOSITION

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Abstract

Aims: The young alluvial soils of the Wairau Plains, Marlborough, New Zealand, are considered to play an important role in determining this unique wine style. The aim of this experiment was to investigate, within a single vineyard, the impact of soil texture on vine vigour, vine earliness and fruit composition.

Methods and results: Trunk circumference and pruning weights, were greater as the depth to gravel increased. Soil conductivity measurements, using an electromagnetic sensor (EM38) in conjunction with global positioning related well to vine trunk circumference. Where gravels came to the surface, soil temperatures measured at 30 cm depth were consistently higher by 1 to 2 °C (air temperature was unaffected) and vine phenology was more advanced, when compared to the deep silt soils. At harvest, fruit soluble solids and pH were higher and titratable acidity lower when vines grown on shallow soils, but soil type had no significant effect on fruit yield.

Conclusions and significance of the study: Vine phenology during the growing season and fruit composition at harvest but not yield, reflect changes in soil texture over quite short distances within vineyards on the Wairau Plains. Within a vineyard, the higher the proportion of gravelly soils, the more advanced the vine phenology and the riper the fruit and wine style will exhibit riper (more tropical) and lower unripe (herbaceous) characteristics on a particular date.

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

Résumé

Objectif : Les sols jeunes et alluviaux de la Vallée de Wairau, Marlborough, Nouvelle Zélande, jouent un rôle très important dans la détermination de la typicité du vin. L'objectif de ce travail est d'étudier, dans un vignoble, l'influence de la structure du sol sur la vigueur d'un pied de vigne, sa précocité et la composition du fruit.

Méthodes et résultats : La circonférence des troncs de vigne et le poids des sarments étaient plus importants avec la diminution de la profondeur de la couche de gravier. En utilisant un magnétomètre (l'EM 38), nous avons trouvé une bonne corrélation entre les valeurs de conductivité du sol et la circonférence des troncs de vigne. Les températures du sol mesurées à 300 mm de profondeur ont montré qu'elles étaient de 1 à 2 °C supérieures quand les graviers étaient près de la surface (La température de l'air restait inchangée.). La phénologie des vignes était plus avancée par comparaison avec les sols profonds limoneux. Lors de la vendange, la teneur en sucres (°Brix) et le pH étaient plus élevés, et l'acidité titrable plus basse, pour les vignes poussant sur des sols peu profonds. La nature du sol n'a pas d'influence sur le rendement.

Conclusions et signification de l'étude : La phénologie de la vigne pendant sa croissance et la composition du fruit lors de la vendange, et non le rendement, reflètent les changements de structure du sol sur des distances très courtes dans les vignobles de la Vallée de Wairau. Dans un vignoble, plus la proportion de sols graveleux est importante, plus la phénologie du vin est plus avancée, ce qui entraîne une bonne maturité du fruit et donc un vin avec des goûts plus mûrs et moins verts.

Mots-clés : terroir, Sauvignon blanc, structure du sol, développement du fruit, phénologie de la vigne

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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.

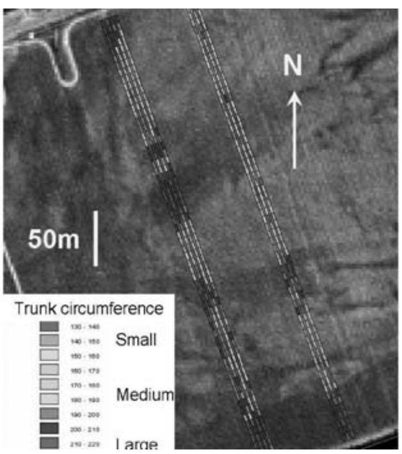

Fig. 1 - Trunk circumference of vines superimposed on an aerial photograph of the vineyard (173o53.35'E, 41o29'S).

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 and 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°3.35'E, 41°29'S). The native soils of the Wairau Plains are typically free draining with variable depths of surface horizons to gravel sub-horizons and of low fertility (pH 6.4, cation exchange capacity ~12 me.% (Anon, 1968). 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 wooden 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 hedging and topping the canopy to maintain these dimensions 3 times during the season and mechanical leaf removal in the fruiting zone to expose fruit shortly after bunch closure.

Pest and disease management was achieved following NZ Sustainable Winegrowing practice (http://www.nz wine.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 (165 mm XS-extra small; 176 mm S-small; 187 mm M-medium (2 bays); 202 mm L-large; 220 mm XL-extra large). Vine phenology and fruit development was monitored on the bays in each row. Four shoots in the canopy were tagged

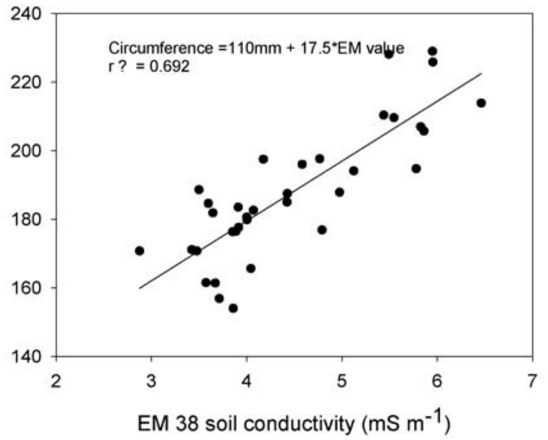

Fig. 2 - Relationship between EM38 (ECa) and trunk circumference

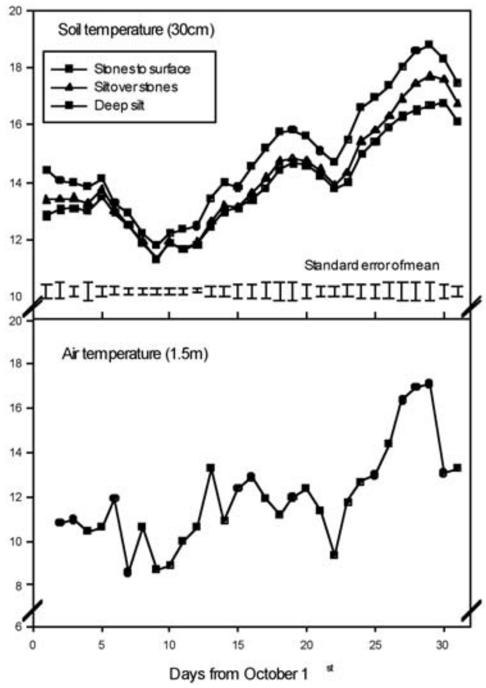

Fig. 3 - Mean daily air temperature and the influence of depth to gravel on soil temperature at a depth of 30cm

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 were 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 apparent soil electrical conductivity (ECa) of the vineyard. EM38 sampling density was approximately one reading per 10 m^2. Data points were kriged using Spatial Analyst (ESRI© 1999), using ordinary kriging. The soil profiles were described in pits that were approximately 1.5 m deep in the inter-row, one row away from the measured bays (to prevent root pruning of the measured vines).

Air and soil temperatures were measured on three plots of each trunk circumference category, using an arel-wire temperature sensor enclosed in a 75 mm stainless steel sheath with the sensing element at the tip. The temperature sensors were calibrated to (+/- 0.1 °C). A wireless mesh network (operating in the 2.4 GHz band) was used to transport the data central computer. Soil temperatures were measured at 30 cm deep on two plots of the XS, M and XL trunk sizes, and screens attached to the posts at a height of 1.5 m to measure air temperatures. Data was collected every minute and averaged over 24 hours.

Statistical analysis of the data was undertaken using Genstat 5, version 4.1. Graphs were produced using Sigmaplot version. 9, which was used to to smooth data in figure 7.

RESULTS AND DISCUSSION

Vine trunk circumferences in the eight rows varied from approximately 130 to 250 mm. The trunk

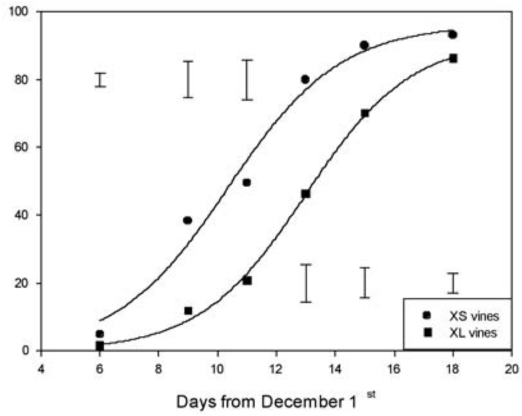

Fig. 4 - Flowering progression for two sizes of trunk circumference of vine

Vertical bars represent LSD P<0.05.

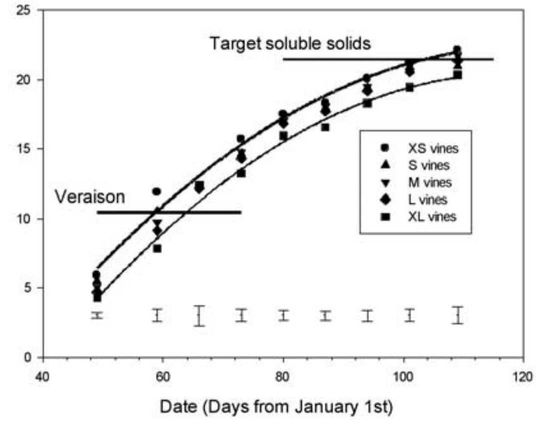

Fig. 5 - Accumulation of fruit soluble solids for various vine trunk circumferences

Vertical bars represent LSD P<0.05.

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 (Mills, 2006). Electromagnetic induction sensing of soils in New Zealand has been shown to relate well to soil-particle-size classes, particularly to soil clay percentage (Hedley *et al.*, 2004). Vines with extra small trunk circumferences grow in soils where the gravels reach the surface and EM38 values were low, while vines with extra large circumferences grow in silty loams with no stones to a depth of at least two metres and EM38 values were higher. 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 (Mills, 2006). As the rows were planted approximately north-south and the historical river channels ran east-west, the variation in vine size was observed along single rows of vines within the vineyard.

Higher soil temperatures (at 30 cm) were recorded where gravels came to the surface of the soil profile (Figure 3), possibly reflecting the higher thermal conductivity of the quartz versus other soil constituents (Monteith and Unsworth, 1990; McLaren and Cameron, 1993). Air temperatures were not significantly affected by the soil. While the soil temperature differences are relatively small, soil temperature is reported to advance bud break and shoot development (Zelleke and Kliewer, 1979; Woodham and Alexander, 1966) and at this time of the season, small differences in temperature may have a greater influence on root activity than similar differences later in the year. In our experiment, differences in vine phenology were correlated with trunk circumference and in turn spring soil temperature: 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 negatively skewed (more lower soluble solids fruit than expected) 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).

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 cannot 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 (Figure 6), and an understanding of the impact of soil texture on vine phenology and in particular fruit development (Figure 5), 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 °Brix and a mean of 23.8 °Brix (figure 7), suggesting that there would be a riper, less herbaceous style of wine from this vineyard.

Traditionally fruit composition at harvest has focussed on the mean values of soluble solids, pH and titratable acidity, however, it has been suggested that the variation around the mean may be important in determining final style (Trought, 1966). For example, relatively low proportions of low soluble solids (unripe) fruit may have a herbaceous character, considered detrimental in many wine styles, but contributing positively to the typical style of Marlborough Sauvignon blanc (Parr *et al.*, 2007). Thus managing the relative proportions of ripe and less ripe fruit may be important in determining final wine style. 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.

CONCLUSION

Changes in apparent soil electrical conductivity mapped in a single vineyard using an EM38 electromagnetic sensor 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.

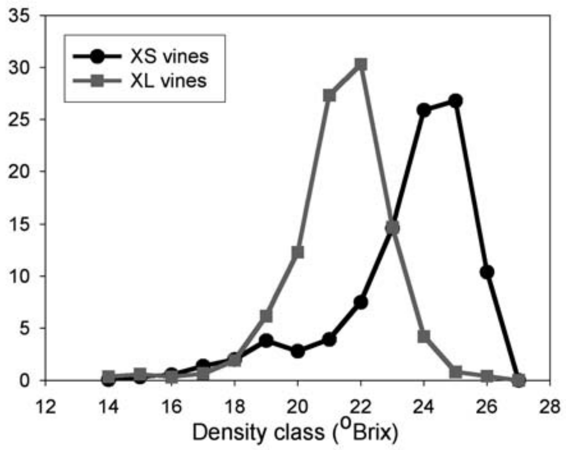

Fig. 6 - Berry density distribution determined by floatation for two sizes of vine trunk circumference

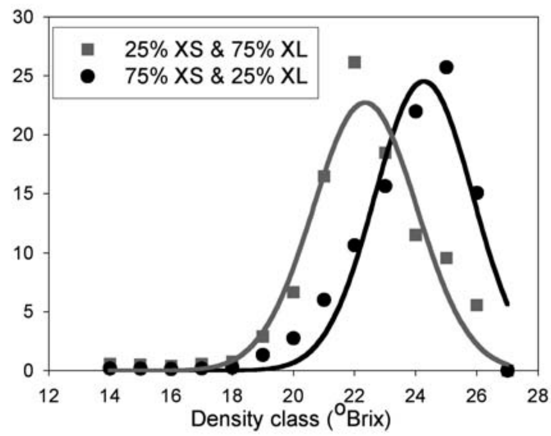

Fig. 7 - Soluble solids distribution for different proportions of XS and XL vines in the vineyard

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

	XS vines	XL vines	P
Fruit yield (kg/vine)	7.1	6.1	ns
Average bunch weight (g)	95.8	92.5	ns
Berry weight (g)	1.85	1.72	ns
Harvest composition (19th April)			
Soluble solids (°Brix)	22.1	20.3	0.032*
Titratable Acidity (g tartaric acid/L)	8.38	10.41	<0.001***
pH	3.09	3.00	0.014*
Pruning weight (kg/vine)	2.12	3.24	<0.001***
Average shoot weight (g)	64.6	107.9	0.003**
Leaf chlorophyll levels at harvest (SPAD units)	28.8	41.9	<0.001***

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 gravely soils in the vineyard and hence the proportion of XS vines, the riper the fruit will be on a particular date and the wine produced is likely to exhibit riper (i.e. more tropical) flavour and aroma and less unripe (i.e. herbaceous) characteristics.

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