CHANGING NEW ZEALAND CLIMATE EQUALS A CHANGING NEW ZEALAND TERROIR?

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1 INTRODUCTION

New Zealand is a long, narrow country in the South Pacific comprised of two main islands stretching between latitudes 34°S and 47°S. The predominant New Zealand winegrowing regions are within a latitude range of 38 to 45°S, and to the east of the mountain ranges of both islands which protect vineyards from the predominant strong westerly winds and in a rain shadow created by mountains (Figure 1).

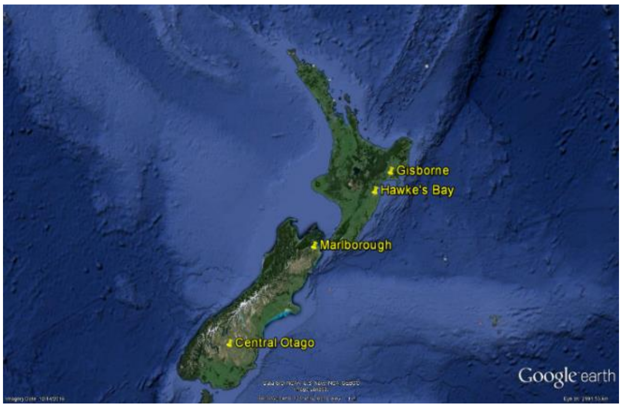

Figure 1: Predominant New Zealand winegrowing regions.

Internationally, high-quality wine grapes are grown within latitudes 35° and 50° and annual isotherms of 10 to 20°C (Jackson 2008), and niche climatic environments within this zone influence the development of flavour and aroma within the grapes and ultimately the wine. Differences in vine development and fruit ripening between wine grape cultivars have been characterized by using temperature-based models to predict phenology (Parker et al. 2013, Duchêne et al. 2014) or by classifying varieties according to temperature groups (Gladstones 1992, Jones et al. 2005). This temperature grouping is based on the ability of varieties to achieve an optimum balance of primary and secondary metabolites when mature, which in turn determines wine style. While it is not possible to define the ideal climate for fine wines, the best expression of a grapevine variety occurs when full ripeness is reached at the end of the growing season (van Leeuwen and Seguin 2006). If the environment is too warm, the development of flavour may be decoupled from acidity (Duchêne et al. 2014) and secondary metabolites (Sadras and Moran 2012), resulting in a negative effect on wine quality (Jones et al. 2005).

Generations of viticultural experience have resulted in identifying the environment best suited to a particular grape variety and wine style. As a result, traditional wine regions of the world are associated with specific cultivars. However, a predicted increase in global temperatures associated with climate change has the potential to cause either a shift (generally away from the equator) in the optimum latitude for a particular variety or alternatively a change in the variety grown in any particular region (Jones et al. 2005; Moriondo et al. 2013). An alternative approach to adapting to higher temperatures is to adopt management practices that may change the phenology. For example, spur-pruning vines late in the winter (at about the time of budburst) can delay the onset of budburst by eight to 11 days (Dami et al. 1997, Martin and Dunn 2000, Friend and Trought 2007) compared with traditional mid-winter pruning. This can in turn result in a delay in flowering and véraison dates of up to four or five days (Martin and Dunn 2000, Friend 2005). More recently, pre-véraison applications of 1-naphthaleneacetic acid (NAA) have been shown to delay véraison by 12 to 40 days, with similar effects on the time taken for fruit soluble solids concentrations to reach 20 °Brix (Böttcher et al. 2012, Ziliotto et al. 2012).

An alternative approach to delay phenology is to manipulate the leaf area to fruit weight (LA:FW, carbohydrate source-sink) ratio. Trimming the canopy of vines shortly after fruit set, to reduce exposed canopy area to less than 0.75 m^2/kg of fruit, can increase the time from flowering to véraison date by approximately 5 days (Parker et al. 2014), while trimming at fruit set or véraison will slow the rate of sugar accumulation (Parker et al. 2015). For example, a reduction of leaf area to 0.5 m^2/kg fruit slowed the rate of soluble solids accumulation by approximately 50%, delaying the date of harvest to a cooler part of the year.

The interim report from the International Panel for Climate Change (IPCC) indicated that average New Zealand temperatures had increased by 0.9°C since 1900 and are expected to rise by a further 0.8 to 3.5°C by 2100 (Hollis 2014). Recently, a seven-station time series of mean annual temperature for New Zealand showed a clear upward trend of around 0.1°C per decade between 1941 and 2010 (Sturman and Quenol 2013). However, there were differences between the various stations, and to evaluate the consequences of changes in temperatures from 1991 to 2015, the Grapevine Flowering Véraison (GFV) and maturity models were used to predict the date of véraison and of reaching the 20 ^{o}Brix soluble solids concentration threshold for the four main grape-growing regions in New Zealand. The effects of differences in the leaf area to fruit weight ratio on phenology and fruit development were measured and these results integrated into the phenology models to evaluate the extent to which temperature changes may be moderated by vine management. Results suggested that while reduced leaf area to fruit weight ratio may delay the date of véraison and soluble solids accumulation during ripening, it had little effect on acidity. To maintain the current sugar to acid ratio at harvest, further canopy management techniques (e.g. increased fruit shading) to increase acidity may need to be used in the vineyard to minimise the effect of warming on acids.

2 METHODS

Meteorological data from the regional meteorological station G 13495 (1991 to 2015) and the Grapevine Flowering Véraison (GFV) model (Parker et al. 2011, Parker 2012, Parker et al. 2013) were used to predict flowering, véraison (8.0 ^{o}Brix), and dates of reaching 20 ^{o}Brix values in Sauvignon blanc for four wine-growing regions: Gisborne, Hawke's Bay, Marlborough and Central Otago, representing the predominant geographic spread of vineyards in New Zealand. Using annual data, trend lines of the key phenological dates were determined, together with the mean daily temperatures of the period from véraison to 20 ^{o}Brix.

To investigate the consequence of manipulating phenology using viticulture techniques the leaf area:fruit mass ratio was altered in two ways.

1. Replicated trials were used to investigate the influence of leaf area:fruit mass ratio on véraison and/or fruit development. Pinot noir and Sauvignon blanc vines were trimmed to a range of leaf areas either shortly after fruit set or at véraison, and fruit soluble solids concentrations and titratable acidity were measured on samples taken weekly from before véraison to harvest (full details of the experiments can be found elsewhere – ((Parker et al. 2014, 2015, Parker et al. 2016).
2. Double Guyôt-trained vines, pruned each year to retain 24 nodes, were monitored from 2005 to 2014. The vines were selected by measuring the trunk circumferences of vines in a vineyard on the Wairau Plain, Marlborough (41^{o} 28'S, 173^{o} 53'E), and eight plots of four vines per plot were identified to be representative of average vine size in the vineyard. Vines were managed in a similar way each year. Vines were trained using vertical shoot positioning (VSP), with an exposed leaf area height of 1.2 m, and trimmed to maintain a compact canopy. Vines were planted 1.8 m apart within the row, and 2.4 m apart between rows. Average flowering date was determined by monitoring all the inflorescences on one cane on a vine in each plot on a regular basis throughout flowering. Likewise, regular berry samples (at least weekly) were taken from before the date of véraison until harvest at a soluble solids concentration value of 21.5 ^{o}Brix. The seasonal flowering and véraison (8 ^{o}Brix) dates were interpolated by fitting, respectively, three-parameter Gompertz or exponential rise to the maximum curves to the data using SigmaPlot v12.5. The mean ripening temperature was calculated from the sum of the average daily temperature [(maximum+minimum)/2], divided by the number of days from véraison to the date of reaching soluble solids concentration of 20 ^{o}Brix.

The data collected from the Marlborough vineyard were used to validate the GFV véraison date estimate and to investigate the seasonal effect of vine yield on the time from véraison to harvest at soluble solids concentration of 21.5 ^{o}Brix.

3 RESULTS AND DISCUSSION

The date at which fruit reaches a target soluble solids is determined by the date of véraison (onset of ripening) and the rate of soluble solids accumulation from that time. The Grapevine Flowering Véraison (GFV) model predicted the date of véraison with an acceptable (± 4 days) degree of accuracy over 10 growing seasons in our monitored Marlborough vineyard (Figure 2), although the predicted véraison date was slightly later than observed in the seasons with early fruit maturity (2004 and 2006), and earlier in the seasons with later fruit maturity 2005 and 2009).

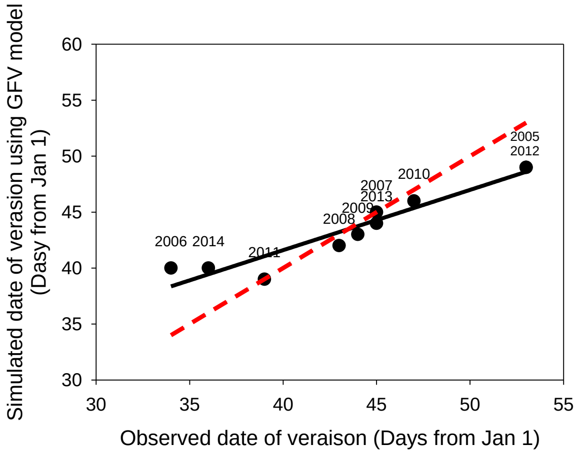

Figure 2. Relationship between observed (8 oBrix) and simulated verasion date using the GFV model on a monitored Marlborough vineyard. The red dotted line is the 1:1 relationship

The véraison (8 °Brix) dates of Sauvignon blanc in Marlborough, simulated by the GFV model, advanced by 0.4 days per year over the period from 1991 to 2015 (Figure 3). This is intermediate between those simulated for Gisborne, Hawke's Bay and Otago (0.3, 0.2 and 0.5 days per year, respectively) (Figure 3).

Similar advances (0.3, 0.2, 0.6 and 0.9 days per year for Gisborne, Hawke's Bay, Marlborough and Otago respectively) in the simulated date at which the fruit would reach soluble solids concentration of 20 °Brix are predicted as per Parker (2012) (Figure 4).

Despite a simulated earlier ripening, the average daily temperature during the ripening period (véraison to harvest) is predicted to remain within the temperatures currently experienced in Gisborne and Hawke's Bay. However, the average ripening temperatures in Marlborough and particularly Central Otago are predicted to have increased by 1.8 and 3.8 °C, respectively, over the 25 years studied (Figure 5).

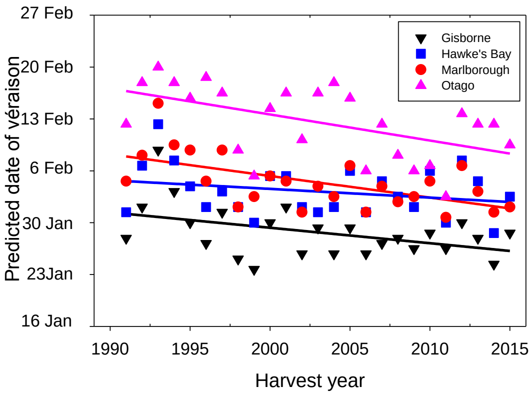

Figure 3. Simulated véraison dates for Sauvignon blanc in Gisborne, Hawke's Bay, Marlborough and Otago predicted from regional meteorological stations and the GFV model.

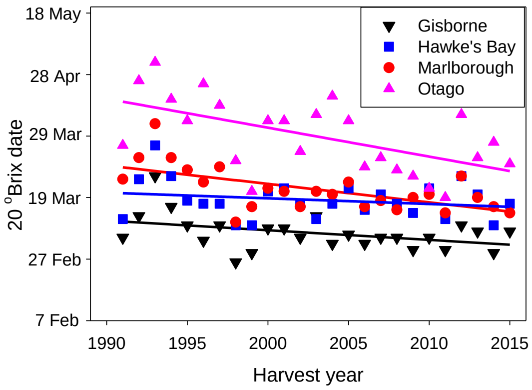

Figure 4: Simulated date of fruit reaching 20 ºBrix, using the Parker maturity model and temperature data from regional meteorological stations.

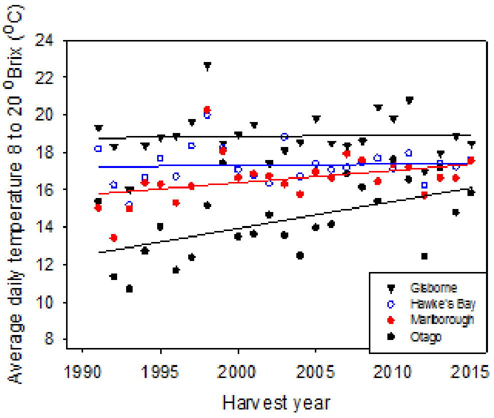

Figure 5: Simulated seasonal changes in the mean daily temperature during ripening of Sauvignon blanc. The date of véraison and of fruit reaching soluble solids contents of 20 ºBrix were simulated for each year and site using the GFV model. The mean daily temperature was calculated between these dates.

Manipulating the start and duration of ripening

While phenology is largely controlled by temperature, grapevine véraison date and fruit development can also be slowed in the vineyard by various techniques (see Introduction). Of these, reducing the leaf area:fruit mass ratio (Parker et al. 2014, 2015) has received significant attention. In experiment 1, marked differences in the date of véraison could largely be attributed to temperature (Figure 2). However, the rate of soluble solids accumulation from véraison to 21.5 ºBrix was predominantly determined by vine yield (Figure 6). The duration from 8 to 21.5 ºBrix increased by approximately 5 days per 1 kg of additional fruit yield over the range 3 to 7 kg per vine (Figure 6). This suggests that one way to counteract the consequences of warming may be to increase the vine yield, thereby extending the ripening period to a later cooler part of the growing season. For example, adding 2 kg per vine would extend the period of soluble solids accumulation from 8 to 21.5 ºBrix by 10 days, with the result that the average ripening temperature (over the same 8-21.5 Brix period) would be reduced by an average of 0.3ºC in Marlborough. However, while the average temperature may be marginally reduced, temperatures early in ripening are unlikely to be lower.

An alternative is to reduce the leaf area, either shortly after fruit set, or at véraison. Reducing the leaf area:fruit weight ratio delayed the date at which soluble solids concentration of 8 ºBrix was reached and slowed the rate of soluble solids accumulation (Figure 7). However, reduced leaf:fruit ratio had little effect on titratable acidity (Figure 7). As a consequence, despite the slowing of soluble solids accumulation, the sugar:acid ratio was quite different at a given soluble solids concentration.

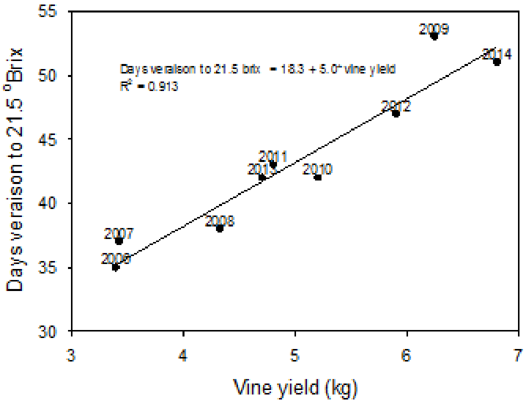

Figure 6: Influence of Sauvignon blanc grapevine yield on the duration of ripening (days of soluble solids accumulation from 8 to 21.5 ºBrix) in a monitored Marlborough vineyard for harvests 2006 to 2014.

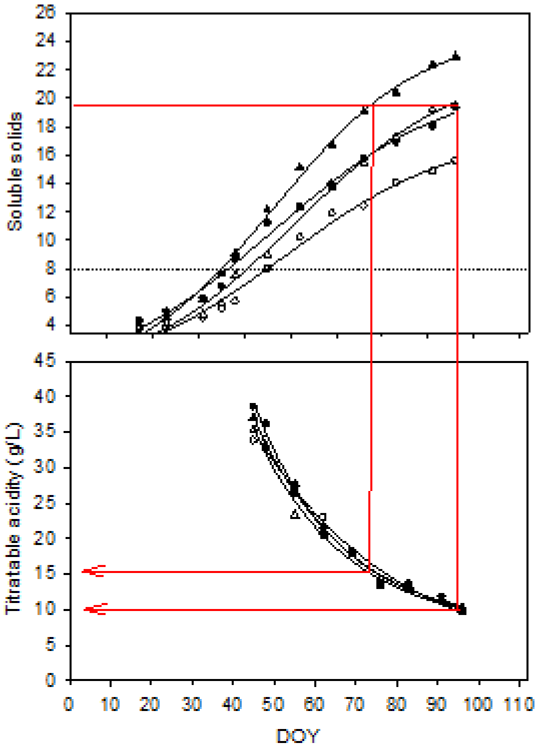

Figure 7: Influence of differences in leaf area:fruit weight ratio on Sauvignon blanc soluble solids and titratable acidity concentrations. ● 100% crop ▲ 50% removed. Closed symbols 12 leaves per shoot, open symbols 6 leaves per shoot. Each point is the mean of four replicates. Curves fitted using SigmaPlot v12.5. Trimming and fruit thinning undertaken shortly after fruit set. Red lines track the titratable acidity of fruit harvested on different dates but at the same soluble solids concentration from 12-leaf full crop and 6-leaf 50% thinned crop. Vines with full crop and 6 leaves did not reach an acceptable soluble solids concentration before fruit the final harvest date.

4 CONCLUSION

Using the GFV model, results suggest that vine phenology in New Zealand has advanced, particularly at higher latitudes, in the period 1991 to 2015 and that the temperatures during ripening (véraison to 20 ºBrix soluble solids concentration) are increasing. One method that may counteract the effect of this warming is a reduction in the leaf area:fruit weight ratio and a subsequent delay in véraison. This potentially enables fruit to ripen at temperatures similar to current conditions.

Results from experiments reducing the leaf area:fruit weight ratio, both by trimming canopies and by comparing inter-seasonal differences in vine yield, suggest that reducing the leaf area:fruit weight ratio may be used to delay and slow the time and rate of soluble solids accumulation. However, the trimming experiments indicated that titratable acidity was unaffected by trimming and significant differences in the ratio between sugar and acid concentrations may remain. To counteract the consequences of climate warming, techniques to slow soluble solids accumulation to enable ripening to occur in a later, cooler time of the year need to be linked to methods to compensate for the changes in other metabolites, to maintain the balance of metabolites in the fruit and consequently the wine.

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