Influences of pre- and post-veraison cluster thinning treatments on grape composition variables and monoterpenic levels of *Vitis vinifera* L. cv. Sauvignon Blanc

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Abstract

Grape composition plays important role for wine grapes in terms of wine grape quality. Besides, monoterpenes are a chemical class of compounds present in many highly aromatic *Vitis vinifera* L. cultivars belonging to Muscat family and some other special cultivars. One of these special grape cultivars is Sauvignon Blanc, and in this study, cluster thinning and its treatment times were used for a tool to increase quality attributes of cv. Sauvignon Blanc. The effects of cluster thinning times at different stages of berry development (B+4W (Bloom +4 Week), B+6W (Bloom +6 Week), B+8W (Bloom +8 Week), B+10W (Bloom +10 Week) and B+12W (Bloom +12 Week)) on grape quality and yield components of cv. Sauvignon Blanc grapevines were investigated during the vegetation period of year 2008. Crop reduction by cluster thinning was roughly 37.5% in yield per grapevine. 

Grape composition characteristics (FVT (free volatile terpenes), PVT (potentially volatile terpenes), TSS (total soluble solids), TA (total acidity), pH, contents of K+ and Na+) and yield components (berry width, berry length, berry weight, cluster width, cluster length, cluster weight) were variously influenced by cluster thinning times. In spite of differences in canopy density and cluster thinning times, grape composition and yield attributes were not statistically found to be significant except juice pH. Between pre- and post-veraison treatments, cluster thinning at B+8W especially improved grape quality characteristics of cv. Sauvignon Blanc.

Key words: *Vitis vinifera* L., cluster thinning, berry development, veraison, grape composition, monoterpenes.

Introduction

It is well-known fact that high-quality wines are generally obtained from wine grapes of vineyards having low to moderate yields based on variety and cultural practices 1-3. A lot of studies have shown that low crop level can increase quality attributes of wine grape 4-5 and yield reduction might lead to an increase of sugar, color and flavor in grapes at harvest 6-9.

Cluster thinning and basal leaf removal are two viticultural practices widespread used to improve grape composition. Previous studies have shown that these practices can be used to alter basic grape composition, particularly maturity indices such as TSS, pH and TA 10-14. Cluster thinning is an essential “maturing” and “quality” tool that should be especially practiced for colored grape cultivars grown in cool-climate regions and regions with short growing season 1, 15,16. It can be also used to advance the timing of grape ripening in white grape cultivars as well, including Riesling in South Australia 17 and Western Canada 16, 18.

Significant component of the typicity of “aromatic” grape cultivars is the monoterpenic aroma compounds, found in varying concentrations in many fruits including grapes. Monoterpenes are a chemical class of compounds present in many highly aromatic *Vitis vinifera* L. cultivars and can impart distinctive aromas and flavors to those cultivars belonging to the muscat family. Terpenes have been observed to be responsive to modifications to crop level 18,19.

As with many previous researches 20-22, terpenes began to accumulate in the berries before veraison, reached a maximum level shortly after commercial harvest and reduced when the berries became overripe.

Berry development in grapes consists of three main stages, respectively, pre-veraison, the lag phase and post-veraison. The post-veraison stage of berry development is associated with cell wall softening, anthocyanin accumulation in colored grapes and significant accumulation of fructose and glucose 23-25. Most of the studies on the assessing of volatile compounds in grapes have focused on the post-veraison stage. It is still unclear what happens to volatile compounds and their precursors prior to veraison, whether some potential aroma compounds are synthesized or sequestered during this period.

The goal of cluster thinning in wine grape growing is to adjust crop load, so grape ripening may be enhanced and potential wine quality may be improved. On the other hand, the treatment time of cluster thinning plays important role on berry growth and grape composition. The purpose of present study was to ascertain whether cluster thinning time performed at different stages of berry influence grape composition and monoterpenic levels of cv. Sauvignon Blanc.

Materials and Methods

Vineyard site and experimental design: The experiment was carried out during the vegetation period of 2008 on 15-year-old cv. Sauvignon Blanc grapevines grafted onto 5BB rootstock and planted in a hillside vineyard in Tekirdag, Turkey (lat. 40°55’N,
long. 27°25'E, 153 m. a.s.l.) on a clay-loam soil with a pH of 7.64. Grapevines were spaced 2.5 m \times 1.5 m (intra- and inter-row) in rows oriented north-south; trained to a bilaterial cordon and typically pruned to 12±1 nodes (6 spurs with 2 nodes, ~24 clusters) per grapevine and shoots were vertically trained.

The vineyard was managed according to local standard practices and no irrigation was used. In experiment region, climate is mild and annually means of temperature, sunshine duration per day, relative humidity and total rainfall were respectively 13.91°C, 6.23 h, 78.01% and 578.76 mm (long-term mean for the period of 1950-2007).

**Treatment times of cluster thinning:** At the beginning of current research, all grapevines had approximately 24 clusters, and clusters on each grapevine were removed at the different stages of berry development, reducing the number of clusters per grapevine to 15. Cluster thinning treatments consisted of removing clusters adjacent to the most basal clusters on the shoot.

The timing of cluster thinning treatments was carried out according to five following stages of berry development as follows: Bloom +4 Week (B + 4 W, ~pea-size berry); Bloom + 6 Week (B + 6W, ~14 day before verasion); Bloom + 8 Week (B + 8 W, ~7 day before verasion); Bloom + 10 Week (B + 10 W, 7 day after verasion); Bloom + 12 Week (B + 12 W, 13 day before harvest) (Table 1).

**Grape quality and yield components used in the experiment:** In current study, quality attributes such as monoterpens (free volatile terpenes, FVT (mg L$^{-1}$) and potentially volatile terpenes, PVT (mg L$^{-1}$)), total soluble solids (TSS) (°Brix), titratable acidity (TA) (g L$^{-1}$), K$^+$ content (mg L$^{-1}$), Na$^+$ content (mg L$^{-1}$) (Fig. 1), pH (Fig. 2) and yield components such as grape width (mm), grape length (mm), grape weight (g), cluster width (cm), cluster length (cm) and cluster weight (g) (Table 3) were assessed for cv. Sauvignon Blanc.

**Grape sampling and harvest:** Collections of grape samples were performed at 7 and 3 days before harvest (24th and 27th August 2008) and at harvest (31st August 2008). Samples of 250 berries were collected from each treatment replicate and eventually used to determine TSS, TA, pH and K$^+$ and Na$^+$ contents of grape. The 300-berry samples were used to determine the concentrations of FVT and PVT. All grape samples were stored at -25°C until monoterpane analyses and prior to monoterpane analyses, grape samples were removed from -25°C, allowed to thaw overnight at 4°C, and then homogenized in a commercial laboratory blender for 20 s.

**Laboratory analyses:** Monoterpane analyses (concentrations of FVT and PVT) were carried out on the grape samples from all three successive sampling dates using a previous method of Dimitriadis and Williams as modified by Reynolds and Wardle.

Na$^+$ and K$^+$ contents of grapes were determined by flame photometric methods according to Kacar and Inal.

**Canopy assessment:** Canopy point quadrat analyses were conducted to characterize canopy density at veraison. Twenty insertions per treatment replicate were performed at ca. 30° angles to the horizontal into the cluster zone with a thin 1 m-long probe at verasion. The number of contacts per insertion and the nature of each contact were recorded. Calculations were made from these data for leaf layer numbers, percentages of exposed leaves, exposed clusters and canopy gap (Table 2).

**Statistical analysis:** The experiment was established according to completely randomized factorial design with four replicates (two grapevines per replicate). All data were subjected to analysis of variance with TARIST pocket program. In order to separate means at p≤0.01, least significant difference (LSD) multiple range test was used.

**Results and Discussion**

**Variations in grape quality parameters:** Yield reduction might lead to an increase of TSS, color and flavor in grape at harvest. The time of cluster thinning in this study did not statistically affect grape quality parameters except pH. FVT, PVT, TSS, pH and

<table>
<thead>
<tr>
<th>Cluster thinning time (week)</th>
<th>Leaf layer number</th>
<th>Canopy gap (%)</th>
<th>Leaves Sun exposed (%)</th>
<th>Clusters Sun exposed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B + 4 W (Pea-size berry)</td>
<td>1.50</td>
<td>3.13</td>
<td>93.75</td>
<td>37.50bc</td>
</tr>
<tr>
<td>B + 6 W (14 day before veraison)</td>
<td>1.47</td>
<td>9.38</td>
<td>78.13</td>
<td>62.50ab</td>
</tr>
<tr>
<td>B + 8 W (7 day before veraison)</td>
<td>1.47</td>
<td>6.26</td>
<td>65.63</td>
<td>68.75a</td>
</tr>
<tr>
<td>B + 10 W (7 day after veraison)</td>
<td>1.53</td>
<td>0.01</td>
<td>76.25</td>
<td>46.88ab</td>
</tr>
<tr>
<td>B + 12 W (13 day before harvest)</td>
<td>2.07</td>
<td>3.13</td>
<td>62.50</td>
<td>3.13d</td>
</tr>
</tbody>
</table>

Means in a column followed by the same letter are not significantly different at the 1% level of probability, LSD range test (p ≤ 0.01). Means of sun exposed clusters are significant where the LSD at p ≤ 0.01 is 26.188.

<table>
<thead>
<tr>
<th>Time of cluster thinning</th>
<th>Berry width (mm)</th>
<th>Berry length (mm)</th>
<th>Berry weight (g)</th>
<th>Cluster width (mm)</th>
<th>Cluster length (mm)</th>
<th>Cluster weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>13.65</td>
<td>14.70</td>
<td>1.76</td>
<td>9.03</td>
<td>14.32</td>
<td>238.95</td>
</tr>
<tr>
<td>B + 4 W</td>
<td>13.50</td>
<td>14.38</td>
<td>1.73</td>
<td>8.93</td>
<td>13.99</td>
<td>245.54</td>
</tr>
<tr>
<td>B + 6 W</td>
<td>12.92</td>
<td>14.02</td>
<td>1.60</td>
<td>9.43</td>
<td>14.53</td>
<td>245.17</td>
</tr>
<tr>
<td>B + 8 W</td>
<td>13.66</td>
<td>14.73</td>
<td>1.80</td>
<td>10.04</td>
<td>14.35</td>
<td>299.84</td>
</tr>
<tr>
<td>B + 10 W</td>
<td>13.36</td>
<td>14.30</td>
<td>1.73</td>
<td>9.88</td>
<td>13.74</td>
<td>252.57</td>
</tr>
<tr>
<td>B + 12 W</td>
<td>13.35</td>
<td>14.39</td>
<td>1.71</td>
<td>8.38</td>
<td>13.56</td>
<td>207.26</td>
</tr>
</tbody>
</table>

Means in a column followed by the same letter are not significantly different at the 1% level of probability, LSD range test (p ≤ 0.01). Means of sun exposed clusters are significant where the LSD at p ≤ 0.01 is 26.188.

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**K**⁺ and **Na**⁺ contents of grape increased and TA decreased in over the grape maturation period of cv. Sauvignon Blanc (Fig. 1-2).

Varietal aroma is one of the vital grape quality factors and is characteristic for every grape variety. In contrast, “simple” or “non-floral” grape varieties like Sauvignon Blanc used in this research may have characteristic varietal aromas that are much more intense in wine after fermentation than in must. Free monoterpenes, which contribute directly to wine aroma and flavor, are less responsive to viticultural practices than the glycosylated (bound) forms, which are odorless until hydrolyzed either chemically or enzymatically. Fig.1 presents data for the production of FVT and PVT components in three following sampling dates of cv. Sauvignon Blanc. FVT and PVT levels of grapes were influenced by the times of cluster thinning in successive sampling dates. Grape samples from all cluster-thinned grapevines at different stages of berry development had higher FVT and PVT concentrations than control. Among the cluster thinning times, concentrations of monoterpenes in grapes increased from berry set to veraison and cluster-thinned grapevines at B+8W had the highest concentration of FVT (1.390, 1.737, and 1.830 mg L⁻¹) and PVT (3.410, 3.673, and 3.737 mg L⁻¹) in three sampling dates (p ≤ 0.01).

Influences of cluster thinning times on the TSS of cv. Sauvignon Blanc grapes are displayed in Fig. 1. Crop reduction in grapevine by cluster thinning has been previously shown to raise TSS. In current study, TSS did not differ significantly among the cluster thinning times and TSS content of grapes from grapevines thinned at B+8W was greater (24.08, 25.07 and 25.63 °Brix).

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**Figure 1.** Influences of cluster thinning times on FVT concentration (mg L⁻¹), PVT concentration (mg L⁻¹), TSS (°Brix), TA (g L⁻¹), K⁺ content (mg L⁻¹), Na⁺ content (mg L⁻¹) of cv. Sauvignon Blanc.
Yield components were not statistically affected at 1% level by the time of cluster thinning at harvest time (Table 3).

Dokoozlian and Hirschfelt\textsuperscript{10} reported that the time of cluster thinning had relatively little impact on berry size at harvest. Grapevines thinned between pre-bloom and 4 weeks after berry set had similar berry weights at harvest, while no significant difference in the berry diameter of cluster thinned and control grapevines was found. A portion of this increase may be attributed to the higher TSS of grape from thinned grapevines. In present study (Table 3), cluster thinning at B+8W tended to cause higher berry width (13.66 mm) than control and other times of cluster thinning (p ≤ 0.01).

Significant differences were not observed between cluster thinning times in terms of berry length (p ≤ 0.01), and cluster thinning treatment at B+8W resulted in higher berry length (14.73 mm) than those from control and other times of cluster thinning (Table 3).

Throughout the grape maturation period of cv. Sauvignon Blanc (Table 3), cluster thinning at B+8W caused higher berry weight (1.80 g) than control and other times of cluster thinning (p ≤ 0.01).

There were no statistically differences between control and cluster thinning treatments at various stages of berry development in terms of cluster width at the harvest time (p ≤ 0.01), and cluster width was highest (10.04 cm) by cluster thinning at B+8W (Table 3).

As indicated in Table 3, the means of cluster length were not significantly affected by cluster thinning time (p ≤ 0.01) and cluster length was increased by cluster thinning at B+6W (14.53 cm) in comparison to control and other cluster thinning times.

Cluster thinning time had little effects on cluster weight and there were no statistically significant differences among the treatments for cluster weight (p ≤ 0.01), however, cluster thinning treatment at B+8W led to higher cluster weight (299.84 g) than control and the other cluster thinning times (Table 3).

**Conclusions**

Cluster thinning is a common practice in viticulture, and treatments of cluster thinning performed at different stages of berry development have great importance on berry growth and grape composition. On the other hand, especially the accumulation of monoterpenes from important quality characteristics during the grape maturation is likely crucial to the identity and typicity of cv. Sauvignon Blanc. Cluster thinning that might increase monoterpenes concentration of cv. Sauvignon Blanc berries, musts and wines are therefore of critical interest to the winemaker seeking to maximize muscat character.

As reported by several authors, veraison has been reported to be an important period when the several important quality characteristics of grapes began to accumulate in the berries before veraison\textsuperscript{2, 12, 18}. Results here were in agreement with those mentioned above. In this research, cluster thinning treatments were mainly carried out in two periods (respectively, pre-veraison and post-veraison). Although the treatment times of cluster thinning affected variously grape composition and yield parameters, pre-veraison treatments from the B+4W to B+8W gradually led to enhancements in wine grape quality and cluster thinning at B+8W particularly improved grape composition and monoterpenes levels of cv. Sauvignon Blanc.
References


