Ciencia e Investigación AGRARIA

Cien. Inv. Agr. 35(3): 271-282. 2008
www.rcia.puc.cl

RESEARCH PAPER

Maturity of Cabernet Sauvignon berries from grapevines grown with two different training systems in a new grape growing region in Brazil

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Abstract

L.D. Falcão, E.S. Chaves, V.M. Burin, A.P. Falcão, E.F. Gris, V. Bonin, and M.T. Bordignon-Luiz. 2008. Ripening of Cabernet Sauvignon berries from grapevines grown with two different training systems and environmental conditions in a new grape growing region in Brazil. Cien. Inv. Agr. 35(3):271-282. The wine grape (*Vitis vinifera*) cv. Cabernet Sauvignon has recently been introduced at a 1160 m altitude in the São Joaquim area (Santa Catarina State, Southern Brazil). The aim of this work was to evaluate the maturation of Cabernet Sauvignon grapes subjected to a Y training system or a vertical shoot positioning trellis (VSP). Grapes were sampled at 10-day intervals throughout their maturation during two consecutive vintage years (2004-2005 and 2005-2006). Climate data were assessed. Based on the results obtained in both vintage years at maturity, titratable acidities (TA) ranged from 0.67 to 0.85 g·100 mL^{-1} of tartaric with the pH fluctuating between 3.49 and 3.77. The maturation index (total soluble solids/TA) at maturity ranged from 26 to 35, and was always higher for berries from the VSP system. Significant differences were observed for the anthocyanin content (TMA) and total polyphenol index (TPI) values that may be attributed to differences in vintage year and climate conditions. Climatic conditions strongly influenced the grape quality, and it is important to note that São Joaquim is a warm region according to the Winkler scale, with 1668-1944 GDD °C. Under these environmental conditions, the VSP system provided better results for TSS, berry weight and acidity than the Y system, which could be seen more clearly in 2005-2006 due to lower rainfall.

Key words: Cabernet Sauvignon grape, ripening, mesoclimate, vertical shoot positioning trellis, Y system,

Introduction

Grape maturity can be defined as the physiological age of the grapevine berry (*Vitis vinifera* L.) (Bisson, 2001). Water, sugars, and nitrogen compounds are transported to the berry via the phloem during maturation. Sucrose is hydrolyzed into glucose and fructose in the berry, increasing the sugar content, which is often used to assess maturity (Watson, 2003). According to Fang and Qian (2006), the concentrations of most aroma-active compounds increase along with grape maturity, but the opposite is true for esters. Phenolic compound accumulation has also been used to determinate the optimal maturity, and these compounds have been strictly related to the vine water status during grape maturation (Esteban *et al*., 2001; Ojeda *et al*., 2002). In general, water deficit has a clear positive effect on berry phenolic composition. A combination of sugar and acid concentrations and pH are generally used to determine whether the grapes have reached optimum ripeness (Hunter *et al*.,

Received 31 January 2008. Accepted 15 August 2008.
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1991; Bergqvist *et al*., 2001). However, it has always been difficult to determine when the grapes are best for wine.

Cabernet Sauvignon is a red cultivar from Bordeaux, France that has been spread worldwide. Important research to improve the quality and adaptation of this grapevine cultivar is being conducted in the USA (Crippen and Morrison, 1986; Nuzzo and Matthews, 2006), Chile (Muñoz *et al*., 2002), Australia (Petrie and Clingeleffer, 2006), New Zealand (Tesic *et al*., 2001) and South Africa (Hunter *et al*., 1991).

There is a continuing research effort by viticulturists to improve wine grape management through vine spacing, training, trellising, and pruning practices. Grapevines are trained to a specific system to favor the sunlight in order to maximize quality and facilitate cultivation, harvesting, and diseases control. As the overall physiological effects of a training system depend on specific meso- and microclimatic conditions, it is difficult to extrapolate results to other growing areas. Even so, the principles of regulating vine performance remain the same (Baeza *et al*., 2005).

All training systems have some basic requirements, such as: 1. Optimal light interception: the grapes need light to develop desirable, colored berries (Weaver and Mccune, 1960). Photosynthesis in the grape leaves results in the production of sugars and other products essential to high quality fruit development; 2. Optimal air movement: sufficient airflow should be established by the training system to reduce potential disease problems; and 3. Optimal management: enabling easy harvest.

Vine-training systems can be classified in a number of ways. In France, it is common to classify vines as low trained (“vignes basses”) or high trained (“vignes hautes”). For low trained vines, the trunk is usually less than 0.5 m to 0.2 m high. Such training systems are more economical, and are suited to lower-vigor vineyards. Grape maturity may benefit because clusters are close to the ground, but both manual harvest and pruning are much less comfortable operations, and vines may also be prone to diseases.

In Santa Catarina State, where *V. vinifera* grapes have been cultivated since 2000, the vertical shoot positioning trellis (VSP) is the most applied training system (Figure 1). Y is a vine-training system similar to the V system, except that the trunk of the vine forms the vertical part of the letter Y (Figure 1). Mechanical harvest is easier in the VSP system than the Y system and it is more easily extended and less expansive than the Y system. Also, the simplicity of the VSP system facilitates the manipulation of the leaf canopy in order to alter the microclimate conditions around the vines during the growing season. The VSP system provides more shade than the Y system, which is a disadvantage considering that shade should be reduced to improve grape quality. The VSP system is used in Bordeaux, Burgundy and Champagne in France, using a short trunk with close planting to increase vine stress. It is also used with a higher trunk in Alsace, Germany and North and South America.

The aim of this work was to evaluate the effect of the VSP and Y systems on the maturity of Cabernet Sauvignon grapes in a new grape growing region in Brazil.

Materials and methods

Plant growth

The experiment was conducted in a single *V. vinifera* vineyard cv. Cabernet Sauvignon, in São Joaquim (1,160 m a.s.l.), Santa Catarina State, Southern Brazil (28°19’0’’ S, 49°34’51’’ W). Five grapevine rows trained in the Y system and five other rows trained in the VSP system were grafted on Paulsen 1103 (*V. berlandierli* Planch *x V. rupestris* Scheele), clone R-5 (Figure 1). The vineyard was planted at 2.9 *x* 1.3 m and 3.2 *x* 1.3 m for the Y and VSP systems, respectively. Yields from the 4- to 5 year-old vineyard ranged from 5 to 8 $t{\cdot}ha^{-1}$. Berry maturity was evaluated in 2004-2005 and 2005-2006 using 30 vines selected randomly in the three central rows for each training system.

Soil analyses

Soil analyses were made according to official methods (USDA, 2005). The color notations

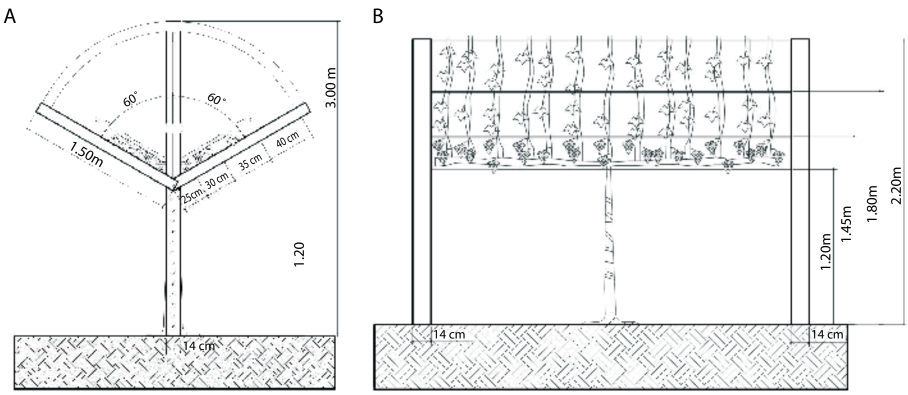

Figure 1. Grapevine training systems. A. Y system and B. Vertical shoot positioning trellis (VSP).

were determined per horizon and converted into color indices using the soil Munsell color chart (Munsell Colour Company, Baltimore, MD, USA, 1990).

Climate data

The maximum, minimum and mean temperatures, and the rainfall were obtained from the meteorological weather station located 4 km from the vineyard in 2004-2005 and 2005-2006. Growing degree-days (GDD), using a 10ºC base, were calculated from the mean daily temperature (T) as GDD = $\sum (T_{>10°C} - 10°C)$, starting at budbreak until harvest.

Berry samples and commercial maturity analysis

The samplings began at véraison when approximately 50% of the berries were red. The vineyard was sampled five to seven times at 10-day intervals in 2004-2005 and 2005-2006, respectively. All samples were collected from plots of 30 vines distributed in two central rows. Each sample consisted of a total of 240 berries, eight berries per vine. Harvest started when each treatment reached commercial maturity, with total soluble solids (TSS) of approximately 24% in 2004-2005 and 22% in 2005-2006. The berry sets collected were immediately counted, weighed, and submitted to physicochemical analysis. Each 240-berry sample was divided into three sub-samples of 90, 90 and 60 berries. A sub-sample of 70 berries was kept at –20°C for future analysis. The juice for berry maturity analysis was squeezed from a fresh randomly selected 30-berry sample in triplicate (= 90 berries). Juice samples were analyzed for pH and titratable acidity (TA) using 0.1 M NaOH, and TSS (Abbe refractometer at 25°C, AusJena, model 265085) (OIV, 1990).

Berry composition

Anthocyanin extraction and quantification. Samples consisting of 30 berries were carefully selected in triplicate (= 90 berries) from the berry sets. The skins were separated from the pulp, weighed and used for anthocyanin extraction. The grape skins were macerated overnight in methanol (p.a):12 N HCl (99:1) in the dark at 4.0±1°C. The extracting skin:solvent ratio of 1:5 (w/v) was used. Then, extracts were filtered through Whatman No. 1 filter paper in a Büchner funnel. The total monomeric anthocyanin (TMA) quantifications were determined using the pH-differential method (Giusti and Wrolstad, 2001), using ε = 28000 and MW = 529 (Amerine and Ough, 1976).

Total polyphenol index (TPI). The same anthocyanin quantification extract was used for TPI determination using the Folin-Ciocalteu assay, with absorbance readings at 760 nm. The total phenolic content was expressed as gallic acid equivalents (GAE) in milligrams per 100 grams of fresh grape skins.

Berry color measurements

Color was determined directly by spectrophotometry using a 1:10 dilution of the methanolic skin extracts. A UV-Vis Hitachi spectrophotometer (U2010) (Tokyo, Japan) was used at 420, 520 and 620 nm wave lengths, with a 1 mm pathlength cuvette. The color index (CI) was calculated according to CI = $Abs_{420}+Abs_{520}+Abs_{620}$ (Glories, 1984). The hue was calculated as Hue = Abs_{420} / Abs_{520}.

Berry seed number

In the 2005-2006 vintage, the number of grape seeds was counted in 100 berries at 10-d intervals during the maturation period.

Design and statistical analysis

Data were analyzed for variance following a completely randomized design with three replicates, each consisting of 30 vine plots. Means were separated according to Tukey´s test. All statistical analyses were performed with Statistica 6 (StatSoft Inc., Tulsa, OK, USA, 2001).

Results and discussion

Environmental conditions

Environmental factors are important to obtain high quality *V. vinifera* grapes for winemaking. The wine style that a region produces is the result of the specific local climate and soil characteristics. Climatic changes therefore have the potential to bring about changes in wine styles. In the present study, the Y and VPS training systems were evaluated in the same vineyard under the same climate and soil type conditions. The climatic data of the 2004-2005 and 2005-2006 growing seasons can be considered as typical climatic conditions for the geographical zone of São Joaquim where this experiment was conducted (Table 1). At véraison in 2004-2005, rainfall was almost three times higher than for the 2005-2006 vintage, wind speed was near 2 $km{\cdot}h^{-1}$, and there was about 1254 h of sunshine (Table 1). Temperatures were more favorable for grape growing in 2005-2006 than in 2004-2005. The minimum GDD level of heat accumulation of 1093 GDD°C was reached in the vineyard site in both vintage years (Amerine and Winkler, 1944). According to the Amerine and Winkler (1944) scale, São Joaquim is classified as Region III (1668 – 1944 GDD°C), which is considered a warm region according to this scale. Similar heat accumulation occurs in other grape growing regions in the world such as the Rhône Valley, France. Climate data from véraison to harvest in both the 2004-2005 and 2005-2006 vintages is given in Figure 2.

Cabernet Sauvignon grapes are grown in temperate to hot regions with mean temperatures varying from 16.5 to 19.5ºC (e.g., Bordeaux, France; Napa Valley, California) (Jones 2007). São Joaquim showed mean daily temperatures from 15.9 to 17.9ºC for the 2004-2005 and 2005-2006 growing seasons, confirming that São Joaquim is a suitable region for planting Cabernet Sauvignon. Nevertheless, further research is need to study wine quality.

In São Joaquim, the dominant relief is steady and the altitudes range from approximately 1100 to 1400 m, with the experimental vineyard at 1160 m a.s.l. The soil type is classified as Inceptisols and placed in the soil with basaltic, extrusive origin material and igneous rock (USDA, 2005). Soil color was a very dark grayish brown (10YR/3/2), soil texture was clay-silty, and soils were well drained, soft, friable, and ‘plastic’, with high water retention capacity. In natural conditions it is a soil with little availability of nutrients and high acidity with aluminum. However, after correction it becomes epitrophic (Table 2).

The soil chemical composition of the experimental vineyard after correction is suitable for planting grapevines. The results of pH analyses showed values slightly acidic in the epipedons (horizon A) and acidic in the subsurface of the soils for all sites (Table 2). Organic matter and potassium content in the epipedons section were considerably high, which increases soil fertility; consequently, grapevine nutrition should be high. Exchangeable

Table 1. Climatic parameters that characterized the experimental area (1160 m a.s.l.) in São Joaquim, SC, Brazil in the 2004-2005 and 2005-2006 growing seasons.

Parameters	Vintage years		Average from 01 Jan, 1955
	2004-2005[1]	2005-2006[1]	to 07 Jan, 2006[2]
Rainfall (Sep-Apr), mm	913.0	417.0	1364.3
Total rainfall from véraison to harvest[3], mm	292.0	112.0	414.0
Degree days (base 10°C) (Sep-Apr)	1735.0	1680.0	-
Mean maximum temperatures (Sep-Apr), °C	23.5	22.3	20.0
Mean daily temperatures (Sep-Apr), °C	17.9	15.9	14.2
Mean minimum temperatures (Sep-Apr), °C	12.3	11.1	10.7
Mean daily thermal amplitude (Sep-Apr), °C	11.6	11.2	8.7
Mean daily temperature from véraison to harvest[3], °C	18.6	19.0	16.0
Cumulative sunshine (Sep-Apr), h	1300.7	1372.8	1253.5

[1] From 14 Sep 2004 to 08 Apr 2005, and from 02 Sep 2005 to 28 Apr 2006.
[2] Data from a meteorological station placed 4 km from the experimental vineyard.
[3] Véraison 15 Feb 2005 and 28 Feb 2006 and harvest 08 Apr 2005 and 28 Apr 2006.

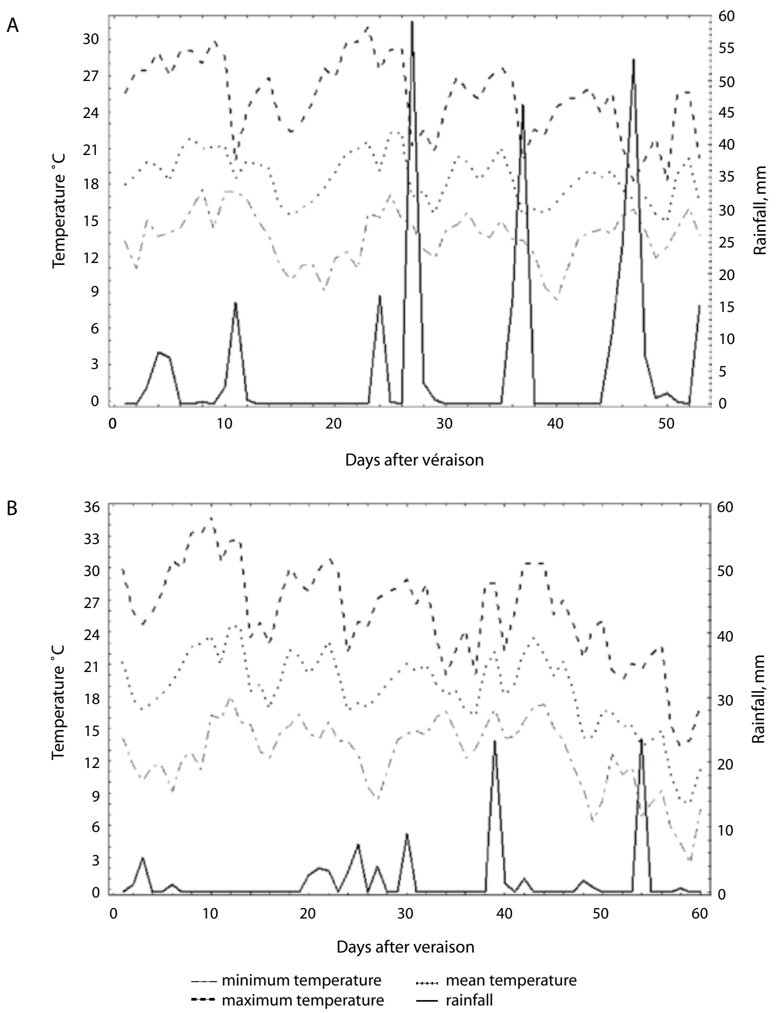

Figure 2. Mesoclimate parameters determined from véraison to harvest in a São Joaquim vineyard at 1,160 m a.s.l. A. 2004-2005 and B. 2005-2006.

Table 2. Soil analyses of the experimental vineyard located at 1160 m a.s.l. in São Joaquim, SC, Brazil.

Parameters	Inceptisols[1]	
	0-20 cm	20-40 cm
Clay, %	48.0	70.0
Organic matter, %	5.2	3.3
pH	6.1	5.2
Phosphorus available, mg·kg^{-1}	3.7	1.0
Potassium exchangeable, mg·kg^{-1}	209.0	63.0
Magnesium exchangeable, mg·kg^{-1}	4.2	1.6
Aluminium available, mg·kg^{-1}	0.0	0.8
Calcium available, mg·kg^{-1}	9.9	3.6
Sum of bases (Ca + Mg + H), cmol·kg^{-1}	14.6	5.4
Saturation of bases (Ca + Mg + H) , %	68.0	51.0
Cation exchange capacity, cmol·kg^{-1}	21.4	10.5

[1] Soil type was classified as Inceptisols on the basis of the U.S. soil taxonomy (USDA, 2005).

potassium, which has a positive effect on yield, plant vigor, and drought resistance (Chone *et al*., 2001), was found in high levels in this soil. The clay-silty texture contributes to a high water-retention capacity of this Inceptisols.

Berry composition during maturation

The most common indicators of grape quality are pH, TSS and TA (Amerine *et al*., 1980). However, these are not the only factors that effect winemaking. Thus, several other parameters were evaluated from véraison to harvest to assess the main grape characteristics produced in this new grape region of Brazil.

The berry weight and TSS evolution during maturation of Cabernet Sauvignon grapes in both the 2004-2005 and 2005-2006 vintages are summarized in Figure 3. It is known that the berry weight evolution during grape maturation is directly related to the number of seeds, to the increase of TSS and to berry water content. In the 2005-2006 vintage, the mean number of seeds was 1.31 and 1.43 seed·berry^{-1} for grapevines subjected to the VSP and Y training systems, respectively. In both vintage years, during the maturation period berries from the Y system were weightier than berries from the VSP training system, which is in accordance with the slightly higher number of seeds per berry obtained from the VSP system. Generally, a strong increase in berry weight was obtained from 10 to 40 d after véraison, with a minor increase thereafter. Independent of the training system, berry weight was below 2.0 g at harvest, which is considered small (OIV, 1985).

The TSS content increased mainly during the berry maturation period (Figure 3), since during earlier berry growth stages sugars are used for growth and seed development. After véraison, a metabolic change occurs enabling sugar accumulation in the berry during maturation (Figure 3). No significant differences in TSS content were obtained between grapes produced in the Y system and grapes produced in the VSP system. Differences in TSS among vintage years can be attributed to the GDD in 2004-2005 (1735), which was higher than in 2005-2006 (1680), and to the mean daily temperature in 2004-2005 (17.9°C), which was higher than in 2005-2006 (15.9°C). However, these differences may not have an enological impact, since the TSS difference between the systems in 2005-2006 was 0.6% (Table 3). These results are similar to those obtained by Baeza *et al.* (2005) where significant differences were found in the TSS of Tempranillo grapes grown in four training systems in 1990 and 1992, but not in 1991 vintages. Auvray *et al.* (1999) did not observe differences in final TSS values for grapevines grown using different systems.

pH is becoming increasingly recognized for its important contribution to wine quality because it plays a key role in prevention of microbial spoilage, malolactic fermentation occurrence and color stability of wines. In 2004-2005 the average temperature values were higher than in

2005-2006 (Table 1); pH values were also higher in 2004-2005 (Figure 4). Butzke and Boulton (1997) reported that overripe grapes or a warm climate can result in higher pH and low acid concentrations due to the respiration of organic acids. As a general trend, the pH increased along with the sugar concentration as grapes matured (Figures 3 and 4). In contrast, titratable acidity (TA) declined during maturation (Figure 4). A positive pH average evolution was observed from pH 2.8 at véraison to pH 3.8 at harvest. The highest increase occurred at the beginning of maturation, concurrent with a sharp decline in TA values. At the beginning of maturity there was a high titratable acidity in the berries under both systems (means of 1.3-1.8 g of tartaric acid/100 mL of must). In the first 20 d of maturation, TA dropped by 0.45 $g \cdot L^{-1}$ in 2004-2005 and 0.90 $g \cdot L^{-1}$ in 2005-2006, on average, every 10 d. After this period acid losses occurred at a rate of 0.07 $g \cdot L^{-1}$ every 10 d, for both vintage years. There were small differences in the pH of the must between training systems at maturity, which were only significant in 2005-2006 (Table 3). Auvray *et al.* (1999) did not find any significant differences in pH levels in grape must from different training systems despite significant differences in titratable acidity imposed by the systems.

The pH values obtained at harvest ranged from pH 3.5 to pH 3.8 (Figure 4). According to Amerine and Ough (1976), wines with a pH above 3.6 may have stability problems. In general, pH and TA values from véraison to harvest were very similar and were independent of the training system. As expected, TA decreased with grape maturation (Figure 4), and a sharp decrease was observed during the first 20 d after véraison. This may be attributed to berry respiratory processes that involve malic acid and also to organic acid dilution due to an increase in berry volume (Borgogno *et al.*, 1984).

It is known that the increase in total grape

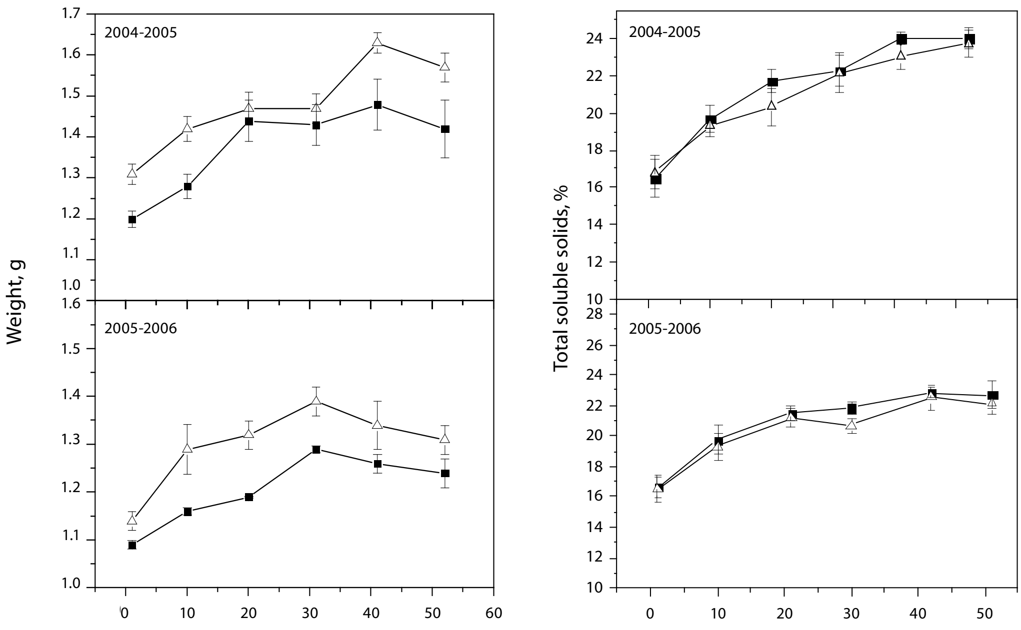

Figure 3. Berry weight evolution and total soluble solids obtained from véraison to harvest in 2004-2005 and 2005-2006 vintages for grapevines (*Vitis vinifera*) Cabernet Sauvignon conducted in Y (–Δ–) and VSP (—■—) training systems. Means of three replicates, ± standard deviation.

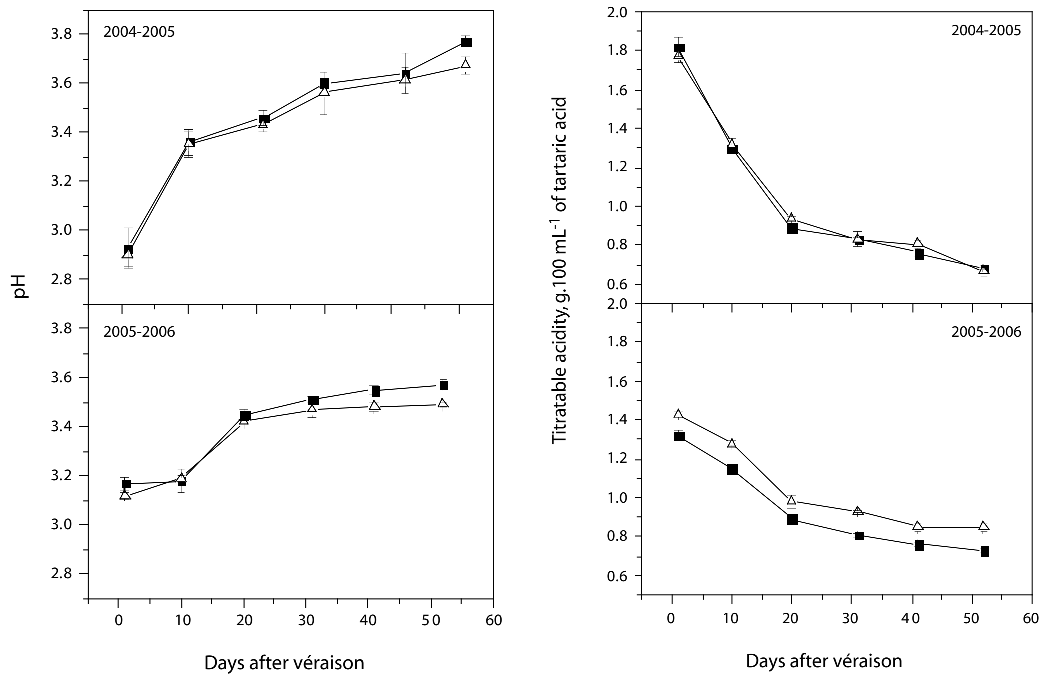

Figure 4. Evolution of pH and titratable acidity from véraison to harvest in 2004-2005 and 2005-2006 vintages for grapevine (*Vitis vinifera*) Cabernet Sauvignon conducted in Y (—△—) and VSP (—■—) training systems. Means of three replicates, ± standard deviation. Titratable acidity was expressed as tartaric acid.

phenolic content is associated with berry maturation (Mateus *et al.*, 2002). In grapes, anthocyanin synthesis begins at véraison and its accumulation occurs in the grape skins during the maturation period (Muñoz *et al.*, 2002). In an analysis of principal components, phenolic content emerged as a key-defining factor of grape maturity (Gonzalez-San Jose, 1991).

The maturation index (MI) relates titratable acidity and sugar level and should be 30 to 32 (Gallander, 1983) or 37 to 38 (Amerine *et al.*, 1980) for wine production. Except for the Y system in the 2005-2006 vintage, MI values above 30 were reached at maturity and differences between the VSP and Y systems were not significant (Table 3).

The total monomeric anthocyanins (TMA) and total polyphenols (TPI) in the 2004-2005 and 2005-2006 vintages had a positive evolution at berry maturation (Figure 5). The maximum TMA and TPI values were obtained 40 d after véraison for both training systems. These results are in accordance with a previous report on grapevines cvs. Touriga Nacional and Touriga Francesa, where anthocyanin content was at its maximum approximately 40 d after véraison (Mateus *et al.*, 2002). In the 2004-2005 vintage, a sharp decline in anthocyanin content was obtained 40 d post-véraison, decreasing from 389 to 275 and from 448 to 300 mg·100 g^{-1} grape skins, for the Y and VSP systems, respectively. Similarly, TPI values dropped from 835 to 646 and from 874 to 589 mg·100 g^{-1} grape skins based on GAE, 40 d post-véraison. Heavy rainfall between 40 and 50 d after véraison may at least partially explain, by a "dilution effect", the drop in anthocyanin and TPI content obtained in the 2004-2005 growing season (Figure 2B). Other work has also described dramatic effects of the environment and culture conditions on anthocyanin accumulation (Ryan and Revilla, 2003; De La Hera Orts *et al.*, 2005).

The color evolution during grape maturation was affected by vintage year (Figure 6). However, during véraison a difference in color

Table 3. Effect of training system and vintage year on berry composition of grapevine (*Vitis vinifera*) cv. Cabernet Sauvignon obtained at harvest in a commercial vineyard in São Joquim, Southern Brazil.

Berry characteristics	Growing seasons			
	2004-2005		2005-2006	
	VSP system[1]	Y system[1]	VSP system[1]	Y system[1]
Weight, g	1.4±0.10a[3]	1.6±0.10b[3]	1.2±0.30a[3]	1.3±0.20a[3]
pH	3.77±0.09a	3.67±0.02a	3.57±0.03a	3.49±0.01b
Total soluble solids, %	23.9±0.70a	23.7±0.40a	22.7±0.3a	22.1±0.2b
Titratable acidity, g·100 mL^{-1}	0.68±0.04a	0.67±0.02a	0.73±0.03a	0.85±0.03b
Maturation index[2]	35±3.4a	31±1.0a	31± 0.60a	26.0±1.20b
Total monomeric anthocyanins, mg·100 g^{-1} of grape skins	300±1.0a	275±2.0b	555±5.0a	575±8.0b
Total polyphenols[2], mg·100 g^{-1} of grape skins	589±2.0a	646 ± 47.0a	905±42a	1003±23a
Color intensity[2]	3.01±0.01a	2.70±0.01b	4.49±0.06a	5.39±0.02b
Color tonality[2]	1.28±0.02a	1.38± 0.03a	1.37±0.01a	1.14±0.02b

[1] Grapevines, grafted on Paulsen 1103 (*V. berlandierli x V. rupestris*), clone R-5, were grown in a vertical shoot positioning trellis system (VSP) or a Y system.
[2] Maturation index = total soluble solids/titratable acidity. Color intensity = Abs_{420} + Abs_{520} + Abs_{620}. Color tonality = Abs_{420}/Abs_{520}. Total polyphenols index as gallic acid equivalent.
[3] Means, ± standard deviations, followed by different letters in the same line, for each vintage, are significantly different according to Tukey's test ($p < 0.05$).

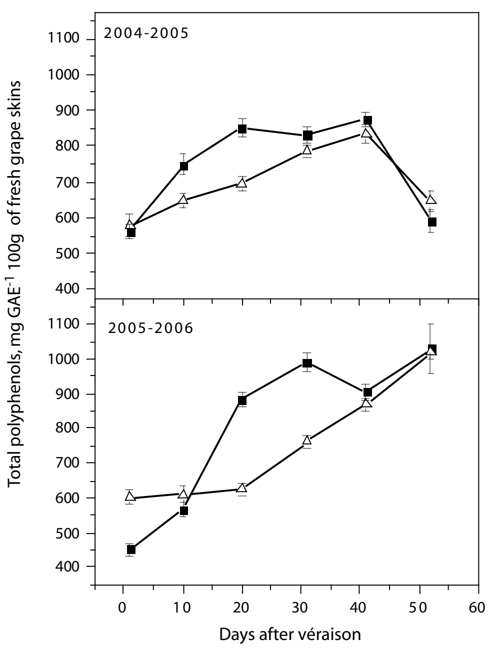

Figure 5. Total monomeric anthocyanins and total polyphenols evolution from véraison to harvest in 2004-2005 and 2005-2006 vintages for grapevine (*Vitis vinifera*) Cabernet Sauvignon conducted in Y (–Δ–) and VSP (—■—) training systems. Means of three replicates, ± standard deviation.

was obtained between the training systems. Color intensity values were higher in 2005-2006 than in 2004-2005, which appears independent of the training system (Figure 7, Table 3). It is interesting to note that for a premium quality wine, high CI values and low berry weight are desirable.

Most berry composition parameters were strongly affected at harvest by vintage year. This may be explained by the marked difference in climatic conditions between 2004-2005 and 2005-2006 (Table 1, Figure 2). In 2004-2005 only TMA and CI values were significantly different between the systems, with VSP giving the best results. In 2006, low rainfall during maturation made the differences between the training systems more evident for almost all parameters evaluated (Table 3). For this vintage, higher values for TMA and CI were obtained with the Y system. More vintages should be evaluated to reach a conclusion on the better training system in relation to chromatic characteristics and anthocyanins content. In relation to TSS and MI, the VSP always showed smaller values, which were significant only in 2006.

In conclusion, the rainfall index between véraison and harvest had a strong influence

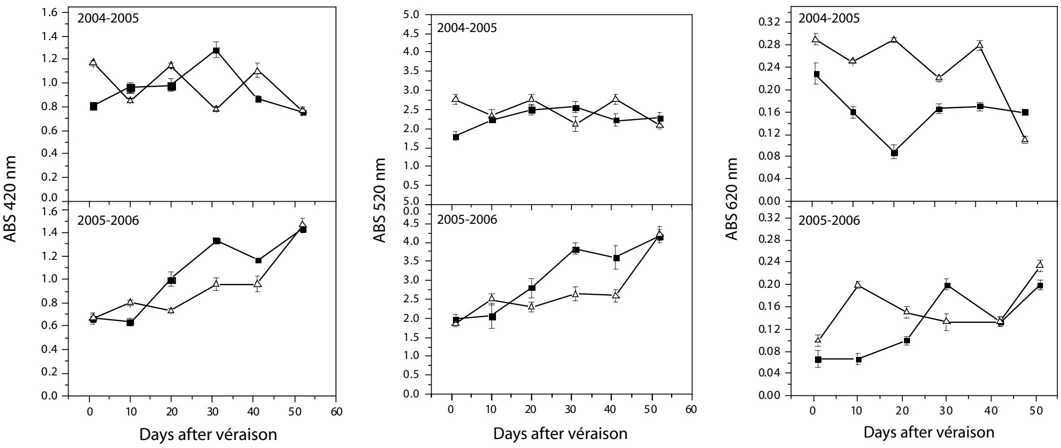

Figure 6. Color evolution from véraison to harvest of grape berry Cabernet Sauvignon in 2004-2005 and 2005-2006 vintages for grapevines (*Vitis vinifera*) conducted in Y (—△—) and VSP (—■—) training systems.

on berry quality. Future research must focus on evaluating the influence of training system on other grape metabolites, such as individual monomeric anthocyanins, malic acid and abscisic acid (ABA), a phytohormone that plays regulatory roles in a host of physiological processes in vines.

Resumen

El objetivo de este trabajo fue evaluar la maduración de uvas Cabernet Sauvignon bajo dos sistemas de conducción: sistema en Y y sistema de espaldera alta (VSP). Las viñas han sido cultivadas recientemente en la ciudad de São Joaquim, Estado de Santa Catarina (Brasil), a 1160m de altitud. Las uvas fueron muestreadas para el análisis de su maduración en dos vendimias consecutivas, 2004-2005 y 2005-2006, cada 10 días, desde envero a cosecha. Parámetros del mesoclima también fueron determinados. Los resultados muestran que a madurez, en ambas vendimias los valores de acidez total (TA) fluctuaron entre 0,67 y 0,85 g·100 mL^{-1} de ácido tartárico y el pH entre 3,49 y 3,77. En general, TA a madurez fue más baja en 2004-2005 que en 2005-2006. El índice de maduración (sólidos solubles totales/TA) en la madurez varió desde 26 a 35, y fue más alto para bayas cultivadas en VSP. Se observaron diferencias significativas en los valores de antocianas y en el índice de los polifenoles totales (TPI); la vendimia y el clima explicaron las fuertes diferencias entre los niveles de antocianas y TPI. Las condiciones climáticas influyeron fuertemente en la calidad de la uva. En São Joaquim, el clima fue clasificado como 'Región III', según la Escala de Winkler, una región cálida (1668 a 1944 °C). En general, el sistema VSP dio mejores resultados en lo referente a TSS, peso de la baya y acidez los que se percibieron más claramente en 2006 debido al menor nivel de precipitaciones.

Palabras clave: Cabernet Sauvignon, maduración, mesoclima, sistema de conducción en Y, espaldera.

Acknowledgements

We gratefully acknowledge Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for financial support and to Hamilton Justino Vieira from EPAGRI - Florianópolis for technical assistence on climate data. We also thank Everson F. Suzin who supplied sections of their private vineyards and to Emílio Brighenti from EPAGRI-São Joaquim for auxilliary assistance collecting the grape samples.

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