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"Extreme viticulture: values, beauties, alliances, vulnerabilities"

ATTI
PROCEEDINGS
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Pratiche agronomiche e ambientamento climatico dei vitigni nella viticoltura di montagna

Agronomic practices and varietal climate adaptation in mountain and steep slope vineyards
Pre-harvest techniques to control ripening dynamic of Sauvignon blanc grapes cultivated in mountain area: first results

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Abstract

The effects induced by climatic changes have become more and more evident in wine regions located in mountain areas during the last years. The trend toward an increasing warming of the temperature is determining new ripening dynamics of grape berries that often lead to excessive sugar accumulation in fruits and alcohol development in wines. This fact somehow conflicts with the actual trend of wine markets that is increasingly asking for fresh, easy-to-drink, low alcohol wines. Moreover, other important quality traits of grapes and wines such as color, aroma, acidity and pH are detrimentally affected by ripening processes that occur largely during the hottest period of the season. Against this background, we aimed with this work to investigate the potentiality of different canopy management techniques to control and postpone the ripening process of Sauvignon blanc grapes.

Grapevine canopies were managed differently starting from the veraison phenological phase and, in detail, treatments were the follows: i) defoliation (partial leaves removal around the bunches); ii) antitranspirant application; iii) sprays with a photosynthesis inhibitor; iv) untreated control. The main biometric and physiological parameters were measured during the vegetative season, including the evolution of the berry quality traits in the period from veraison to harvest.

Results obtained at the end of the first year of the trial were interesting. Both the antitranspirant application and the defoliation approach were able to postpone by 5 to 10 days the achievement of the threshold fixed for the harvest (21.5 °Brix). Differently, the inhibition of the photosynthesis was of short duration and quickly recovered by the vines, leading to no significant effect on the ripening dynamic of grapes. As regarding to the final grape quality there were minor differences in the main traits, pH being the only parameter affected by the leaf pulling treatment (high pH average value). To conclude, first results of our trial show that a temporary and calibrated energy source limitation obtained throughout different canopy management approaches are able to slow down the ripening process and to postpone fruit harvest. More research is needed to test these methods under different seasonal conditions and to further clarify their implementation in the vineyard in terms of time of application, number of treatments and way of application.

Key words: climate change, mountain viticulture, antitranspirant, defoliation, photosynthesis inhibitor, grape quality

Introduction

The general tendency toward an increased concentration of sugars in the must and the consequent obtainment of wines with generally high alcoholic content is the consequence of the establishment of new vineyards (characterized by higher photosynthetic efficiency of the canopies), the climatic changes (higher temperature and CO₂ concentration in the atmosphere) and the implementation of production protocols that led to the reduction of the yield (Schulz, 2000; Jones et al., 2005). This is somehow in conflict with the most recent market trends that show the consumers’ request for easy-to-drink, low alcohol wines. These wines are more adapted to the several societal and political requests to reduce alcohol intake for health or dietetic motivations and are also in line with the lower legal level of alcohol allowed in the driver's body in most of the countries (Seccia and Maggi, 2011). Furthermore, the modified climatic conditions have an effect on the ripening dynamic of grapes: it has been shown a general trend towards early grape maturation in several wine-producing districts in Europe and all over the world (Jones et. al., 2005; Jones and Goodrich, 2007; Caffarra and Eccel, 2011). Early outset of grapevine phenological stages is generally combined with modified final quality of the berries. In more detail, an earlier veraison can shift the biosynthetic process of the aroma and flavor compounds so that they occur during the hottest part of the season with detrimental
effects on final wine quality (flat wines, characterized by altered bouquet and off-flavor, with lower acidity) (Keller, 2010; Webb et. al., 2012).

In order to tackle the problem related to the early onset of the ripening process in grapevine, different technical approaches have been proposed. These approaches can be classified, according to the timeframe, as long-term and short-term. The first group is represented by basic and structural modification of the winegrowing sector, including a geographical redistribution of the vineyards (the shift northward of the grapevine cultivation with the creation of new wine producing districts) and a reconsideration of the genotype assortment (both cultivars and rootstocks) with consequences for the presently established PDO (protected designation of origin) or PGI (protected geographical indication) labels (Schultz, 2000; Keller, 2010). A long/mid term solution is also the establishment of new vineyards at higher altitude with the aim to decrease the thermal excess during the crucial developmental stages of the grape (Caffarra and Eccel, 2011). Short-term solution are mainly based on differential technical approaches for the management of the grapevine canopy. In detail, these approaches can be classified in two groups: i) techniques that aim to enhance the competition between organs during the last phases of ripening and ii) techniques that induce a calibrated and temporary source limitation. The first group is represented by techniques in which a calibrated reduction of the leaf area to cluster ratio is imposed by mean of several shoot trims at different phenological stages (Filippetti et al., 2011; De Toda et al., 2013), or by the controlled competition exerted by secondary shoot growth during sugar accumulation phase in the berries (Palliotti, 2014). The second group is based on the temporary source limitation induced by the use of shading nets or by the application of antitranspirant to the canopy with the goal to slow down and reduce the final accumulation of sugars in berries (Cartechini and Palliotti, 1995; Palliotti et al., 2010; Palliotti et al., 2013a and b; Intrieri et al., 2013; Gatti et al., 2016).

Most of the studies dealing with differential canopy management approaches to postpone the grapevine fruits maturation have been conducted on red cultivars (Sangiovese, Barbera, Sagrantino, etc.) and in wine growing regions located in central Italy. With our research, we aimed to investigate the efficacy of different canopy management techniques to delay the ripening process of a white early ripening grape variety (Sauvignon blanc) cultivated in the Italian north-eastern province of Bolzano, a mountain area characterized by increasingly warmer climatic conditions during the last decades.

Material and methods

Experimental site

The experiment took place in a 10-year-old vineyard located in the municipality of Ora-Auer (province of Bolzano) on a mountain slope site at around 200 meters above sea level. The rows followed the line of maximal slope and were southeast exposed. The grapevine variety was Sauvignon blanc grafted on rootstock S04. The training system was a vertical shoot positioned trellis (unilateral Guyot) with canes hosting approximately 10 nodes after the winter pruning (one cane per vine). Fruiting shoots were mechanically trimmed when they outgrow the top wire of the training system. The planting distance was 2m x 0.8m with a density of 6.250 plants/hectare. Vineyard management (irrigation, fertilization, pest management) was carried out according to the standard practice as indicated by the local extension service.

Set up of the experiment and post-veraison treatments

The experiment was organized as a completely randomized block design. Every treatment was replicated five times and each replicate was composed by 6 vines (30 vines per treatment and 120 vines in total). Treatment were the follows: i) control, canopy management according the standard practice; ii) defoliation, performed immediately after veraison by manually pulling one third of the leaves therefore creating a window of 30-40 cm above the cluster zone (Figure 1, left); iii) antitranspirant, a spray was performed immediately after veraison with a water solution containing 2% of Vapor Gard® (Intrachem Italia), a commercial product based on pinolene (Figure 1, right); iv) photosynthesis inhibitor, sprays were performed immediately after veraison and repeated 2 weeks later with a water solution of Brevis® (ADAMA, Makhshem Agan Industries Ltd., New Zealand) a commercial product containing metamitron (15%) at the concentration of 200 ppm.

Measured parameters and statistical analysis
The effects of the different treatments on the main leaf photosynthetic parameters were monitored with a portable gas exchange analyzer (ADC Bioscientific Ltd, Hoddesdon, UK).

**Figure 1.** Left: defoliation treatment performed at veraison (July 28th). Right: antitranspirant application (leaves are covered by a shiny, uniform layer of Vaporgard®)

The photosynthetic rate (A, µmol CO₂ m⁻² s⁻¹), the stomatal conductance (gs, mol H₂O m⁻² s⁻¹) and the transpiration rate (E, mmol H₂O m⁻² s⁻¹) were measured at weekly interval from veraison to harvest stages. Measurements were performed at saturation level of photosynthetic active radiation (approximately 1,800 µmol m⁻² s⁻¹) on 3 mature well exposed leaves per replicate, inserted between the third and the fifth node above the distal bunch on a main shoot.

Berry ripening dynamic as affected by treatments was monitored at weekly interval from veraison to complete maturation. Samples of 50 berries per replicate were collected at each sampling date and prepared for analysis. Values of soluble solid content (SSC) were measured with a digital refractometer (Atago, Tokyo, Japan) on fresh extracted fruit juice and reported in degrees Brix (°Brix). For the analysis of the titratable acidity (TA), 5 mL fresh extracted grape juice was mixed with 20 mL distilled water and automatically titrated (Titration Unit Titro-Line easy; Schott Instruments, Mainz, Germany) with a solution of 0.1 mol L⁻¹ NaOH to a final pH of 8.1. The final result was expressed as g L⁻¹ of tartaric acid (OECD guidelines 2009). Yield performances as affected by treatments were determined at vintage by measuring individual vine production, number of cluster per vine and average cluster weight. Average number of berries per cluster was measured by counting all the berries of two randomly selected clusters per replicate. Average berry weight was determined by individually weighting 50 randomly selected berries per treatment. The overall effect of treatments on vine vegetative growth was estimated in winter during the pruning operation by weighting all the pruning residues of each individual vine used for the trial. The Ravaz index (Kg yield / Kg pruning residues) was then calculated and averaged at treatment level.

One-way analysis of variance was performed for the statistical evaluation of the data. To evaluate significant differences of treatments with untreated control, a post-hoc study was carried out by mean of the analysis of contrast (a priori) using the statistical software R.

**Results and discussion**

**Photosynthetic performances of vines**

The assimilation rates (A) of the vines fluctuated in the range between 10.6 and 18.8 µmol CO₂ m⁻² s⁻¹ (Figure 2 upper panel). Vines treated with the antitranspirant (Vaporgard®) and the inhibitor of the photosynthesis (Brevis®) both showed a significant reduction of the photosynthetic rate one week after the application when compared with control (approximately -40% and -20% respectively). The other gas exchange parameters (E, transpiration and gs, stomatal conductance – Figure 2 middle and bottom panel) were also significantly reduced after both treatments. The effect of the antitranspirant and of the inhibitor of the photosynthesis was transient and differences with the...
control vines were not significant two weeks after the treatment. The reduction of the main photosynthetic parameters was also evidenced in other experiments on grapevine (different cultivars). On grapevine “Sangiovese” antitranspirant application reduced the assimilation rate for a period of about 15-20 days (Palliotti et al., 2013; Intrieri et al., 2013). The difference in the persistence of the treatment’s effect could be explained with the different weather conditions and specifically with the precipitations regime after the product application. In our experiment the consistent rainfalls that occurred on August 7th and August 8th (18 mm and 23 mm, respectively) could have contributed to the wash-off of the thin film of terpenic polymers on the leaves as also described in Palliotti et al. (2013).
Figure 2. Seasonal trends of assimilation (above), transpiration (in the middle) and stomatal conductance (below) as affected by treatments. The first arrow (at July 28th) indicates the day of all the treatments: defoliation, antitranspirant (Vaporgard®) and the inhibitor of the photosynthesis (Brevis®); the second arrow (at August 13th) indicates the second application of Brevis®. The data are means ±SE (n=15). One-way Anova significant differences: * (p<0.05); ** (p<0.01); *** (p<0.001); ns= not significant

With regard to the Brevis® (inhibitor of the photosynthesis) both sprays (28th of July and 13th of August) induced an inhibition of the assimilation rate that was anyway recovered after 2 weeks. Similarly to what reported in apple trees by McArtney and Obermiller (2012), leaves did not show any of phytotoxic effects at 200 mg L⁻¹. The same concentration caused damages in peach leaves, a fact that might indicate a species-dependent leaf susceptibility with regard to the use of this compound (McArtney and Obermiller (2012)). The defoliation treatment did not show any alteration of the measured photosynthetic parameters when compared with control leaves. No compensation mechanisms were therefore evidenced in reply to the removal of leaves performed at the veraison stage.

Berries ripening dynamic

Defoliation and antitranspirant application were effective in delaying the soluble solids accumulation in berries (Figure 3 upper panel). Both treatments showed significant lower °Brix values starting from approximately 10 days after veraison and this condition was maintained up to the full ripening stage. When berries from the untreated vines reached the threshold value of 21.5 °Brix, berries from the antitranspirant and defoliation treatments showed average Brix values that were 1.5 and 1 °Brix lower respectively. At the sugars accumulation rate calculated for the last period before harvest, these gaps in the Brix values would require respectively 10 (antitranspirant) and 5 (defoliation) more days to be filled, therefore postponing the harvest from the 30th of August (control) to the 9th or to the 4th of September respectively (Table 1). As regarding the parameter of titratable berry acidity, the antitranspirant application resulted the only effective treatment in slowing down the process of degradation of the tartaric acid (Figure 3 bottom panel). With regard to the sugar accumulation, results obtained with the antitranspirant are similar the ones described by Palliotti et al (2013) on Sangiovese vines. Differently, the effect of the antitranspirant on titratable acidity was found not significant when applied in post-harvest (Palliotti et al., 2013), whereas resulted statistically relevant when applied in pre-veraison on Barbera vines (Gatti et al., 2016). Similar to our findings, postveraison defoliation above the fruit zone induced a delay in berry sugar accumulation and a delay in the harvest time in other grapevine cultivars such as Riesling (Stoll et al. 2009) and Sangiovese (Palliotti et al., 2013). As far as the inhibitor of the photosynthesis application is concern, no significant differences were evidenced in both °Brix and titratable acidity when compared with the untreated control. These findings could be probably interpreted with the short-term duration of the photosynthesis inhibition, unable to significantly affect sugars and acids dynamics in berries.
Figure 3. Soluble solids content (above) and titratable acidity (below) of Sauvignon blanc berries from veraison to harvest as affected by treatments. The first arrow (at July 28th) indicates the day of all the treatments: defoliation, antitranspirant (Vaporgard®) and the inhibitor of the photosynthesis (Brevis®); the second arrow (at August 13th) indicates the second application of Brevis®. The data are means ±SE (n=15). One-way Anova significant differences: * (p<0.05); ** (p<0.01); *** (p<0.001); ns= not significant

Table 1. Calculated delay (in day) of harvest determined by treatments. Harvest begin when soluble solids content (°Brix) reached the threshold value of 21.5 °Brix

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Date in which the threshold of 21.5 °Brix was reached</th>
<th>Harvest delay (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>30th of August</td>
<td>0</td>
</tr>
<tr>
<td>Defoliation</td>
<td>4th of September</td>
<td>+5</td>
</tr>
<tr>
<td>Antitranspirant</td>
<td>9th of September</td>
<td>+10</td>
</tr>
<tr>
<td>Photosynt. Inhibitor</td>
<td>31st of August</td>
<td>+1</td>
</tr>
</tbody>
</table>
Table 2. Yield and vegetative growth performances as affected by treatments (One-way Anova significant differences: * (p<0.05); ** (p<0.01); *** (p<0.001); ns = not significant)

<table>
<thead>
<tr>
<th></th>
<th>Berry number per cluster (n.)</th>
<th>Avg. berry weight (g)</th>
<th>Cluster avg. weight (g)</th>
<th>Yield per vine (Kg)</th>
<th>Ravaz index (Kg/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>70.5</td>
<td>1.9</td>
<td>133.4</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Defoliation</td>
<td>66.9</td>
<td>2.0</td>
<td>132.1</td>
<td>1.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Antitranspirant</td>
<td>66.6</td>
<td>2.1</td>
<td>138.7</td>
<td>2.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Photosynth. Inhibitor</td>
<td>68.3</td>
<td>2.0</td>
<td>137.8</td>
<td>2.1</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
<td><strong>ns</strong></td>
<td><strong>ns</strong></td>
<td><strong>ns</strong></td>
<td><strong>ns</strong></td>
<td><strong>ns</strong></td>
</tr>
</tbody>
</table>

Growth and yield performances
The differential canopy management and treatments application did not result in significant differences with regard to the growth and yield performances of the Sauvignon blanc vines (Table 2). There was a tendency toward a higher average yield of antitranspirant-treated vines (2.2 Kg vine\(^{-1}\)) as compared to control (1.9 Kg vine\(^{-1}\)), but differences were not statistically significant. These results were due to the higher berry weight (significant) and cluster weight (Table 2). Previous studies by Palliotti et alii (2013a and b) on Vaporgard\(^\text{®}\) application and post-veraison defoliation confirmed the limited influence of these treatments on yield and vegetative growth. As regarding the ratio between the weight of the harvested grapes and the weight of the pruning residues, no significant differences were registered at the end of the trial.

Conclusion
The goal of the trial to delay grapevine berries maturation was achieved by two experimental post-harvest treatments: the application of an antitranspirant compound based on Pinolene (Vaporgard\(^\text{®}\)) and the calibrated leaf removal in the shoot area immediately above the cluster. Respectively 10 and 5 days of delay as compared to control vines were achieved in reaching the fixed harvest threshold of 21.5 °Brix in the berries. We explain these results as caused by competition between organs and/or by a calibrated and temporary source limitation that characterized the treated vines. Delayed maturation did not significantly alter vegetative growth and yield performances. The commercial product Brevis\(^\text{®}\) had an inhibitory effect on photosynthesis probably too short and limited in intensity to affect the ripening dynamic of Sauvignon blanc berries. Overall, these technical approaches showed good potentiality to counteract the effect of the warming climate on grape ripening. Future studies should clarify the optimal way of application of these techniques (phenological phase, number of application, dosages, etc.), also testing different grapevine cultivars in different climatic conditions.

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Cited literature


