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Double-pruning of 'Syrah' grapevines: a management strategy to harvest wine grapes during the winter in the Brazilian Southeast

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Summary

Grape harvest in the major grapevine growing regions of Brazil occurs during the summer; a period with excessive rainfall. The climatic conditions during the Brazilian summer can have an adverse effect on fruit maturation and wine quality. This study compared the performance of 'Syrah' grapevines cultivated in two growing seasons. A double pruning management system was employed as a technique in the vineyard and the grapevines were cultivated in summer, a cycle normally adopted in the South and Southeast of Brazil and winter during 2005 and 2006 in a non-irrigated vineyard. Vine water stress was minimal for both growing seasons and photosynthetic rates were found to be lower in the winter than the summer. However, no differences in vegetative vigor were observed. The growing season was shorter in summer than in winter. This was predominately due to a faster ripening period in the summer. During the winter harvests, grapevines had a higher yield, accumulation of sugar, anthocyanins and total phenolic compounds, and the lowest rot incidence. Double-pruning proved to be a powerful tool to improve wine grape composition in the Brazilian Southeast. This management will allow the production of quality raw materials for the production of good wines, allowing Southeastern Brazil to enter the competitive globalized wine market.

Key words: double-pruning, growing season, phenolic compounds, wine grape composition.

Introduction

The quality of Brazilian wine has been improved through the introduction of new varieties, adaptation of cultivars, clones, rootstocks, agronomical practices and enological techniques. However, the greatest impediment to this evolution is the low quality of grapes, mainly due to climatic conditions during the growing season (CONCEIÇÃO and TONIETTO 2005, REGINA *et al.* 2006). In the South and Southeast of Brazil, the major grapevine growing regions in the country have only one production cycle per year, in general, from August through to January/February. Grape ripening and harvest occur during the summer months between December and February, which is a period of high

precipitation. This excessive rainfall favors the occurrence of fungal diseases and increased rot incidence; the ripening process is delayed or not completed due to low solar radiation and high soil water availability, which adversely affects grape composition and wine quality (JACKSON and LOMBARD 1993, DELOIRE *et al.* 2004, REGINA *et al.* 2006). In contrast, the Brazilian tropical regions, the Northeast of the country, have higher temperatures and lower thermal amplitudes during the ripening process which slows the synthesis and concentration of the phenolic compounds essential for grape color, structure and wine stabilization (KLEWER 1970, BERGQVIST *et al.* 2001, SPAYD *et al.* 2002, MORI *et al.* 2004, AMORIM *et al.* 2005, CONCEIÇÃO and TONIETTO 2005). Moreover, in warm regions, the high temperatures in berries inhibit color formation. In a study of sunlight exposure and temperature effects on berry composition, BERGQVIST *et al.* (2001) observed that berry color was negatively affected by excessive sunlight exposure.

Minas Gerais is a state in Southeast Brazil, where grapes are traditionally cropped during the summer season. Trials were conducted with some *Vitis vinifera* varieties in the South of the state (a traditional coffee growing region) to identify new regions of Minas Gerais that could offer better ecological conditions to grow grapevines. 'Syrah' is a variety that during the last few decades has been imported for cultivation in several countries. The preliminary results suggested that 'Syrah' showed good performance when the harvest was changed from January (summer) to July (winter) (AMORIM *et al.* 2005). However, in that trial the performance of Syrah growing under the winter cycle was not compared with a traditional summer growing season. In this context, the present work compared some agronomical and ecophysiological responses of field-grown grapevines in two different growing seasons: the first from August to January (the cycle normally adopted in the main Brazilian vineyards), and the second, from January to July, a period with dry weather conditions, to evaluate the viability for production of wine grapes with improved quality in South of Minas Gerais.

Material and Methods

The study was conducted in an experimental vineyard located in Três Corações city, south of Minas Gerais state, Brazil (21°41' S, 45°15' W), at an altitude of 865 m. The evaluations were done from 2004 to 2006 in a 0.1 ha unir-

rigated vineyard, planted in August 2001 with the *Vitis vinifera* L. 'Syrah', clone 747 of ENTAV INRA, grafted onto 3309 C rootstock (*Vitis riparia* x *V. rupestris*). Vine spacings were 1.5 m x 2.5 m and trained on a vertical shoot positioned trellis (VSP), with north-south oriented rows. The whole experimental vineyard (266 vines) was double-pruned, this allowed for the vines to produce grapes in two different cycles, immediately after the other (AMORIM *et al.* 2005, FAVERO 2007). All vines were cordon-trained and spur pruned with two spurs node (≈ 22 buds per vine), twice in a year. Shoots from all pruning dates were lignified and arose from dormant buds.

The treatments consisted of two different pruning dates, one in August and the other in January. These pruning dates determined the growing seasons of summer and winter. The treatments were imposed twice, totaling two summer and two winter growing seasons. In the first summer cycle, grapevines were pruned on August 13th 2004. In the first winter cycle the same vineyard was pruned in January 19th 2005, immediately after the harvest of the previous season. These pruning dates corresponded to treatments one and two for the year of 2005. In the second replication of the experiment, the grapevines from the same vineyard were pruned on August 28th 2005 to start the summer cycle and January 18th 2006, to start the winter cycle.

A complete randomized design was adopted and a comparison between the treatments was performed on 24 vines (24 replicates). New vines were randomly selected at the beginning of each new season. This procedure was to avoid evaluation of the same vines.

The temperature of the clusters' microclimate was monitored from maturation (the end of veraison) to harvest with one temperature sensor (MultiLog, model DT 013, with temperature range from -25 °C to 110 °C) per cycle, located 3 cm from the fruit area, approximately at 1.2 m above the soil surface. Data were collected every 30 minutes during the entire maturation period and stored in a data logger (model DB-526 VER-5 Multilog, Fourier Systems, Inc., Bnei Brak, Israel). Technical problems during the summer of 2006 resulted in temperature values only being recorded towards the end of the grape ripening period.

Pre-dawn leaf water potentials (Ψ_{pd}) were measured with a Scholander type pressure chamber (model 3005, Soil Moisture Equipment Corp, Santa Barbara, USA), at 15-d intervals, from pea-sized berries until harvest measurements were performed on 10 fully expanded leaves, one leaf per vine, situated in the medium portion of the main shoots. The CO₂ assimilation rate (*A*) was measured during the morning (from 0900 hr to 1000 hr), on the same days that Ψ_{pd} was measured. Ten fully expanded and completely exposed leaves, were used, one leaf per plant, situated in the middle portion of the stems, using a portable infrared gas analyzer (model CID 301 PS, CID Bio-Science, Inc., Camas, USA) working in an open system. During the ripening period: between veraison and harvest, the primary leaf surface, represented only by the main shoots, was calculated according to CARBONNEAU (1976).

The duration of each cycle was measured from the pruning date until harvest. Dates of bud break, flowering and veraison were noted following the methodology de-

scribed in Carbonneau (1981). The clusters/shoots ratio was also measured.

Yield per vine was determined by counting and weighing the fruit. The counting of clusters was done on the 24 plants at the beginning of berry ripening and the weighing at harvest. For each treatment, at the moment of the harvest, all clusters from the 24 plants were collected together. Five subsamples of 20 clusters per treatment were taken. These subsamples were used to analyze rot incidence, the mean cluster weight, the weight and diameters of the berries, total soluble solids (TSS), total titratable acidity and pH.

Rot incidence was evaluated by a scale note from 1 (absence of symptoms) to 9 (very severe, above 50 %), in accordance with the severity of the diseases, according to the EMBRAPA Grape and Wine (EMBRAPA/CNPUV, unpublished data). The means data were transformed in \sqrt{x} prior to statistical analysis.

The mean berry weight was obtained from five subsamples of 50 berries per treatment. They were also used to measure the longitudinal and transversal diameters by a caliper with a millimeter scale.

Two hundred berries from each subsample were crushed in a polyethylene bag and filtered. The resulting juice samples were immediately analyzed for total soluble solids (TSS; Brix) with a portable refractometer (Pocket PAL-1, ATAGO CO, LTD. Tokyo, Japan), the pH of undiluted juice of each sample was determined using a pH meter (model B474, MicroNal, São Paulo, Brazil), and titratable acidity (TA) was determined by titration of diluted juice with 0.1 N NaOH to a phenolphthalein end point and expressed as g·L⁻¹. Those analyses were done at the Laboratory of Analyses at the Núcleo Tecnológico EPAMIG Uva e Vinho, located in Caldas city, State of Minas Gerais.

From each of the five subsamples, skin and seeds of 100 berries were carefully isolated from pulp, rinsed with tap and distilled water and then blotted dry with paper towels. Skins and seeds were weighed separately, frozen in liquid N₂ and stored at -20 °C until analysis. The skins were weighed on an analytical balance, placed in tubes containing 8 mL of acidified methanol (1 % HCl, v/v), homogenized with an Ultra-Turrax apparatus (model B14, Digimed, São Paulo, Brazil) at 14,000 rpm for 1 min and stored in darkness at 10 °C for 16 hours. Samples were centrifuged at 8,000 rpm for 15 min and the precipitate washed with acidified methanol until complete removal of pigments. The supernatant was collected in 50 mL volumetric flasks and used for anthocyanins and total phenol analyses. Anthocyanins were measured by the pH differential method (Giusti and Wrolstad 2000) and the concentration (expressed as mg pigment/g berry skin) was determined using the molecular weight (529) and molar absorbance (28,000) values for malvidin-3-glucoside (BERGQVIST *et al.* 2001). Total phenols of skin were evaluated by Folin-Ciocalteu method (AMERINE and OUGH 1980). In seeds, the phenolic compounds extraction was done by solubility in a solution of acidified methanol (1 % HCl v/v). The volume of extraction solution was proportional to must volume found in the berries, where must volume = berry weight - (seed

weight + skin weight). After storage for 48 h in the dark, the samples were filtered in glass wool and total phenols were quantified by the Folin Ciocalteu method. Total phenols concentration was expressed as mg gallic acid/g of berry skin or seeds.

Statistical data analysis was performed by a combined analysis of variance over the years, using the ESTAT software (UNESP, Jaboticabal, Brazil). The statistically significant differences were detected by the F test.

Results and Discussion

It is well known that the weather conditions of the season can affect grape quality through the amount of solar radiation, temperature, or water balance (JACKSON and LOMBARD 1993, BERGQVIST *et al.* 2001, VAN LEEUWEN *et al.* 2004).

Rainfall occurrence is higher during the summer period, from December to March, than in the autumn and winter period of April to August (Fig. 1). There were differences among the studied years in amount of rainfall during the growing seasons. In 2004, during the ripening period of the summer cycle the rainfall was greater (932 mm) than the total rainfall during the same period in 2005 (470 mm). A similar trend was also observed for the winter cycles of 2005 (384 mm) and 2006 (290 mm) (Fig. 1).

During the summer of 2005 and 2006, maximum temperatures ranged from 25 to 33.3 °C, whereas in the win-

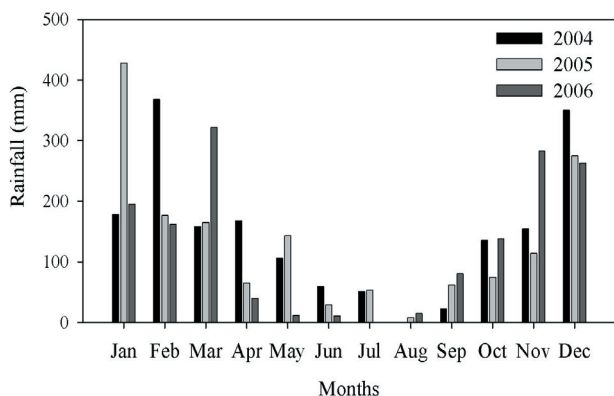


Fig. 1: Monthly rainfall during the years 2004, 2005 and 2006, in Três Corações, Minas Gerais, Brazil.

ter of both years, temperatures ranged from 20 to 29.5 °C (Fig. 2). Minimum temperatures during the summer of both years were around 16 °C, whereas during the winter cycles they were around 10 °C in 2005, and lower than 10 °C in 2006.

The effects of climate and soil on vine development and grape composition can be explained by their influence on vine water status (DELOIRE *et al.* 2004; VAN LEEUWEN *et al.* 2004). The Ψ_{pd} values (Tab. 1), in summer and winter cycles, were above -0.2 MPa, a range in which water stress is mild or absent according to the literature (SANTOS *et al.* 2003, DELOIRE *et al.* 2004, SOUZA *et al.* 2004). In this trial, despite the low rainfall observed during the months of autumn and winter, there was only a slight decrease in the

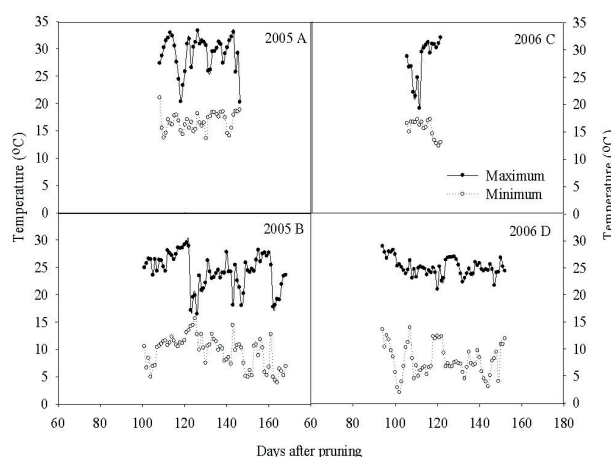


Fig. 2: Maximum and minimum temperatures during ripening of 'Syrah' grapevines in summer cycles (A and C) and winter cycles (B and D) of 2005 and 2006 in Três Corações, Minas Gerais, Brazil.

Table 1

Effects of growing season on pre-dawn leaf water potential (Ψ_{pd}), from pea-sized berries until near harvest

Phenologic phases	2005		2006	
	Summer	Winter	Summer	Winter
	Ψ_{pd} (MPa)			
Pea-sized berries	-0.18 a	-0.05 b	0.00 A	0.00 A
Veraison	-0.03 b	-0.06 a	-0.01 A	0.00 B
Ripening	-0.08 a	-0.01 b	0.00 B	-0.08 A
Before harvest	-0.04 a	-0.02 a	-0.02 B	-0.06 A

The values are means \pm SE. Means followed by different subscripts within a line are significantly different ($p < 0.01$).

†The comparisons were done only between seasons from the same year.

soil water availability, as shown by the high values of Ψ_{pd} measured in that period. In addition, the low evaporative demand of the winter atmosphere and the high water-holding capacity of the soil (Oxisol - clay texture) contributed to avoidance of vine water stress.

In most phenological stages sampled, the grapevines grown during the summer showed greater net photosynthesis rates (A) than during the winter cycle (Fig. 3). In 2005, the highest photosynthesis rates were observed in the summer cycle throughout berry touch (80 d after pruning) and ripening (Fig. 3). However, at harvest there were no differences between seasons. There was a trend in 2006, for A to be higher in grapevines growing during the summer cycle in the ripening period (from 140 d after pruning) than during the winter cycle.

The reductions in A observed during the winter as compared to the summer cycles were not due to decreased water soil availability, but probably due to the low night temperature recorded in that period. It also should be noted that most of the photosynthesis data were in the range of 8 to 12 $\mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, values also observed by some authors for 'Syrah' and other cultivars under Mediterranean conditions (SOUZA *et al.* 2004, REGINA and AUDEGUIN 2005, SIVILOTTI *et al.* 2005). However, in the winter of 2006, there

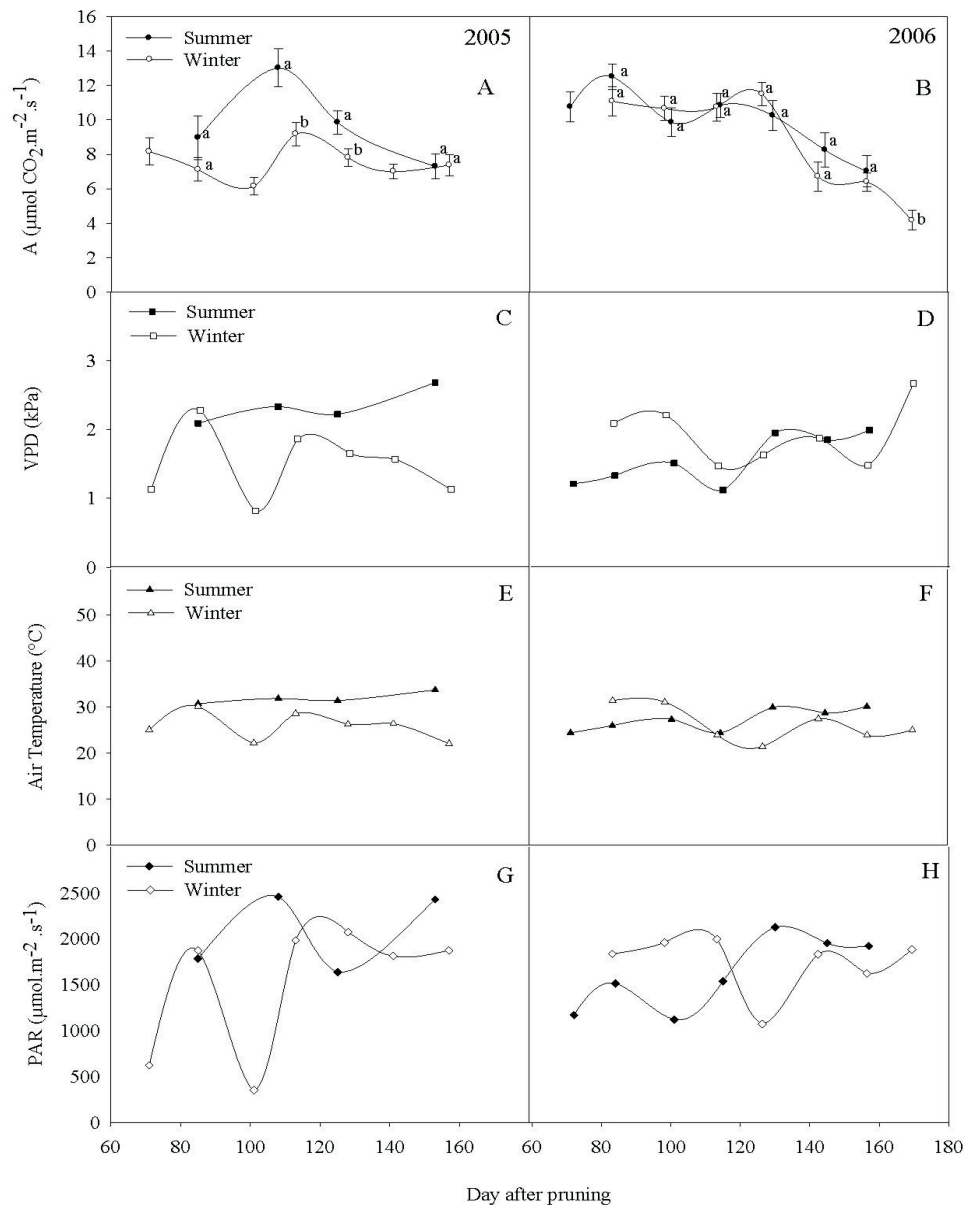


Fig. 3: Effects of growing season on net CO_2 assimilation rate (A) of 'Syrah' grapevines (A, B), VPD (C, D), air temperature (E, F) and radiation (PAR) (G, H) in Três Corações, Minas Gerais, Brazil (summer and winter of 2005 and 2006).

was a greater reduction in photosynthetic rates. The lowest minimum temperature (lower than $10\text{ }^\circ\text{C}$) observed during winter could have contributed to decrease CO_2 assimilation of 'Syrah' grapevines in this cycle. The chilling stress during the winter nights may have direct effects on carbon assimilation by impairing enzymatic activity of the Calvin cycle or inhibiting key enzymes in sucrose and starch biosynthesis (FLEXAS *et al.* 1999, HENDRICKSON *et al.* 2004). As the measurements of gas exchange were always performed on mature leaves on the middle position of the main shoots, the reductions in photosynthetic rates through phenological stages, observed in both growing seasons, could be attributed to leaf ageing, as also observed by SOUZA *et al.* (2004) even in fully irrigated vines.

Regardless of the observed reduction on carbon assimilation, the primary leaf surface was not affected by the cooler nights and days during the winter cycles (Tab. 2). The leaf area ranged from 2.7 to 4.3 m^2 per vine among the

treatments. Furthermore, vine vegetative and reproductive organs growth was not reduced until veraison as shown by the extent of the main phenological stages during the winter cycles. However, the ripening period and harvest were delayed during the winter as compared to the summer cycles. The length of summer growing season of 2005 and 2006, was, respectively, 159 and 157 d, from pruning to harvest, and the length of ripening period (from veraison to harvest) was 51 d, in both years (Tab. 2). The length of winter cycles was 183 days in 2005 and 180 days in 2006, and the ripening period ranged from 82 to 86 d. The higher temperatures observed during the summer growing season was responsible for hastening growth and fruit ripening (JACKSON and LOMBARD 1993). The low ripening speed of 'Syrah' during the winter, due to low night temperature may be an advantage as compared to faster ripening period observed in the summer cycles, since the permanence of the clusters in the vines for a longer period can provide

Table 2

Effects of growing season on primary leaf surface (m²/plant), on the main phenological stages, on bud break percentage and yield components

	2005		2006	
	Summer	Winter	Summer	Winter
Primary leaf surface (m ² /plant)	2.67 a ± 0.21	3.11 a ± 0.11	4.27 A ± 0.33	3.78 A ± 0.30
Main phenological stages (D.A.P. ^a)				
Bud break	12	13	14	12
Flowering	48	50	47	42
Veraison	108	101	106	94
Harvest	159	183	157	180
Bud break percentage	76.64 a ± 2.37	68.78 b ± 2.63	76.40 A ± 2.14	65.12 B ± 2.49
Yield components				
Clusters/shoot ratio	0.82 b ± 0.07	1.49 a ± 0.07	0.90 B ± 0.03	1.18 A ± 0.06
Mean cluster number	10.00 b ± 0.97	20.75 a ± 1.24	17.04 A ± 0.85	20.25 A ± 1.23
Mean cluster weight (g)	147.09 a ± 3.52	111.15 b ± 5.05	127.40 A ± 12.23	142.56 A ± 1.40
Mean berry weight (g)	2.24 a ± 0.01	1.45 b ± 0.03	2.08 A ± 0.04	1.52 B ± 0.01
Longitudinal berry diameter (mm)	15.24a ± 0.12	12.78 b ± 0.09	14.67 A ± 0.11	13.76 B ± 0.09
Transversal berry diameter (mm)	14.24 a ± 0.04	12.24 b ± 0.04	13.85 A ± 0.10	13.03 B ± 0.05
Total yield per vine (kg·plant ⁻¹)	1.47 b ± 0.14	2.31 a ± 0.14	2.17 B ± 0.11	2.89 A ± 0.18
Estimated productivity (kg·ha ⁻¹)	3919.02	6158.46	5785.22	7704.74

The values are means ± SE. Means followed by different subscripts within a line are significantly different ($p < 0.01$).

^aD.A.P. – days after pruning

an improvement on grape composition (ROSIER 2006). As expected, the greatest values of bud break percentage were observed during the summer cycles. This could be attributed to the chilling requirement during winter dormancy (Tab. 2). However, winter cycles' clusters/shoot ratios were greater than in the summer cycles and, consequently, it resulted in a greater production per vine; around 20 clusters/vine in both years. In 2005 there were differences between seasons in the mean cluster and berry weight. However, in 2006, differences were observed only in berry weight. In both years, berry size was greater in the summer than in the winter, as shown by longitudinal and transversal diameters. However, in both years, due to increased shoot fruitfulness, the yield per vine and estimated productivity per hectare were greater in the winter than the summer harvest.

A significant treatment-by-year interaction was found for yield components. The exception to this was total yield per vine. There was an increase in clusters/shoot ratio in the winter cycles, which largely compensated for the reduced percentage of bud break due to an absence of chilling after a summer harvest favorable to bud break. Shoot light exposure has a significant effect on clusters/shoot ratio due to light interception by individual buds which resulted in a high net carbon assimilation and available photosynthates at the time of fruit bud differentiation (KLEWER 1990, DRY 2000, SÁNCHEZ and DOKOOZLIAN 2005). In this study, the clusters harvested during the winter cycle originated from differentiated buds on the shoots developed in the previous year, where bud differentiation occurred during the months of September-October, when the light intensity and photosynthesis were high for this region. As a consequence, the winter cycle showed greater yield than the summer cycle, mainly due to increased cluster numbers. The shoot fruitfulness and yield per vine was in the range found in the literature for the same cultivar growing in other regions of

Brazil (AMORIM *et al.* 2005) and also in France (REGINA and AUDEGUIN 2005).

Besides an increase in yield, the composition of grapes cropped at the winter cycles was improved (Tab. 3). In both years, berry sugar concentration was greater during the winter than the summer harvests. It is well known that most of the sugar loaded in the berries is synthesized in the leaves by photosynthesis and transported to the berries, via the phloem, mainly as sucrose (DAVIS and ROBINSON 1996). However, in this study the photosynthetic rates were lower during the winter season. The greatest total soluble solids obtained at winter harvest were due to the decrease in weight and diameter of berries, since smaller berries have a relatively greater solute to solvent ratio than larger berries. Several authors affirmed that the berry size is influenced by the vine water status and, water deficits generally lead to smaller berries and changes fruit composition (BRAVDO *et al.* 1985, KENNEDY *et al.* 2002). ROBY *et al.* (2004) showed that the °Brix of berries from heavily-irrigated vines was consistently lower than from berries from reduced irrigation treatments. In the summer cycles, due to excessive rainfall during ripening, a thin wet surface stands over the berries in compact clusters such as 'Syrah's that may be responsible for the observed increase in berry diameters due to water intake through the skin (REBUCCI *et al.* 1997, BLOUIN and GUIMBERTEAU 2004). The increase of berry sizes found in the summer cycles could also be a consequence of an increased incidence of rainfall from flowering and veraison in these seasons. OJEDA *et al.* 2001 affirmed that water restriction in those phenological stages affects the cell growth and decreases the cell volume. Although the titratable acidity did not show a similar pattern between years, in 2005, the acidity was lower in the winter cycle than in the summer (Tab. 3). In contrast, in 2006 the lowest acidity was observed in the summer harvest. Differences between

Table 3

Effects of growing season on total soluble solids (TSS; °Brix), titratable acidity (g·L⁻¹), pH and cluster rot incidence

Parameter	2005		2006	
	Summer	Winter	Summer	Winter
TSS (°Brix)	15.86 b ± 0.15	18.24 a ± 0.08	17.38 B ± 0.12	20.66 A ± 0.21
Titratable acidity (g·L ⁻¹)	9.09 a ± 2.06	8.11 b ± 1.44	7.70 B ± 0.40	7.89 A ± 0.85
pH	3.46 a ± 0.04	3.44 a ± 0.02	3.39 A ± 0.02	3.26 B ± 0.01
Rot incidence	4.90 a ± 0.20	1.32 b ± 0.05	3.32 A ± 0.30	1.04 B ± 0.02

The values are means ± SE. Means followed by different subscripts within a line are significantly different ($p < 0.01$).

* and ** indicate significance at $p = 0.05$ and 0.01 , respectively.

growing seasons and pH were observed in 2006 with the lowest value observed during the winter cycle. The greatest differences in titratable acidity observed in 2005 were due to anticipated harvest in the summer caused by excessive rainfall in that year. In contrast, in 2006, the increased must acidity at the winter harvest may be better explained by the lower maximum and minimum temperatures in the air (Fig. 2) and near the cluster zone observed in the winter than by the differences in soil water availability between growing seasons. The mean values of maximum and minimum temperatures and the thermal amplitude recorded near the cluster zone, during the ripening period, are shown in Tab. 4. In both summer cycles, the values of maximum temperatures were around 29 °C whereas in the winter cycles, they were around 25.1 °C. The minimum temperatures observed near the cluster zone were lower in the ripening period during winter (around 8 °C) than in the summer (around 16 °C). Therefore, the smallest thermal amplitudes occurred in the summer cycle (around 12 °C) and the greatest (around 17.3 °C) was observed in the 2006 winter. Cool nights associated with warm day temperatures are able to reduce pH and increase acid concentration compared to warm days and warm nights (JACKSON and LOMBARD 1993). This reduction in acidity may have been the result of malic acid degradation associated with temperature rise (LAKSO and KLIEWER 1975).

The seasonal evolution of anthocyanins and total phenolic compounds in the skin and seeds are shown in Fig. 4. In general, the concentration of anthocyanins and phenolic compounds in the skin was greater in the winter than in the summer cycle in both years (Fig. 4 A, B, D, E). In the winter cycles, the maximum concentration of anthocyanins (7.67 - 10.36 mg·g⁻¹) and total phenols (20 - 25 mg·g⁻¹) were reached 4 to 6 weeks after veraison. The accumulation of these compounds was faster in the summer cycles, when the grapes reached a maximum concentration of anthocyanins (4.36 mg·g⁻¹ - 8.13 mg·g⁻¹) and total phenolics (11.95 mg·g⁻¹ - 17.6 mg·g⁻¹) 2 to 3 weeks after veraison. The concentration of phenolics in the seeds decreased from beginning of ripening until harvest, in both growing seasons (Fig. 4 C, F). However, only in 2005 there were differences between seasons. The highest concentration was observed during the summer cycle. Phenolics concentration in seeds was around 53 mg·g⁻¹ for the summer harvests, whereas values ranged from 41 to 45 mg·g⁻¹ during winter.

Table 4

Maximum and minimum temperature means and thermal amplitude near clusters, during berry ripening

Mean Temperature (°C)	2005		2006	
	Summer	Winter	Summer	Winter
Maximum	29.1	24.3	28.1	25.1
Minimum	16.7	9.5	15.5	7.8
Thermal amplitude (max - min)	12.4	14.8	12.6	17.3

The largest thermal amplitude during the winter season also contributed to an increase in the anthocyanins and total phenolic concentrations in the berries' skin. Several studies have shown that cool night temperature ripening conditions are essentially favorable to the synthesis of anthocyanins and aroma precursors (JACKSON and LOMBARD 1993, BERGQVIST *et al.* 2001, SPAYD *et al.* 2002, DELOIRE *et al.* 2004, TONETTO and CARBONNEAU 2004, MORI *et al.* 2005, KOSHITA *et al.* 2007). The reduction observed in the seeds polyphenol concentration was greater in the winter than in the summer cycle, mainly in 2005. This reduction is favorable for grape quality since the tannins, the main group of phenolic compounds in the seeds, are responsible for wine astringency (BLOUIN and GUIMBERTEAU 2004). Generally, there is a decline in seed tannins during ripening that accompanies seed browning, possibly due to tannin oxidation (ADAMS 2006).

Diseases may add negative compounds to the grapes resulting in a reduction of wine quality (JACKSON and LOMBARD 1993). Grape ripening during the winter cycles occurred under better climatic conditions than in the summer, the incidence of rot was higher in the summer cycles compared to the winter due mainly to a reduction in rainfall and temperature.

Conclusions

Três Corações city, located in the South of Minas Gerais state, has a potential to become a new region for production of high quality wine when production occurs during the autumn-winter season. The low rainfall and high thermal amplitude in the winter season were favorable to improve grape composition as shown by an increase

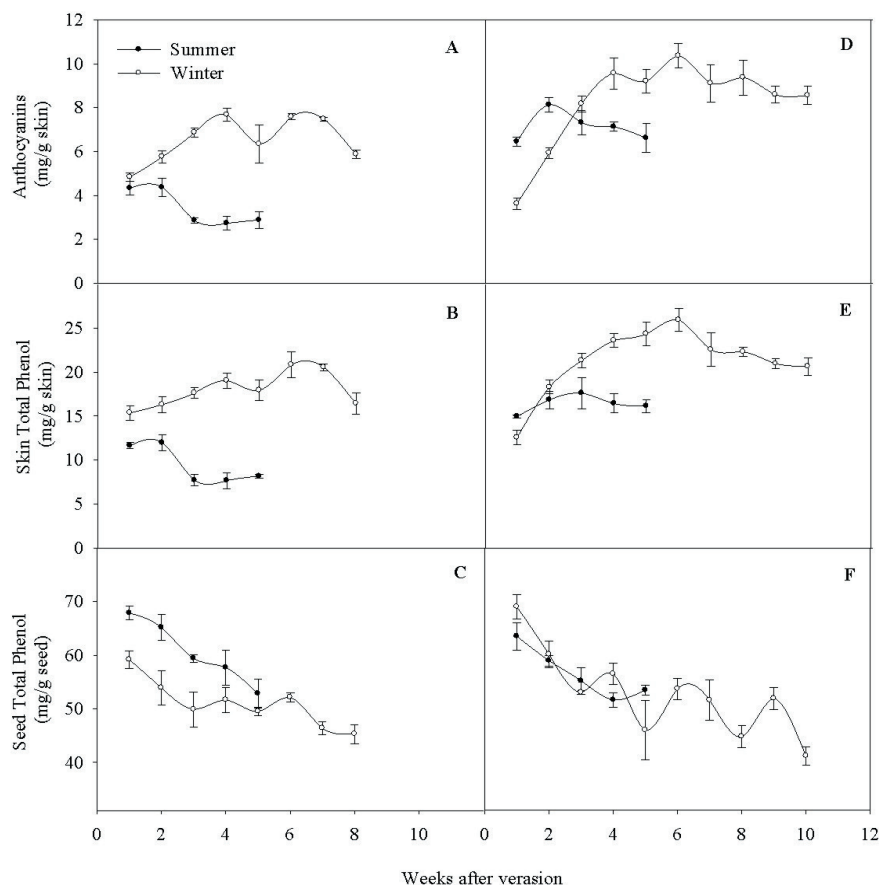


Fig. 4: Anthocyanins ($\text{mg}\cdot\text{g}^{-1}$), skin and seeds total phenolics contents ($\text{mg}\cdot\text{g}^{-1}$), during ripening of 'Syrah' grapevine, in summer and winter growing season of 2005 (A, B and C) and 2006 (D, E and F), in Três Corações, Minas Gerais, Brazil.

in sugar, anthocyanins and total phenolic concentration in the berries. Furthermore, there was no negative impact on vines subjected to annual production cycles as shown by the good performance of Syrah. Therefore, the double pruning practice could be considered as an important tool for improving wine grape quality in other regions with climates similar to the south of Minas Gerais.

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