Influence of retained cane number and pruning time on grapevine yield components, fruit composition and vine phenology of Sauvignon Blanc vines

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Abstract

Background and Aims: Traditionally, the start of cane pruning is delayed until after leaf fall, when carbohydrate accumulation and cane maturity are complete. However, by starting immediately after harvest, the period for pruning may be increased by at least 4 weeks, reducing peak labour demands. Trials were conducted to investigate the consequences of various pruning times on vine phenology and yield.

Methods and Results: Vines were pruned using 2- or 4-canes at one of four times during the winter from shortly after harvest to just before bud break in the spring. Pruning shortly after harvest caused no significant adverse effects on vine phenology or productivity. Pruning just before bud break delayed vine development. Stored total carbohydrate concentrations in the trunk were unaffected by pruning time or cane number retained after pruning.

Conclusions: Carbohydrates accumulated in the trunks of grapevines to adequate levels by harvest and any post-harvest photosynthesis and/or cane maturation that may be occurring at this time had little effect on subsequent vine growth and development. Pruning shortly before bud break delayed bud break and may be an advantage where vines are at risk to spring frosts.

Significance of Study: In cool climates where leaves senesce shortly after harvest, pruning immediately after harvest will have no adverse effects on subsequent vine phenology or yield, but will extend the period available to prune the vines, reducing the peak labour demand in the vineyard. Pruning late, slightly delays bud break potentially providing greater tolerance to late spring frosts.

Keywords: grapevine phenology, labour demand, productivity, pruning time, Sauvignon Blanc

Introduction

Seasonal labour demands in a vineyard generally peak at pruning. The labour requirement is particularly important in regions like Marlborough, New Zealand, where a relatively small local population (the population of Blenheim was 26 000 in 2008) is insufficient to meet the need to prune the vineyard area in production (15 915 ha in 2008, Anonymous 2008). Traditionally, the start of cane pruning in Marlborough is delayed until leaf fall, often two to six weeks after harvest. This is considered necessary, to enable accumulation of carbohydrate reserves in the trunks and roots of vines and to enable canes to become fully mature. However, research (Bennett et al. 2005) would suggest that most of the vines carbohydrate reserves have accumulated by harvest and while the vines may photosynthesise between harvest and leaf fall, lower temperatures, shorter days and the onset of senescence would suggest that rates of photosynthesis would be low and pruning soon after harvest is unlikely to adversely affect overwintering carbohydrate reserves. This is in contrast to vines growing in warmer climates, where photosynthesis can continue post-harvest, and starch and sugar accumulation in trunks can continue until leaf fall (Williams 1996). Achieving adequate overwintering carbohydrate reserves is important to ensure reserves are adequate to support uniform and rapid bud break and early shoot growth in the following season (Murisier and Aerny 1994, Smith and Holzapfel 2003).

Delaying spur pruning has been reported to delay the date of bud break, which can in turn reduce the susceptibility of vines to spring frost damage (Friend 2005), and result in higher yields (Barnes 1958, Coombe 1964, Bouard 1976, Whittles 1986, Friend and Trought 2007). Any advantages, particularly associated with the greater spring frost tolerance, have to be weighed against the consequences of shortening the period available for pruning, and increasing peak labour requirements. Unlike spur pruning, which can be done mechanically, cane pruning often requires a significant labour input.

We investigated the response of Sauvignon Blanc vines to cane pruning at different times during the winter, in particular how the timing influenced vine yield, phenology and overwintering carbohydrate accumulation with a view to assessing whether starting pruning early had an adverse effect on vine performance. Yield was manipulated by pruning vines to either 2-cane or 4-cane. This was done to determine the extent to which yield and pruning time interact and influence overwintering carbohydrate reserves and subsequent vine development.
Materials and methods

Sauvignon Blanc vines (4 years old at the start of the experiment in 2006) were pruned in three consecutive seasons to either 2-cane (20 nodes + 2 x 2 node spurs) or 4-cane (40 nodes + 2 x 2 node spurs) at one of four times: shortly after harvest, at two times during conventional winter pruning time (between June and August) and just before bud break in spring. Thus, the timing of pruning varied from 10 to 166 days after harvest (Table 1). After the first pruning in May 2006, the canes were cut, but the shoots were not removed from the canopy trellis until they had shed their leaves approximately 3 weeks later. Shoots of all treatments were then wrapped on the fruiting wires at the same time in late September. In subsequent years, pruning, stripping and wrapping was done on each pruning date.

Each pruning treatment was applied to five replicate plots (bays) of four vines in two rows of vines at the Marlborough Research Centre commercial vineyard (41°29'S; 173°57'E) in a randomised block design. Vines were planted 1.8 m within and 2.7 m between rows and grafted to Schwartzmant rootstock. Canes were lightly wrapped on fruiting wires, 0.9 and 1.1 m above the ground. Only the lower wire was used for 2-cane vines. Foliage wires were used to keep shoots in a vertical position and vines were trimmed two or three times during the season, at a height of 2.0 m from the ground and a depth of 0.5 m between the vertical faces of the canopy. Pest and disease management was achieved following Sustainable Winegrowing New Zealand guidelines (http://www.nzwine.com/swnz/). The soil was a Wairau-series well-drained alluvial silt/sand (Rae and Tozer 1990). The under-vine area was kept weed free using herbicides while the inter-row was a closely mown rye-grass sward. Vines were harvested shortly before commercial harvest at a soluble solids level of approximately 21.5°Brix.

Bud break and shoot development was assessed for the first month after bud break using the Bundesortsamenamt and Chemische Industrie (BBCH) phenology code system (Lorenz et al. 1995). Development was recorded every three or four days at all ten node positions along one cane on one vine in each plot. Likewise, flowering (anthesis) was visually assessed on the same ten nodes every 2–4 days from start to finish. The date of bud break was calculated by regressing quadratic polynomial functions of shoot development over time for each node position. The time at which the shoot reached BBCH stage 9 (bud break) was estimated from this data and used to test the effect of node position and pruning treatment on the date of bud break.

Fruit composition was measured at harvest. Berry samples (32 berries) were collected from each plot, cooled in an insulated box and analysed in the laboratory. The fruit was weighed and gently macerated by hand, coarsely sieved and the juice was re-suspended in 80% ethanol re-spun and supernatants were taken from the midsection of the trunk of one vine in each plot using a 5-mm trunk corer (Kymen Pin and Implement, Kouvala, Finland). Sampling from the midsection of trunks provides a representative sample of the overall CHO status of grapevine trunks (Bennett et al. 2005). The core samples (0.8 to 1.2 cm³ in volume depending on trunk size) were freeze dried and stored at −20°C until they were ground to a powder using a ring grinder (Rocklabs Ltd, Auckland, New Zealand). The carbohydrate analysis was undertaken on an approximately 50 mg subsample of ground wood. This was extracted using 80% v/v ethanol, with the addition of adonitol as internal standard, for 1 h at 60°C. Samples were centrifuged (spun to 4964 × g for 10 min) and supernatant decanted off. The residue was re-suspended in 80% ethanol re-spun and supernatants combined. The insoluble residue was transferred into Erlemeyer flasks and analysed for starch as per Smith et al. (1992). A subsample of the supernatant was dried using a stream of nitrogen gas. The sugars were analysed using DIONEX ICS-3000, Reagent-Free™ IC system, Dionex, Sunnyvale, California, USA with a CarboPac PA20 column. Standard sugars were used as a retention reference for peak identification for all sugars.

Data were analysed using general analysis of variance testing (Genstat v. 10, VSN International Ltd, Hemel Hempstead, UK). Means were separated using least significant difference testing (Genstat v. 10, VSN International Ltd, Hemel Hempstead, UK). Means were separated using least significant difference (LSD) at the 5% level of significance. The shoot data were analysed as a sub-plot of the pruning time treatments. Graphs were prepared and fitted curves calculated using SigmaPlot 9 (Systat Software Inc., Chicago, Illinois, USA).

Results and discussion

Results were generally similar for each growing season of the trial. Very late pruning in particular delayed bud break (Figure 1a) and flowering (Figure 1b) but had no consistent effect on yield (Table 2). The late pruning led to slightly lower soluble solids and higher TA at harvest (Table 2), suggesting the later flowering (Figure 1b) delayed the ripening processes, as early and very late pruning resulted in similar yields (Table 2). Early pruning had no adverse effect on vine yield or fruit composition in any season of the trial.

The sensitivity of buds to frost damage increases markedly at bud break (Sugar et al. 1992) and a later bud break may reduce the vulnerability of the vines to frost damage. However, in our

<table>
<thead>
<tr>
<th>Season</th>
<th>Harvest date</th>
<th>Early pruning</th>
<th>Normal pruning</th>
<th>Late pruning</th>
<th>Very late pruning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prune date 1</td>
<td>Prune date 2</td>
<td>Prune date 3</td>
<td>Prune date 4</td>
<td></td>
</tr>
<tr>
<td>2006–07</td>
<td>14/4/06</td>
<td>26/6/06</td>
<td>8/8/06</td>
<td>24/9/08</td>
<td></td>
</tr>
<tr>
<td>2007–08</td>
<td>16/4/07</td>
<td>26/6/07</td>
<td>19/8/07</td>
<td>27/9/07</td>
<td></td>
</tr>
</tbody>
</table>

DH days after harvest.
Figure 1. Influence of time of pruning on bud break/shoot development (a) and flowering (b) of Sauvignon Blanc in 2008. (Mean of all node positions). Note: BBCH 9 is considered to be bud break, DAH, days after harvest. Vertical bars represent LSD (least significant difference $\alpha = 0.05$). For clarity lines are fitted to early and very late pruning only.

Table 2. Influence of pruning time and number of retained canes on yield components and fruit composition of Sauvignon Blanc grapevines for the three growing seasons.

<table>
<thead>
<tr>
<th>Season</th>
<th>Pruning time (days after harvest)†</th>
<th>Cane number†‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early (10–20)</td>
<td>Normal (71–78)</td>
</tr>
<tr>
<td>Vine yield (kg)</td>
<td>2006–07 5.8</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>2007–08 7.0</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>2008–09 8.1†‡</td>
<td>7.1†‡</td>
</tr>
<tr>
<td>Bunches per vine</td>
<td>2006–07 67</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>2007–08 49</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>2008–09 61</td>
<td>57</td>
</tr>
<tr>
<td>Bunch weight (g)</td>
<td>2006–07 85</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>2007–08 147</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>2008–09 134</td>
<td>124</td>
</tr>
<tr>
<td>Berry weight (g)</td>
<td>2006–07 2.11</td>
<td>2.09</td>
</tr>
<tr>
<td></td>
<td>2007–08 2.29</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>2008–09 2.05</td>
<td>2.06</td>
</tr>
<tr>
<td>Berries per bunch</td>
<td>2006–07 67</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>2007–08 64</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>2008–09 66</td>
<td>60</td>
</tr>
<tr>
<td>Soluble solids (°Brix)</td>
<td>2006–07 21.0</td>
<td>21.2</td>
</tr>
<tr>
<td></td>
<td>2007–08 20.2</td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td>2008–09 21.8†</td>
<td>21.6†</td>
</tr>
<tr>
<td>Titratable acidity (g/L)</td>
<td>2006–07 10.6</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td>2007–08 9.47†‡</td>
<td>9.75†‡</td>
</tr>
<tr>
<td></td>
<td>2008–09 11.5</td>
<td>11.8</td>
</tr>
<tr>
<td>pH</td>
<td>2006–07 3.06</td>
<td>3.08</td>
</tr>
<tr>
<td></td>
<td>2007–08 2.98</td>
<td>2.97</td>
</tr>
<tr>
<td></td>
<td>2008–09 3.00</td>
<td>2.99</td>
</tr>
</tbody>
</table>

†Means within the same row followed by the same letter are not significantly different ($\alpha = 0.05$). ‡There were no significant interaction factors between pruning time and cane number.
trial, the delay in bud break and flowering (Figure 1) was small when compared to similar trials on spur-pruned vines (Vergnes 1981, Kasimatis and Vilas 1985, Whittles 1986, Friend and Trought 2007).

The majority of previous pruning time research has been carried out on spur-pruned vines. In many cases, later pruning delayed vine phenology, and yield was increased when compared with standard pruning time. This slowed fruit ripening and altered composition at harvest (Coombe 1964, Vergnes 1981, Whittles 1986, Friend and Trought 2007). While research suggests that later pruning delays bud break phenology, the work of Friend and Trought (2007) implied that late spur pruning suppressed buds at the base of last season’s unpruned shoots. Photographic evidence indicates that on unpruned shoots the development of apical buds were well in advance of the basal buds, suggesting that late pruning does not affect vine dormancy per se, but suppresses the development of basal buds. The most plausible reason for this is the action of correlative inhibition or acrotony (Lauri 2007) – the suppression of basal node growth by the apical dominance of developing apical nodes at the top of unpruned shoots (Howell and Wolpert 1978). In addition, spur pruning can be delayed much further into spring as swelling buds may be damaged by wrapping onto the fruiting wire during cane pruning.

The number of canes retained after pruning had no influence on bud break or the time of flowering (data not presented). Yields were higher when vines were pruned to 4-canes (Table 2), reflecting higher bunch numbers, and in 2007 only, higher berry and bunch weights. The higher yield resulted in lower soluble solids at harvest in each growing season (Table 2).

Bud break, shoot development and flowering were earlier at apical node positions on the cane (Fig. 2a,b), when compared to
shoots arising at the base of the cane. These responses were unaffected by the number of canes retained after pruning. There were no interactive effects of pruning time and node position. Where vines had been pruned early, the date on which a bud within a cane reached BBCH9 varied by 10 days from 5th to 15th October (Figure 2c). Bud break varied less when vines were pruned late.

Our results indicate that pruning shortly after harvest (before leaf fall) had little effect on trunk carbohydrate concentrations (Table 3) and no effect on bud break, shoot development or fruit yield and composition at the following harvest. Trunk carbohydrate concentrations were comparable to Chardonnay vines sampled at similar time of the year (Bennett et al. 2005). These results suggest that sufficient reserves of carbohydrate had accumulated by harvest and any post-harvest photosynthesis and/or cane maturation that occurred after the first pruning time (10–20 days after harvest) had little effect on the following seasons vine development. The results also suggest that frost events, which defoliate vines close to or shortly after harvest, are unlikely to cause adverse effects on CHO reserves and subsequent vine development in the following growing season.

Acknowledgements
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Table 3. The influence of pruning time and number of retained canes on over-wintering trunk carbohydrate reserves of Sauvignon blanc grapevines.

<table>
<thead>
<tr>
<th>Carbohydrate (mg/g Dwt)</th>
<th>Season</th>
<th>Early (10–20)</th>
<th>Normal (71–78)</th>
<th>Late (116–136)</th>
<th>Very late (144–166)</th>
<th>Cane number</th>
<th>Main effects probabilities§</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sugars</td>
<td>2006–07†</td>
<td>53.0</td>
<td>53.5</td>
<td>55.5</td>
<td>55.1</td>
<td>54.1</td>
<td>54.5</td>
</tr>
<tr>
<td></td>
<td>2007–08‡</td>
<td>23.7</td>
<td>26.0</td>
<td>27.1</td>
<td>24.5</td>
<td>25.6</td>
<td>25.0</td>
</tr>
<tr>
<td>Starch</td>
<td>2006–07</td>
<td>110.9</td>
<td>121.0</td>
<td>111.0</td>
<td>116.2</td>
<td>116.6</td>
<td>112.9</td>
</tr>
<tr>
<td></td>
<td>2007–08</td>
<td>138.4</td>
<td>149.0</td>
<td>131.7</td>
<td>145.9</td>
<td>143.9</td>
<td>138.6</td>
</tr>
<tr>
<td>Total carbohydrates</td>
<td>2006–07</td>
<td>164.0</td>
<td>174.5</td>
<td>166.5</td>
<td>171.2</td>
<td>170.7</td>
<td>167.4</td>
</tr>
<tr>
<td></td>
<td>2007–08</td>
<td>162.1</td>
<td>175.0</td>
<td>158.7</td>
<td>170.4</td>
<td>169.3</td>
<td>163.6</td>
</tr>
</tbody>
</table>

†Sampled on 23 August 2007. ‡Sampled on 16 September 2008. §There were no significant interactions.