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Quality and antioxidant potential of ‘BRS clara’ and ‘Arizul’ grapes influenced by rootstocks in a tropical region

Qualidade e potencial antioxidante das uvas ‘BRS clara’ e ‘Arizul’ influenciados por porta-enxertos em região tropical

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ABSTRACT

Seedless table grapes cultivars have been studied in the Sub-middle region of São Francisco Valley at northeast Brazil. For that region, it is important to identify cultivars with productive potential, better quality and efficiency, minimizing the expenses in terms of inputs and workforce, when compared to traditional cultivars. Specifically, the objective of this study was to determine the influence of different rootstocks on the quality and on the antioxidant potential of BRS Clara and Arizul table grapes cultivars of two production cycles. The experimental area belongs to the Experimental Field of Bebedouro/Embrapa Semiárido, located in the sub-middle region of São Francisco Valley, in Petrolina - PE, northeast Brazil. Both BRS Clara and Arizul cultivars were analyzed individually using IAC 313, IAC 572, IAC 766, SO4, Paulsen 1103 and Harmony rootstocks, during production cycles from October/2016 to February/2017 and from March/2007 to June/2017. The experimental design was planned in randomized blocks, in a 2 (production cycle) x 6 (rootstock) factorial, with three replications each. More favorable conditions to quality for ‘BRS Clara’ grapes, as evidenced by higher berry mass, lower soluble solids (SS)/titratable acidity (TA) ratio and higher antioxidant activity, were observed after the March-June, 2017 harvest, especially from scions grafted onto IAC 572, SO4 and Harmony. The Arizul cultivar was characterized by better quality after the March-July, 2017 harvest, showing higher berry mass, lower acidity and lower SS/TA ratio and a better color mainly in SO4 and Harmony rootstocks. Therefore, an appropriate rootstock enhances the quality of the grapes.

Index terms: Cultivars; seedless grapes; tropical viticulture.

RESUMO

Cultivares de uvas de mesa sem sementes têm sido avaliadas no Submédio do Vale do São Francisco. Para esta região, é importante identificar cultivares com potencial produtivo, qualidade e manejo com menor exigência por insumos e mão-de-obra, comparadas às comercialmente adotadas. O objetivo deste trabalho foi determinar a influência de diferentes porta-enxertos sobre a qualidade e o potencial antioxidante das cultivares de uva de mesa BRS Clara e Arizul, em dois ciclos de produção, no Submédio do Vale do São Francisco. A área de estudo foi instalada no Campo Experimental de Bebedouro/Embrapa Semiárido, em Petrolina-PE. As cultivares foram avaliadas em experimentos separados, tendo como tratamentos os porta-enxertos IAC 313, IAC 572, IAC 766, SO4, Paulsen 1103 e Harmony e dois ciclos de produção, correspondentes a outubro/2016-fevereiro/2017 e março-junho/2017. O delineamento experimental foi em blocos ao acaso, em fatorial 2 (ciclo de produção) x 6 (porta-enxerto), com três repetições. As condições mais favoráveis à qualidade da uva ‘BRS Clara’, evidenciado por maior massa da baga, diminuição da relação sólidos solúveis/acidez titulável (SS/AT) e maior atividade antioxidante, foram observadas na safra março-junho/2017, com destaque para as procedentes de plantas enxertadas sobre IAC 572, SO4 e Harmony. A cultivar ‘Arizul’ também se caracterizou por melhor qualidade na safra março-julho de 207, demonstrada por maior massa da baga, menor acidez e relação SS/AT e melhor coloração, principalmente para os porta-enxertos SO4 e Harmony. Portanto, um porta-enxerto adequado potencializa atributos de qualidade nas uvas.

Termos para indexação: Cultivares; uvas sem sementes; viticultura tropical.

INTRODUCTION

During the last years, cultivars of seedless table grapes increased the interest of farmers because of a growing acceptance among consumers, especially those from abroad. In order to fit to the interests of this market, research institutions have been developing cultivars of seedless grapes adapted to the climate conditions of Brazil, including those over the sub-middle region of the São Francisco Valley (Santos, et al., 2013). That region has expanded its participation in the production and exportation of grapes, which has turned that fruit important for the dynamization of agribusiness (Ministério da Agricultura, Pecuária e Abastecimento - MAPA, 2015). The main advantage of grapevine cultivation in that region is based on local edaphoclimatic conditions, providing two harvests per year. This allows minor investments in infrastructure, which implies a higher profitability by reducing expenses (Amaral et al., 2016).

Considering the Brazilian territory, the favorable climate conditions have benefited the growth of vitiviniculture, which consequently has been raising employment rates and have expanded both national and international commercial trading (Food and Agricultural Organization-FAO, 2015). Such an increase in production has allowed Brazil to soar exports, laying the country as a strong international trader.

In that market, white cultivars such as 'Thompson Seedless', 'Centennial Seedless' and 'Italia' are considered traditional (Aubert; Chalot, 2018). Currently, there is a diversity of cultivars being traded among countries. Those cultivars are raised under specific climatic conditions, since temperature, relative humidity, solar radiation, precipitation and water interception affect the water requirements of the grapes, which may increase the vulnerability of the plant to pests and diseases (Botton; Lorini; Afonso, 2005), which in turn overall affect the development of the vineyard, having an ultimate impact on the quality of the fruit (Moreira et al., 2012).

Due to the regional importance of viticulture, Embrapa Semiárido has been maintaining and characterizing an Active Germplasm Bank (AGB) of Grapevines to support the breeding program for the development of suitable cultivars for cultivation in the sub-middle region of the São Francisco Valley. AGBs allow the maintenance and conservation of genotypes, as they serve as a mean of studying the introduction of desirable genes into breeding programs (Batista et al., 2015). In fact, the study of genotypes of this AGB led to the identification of cultivars with significative productive potential for the region.

In this context, the Brazilian Grape Breeding Program has suggested the 'BRS Clara' grape as an alternative to the viticulture. This cultivar was obtained from the cross between CNPUV 154-147 and 'Centennial Seedless'. Such cultivar was tested in the sub-middle of the São Francisco Valley and also on production areas of the northern region of Minas Gerais State and northwest of São Paulo State (Embrapa Uva e Vinho, 2005).

Studies in the province of San Juan, Argentina, developed the cultivar 'Arizul', initially denominated Selection CG-351. The cultivar was obtained from the cross between the white grapes of 'Gibi' and 'Sultanina', carried out at the Instituto Nacional de Tecnología Agropecuaria - INTA, 2017. Both cultivars were introduced in the sub-middle of São Francisco Valley, but 'Arizul' was only studied as an accession in the AGB of Embrapa Semiárido. In general, white grape cultivars cropped in that region have irregular productions, mainly due to the occurrence of rain events during maturation (Oliveira et al., 2017). Consequently, new white grape cultivars are demanded in order to resolve that issue.

'BRS Clara' and 'Arizul' grapes have presented medium to high productivity under tropical conditions and quality enough for fulfilling both national and international requirements for commercial trading. According to Yamamoto et al. (2012), these cultivars presented agronomic and commercial characteristics for a profitable cultivation. However, technical adjustments are still required, particularly for 'Arizul' grapes, for which an efficient crop management under tropical conditions is unknown. In addition, more detailed information on quality, such as phenolic content and antioxidant potential of berries, represents a research opportunity.

The vigor and quality of the vineyard depend on factors that influence its growing. For instance, the rootstock influences the canopy physiology. Also, this choice characterize other factors such as resistance to pests and diseases and compatibility with canopy cultivar and growing conditions. However, there are few studies on scion/rootstock interaction that focus on physiological responses and their repercussion on fruit quality (Santarosa, 2016).

Grapes are considered important sources of phenolic compounds, which are attributed to the astringent and antioxidant properties. Some studies indicate that these contents as well as the total antioxidant capacity vary significantly among cultivars (Cantos; Espín; Tomás-Barberán, 2002). Besides, phenolic biosynthesis is affected by climatic conditions. Therefore, improving these features during the production season may be a commercial strategy to attract consumers, who usually care about maintaining a healthy diet.

The objective of this work was to determine the influence of different rootstocks on the quality and antioxidant potential of 'BRS Clara' and 'Arizul' table grape cultivars in two production cycles at the sub-middle region of São Francisco Valley.

MATERIAL AND METHODS

Bunches of 'BRS Clara' and 'Arizul' cultivars were harvested from a vineyard located in an area of Ultisol Plinthic (Empresa Brasileira de Pesquisa Agropecuária - Embrapa, 2013), inside the experimental field of Bebedouro, belonging to Embrapa Semiárido (Petrolina, Brazil: 9º04'14" S, 40º19'5" W, 366 m).

According to the classification of Köeppen (Köppen; Geiger, 1918), the climate of the region is BSwh, which corresponds to a very hot semi-arid region. The annual rainfall is 435 mm and the average annual temperature is 26.4 ºC, with a minimum daily mean of 20 ºC and a maximum of 33.4 ºC (Embrapa Semiárido, 2015).

The rootstocks evaluated were IAC 313, IAC 572, IAC 766, SO4, Paulsen 1103 and Harmony. The 'BRS Clara' and 'Arizul' scions were grafted on April 2012. The study was divided in two cycles. For the 'BRS Clara' cultivar, the first cycle started by pruning on October 17, 2016, harvesting on January 17, 2017, and the second cycle started by pruning on March 28, 2017 and harvesting on June 28, 2017. For the cultivar 'Arizul', the first cycle began on October 17, 2016, harvesting on February 7, 2017, and the second cycle started on March 28, 2017, harvesting on July 24, 2017. Climatic data spanning the period of study are shown on Table 1.

The canopy management was restricted to pruning and thinning of berries. Plant growth regulators for stretching of the berries was not applicated. Phytosanitary control was performed when insects, mites and fungi occurred at a level that caused economic damage, according to recommendations for regional conditions (Soares; Leão, 2009).

For both experiments (entitled Quality and antioxidant activity of 'BRS Clara' grapes and Quality and antioxidant activity of 'Arizul' grapes, which will be discussed separately in the next section), an overhead trellis system with 3 x 2 m spacing and a drip irrigation system were used. In both of the cycles studied for each experiment, nutritional management included organic and phosphate fertilization from pruning to harvest, and fertirrigation during the productive cycle, following soil and physiological requirements.

Bunches of both cultivars were harvested at ripe stage, that is, when uniformity of maturation and absence of rot, disease symptoms or nutritional deficiencies were observed. After being harvested, the following physical and chemical analyzes were performed:

Bunch weight (g) and berry weight (g), using semi-analytical balance (precision: 0.01 g);

Berry firmness (N), in electronic texturometer with graphical interface;

Skin color, measured in a CR-400 digital colorimeter (Konica Minolta), determining luminosity (L), Croma (C) or saturation and Hue angle (H);

Soluble solids content (SS, ºBrix), measured in ATAGO digital refractometer with variation from 0 to 32º Brix and automatic temperature compensation (Association of Official Analytical Chemists-AOAC, 1990);

Table 1: Monthly average, maximum and minimum temperatures, global radiation, relative air humidity and rainfall during the period from October 2016 to July 2017, in Petrolina-PE, Brazil.

Month/ year	Average temperature (°C)	Maximum temperature (ºC)	Minimum temperature (ºC)	Global Radiation (MJ/m^2)	Relative Air Humidity (%)	Rainfall (mm)*
Oct/2016	28.13	35.27	21.93	17.62	0.48	33.0
Nov/2016	28.83	35.88	23.01	17.31	0.48	8.9
Dec/2016	28.95	35.74	23.09	17.09	0.48	31.8
Jan/2017	29.32	36.00	23.20	18.23	0.45	10.2
Feb/2017	29.12	35.80	23.45	19.81	0.54	24.3
Mar/2017	28.78	35.33	23.32	19.81	0.58	5.6
Apr/2017	27.98	34.20	22.59	17.37	0.62	3.2
May/2017	27.03	32.71	21.87	16.79	0.65	26.0
Jun/2017	24.21	30.38	18.83	15.72	0.74	9.4
Jul/2017	22.91	28.35	17.56	15.09	0.69	4.7

*Monthly total.
Source: Data obtained from the Agrometeorological Station of the Experimental Field of Bebedouro. Petrolina, PE. (Embrapa Semiárido, 2017).

Titratable acidity (TA), determined from a solution of 5 mL of juice to 50 mL of distilled water, titrated with 0.1 M NaOH to pH 8.1, in a Mettler® automatic titrator model DL 12. Results were expressed in g of tartaric acid 100 mL^{-1} (Official Methods of Analysis - AOAC, 1990);

SS/TA ratio, obtained through the quotient between the two variables;

Total soluble sugars content (TSS), the reagent anthrone method (Dische, 1962), after extraction and warming to 100 ºC, followed by measuring at 620 nm, in g 100 g^{-1}.

Yellow flavonoids content in skin, expressed as mg 100 g^{-1}. The process was carried out by using 0.5 g of skin in ethanol extractive solution 1.5 N HCl (85:15) during dark conditions. The extract remained overnight at 4 ºC for measuring at 374 nm (Francis, 1982).

Total extractable polyphenols content, extracted by the method proposed by Larrauri, Rupérez and Saura-Calixto, (1997) and determined from the recommendation of Obanda and Owuor (1997), from the test to obtain an appropriate aliquot, the Folin-Ciocalteau reagent, 20% sodium carbonate and distilled water were added for measuring at 700 nm. The results were expressed as mg 100 g^{-1}.

Determination of the antioxidant activity by the free radical capture method ABTS (2,2'-azino-bis (3-ethylbenzothiazolin) 6-sulphonic acid), from extract obtained by the method proposed by Larrauri et al. (1997). The radical was diluted in ethanol until an absorbance of 0.70 (± 0.02) at 754 nm and then obtained at equilibrium temperature of 30 ºC. The absorbance was measured in a spectrophotometer after 8 minutes of sample addition (Miller, et al., 1993). The results were expressed in TEAC, an antioxidant activity equivalent to Trolox.

The 'BRS Clara' and 'Arizul' grapevines were studied in individual experiments, following an experimental design in randomized blocks in a 2 x 6 (production cycle x rootstock) factorial with three replications each. For each experiment, the plot was composed of five useful plants. Finally, two bunches were harvested from each of these plants.

The normal distribution of data was checked using XLSTAT® program. Data with normal distribution was submitted to analysis of variance followed by a comparison of means by Tukey's test (p<0.05). A generalized linear model using the Statistical Analysis Program System - SAS® was applied for the variables that did not present normal distribution. Also, the average values for each variable were subjected to principal component analysis (PCA) using the program XLSTAT® 2018.

RESULTS AND DISCUSSION

Quality and antioxidant activity of 'BRS Clara' grapes

The treatment with 'SO4' rootstocks presented the greatest mass of the bunch in the production cycle from October 2016 to January 2017, but overall there were no statistical differences among the treatments applied to 'BRS Clara' grapes (Table 2). However, in the cycle from March to June 2017, the masses of the bunches were equivalent, regardless of the rootstock. Although to some extent the rootstock contributes to the vigor of the plant, since a vineyard has a limited productive life, the timing of the growing period during the year showed a decisive influence on the mass of the bunch, which is a component of production. In the March to June 2017 cycle, scions grafted onto 'IAC 572', 'IAC 766', 'Paulsen 1103' and 'SO4' presented heavier bunches compared to the previous cycle, but they showed equivalent performances for all of the rootstocks, suggesting that the climatic conditions prevailing in the region contributed to this response. Values consistent with ours were reported by Batista et al. (2015). In fact, the authors observed masses of the bunch of 200 g for the same cultivar. In any case, as it was also found by these authors, variations between the harvests in our study were associated to temperature, global radiation and rainfall conditions (Table 1).

Regarding the average berry mass of 'BRS Clara' grapes, the highest value was observed in the second production cycle (Mar - Jun / 2017) with an increase of 1.19 g (Table 3). Differences between the cycles can be attributed to different climatic conditions, which affect the growth of the fruit and characterize the genetic potential of the cultivar, since no plant growth regulators were applied to stimulate the elongation of the bunches. When plant growth regulators are applied, the berry mass of 'BRS Clara' grapes reaches 3.50 g, as it was shown by Souza et al. (2010) in a study developed in Southeast Brazil. Considering the importance of commercial cultivar as reference, Leão, Silva and Silva (2005) reported an average berry mass of 1.87 g for 'Thompson Seedless' grapes in a cultivation with no plant regulators, cropped in the sub-middle region of the São Francisco Valley.

Regarding the berry firmness, the use of IAC 313, IAC 766, Paulsen 1103 and SO4 rootstocks provided uniform values in the two production cycles, being therefore more suitable for shipping (Table 2). The values observed were similar among the treatments, obtaining an overall mean of 3 N. The greatest variation in berry firmness between cycles was observed in bunches harvested from scions grafted onto IAC 572 and Harmony. On the other hand, the climatic conditions of the second production cycle favored differences between grapes from scions grafted onto IAC 572 and SO4. Indeed, the treatment IAC 572 resulted on firmer berries for that cycle. However, it should be noted that overall climatic conditions are the main responsible for the berry firmness. Finally, for 'BRS Clara' grapevines grafted onto Paulsen 1103, Oliveira et al. (2017) mentioned pulp firmness of 4.40 N for a cultivar conducted in the same region of ours.

There were significant differences for the color parameters L, C and H, in the two production cycles (Table 3). The values of L and C were higher for the first cycle, and only the hue angle resulted in higher values for the second cycle of production. The hue angle values for this cultivar were indicative of yellowish-green coloration. Temperature is directly related to these responses, and when it is higher, as it was observed in the first cycle, there may be greater degradation of green pigments that expose the yellow pigments presented in the skin (Valverde et al., 2005). This factor affects the quality of the grape because it is related to the levels of yellow flavonoids, which are antioxidant compounds (Ejsmentewicz et al., 2015; Sato et al.,1997) and therefore highly demanded by consumers.

Table 2: Mean values of bunch mass, berry firmness, titratable acidity (TA), yellow flavonoids in the skin and total extractable polyphenols in 'BRS Clara' table grapes under different rootstocks in two production cycles.

Production Cycle	Rootstock	Bunch mass (g)[1]	Berry firmness (N)[1]	TA (g tartaric acid 100 mL^{-1})[2]	Flavonoids (mg 100 g^{-1})[1]	Polyphenols (mg 100.g^{-1})[2]
Oct/2016-Jan/2017	IAC 313	155.8Aa	3.31Aa	0.35Ba	16.29Bab	106.95Bab
	IAC 572	98.7Ba	2.94Ba	0.36Ba	15.11Bab	92.99Bbc
	IAC 766	135.7Ba	3.06Aa	0.34Ba	16.67Bab	137.87Ba
	Paulsen 1103	117.8Ba	3.08Aa	0.37Ba	17.29Aab	81.39Bc
	SO4	163.0Ba	3.07Aa	0.39Ba	19.39Ba	119.77Bab
	Harmony	162.3Aa	2.94Ba	0.46Ba	13.05Bb	83.99Bc
Mar/2017-Jun/2017	IAC 313	171.5Aa	3.37Aab	0.81Aa	20.69Aabc	226.07Aa
	IAC 572	171.6Aa	3.69Aa	1.07Aa	19.81Abc	238.98Aa
	IAC 766	211.7Aa	3.33Aab	0.88Aa	20.76Aabc	214.31Aa
	Paulsen 1103	234.9Aa	3.35Aab	0.82Aa	16.44Ac	262.62Aa
	SO4	221.1Aa	3.20Ab	0.83Aa	24.25Aab	222.21Aa
	Harmony	202.7Aa	3.54Aab	0.81Aa	24.42Aa	205.42Aa

[1]Variables whose data had a normal distribution and were submitted to analysis of variance. [2]Variables whose data had no normal distribution and which were subjected to the generalized linear model with lognormal distribution. Means showing the same capital letters compares production cycle and means showing lower case, for rootstocks, did not differ between them, respectively, by the F and Tukey's tests ($p < 0.05$).

Table 3: Mean values of berry mass; luminosity - L, chroma - C and Hue angle - H color attributes; soluble solids/ titratable acidity - SS/TA ratio and antioxidant activity, determined by the free radical ABTS capture method, in 'BRS Clara' table grapes, in two production cycles.

Production cycle	berry mass (g)[2]	L[2]	C[2]	H[1]	SS/TA[2]	ABTS (μM Trolox g^{-1})[1]
Oct/2016- Jan/2017	1.60b	53.16a	24.38a	110.40b	54.60a	13.25b
Mar/2017- Jun/2017	2.79a	46.65b	17.61b	114.02a	23.60b	19.52a

[1]Variables whose data had a normal distribution and were submitted to analysis of variance. [2]Variables whose data had no normal distribution and which were subjected to the generalized linear model with lognormal distribution. Means followed by distinct letters represent significant effect of the production cycles, by the F test ($p < 0.05$).

The ‘BRS Clara’ grapes presented differences in relation to soluble solids (SS) and total soluble sugars (SST) content, when growing from different rootstocks, regardless of the production cycle evaluated (Table 4). The IAC 313 rootstock, which resulted in higher contents of both SS and SST inside the berries of the scions grafted on it, was compared with the Harmony treatment for SS and IAC 572 and SO4 for SST. In addition, the grapes harvested from scions grafted on IAC 313 did not differ from IAC 766 and Paulsen 1103 treatments as regards to both SS and TSS. Similarly, Oliveira et al. (2017) mentioned a SS content ranged from 19.5 to 19.9 ºBrix in ‘BRS Clara’ berries from scions grafted on Paulsen 1103. Traditional cultivars for international markets such as ‘Thompson Seedless’ also present high SS content, reaching values of about 19 ºBrix (Ejsmentewicz et al., 2015). However, differences in fruit quality are related to the vigor of the rootstock. Miele and Rizzon (2017) mentioned that low to medium vigor rootstocks provide higher SS contents. On the contrary, a vigorous rootstock in this study distinguished higher SS contents compared to Harmony treatment, which is characterized as moderately vigorous. Overall, it is assumed that the high the vigor of the rootstock is, the high leaf density of the scion, which favor the uptake of solar energy and, consequently, enhancing the photosynthetic efficiency. As a consequence, higher carbohydrate contents would be available to be transported to the berries. The identification of a rootstock that favors the accumulation of SS in the berries is in fact of great interest to producers, in order to fulfill the preferences of consumers, who typically prefer sweeter and tastier grapes (Sato et al., 1997).

Table 4: Mean values of soluble solids contents (SS) and total soluble sugars (TSS) contents in ‘BRS Clara’ table grapes under different rootstocks.

Rootstock	SS (ºBrix)	TSS (g 100 g^{-1})
IAC 313	22.33a	19.68a
IAC 572	19.48ab	16.65b
IAC 766	20.30ab	17.39ab
Paulsen 1103	19.75ab	17.97ab
SO4	19.55ab	16.89b
Harmony	19.26b	17.66ab

[1]Variables whose data presented normal distribution, having been submitted to analysis of variance and their means compared by Tukey’s test (p <0.05). Means followed by the same letter in the column do not differ by Tukey’s test (p <0.05).

Although the statistical analysis indicated a significant interaction between production cycle and rootstock, the test of means comparison found no differences among rootstocks for the titratable acidity (TA) variable (Table 2). However, it showed higher levels for the March-June 2017 cycle. Indeed, TA values of 0.72 g of tartaric acid100 mL^{-1} were observed for this cultivar in a study about agronomic characteristics and sensitivity to berries cracking during second-semester production cycles (Oliveira et al., 2017). These results are similar to those found in other cultivars, such as Thompson Seedless, which presented approximate values of 0.75 to 0.82 g of tartaric acid 100 mL^{-1} (Ejsmentewicz et al., 2015; Leão; Silva; Silva, 2005). According to Vieites et al. (2012), the decrease in acidity is a natural consequence of fruit ripening, in which organic acids are metabolized in the respiratory reaction and converted into non-acidic molecules. We therefore advocate that environmental conditions during the first production cycle may have favored the degradation of organic acids. In fact, it is usual to find lower TA values and higher SS contents in regions with higher air temperature. This is also the case in this study, where climatic differences between the two production cycles are the main factor to explain the different responses observed in TA and other chemical compounds associated with grape quality. Differences among rootstocks would probably be evident with the use of more precise methods of quantification of organic acids in ‘BRS Clara’ grapes. Additionally, Miele and Rizzon (2017) informed the earlier ripening of grapes, including a faster decrease on TA, which were influenced by rootstocks.

Overall, the SS/TA ratio was not influenced by the rootstocks. The SS/TA was lower in the second production cycle, but it still remained under the recommended standards for fresh consumption (Table 3). The values obtained are comparable to those of some commercial cultivars, such as Thompson Seedless, which shows a SS/TA ratio of approximately 29% in irrigated cultivations under semi-arid conditions (Leão; Silva; Silva, 2005). This is interesting to producers because this ratio indicates a greater content of sugars in the berries, which enhance the flavor of the grape.

The yellow flavonoids content in the skin was higher in the second cycle for the grapes harvested from grapevines grafted on every rootstock, except for Paulsen 1103 (Table 2). The combination between the first productive cycle and the SO4 rootstock resulted in higher yellow flavonoids content than the use of Harmony under the same production conditions of the year. On the other hand, the adoption of Harmony allowed higher contents than the Paulsen 1103 treatment, in the production cycle from March to June, 2017. The differential influence of the production cycle interacting on the Harmony rootstock, on yellow flavonoids content, was highlighted. The values practically doubled in the production period from March to June 2017. Soares et al. (2008), studying the Niagara cultivar, reported 37.75 mg 100 g^{-1} for yellow flavonoids content and stated that these compounds may influence antioxidant activity, astringency, bitterness and color. Therefore, the highlighted rootstocks here for this factor determine the potential of differentiated quality of the grapes of the scion.

Additionally, the content of total extractable polyphenols was influenced by the production cycle x rootstock interaction (Table 2). Similarly to the yellow flavonoids content, in the production cycle from March to June, 2017, total extractable polyphenols contents were higher than in the first cycle when using grapes harvested from grafted scions for all of the rootstocks studied. In the production cycle from October, 2016 to January, 2017, it was observed that the grapes harvested in the scions grafted on IAC 766 presented higher contents than those from IAC 572, Paulsen 1103 and Harmony.

According to Lago-Vanzela, et al (2011), berries of BRS Clara cultivar growing in Northwestern region of São Paulo State, Brazil, showed about 135 mg of gallic acid 100 g^{-1}. In our study, we observed a value approximated to that one reported by these authors in the cycle from October, 2016, to January, 2017. The following production cycle was, however, characterized by values above those records (Table 2). Therefore, both milder temperatures and moderate solar radiation seem to enhance total extractable polyphenols, including yellow flavonoids, which are key on the quality of the grape. Also, differences between harvests can be attributed to others factors rather than climate, such as fertilization and irrigation. For our experimental conditions, the influence of climate can be considered determinant since the management was similar for both cycles. In relation to the rootstocks, there were no significant differences among them in the production cycle from March to June, 2017. However, in this cycle, a greater accumulation of polyphenols was possibly favored by lower temperatures and global radiation during the maturation period of the grapes.

The effects of temperature and solar radiation on the synthesis of polyphenols are well documented for anthocyanins. Liang et al. (2014) emphasized that the thermal amplitude between day and night plays an essential role in the accumulation of sugars, which may be related to the conversion of anthocyanidins into anthocyanins in red grapes. On the other hand, high nocturnal and diurnal temperatures (above 30 ºC) prevent the synthesis of phenolics. This threshold is particularly important for the management of grapevines in Semi-arid regions. In white grapes and under tropical conditions, the response observed in this study advocates for more detailed studies on the phenolic responses to interannual climatic variations.

The values of the antioxidant activity determined by the ABTS method, were higher in the second cycle, corresponding to 19.52 µM Trolox g^{-1} of grape (Table 3), and they were not influenced by the rootstocks. Other studies indicated 21 µM Trolox g^{-1} for this cultivar produced in the semi-arid region of Jales, São Paulo State, Brazil (Lago-Vanzela et al., 2011). In general, the climate conditions of the Semiarid regions contribute to an increase in the antioxidant potential during production periods of higher temperature and global radiation and low rainfall. Finally, regarding the genetic potential of each cultivar, Batista (2015) mentioned 13 µM Trolox g^{-1} for 'Piratininga' grapes, grown in the same region of ours, and Soares et al. (2008) registered antioxidant activity of 28 µM Trolox g^{-1} with Niagara grapes in Southeast Brazil.

Quality and antioxidant activity of 'Arizul' grapes

No significant differences were found in the bunch mass for the 'Arizul' grapes among different rootstocks (Table 5). However, it is important to emphasize that all values were higher than 92 g, which is the typical value mentioned in the literature for this cultivar for the same regional conditions of our study (Oliveira et al., 2017) and without specific crop management for promoting growth and elongation of bunches and berries. On the other hand, other studies in the region indicate an average bunch mass of 199 g for cv. Arizul (Leão; Pereira, 2001).

The berry mass was significantly different between production cycles, increasing 1.37 g in the cycle of March-July 2017 in relation to the first one (Table 6). Generally, higher values of berry mass are related to heavier bunches. Since this association was not observed in our study, we suggest that there was a compensation with a greater number of berries per bunch or a greater rachis mass in the production cycle from October, 2016, to January, 2017 (Table 5).

Berry firmness is an important attribute for the quality, since it increases the resistance to shipping, prevents the attack of microorganisms and improves the sensorial features. Regarding the treatments studied, the statistical results indicate an effect of the interaction between the factors (Table 5). However, the Tukey's test did not distinguish the means of the treatments. It is likely that the natural variability of the individual berries analyzed or the variability among the bunches of the berries from the same sample resulted in difficulties to differentiate treatments through rigorous tests such as Tukey's. The observed values indicate berries with good resistance for shipping and storing, suggesting suitable features for commercial management.

Concerning the coloring of the berries, the 'Arizul' grape showed higher brightness and chroma or color saturation (C) and less greenish color, identified by lower value of H, for the cycle from October, 2016, to February, 2017 (Table 6). However, differences among rootstocks for L and H values indicated that grapes grown from the Harmony rootstock were characterized by a higher brightness compared to those in which the grapevines were grafted on IAC 572 and IAC 766 (Table 7). Regarding the hue angle of berries from grapevines, the SO4 rootstock presented higher yellowish coloring (Table 7).

The data suggest differences in coloration for both cycles, which was related to the influence of environmental conditions, especially temperature (this became more evident during fruit maturation), which indeed contributed to a quicker color development during the cycle October, 2016 - February, 2017. The berries were characterized by higher brightness, chroma and more yellowish-green color in that cycle.

Table 5: Mean values of bunch mass (BM), berry firmness, soluble solids content (SS), titratable acidity (TA), yellow flavonoid content in the skin (FLAV), total extractable polyphenols (TEP) and antioxidant activity, determined by the method of the ABTS free radical capture for the Arizul table grape cultivar under different rootstocks in two production cycles.

Production Cycle	Rootstock	MC (g)[1]	Berry firmness (N)[2]	SS (ºBrix)[1]	TA (g tartaric acid mL^{-1})[2]	FLAV (mg 100 g^{-1})[1]	TEP (mg 100 g^{-1})[2]	ABTS (μM Trolox g^{-1})[2]
Out/2016-Feb/2017	IAC 313	189.3 [ns]	3.53Aa	18.8Aa	0.33Bb	9.0Bb	85.41Aab	2.02Bc
	IAC 572	244.1	3.46Aa	18.3Ba	0.35Bab	9.8Bab	128.84Aa	4.71Aab
	IAC 766	224.5	3.67Aa	18.9Aa	0.35Bab	10.9Aab	95.96Aab	3.58Ab
	Paulsen 1103	223.9	3.55Aa	19.3Aa	0.37Bab	9.6Bab	80.02Bab	3.91Ab
	SO4	228.6	4.26Aa	19.8Aa	0.40Ba	12.5Aa	145.91Aa	5.82Aa
	Harmony	212.6	3.65Aa	19.3Aa	0.38Bab	11.1Aab	114.73Aa	5.83Aa
Mar/2017-Jul/2017	IAC 313	193.8	4.65Aa	18.1Bb	0.87Aa	11.3Aab	85.23Aab	3.22Aa
	IAC 572	218.8	4.44Aa	19.6Aab	0.92Aa	12.4Aa	94.10Bab	3.20Ba
	IAC 766	220.8	4.40Aa	19.7Aab	0.94Aa	8.5Bb	76.63Bb	2.78Bb
	Paulsen 1103	222.5	4.54Aa	20.4Aa	0.94Aa	13.4Aab	100.57Aa	2.85Bab
	SO4	199.4	4.32Aa	18.9Aab	0.87Aa	11.9Aab	106.86Ba	2.45Bb
	Harmony	184.4	4.56Aa	18.7Aab	0.80Aa	13.1Aab	108.74Aa	2.84Bab

[1]Variables whose data presented normal distribution, having been submitted to analysis of variance. [2]Variables whose data had no normal distribution and which were subjected to the generalized linear model with lognormal distribution. Means followed by the same capital letters, comparing production cycle, and lower case, for rootstocks, did not differ between them, respectively, by the F and Tukey's tests (p <0.05). ns = not significant.

Table 6: Mean values of berry mass, soluble solids/titratable acidity ratio - SS/TA, total soluble sugar (TSS) and luminosity (L), chroma (C) and hue angle (H) color attributes for 'Arizul' grape in the two production cycles of 2017.

Production cycle	Berry mass (g)[2]	L[1]	C[1]	H[2]	SS/AT[2]	TSS (g 100 g^{-1})[1]
Oct/2016-Jan/2017	1.59b	45.95a	19.29a	104.81b	52.94a	16.96a
Mar/2017- Jul/2017	2.96a	43.62b	16.52b	114.04a	21.77b	16.42a

[1]Variables whose data presented normal distribution, having been submitted to analysis of variance. Means followed by distinct letters represent significant effect of the production cycles, by the F test (p <0.05). [2]Variables whose data had no normal distribution and which were subjected to the generalized linear model with lognormal distribution.

Table 7: Mean values of the luminosity (L) and Hue angle (H) color attributes for the Arizul cultivar, under different rootstocks.

Rootstock	L[1]	H[2]
IAC 313	44.5ab	109.40ab
IAC 572	44.2b	110.87a
IAC 766	44.2b	110.33a
Paulsen 1103	44.6ab	109.29ab
SO4	44.8ab	106.97b
Harmony	46.2a	109.67ab

[1]Variables whose data presented normal distribution, having been submitted to analysis of variance and their means compared by Tukey's test ($p < 0.05$). Means followed by the same letters do not differ from each other by the Tukey test, at 5% probability. [2]Variables whose data had no normal distribution and which were subjected to the generalized linear model with lognormal distribution.

Regarding SS content, the interaction between production cycle and rootstock indicated lower values in the grapes from plants grafted on IAC 313, in the cycle of Mar-Jul/2017 (Table 5). It is noteworthy that the fruits harvested from scions grafted on IAC 572 were characterized by lower SS content in the cycle from October, 2016, to February, 2017. The mean values observed were higher than those reported in the literature for this cultivar. As an example, Oliveira et al. (2017) reported a SS content of 17.6 ºBrix. This value is indeed close to those (17-19 ºBrix) observed in other studies (Yamamoto et al., 2012; Ejsmentewicz et al., 2015). Regarding the TSS content, there were no significant differences (Table 6).

The TA was higher in the second production cycle, as there were no important differences among rootstocks in this season (Table 5). However, for the first cycle, the rootstock SO4 favored a higher TA of the berries in relation to the treatment IAC 313. These data indicate that temperature and global radiation influenced the acidity and the SS content of the berries. Up to a certain limit, high values of both acidity and SS are desirable as to prolong the exposure of the fruit while being sold at groceries (Ejsmentewicz et al., 2015).

The highest values of SS/TA ratio were observed in the cycle from October, 2016, to February, 2017, independently of the rootstock (Table 6). These values influenced the differentiated taste between the harvests, determined by the variation in TA. In the first cycle, a more uniform SS content (18.3-19.8 ºBrix) was observed regardless of the rootstocks and lower TA (0.33-0.40 g tartaric acid 100 mL^{-1}) with respect to the second cycle. After the March-July/2017 cycle, the highest variation in SS content (18.1-20.4 ºBrix) was observed, although the rootstocks did not contribute to significant differences in TA (0.80-0.94 g tartaric acid 100 mL^{-1}). Similar values for both variables were also observed in other studies for this cultivar (Yamamoto et al., 2012; Ejsmentewicz et al., 2015). These values are also close to those mentioned for other table grape cultivars (Moreira et al., 2012; Sonego et al., 2002).

There were differences in the yellow flavonoids content of the skin among the rootstocks for the two cycles studied (Table 5). In the cycle from October, 2016, to February, 2017, SO4 rootstock was highlighted for presenting higher levels of yellow flavonoids content than IAC 313. For the cycle from March to July, 2017, grapes from plants grafted on IAC 572 rootstock showed higher content of those compounds than the IAC 766 treatment. There are reports of yellow flavonoids contents of 17-43 mg 100 g^{-1} for white grapes cultivars such as Centennial Seedless, Chasselas and Italia (Aubert; Chalot, 2018). Flavonoid content can be affected by variations caused by seasonality, humidity, solar radiation and temperature. These compounds are known to be antioxidants, which are capable of inhibiting the oxidation of low density lipoproteins (Santos et al., 2017). Therefore, the use of IAC 572 and SO4 rootstocks would result in 'Arizul' grapes with higher contents of compounds with anti-oxidant potential.

The total extractable polyphenols content differed in 'Arizul' grapes according to the interaction between production cycles and rootstocks (Table 5). Analyzing the responses of the rootstocks in each cycle, it was possible to highlight IAC 572, SO4 and Harmony in the first cycle, and Paulsen 1103 and Harmony in the second cycle, as they showed an increase in the polyphenolic compounds contents. The efficiency of rootstocks is associated with differences in physiological and biochemical conditions of scions, which may influence the quality of the fruit (Bettoni et al., 2015). It is expected that less vigorous rootstocks increase the content of some classes of phenolics, such as flavonoids, catechins and stilbenes, which are recognized for their healthy properties. The mentioned properties are also influenced by genetic factors, environmental conditions, type of cultivation, maturity stage, species and cultivar (Santos et al., 2017). Several studies indeed revealed differences in canopy behavior regarding grafting, vigor and phenolic content of grapes depending of the rootstock (Lago-Vanzela et al., 2011). Silva et al. (2017) observed that 'BRS Violeta', 'Syrah' and 'Isabel' grapes from vines grafted on IAC 766 presented higher phenolic compounds than berries harvest from grapevines grafted on 106-8 Mgt, under subtropical conditions of Jundiaí, São Paulo State, Brazil. Concerning the contents, the values observed in our study corroborate the observations of Fabani et al. (2017), who mentioned a total polyphenols content of 120 mg.100 g^{-1} for 'Arizul' grapes, grown in a continental climate with hot summers in the Province of San Juan, Argentina.

In relation to the antioxidant activity, determined from the ABTS free radical capture method, most of the rootstocks studied in the first cycle resulted in a greater activity for 'Arizul' grapes, except IAC 313 treatment (Table 5). On the other hand, grapes of IAC 313 treatment presented high values in the second production cycle. In general, the antioxidant activities associated to SO4 and Harmony were higher than for grapes from plants grafted on IAC 313 during the cycle from October, 2016, to February, 2017. In the cycle from May to July, 2017, responses of IAC 313 treatment distinguished from the others. The increase in antioxidant activity in grapes have been justified by increases of phenolic compounds, which, in turn, can be induced by stress. Molina-Quijada et al. (2010) reported 3-4 μM Trolox g^{-1} for white grape cultivars, such as Perlette and Sugraone, grown in dry climate in Sonora region, Mexico.

The multivariate analysis was used to verify the clustering of different responses and also used to obtain additional information about the influence of the variables analyzed in relation to the treatments tested for both canopy cultivars (Figure 1). It was verified that components 1 and 2 (cultivars and production cycle-

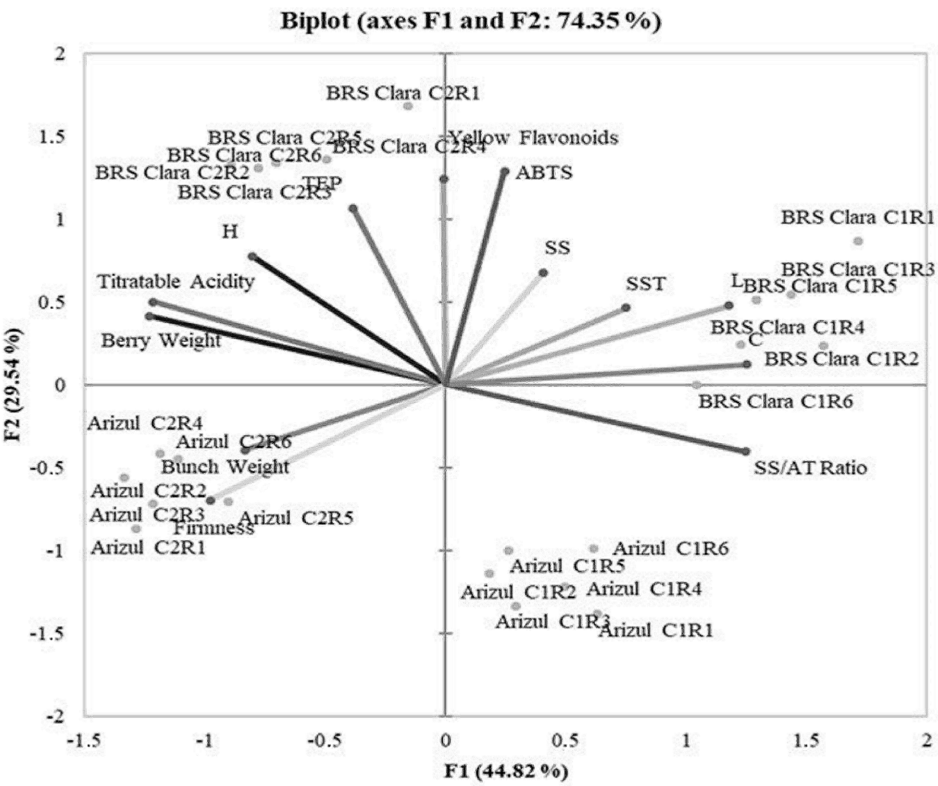

Figure 1: Main component analysis for evaluating the quality and antioxidant activity of table grapes BRS Clara and Arizul, harvested from two production cycles (from October 17, 2016 to January 17, 2017 and March 28, 2017 on June 28, 2017, for BRS Clara, and from October 17, 2016 to February 7, 2017 and from March 28, 2017 to July 24, 2017, Arizul) by using six rootstocks (IAC 313, IAC 572, IAC 766, SO4, Paulsen 1103 and Harmony).
C1 = Cycle 1 (from October 17, 2016 to January 17, 2017, for 'BRS Clara', and from October 17, 2016 to February 7, 2017, for 'Arizul'); C2 = Cycle 2 (28 March 2017 to 28 June 2017, for 'BRS Clara', and from 28 March 2017 to 24 July 2017, for 'Arizul'); R1 = rootstock IAC 313; R2 = rootstock IAC 572; R3 = rootstock IAC 766; R4 = rootstock SO4; R5 = rootstock Paulsen 1103; R6 = rootstock Harmony; L = luminosity; C = chroma; SS/AT ratio = soluble solids/titratable acidity ratio; H = Hue angle; TEP = total extractable polyphenols; and TSS = total soluble sugars.

rootstock combinations, respectively) explained 74.35% of the variation of the data. Data from cultivars clustered in isolated groups, indicating particular characteristics for each one. Differences between the production cycles resulted in the formation of distinct groups for both cultivars for all of the rootstocks. This ratifies what was previously discussed about the timing of the growing and how it affects the quality of the grapes, which ultimately determine their physiological and biochemical properties of the grapes. The variables that contributed the most to the quality of 'BRS Clara' grapes were luminosity, chroma and the total soluble sugars content in the production cycle from October, 2016, to February, 2017. In the cycle from March to July, 2017, the variables berry mass, Hue angle and titratable acidity were the ones that contributed the most to the quality of 'BRS Clara' grapes. For the Arizul cultivar, the variable that differentiated the quality of the grape in the cycle from October, 2016, to February, 2017, was the SS/TA ratio, while in the cycle from March to July, 2017, were the bunch mass and the berry firmness. Considering the combination of production cycle and rootstock, the grapes from the scions grafted on IAC 313 highlighted in both cycles. The Harmony treatment was particularly differentiated in the cycle from October, 2016, to February, 2017.

The quality of 'BRS Clara' and 'Arizul' grapes changed during seasons in the Sub-middle of São Francisco Valley. Depending on the timing of the growing season during the year, some quality characteristics stood out, indicating particularities for each one. The influence of the rootstock on the scion is characterized not only by the traditional criteria documented in the literature, such as yield, tolerance or resistance to pests, diseases, water stress, and efficiency of absorption of some nutrients, but also by the quality attributes of the grapes. Responses related to SS, TA and phenolic compounds have been elucidated here for both cultivars.

CONCLUSIONS

The production cycle from March to June, 2017, provided conditions for higher berry mass, extractable polyphenols content and antioxidant activity in 'BRS Clara' grapes. In the season characterized by higher temperatures and radiation, IAC 313, IAC 766 and SO4 rootstocks for 'BRS Clara' grapevines increased the extractable polyphenols content in the berries. 'Arizul' grapes from plants grafted on IAC 572, SO4 and Harmony rootstocks were distinguished by higher extractable polyphenols content in the production cycle corresponded to October, 2016, to February, 2017. During the cycle from March to July, 2017, the same response was associated to Harmony and Paulsen 1103 rootstocks. The climatic conditions during the growing season affected physiological and biochemical characteristics of the berries for both BRS Clara and Arizul cultivars, but the management of suitable rootstocks enhance the quality of the grape.

REFERENCES

AMARAL, G. V. et al. O desempenho das exportações brasileiras de uva: Uma análise da competitividade da região do vale do São Francisco no período de 2005 a 2014. **C@LEA - Revista Cadernos de Aulas do LEA**, 1(5):1-17, 2016.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS - AOAC. **Official Methods of Analysis,** 15th edn. Association of Official Analytical Chemists, Washington, DC. 1990. 771p.

AUBERT, C.; CHALOT, G. Chemical composition, bioactive compounds, and volatiles of six table grape varieties (*Vitis vinifera* L.). **Food Chemistry**, 240:524-533, 2018.

BATISTA, P. F. et al. Divergência genética entre variedades de videiras do Banco Ativo de Germoplasma da Embrapa Semiárido. **Revista Ciência Agronômica**, 46(4):800-808, 2015.

BETTONI, J. C. et al. Rooting of hardwood cuttings of promising grapevine rootstocks for regions with history of plants' death. **Revista Brasileira de Fruticultura**, 37(2):534- 539, 2015.

BOTTON, M.; LORINI, I.; AFONSO, A. P. Ocorrência de *Sitophilus zeamais* Mots. (Coleoptera: Curculionidae) danificando a cultura da videira no Rio Grande do Sul. **Neotropical Entomology**, 34(2):355-356, 2006.

CANTOS, E.; ESPÍN, J. C.; TOMÁS-BARBERÁN, F. A. Varietal differences among the polyphenol profiles of seven table grape cultivars studied by LC-DAD-MS-MS. **Journal of Agricultural and Food Chemistry**, 50:5691-5696, 2002.

DISCHE, Z. General color reactions. In: WHISTLER, R. L.; WOLFRAN, M. L. **Carbohydrate Chemistry**. New York: Academic, 477-512, 1962.

EJSMENTEWICZ, T. et al. Comparative study of two table grape varieties with contrasting texture during cold storage. **Molecules**, 20(3):3667-3680, 2015.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA. **Sistema brasileiro de classificação de solos**. rev. ampl. Brasília, DF: Embrapa Informação Tecnológica, 2013. 353p.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA SEMIÁRIDO. **Dados Estação Agrometeorológica de Bebedouro - Petrolina-PE**. 2015. Available in: < http://www.cpatsa.embrapa.br:8080/servicos/dadosmet/ceb-mes.html >. Access in: September, 2017.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA Uva e Vinho. **Sistema de Produção 8**. 2005. Available in: <https://sistemasdeproducao.cnptia.embrapa.br/FontesHTML/Uva/UvasSemSementes/index.htm>. Access in: September, 2017.

FABANI, M. P. et al. Changes in the phenolic profile of Argentinean fresh grapes during production of sun-dried raisins. **Journal of Food Composition and Analysis**, 58:23-32, 2017.

FOOD AND AGRICULTURAL ORGANIZATION - FAO. **Statistic 2015**. 2015. Available in: <http://faostat3.fao.org/browse/Q/QC/E>. Access in: December 12, 2017.

FRANCIS, F. J. Analysis of anthocyanins. In: MARKAKIS, P. **Anthocyanins as Food Colors**. London: Academic Press, 1st ed. 181-206, 1982.

INSTITUTO NACIONAL DE TECNOLOGÍA AGROPECUARIA - INTA. **Estación Experimental Agropecuaria Rama Caida, Argentina**, 2017. Available in: <http://www.vivc.de/index.php?r=passport%2>. Access in: September, 2017.

KÖPPEN, W.; GEIGER, R. Classification der climate nach temperature neiderschlag und jahreslauf. **Petermanns Geographic Miteillunger**, 64:193-203, 1918.

LAGO-VANZELA, E. S. et al. Phenolic composition of the Brazilian seedless table grape varieties BRS Clara and BRS Morena. **Journal of Agriculture and Food Chemistry**, 59:8314-8323, 2011.

LARRAURI, J. A.; RUPÉREZ, P.; SAURA-CALIXTO, F. Effect of drying temperature on the stability of polyphenols and antioxidant activity of red grape pomace peels. **Journal of Agricultural and Food Chemistry**, 45(4):1390-1393, 1997.

LEÃO, P. C. S.; PEREIRA, F. M. Avaliação de seis variedades de uvas sem sementes no Submédio São Francisco. **Pesquisa Agropecuária Brasileira**, 36(4):607-613, 2001.

LEÃO, P. C. S.; SILVA, D. J.; SILVA, E. E. G. Efeito do ácido giberélico, do bioestimulate Crop Set e do anelamento na produção e na qualidade da uva 'Thompson Seedless' no Vale do São Francisco. **Revista Brasileira de Fruticultura**, 27(3):418-421, 2005.

LIANG, N. N. et al. Regional characteristics of anthocyanin and flavonol compounds from grapes of four *Vitis vinifera* varieties in five wine regions of China. **Food Research International**, 64:264-274. 2014.

MIELE, A.; RIZZON, L A. Rootstock-scion interaction: Effect on the yield components of Cabernet Sauvignon grapevine. **Revista Brasileira de Fruticultura**, 39:434. 2017.

MILLER, N. J. et al. A novel method for measuring antioxidant capacity and its application to monitoring the antioxidant status in premature neonates. **Clinical Science**, 84(4):407-412, 1993.

MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO - MAPA. **Culturas:** Soja. Brasília, 2015. Available in: <http://www.agricultura.gov.br/vegetal/culturas/soja>. Access in: December 15, 2017.

MOLINA-QUIJADA, D. M. A. et al. Compuestos fenólicos y actividad antioxidante de cáscara de uva (*Vitis vinifera* L.) de mesa cultivada en el noroeste de México. **CyTA - Journal of Food**, 8(1):57-63, 2010.

MOREIRA, A. N. et al. Variação sazonal de espécies de tripes em videira de acordo com sistemas de manejo e fases fenológicas. **Pesquisa Agropecuária Brasileira**, 47(3):328-335, 2012.

OBANDA, M.; OWUOR, P. O. Flavanol composition and caffeine content of green leaf as quality potential indicators of Kenyan black teas. **Journal of the Science of Food and Agriculture**, 74:209-215, 1997.

OLIVEIRA, L. D. S. et al. Características agronômicas e sensibilidade ao rachamento de bagas de uvas sem sementes. **Journal of Environmental Analysis and Progress**, 2(3):274-282, 2017.

SANTAROSA, E. Alterações anatômicas do sistema vascular em porta-enxertos de videira. **Pesquisa Agropecuária Brasileira**, 51(4):320-329, 2016.

SANTOS, A. E. O. et al. Resposta fenológica e exigência térmica de uvas apirenas cultivadas no Submédio do São Francisco. **Revista Brasileira de Ciência Agrária**, 8(3):364-369, 2013.

SANTOS, I. C. et al. Frutas e hortícolas: Análise comparativa dos seus teores em compostos fenólicos e flavonoides totais. **Boletim Epidemiológico Observações**, 6(Supl 9):60-63, 2017.

SATO, A. et al. Varietal differences in the texture of grape berries measured by penetration tests. **Vitis**, 36:7-10, 1997.

SILVA, M. J. R. et al. Phenolic compounds and antioxidant activity of red and white grapes on different rootstocks. **African Journal of Biotechnology**, 16(13):664-671, 2017.

SOARES, J. M.; LEÃO, P. C. de S. **A vitivinicultura no Semiárido**. Embrapa Informação Tecnológica: Brasília, Embrapa Semiárido: Petrolina, 2009. 756p.

SOARES, M. et al. Compostos fenólicos e atividade antioxidante da casca de uvas Niágara e Isabel. **Revista Brasileira de Fruticultura**, 30(1):59-64, 2008.

SONEGO, L. et al. Factors affecting taste scores of early season seedless table grape cv. Mystery and Prime. **Journal of Agricultural and Food Chemistry**, 50:544-548, 2002.

SOUZA, R. T. D. et al. Efeitos de doses e formas de aplicação de reguladores de crescimento em uvas sem sementes, cv. Brs Clara, em região tropical. **Revista Brasileira de Fruticultura**, 32(3):763-768, 2010.

VALVERDE, J. M. et al. Improvement of table grapes quality and safety by the combination of modified atmosphere packaging (MAP) and eugenol, menthol, or thymol. **Journal of Agricultural and Food Chemistry**, 53:7458-7464, 2005.

VIEITES, R. L. et al. Radiação gama na conservação de caqui 'Giombo', destanizado e frigoarmazenado. **Revista Brasileira de Fruticultura**, 34(3):719-726, 2012.

YAMAMOTO, L. Y. et al. Produção e características físico-químicas dos cachos da videira 'BRS Clara' sob cobertura plástica e sombrite em safra fora de época. **Revista Brasileira de Fruticultura**, 34(1):160-166, 2012.