Qualification of 'Bordô' grape clones in Vale do Rio do Peixe, in the state of Santa Catarina, Brazil

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Abstract – The objective of this work was to characterize the productive and qualitative performances of 11 clones of 'Bordô' grape (*Vitis labrusca*) destined to wine and juice production, in the region of Vale do Rio do Peixe, in the state of Santa Catarina, Brazil. The experiment was carried out in the 2011, 2012, 2014, and 2015 crop seasons. The analyzed yield components were: number of clusters per vine, yield, cluster weight, accumulated yield, and alternate bearing index. The analyzed morphological characteristics of clusters were: number of berries per cluster, berry diameter, cluster compactness index, and cluster length. In order to assess grape quality, the following parameters were analyzed: soluble solids (SS), pH, titratable acidity (TA), SS/TA ratio, total anthocyanins, and total polyphenols. The 'Bordô' grape clones 13 and 16 ('Paco' and 'Bocaina') are the most suitable ones for cultivation in the wine producing region of Vale do Rio do Peixe, as they show the highest yields, production stability, and grapes with adequate quality for wine and juice elaboration.

Index terms: *Vitis labrusca*, agronomic performance, clonal selection, 'Ives'.

Qualificação de clones da uva 'Bordô' no Vale do Rio do Peixe, em Santa Catarina

Resumo – O objetivo deste trabalho foi caracterizar o desempenho produtivo e qualitativo de 11 clones da uva 'Bordô' (*Vitis labrusca*), destinados à produção de vinhos e sucos, na região do Vale do Rio do Peixe, no Estado de Santa Catarina. O experimento foi realizado nas safras 2011, 2012, 2014 e 2015. Os componentes de rendimento analisados foram: número de cachos por planta, produtividade, massa de cachos, produtividade acumulada e índice de alternância de produção. As características morfológicas dos cachos analisadas foram: número de bagas por cacho, diâmetro de baga, compactação do cacho e comprimento do cacho. Para avaliar a qualidade da uva, foram analisados os seguintes parâmetros: sólidos solúveis (SS), pH, acidez titulável (AT), relação SS/AT, antocianinas totais e polifenóis totais. Os clones da uva 'Bordô' 13 e 16 ('Paco' e 'Bocaina') são os mais indicados para cultivo na região vitícola catarinense do Vale do Rio do Peixe, pois apresentam produtividade mais elevada, estabilidade de produção e uvas com qualidade adequada para a elaboração de vinhos e sucos.

Termos para indexação: *Vitis labrusca*, desempenho agronômico, seleção clonal, 'Ives'.

Introduction

In the state of Santa Catarina, Brazil, viticulture is an important economic activity. The planted area with grapevines is of 5,060 ha, and the production is about 66,000 tons of grapes. The region of Vale do Rio do Peixe, in the middle west of the state, is the most traditional producing region, responsible for more than two-thirds of grape production in the state. The main producing municipalities are Tangará, Videira, Pinheiro Preto, and Caçador. The grapes are mainly used for wine and juice elaboration, with a small percentage destined for fresh consumption (Back et al., 2013), and the main cultivars produced in the region are the American ones and hybrids, among which are 'Isabel', 'Niagara', and 'Bordô'.

'Bordô' (also known as 'Ives') is one of the main American cultivars produced in Brazil, standing out for its high rusticity due to resistance to fungal

DOI: 10.1590/S0100-204X2018000700003

diseases (Hoffmann et al., 2005). In addition, its berries and wines are deeply colored, making them useful in blends, in order to improve, for instance, the color of 'Isabel' and 'Concord' products (Robinson et al., 2012). The wines and juices elaborated with 'Bordô' grape are marked by a "foxy" aroma, very appreciated by a certain range of Brazilian consumers (Castilhos et al., 2016).

However, since 'Bordô' grape has some cultivation restrictions, it is not grown in most wine producing countries. Constant drops in productivity, for instance, are observed as a result of poor fruit set. This physiological disorder can reduce productivity by up to 8 Mg ha^{-1}, significantly reducing the grower's profitability (Miotto, 2012; Miotto et al., 2014).

Therefore, the world literature about this cultivar and its products – grape juice and wine – is practically nonexistent. In Brazil, published works about the agronomic and biological performance and physicochemical composition of grape, juice, and wine of 'Bordô' are limited (Tecchio et al., 2007), mainly for the state of Santa Catarina, specifically for the Vale do Rio do Peixe region. In the country, there is no restriction on the cultivation of this grape due to the viticulture structure adopted; however, in South and Southeastern Brazil, the ripening period of 'Bordô' grape coincides with the rainy season (Regina et al., 2010), and, in certain situations, the cultivar does not reach a soluble solids and titratable acidity ratio (SS/TA) high enough to produce quality wines and juices (Chiarotti et al., 2011).

One of the suggested ways to solve these problems is the planting of clones better adapted to specific cultivation conditions. In order to do this, Empresa de Pesquisa Agropecuária de Minas Gerais (Epamig) started a clonal selection program of 'Bordô' grape, with emphasis on plant health, and on the increase and constancy of production (Villa et al., 2010).

Due to all previously mentioned obstacles, in Santa Catarina, especially in the Vale do Rio do Peixe region, the current production of 'Bordô' grape cannot supply the demand of wineries and juice industries. This way, the companies of the region continue to buy grapes from another Brazilian state – Rio Grande do Sul –, which indicates the need to plant new vineyards for juice and wine production (Caliari, 2016). The identification of clones better adapted to the conditions of Vale do Rio do Peixe region, which can make feasible the growing of 'Bordô' grapes, shows is of strategic importance for the development of viticulture in Santa Catarina state.

The objective of this work was to characterize the productive and qualitative performance of 11 clones of 'Bordô' grape, destined for wine and juice production, in the region of Vale do Rio do Peixe, in the state of Santa Catarina, Brazil.

Materials and Methods

The clones were obtained from the clonal selection of 'Bordô' grape in the Epamig vineyards, and in private properties in the municipality of Caldas, MG, Brazil (22°55'S, 46°23'W).

The experiment was carried out at Vinícola Panceri, located in the municipality of Tangará, in Vale do Rio do Peixe region, in the state of Santa Catarina, Brazil (26°11'17"S, 51°10'25"W, at 870 m altitude). The climate of the region is mesothermal humid (Cfb), according to Köppen-Geiger's classification, that is, a temperate climate constantly humid, without dry season, and cool summer. The mean annual temperature varies from 15.8 to 17.9°C, the maximum mean temperature from 22.3 to 25.8°C, and the minimum from 10.8 to 12.9°C. Annual rainfall varies from 1,460 to 1,820 mm, and the number of rainy days per year from 129 to 144 days. Frosts may average from 12 to 22 per year. Average accumulation of temperatures below 7.2ºC ranges from 437 to 642 hours per year (Back et al., 2013).

Plants of 11 'Bordô' clones were grafted on 'Paulsen 1103', planted in December 2008, at 3.0x2.0 m spacing, trained in horizontal trellis with a mixed pruning system (canes and spurs). The Panceri winery carried out the vineyard management (pruning, shoot removal, shoot topping, and phytosanitary treatments) according to the recommendations for the grape production system developed by Embrapa Uva e Vinho (Protas, 2003).

The experiment was implemented in a completely randomized design, with four replicates. Each plot was composed of five plants. For the evaluations, the three central plants of each plot were considered. The 11 clones were evaluated during the 2011, 2012, 2014, and 2015 crop seasons. In the 2013, there were no evaluations due to a late frost that occurred in September 2012 and caused severe damage to the plants. In the crop seasons of 2011 and 2012, the harvests occurred on February 3 and 8 respectively, and in the crop seasons 2014 and 2015, grapes were harvested on February 6.

The production variables were the number of clusters, yield per plant, and yield per hectare. Yield per plant (kg per plant) was determined with the UR1000 light digital field scale (Urano Indústria de Balanças e Equipamentos Eletrônicos Ltda., Canoas, RS, Brazil). Yield per hectare (Mg ha^{-1}) was obtained by multiplying yield per plant by planting density (1,666 plants ha^{-1}). At the end of the evaluation period, the cumulative yield of the four seasons (Mg ha^{-1}) was calculated.

The biennial bearing tendency of each clone was assessed by calculating the alternate bearing index (ABI) by the formula ABI = $[(a_{y2} - a_{y1})/(a_{y2} + a_{y1}) + (a_{y3} - a_{y2})/(a_{y3} + a_{y2})\ldots(a_y - a_{y-1})/(a_y + a_{y-1}))]/n-1$, in which: a is the yield (Mg ha^{-1}); y is the year; and n is the number of years. This index gives values from 0 to 1, in which 0 represents no biennial bearing, and 1 represents a complete biennial bearing (Pasa et al., 2017).

During the harvest, 20 clusters per plot were randomly sampled to carry out the physical analyses: cluster length (cm), which was measured using a digital caliper; cluster weight (g), which was measured with an analytical precision scale of 0.005 g; and number of berries per cluster, which was obtained by manual counting.

The cluster compactness index was obtained by [(cluster weight)/(cluster length)^2], proposed by Tello & Ibanez (2014). The diameter of berries (mm) was measured by the transversal measurement of 50 berries diameter per plot.

The analyses were carried out in the laboratory of morphogenesis and plant biochemistry of Universidade Federal de Santa Catarina (UFSC). From the grape must of each clone, soluble solids (SS, ºBrix), and titratable acidity (TA, % of tartaric acid), pH, and maturation index (SS/TA) were determined according to the methodology proposed by the International Organisation of Vine and Wine (OIV, 2009).

Technological maturity indices were obtained from a sample of 50 berries randomly collected per plot. The titratable acidity (TA) was obtained by the titration method, in which 5 mL must, 75 mL distilled water, and two drops of phenolphthalein (1%) were added. Under stirring, a solution of sodium hydroxide (0.1 N NaOH) was added until color change. The SS content (°Brix) was determined in the RTD-45 digital temperature-compensated refractometer (Instrutherm, Instrumentos de Medição Ltda., São Paulo, SP, Brazil). The pH was evaluated by reading the samples in the MP220 Mettler pH meter (Toledo, Schwerzenbach, Switzerland) calibrated with buffer solutions at pH 4.0 and 7.0.

For the analysis of total anthocyanins (mg L^{-1}) and total polyphenols (mg L^{-1} gallic acid), a grape methanolic extract was prepared with 30 berries in triplicate, totaling 90 berries. For this, the skins were separated from the pulp, weighed, and acidified methanol (1% hydrochloric acid) was added to them. The extracts were kept in the dark at 4.0±1°C for 24 hours (Lees & Francis, 1972). After that period, they were filtered on Whatman nº1 paper, using Büchner's funnel, transferred to amber bottles, kept under nitrogen flow for 30 s, then sealed and kept at -18ºC until analysis.

The quantification of total monomeric anthocyanins was performed by differential pH, following the methodology described by Giusti & Wrolstad (2001), considering Ɛ = 28000 and MM = 529, for which the methanolic extract was diluted in a buffer pH 1.0 of potassium chloride (0.025 mol L^{-1}) and in another buffer pH 4.5 of sodium acetate (0.4 mol L^{-1}). They remained in rest for 15 min out of the light. Absorbance readings for each buffer were performed at wavelengths of μ vis-max 520 and 700 nm, using the UV 1203 spectrophotometer (Shimadzu, Kyoto, Japan); the results were expressed in malvidin-3-glycoside mg L^{-1}.

The content of total polyphenols (mg L^{-1} gallic acid) was determined according to the methodology described by Singleton & Rossi (1965), using the Folin-Ciocalteu method, with absorbance readings at 760 nm in the UV 1203 spectrophotometer (Shimadzu, Kyoto, Japan).

Descriptive statistics (mean, standard deviation, and coefficient of variation), analysis of variance, and the Scott-Knott's test, at 5% probability, were used to evaluate and interpret the results.

Results and Discussion

'Bordô' grape clones showed a significant plant performance both in the productive and qualitative ways. Among the 11 evaluated clones, it was possible to identify were the most adapted ones to the conditions of Vale do Rio do Peixe region.

Regarding the productive variables, the highest yield values were observed in the clones 13 and 16 (Table 1). For both, the average yield was 23.0 Mg ha^{-1}. Among the eleven clones studied, the average yields ranged from 8.8 to 14.0 kg per plant or 15.0 to 23.0 Mg ha^{-1}. These values are superior to the average yields of the same clones evaluated in the state of Minas Gerais, where average values of 11.6 Mg ha^{-1} were observed in plants trained in vertical shoot position (VSP) (Miotto et al., 2014). In addition, the average yield obtained in the present study was also higher than the observed ones in studies conducted in the municipality of Caldas, MG (9.0–10.0 Mg ha^{-1}) and Farroupilha, RS (12.0 Mg ha^{-1}) (Maia et al., 2013).

The adoption of selected clones is a real possibility to increase vineyard yield. For example, in the state of São Paulo, the 'Bordô' grape clone called ‘Barberinha’ produced an average of 3.3 kg per plant, corresponding to 68% yield increase, in comparison with the average yield per plant of the region, similarly to the results obtained in southern Minas Gerais (Santos et al., 2011; Miotto et al., 2014). The average yield in Santa Catarina was 11.1 kg per plant; and, for the most productive clones (13 and 16), the average yield was around 13.9 kg per plant, which corresponds to 200% yield increase, which is above the average yield obtained in São Paulo and Minas Gerais. Clone 3 showed the worst production indices, with 8.8 kg per plant, 15 Mg ha^{-1}, and 91 clusters per plant.

The clones 8, 13, and 16 also produced on average more clusters per plant, statistically differing from the other clones studied. In addition, these clones are among those with clusters of the highest-average weight.

The clones 13 and 16 also stood out with the highest-cumulative yield, which was superior to 100 Mg ha^{-1}

Table 1. Yield components of ‘Bordô’ (*Vitis labrusca*) clones, during the 2011, 2012, 2014, and 2015 crop seasons, in Tangará, in the region of Vale do Rio do Peixe, Santa Catarina state, Brazil.

Clone	2011		2012		2014		2015		Average		2011		2012		2014		2015		Average		Cumulative	
	Yield (kg per plant)										Estimated yield (Mg ha^{-1})(2)											
3	2.5	a	13.3	c	7.6	d	13.5	c	8.8	c	4.2	a	22.1	c	12.8	d	22.4	c	15.1	c	62.3	d
7	1.4	a	12.9	c	11.8	c	17.8	b	10.4	b	2.3	a	21.4	c	20.4	c	30.0	b	17.4	b	73.0	c
8	1.6	a	12.6	c	17.0	b	20.5	a	11.6	b	2.7	a	21.2	c	28.1	b	34.1	a	19.3	b	85.7	b
10	3.7	a	11.3	c	14.1	c	18.3	b	10.6	b	6.1	a	18.9	c	23.9	c	31.3	b	18.0	b	79.2	c
12	3.2	a	14.4	b	18.7	b	13.8	c	11.5	b	5.3	a	23.8	b	31.0	b	22.8	c	18.9	b	83.0	b
13	2.9	a	15.4	b	20.5	a	22.6	a	14.0	a	4.8	a	26.2	b	34.2	a	38.1	a	23.2	a	101.9	a
15	2.8	a	12.4	c	17.6	b	16.2	c	10.9	b	4.6	a	21.5	c	29.5	b	26.9	c	18.0	b	82.4	b
16	3.2	a	14.7	b	22.6	a	20.5	a	13.7	a	5.3	a	25.2	b	38.2	a	34.3	a	23.1	a	102.0	a
17	3.7	a	13.2	c	8.4	d	13.2	c	9.2	c	6.1	a	21.7	c	13.7	d	22.0	c	14.8	c	64.5	d
18	4.3	a	12.9	c	11.7	c	15.2	c	10.2	b	7.2	a	22.0	c	19.5	c	25.3	c	17.0	b	74.3	c
19	4.1	a	17.5	a	7.6	d	22.5	a	11.5	b	6.9	a	29.4	a	13.1	d	36.8	a	19.1	b	86.1	b
CV (%)	26.1		25.0		26.2		27.8		24.9		26.1		25.0		26.2		27.8		24.9		11.3	
	Number of clusters per plant										Cluster weight (g)										ABI	
3	22.7	a	107.4	a	117.2	e	173.6	d	91.3	d	117.1	c	123.6	b	66.6	b	77.6	b	104.3	b	0.40	c
7	14.3	a	98.2	a	134.5	e	211.4	b	103.3	c	95.3	c	134.8	a	89.3	a	84.4	a	104.3	b	0.34	b
8	15.7	a	112.8	a	233.3	a	234.8	a	129.7	a	106.9	c	114.5	b	73.5	b	87.9	a	98.2	c	0.34	b
10	31.9	a	100.7	a	155.2	d	216.3	b	108.3	b	120.6	c	113.4	b	92.7	a	85.0	a	107.7	b	0.25	a
12	21.5	a	115.2	a	213.7	b	167.0	d	113.5	b	157.3	a	125.2	b	87.2	a	83.6	a	120.4	a	0.31	a
13	25.3	a	118.5	a	225.7	a	249.2	a	136.2	a	120.2	c	132.3	a	91.8	a	91.2	a	113.2	a	0.29	a
15	25.2	a	98.1	a	209.3	b	187.6	c	110.1	b	111.9	c	127.6	b	84.3	a	87.9	a	107.8	b	0.28	a
16	24.8	a	109.9	a	241.7	a	223.2	b	128.9	a	135.2	b	137.8	a	94.8	a	92.9	a	120.9	a	0.30	a
17	34.3	a	123.3	a	175.1	c	197.2	c	116.2	b	108.8	c	107.0	b	48.2	b	67.0	b	90.0	c	0.34	b
18	37.0	a	108.6	a	179.8	c	199.7	c	111.1	b	118.2	c	122.4	b	67.4	b	78.4	b	104.1	b	0.24	a
19	32.5	a	119.4	a	150.3	d	240.6	a	101.0	c	130.7	b	148.7	a	47.2	b	93.6	a	123.3	a	0.49	c
CV (%)	33.3		18.3		26.0		20.2		19.7		23.7		20.9		25.9		16.3		19.8		21.9	

(1)Means with different letters, in the columns, indicate significant differences, by the Scott-Knott test, at 5% probability. (2)Estimated by mean yield per plant and number of plants per hectare.

over four years of evaluation. These two clones are already registered by Epamig, with the names ‘Paco’ and ‘Bocaina’, respectively, in the database of the national authority for cultivar registration (Registro Nacional de Cultivares) of Ministério da Agricultura, Pecuária e Abastecimento. However, it is worth mentioning that clones 8, 12, and 19 also showed a high-cumulative yield, which is superior to 80 Mg ha^{-1}.

As for the biennial bearing tendency, clones 13 and 16, along with clones 10, 12, and 15 showed a good production stability, in some cases, with increasing yields between seasons and lower-alternate bearing index (ABI), which is important for the economic stability of the grower and the winery. When evaluating these same clones in Minas Gerais, Miotto et al. (2014) also observed the highest-average yield (14.9 Mg ha^{-1}) in the clone 13. The clones 3, 7, 8, 17, and 19 had the highest ABI and a biennial bearing tendency, with reductions up to 10.0 Mg ha^{-1} in less productive years.

The average number of berries per cluster varied from 50 to 66. Except for clone 7, the other clones showed a decreased number of berries per cluster in the 2014 and 2015 seasons (Table 2). However, the reduction of the number of berries per cluster did not directly affect the yield values observed in Table 1. It is also possible to observe, especially in clones 8, 10, and 17, a large variation of the number of berries between seasons, which suggests that such clones are more susceptible to fruit set problems, characterized by the fall of flowers and young berries. This disorder may occur due to several factors, such as genetic, environmental, phytosanitary, and cultural management.

The berry diameter varied according to season and clone; on average, the smallest berries were observed in clones 7 and 17, with 14.9 and 14.8 mm, respectively. Clone 18 showed the largest diameter of berries with 15.8 mm (Table 2). Berry size has always been considered a factor related to grape quality, and there

Table 2. Clusters physical characteristics of 'Bordô' (*Vitis labrusca*) clones, during the 2011, 2012, 2014, and 2015 crop seasons, in Tangará, in the region of Vale do Rio do Peixe, in Santa Catarina state, Brazil[(1)].

Clones	2011	2012	2014	2015	Average	2011	2012	2014	2015	Average
	Berries per cluster					Cluster length (cm)				
3	61.5 b	73.1 c	55.4 b	45.2 b	59.2 c	13.1 c	10.1 b	13.5 a	11.8 a	12.1 c
7	63.7 b	73.5 c	76.7 a	34.6 c	59.6 c	14.4 b	12.7 a	14.7 a	11.4 a	13.2 a
8	53.7 c	69.9 d	61.9 b	40.8 c	55.1 d	11.6 d	12.1 a	15.3 a	11.9 a	12.2 c
10	57.3 c	81.7 a	47.0 c	41.1 c	58.9 c	14.3 b	11.7 a	13.2 b	12.6 a	13.1 a
12	71.5 a	81.5 a	75.3 a	37.7 c	65.2 a	14.9 a	10.8 b	14.7 a	10.2 b	12.7 b
13	64.1 b	83.4 a	58.6 b	53.8 a	65.7 a	14.5 b	11.2 b	12.5 b	12.3 a	12.9 a
15	58.8 c	77.8 b	72.2 a	36.4 c	60.3 c	13.8 b	11.9 a	15.2 a	11.7 a	13.1 a
16	63.3 b	77.5 b	58.6 b	45.0 b	62.2 b	15.0 a	11.0 b	14.5 a	10.8 b	13.0 a
17	55.0 c	67.2 d	42.2 c	27.6 d	50.1 e	13.4 c	10.7 b	11.2 c	10.9 b	11.9 c
18	67.8 a	84.0 a	60.9 b	34.3 c	61.0 b	15.2 a	11.1 b	11.7 c	10.5 b	12.6 b
19	62.4 b	75.5 c	62.6 b	56.7 a	66.5 a	14.0 b	10.9 b	14.2 a	11.5 a	13.0 a
CV (%)	20.0	16.3	21.7	29.2	17.8	13.1	13.3	13.7	16.0	11.9
	Cluster compactness (g cm^{-2})					Berry diameter (mm)				
3	0.71 b	1.22 b	0.77 c	0.59 c	0.80 c	15.7 c	17.1 b	11.8 c	14.8 a	15.1 c
7	0.44 d	0.86 d	0.85 b	0.75 b	0.67 d	15.5 d	16.8 b	11.2 c	15.1 a	14.9 d
8	0.84 a	0.82 d	0.60 c	0.65 c	0.76 c	15.5 d	17.0 b	17.1 a	15.2 a	15.6 b
10	0.60 c	0.90 d	0.72 c	0.55 c	0.68 d	16.0 b	17.3 a	11.7 c	14.6 b	15.2 c
12	0.74 b	1.37 a	0.86 b	0.89 a	0.94 a	16.0 b	16.5 c	11.7 c	14.6 b	15.1 c
13	0.61 c	1.16 b	0.84 b	0.63 c	0.77 c	15.8 c	16.7 b	11.6 c	14.9 a	15.1 c
15	0.60 c	0.97 c	0.74 c	0.66 c	0.72 d	16.3 a	16.4 c	11.4 c	14.2 c	15.1 c
16	0.62 c	1.17 b	0.72 c	0.87 a	0.83 b	16.3 a	16.2 c	11.9 c	15.0 a	15.5 b
17	0.63 c	0.99 c	0.86 b	0.60 c	0.74 c	15.5 d	16.7 b	12.2 c	14.3 c	14.8 d
18	0.52 d	1.03 c	1.15 a	0.77 b	0.78 c	16.2 b	17.1 b	16.4 b	14.6 b	15.8 a
19	0.69 b	1.28 a	0.76 c	0.72 b	0.88 b	16.6 a	17.5 a	11.3 c	14.9 a	15.6 b
CV (%)	29.6	28.0	28.2	42.1	27.9	7.8	3,0	18.6	4.6	6.9

[(1)]Means with different letters, in the columns, indicate significant differences, by the Scott-Knott test, at 5% probability.

are significant correlations between berry size and grape quality (Roby et al., 2004).

Liang et al. (2012), studied the berry composition and polyphenols content of wild species of *Vitis*, and reported that berry size may affect the accumulation of polyphenols, but it is not the only factor involved. Roby & Matthews (2004) found that skin, seed, and pulp proportions do not vary according to this relation, pointing out that the skin does not extend around a larger pulp, but grows with it. The surface/volume ratio, therefore, cannot always be considered as a measure of extractable solutes level (Matthews& Nuzzo, 2007).

As to cluster compactness index, the clones 7, 10, 13, 15, 16, and 19 showed the highest-average values of cluster length. However, the clones 10, 7, and 15 have the lowest-average values of cluster compactness, with 0.68, 0.67, and 0.72 g cm^{-2}, respectively. The clone 12 showed the highest value for cluster compactness index (Table 2).

The cluster compactness is an important factor that affects the quality of wine and table grapes (Roberto et al., 2015). Compact clusters show favorable conditions for the development of different pests and diseases, mainly botrytis bunch rot caused by the fungus *Botrytis cinerea* (Hed et al., 2009). The cluster compactness results in a microclimate more favorable for disease development, when there is poor air circulation and less sun exposure inside the clusters (Molitor et al., 2011).

In a clonal selection work of 'Vignoles' grape, several individuals produced less compact clusters. A lower-cluster compactness is considered more related to differences for flower fertility and berry set than for rachis length (Cousins & Garris, 2014).

For technological maturity, the average levels of SS varied from 14.7 to 16.5°Brix (Table 3). Throughout the evaluated seasons, the clones 3, 7, and 8 stood out with the highest-SS levels of, while the clone 19 showed the

Table 3. Technological maturity of ‘Bordô’ (*Vitis labrusca*) clones, during the 2011, 2012, 2014, and 2015 crop seasons, in Tangará, in the region of Vale do Rio do Peixe, in Santa Catarina state, Brazil[(1)].

Clone	2011		2012		2014		2015		Average		2011		2012		2014		2015		Average	
	Soluble solids (°Brix)										Titratable acidity (%)									
3	16.2	b	16.4	b	16.2	a	15.3	a	16.0	a	0.78	b	0.79	b	0.50	a	0.71	a	0.70	a
7	16.6	a	17.6	a	15.0	b	15.4	a	16.2	a	0.66	a	0.67	a	0.45	a	0.69	a	0.62	a
8	16.8	a	17.8	a	15.9	a	15.5	a	16.5	a	0.81	b	0.79	b	0.70	b	0.79	a	0.77	b
10	16.3	b	15.7	c	15.5	a	14.9	b	15.6	b	0.62	a	0.76	b	0.47	a	0.67	a	0.63	a
12	15.9	b	15.2	c	14.7	b	14.4	b	15.1	b	0.60	a	0.79	b	0.47	a	0.86	b	0.68	a
13	15.9	b	15.6	c	15.3	b	14.3	b	15.3	b	0.68	a	0.66	a	0.43	a	0.86	b	0.66	a
15	16.0	b	16.8	b	15.2	b	14.4	a	15.6	b	0.86	b	0.67	a	0.66	b	0.97	b	0.79	b
16	16.1	b	16.6	b	14.7	b	13.9	c	15.3	b	0.66	a	0.89	c	0.58	a	0,64	a	0.69	a
17	15.9	b	16.6	b	14.6	b	15.3	a	15.6	b	0.74	b	0.72	a	0.74	b	0.93	b	0.78	b
18	15.8	b	15.6	c	15.5	a	14.3	b	15.3	b	0.67	a	0.65	a	0.51	a	0.87	b	0.68	a
19	14.8	c	15.1	c	14.6	b	13.9	c	14.6	c	0.80	b	0.93	c	0.70	b	0.86	b	0.82	b
CV (%)	4.5		5.9		3.5		4.2		5.5		14.1		14.1		18.0		9.4		18.7	
	pH										SS/TA ratio									
3	3.18	a	3.20	a	3.48	a	3.39	a	3.31	a	20.9	b	20.9	b	32.8	a	21.5	a	23.9	a
7	3.27	a	3.25	a	3.47	a	3.40	a	3.35	a	25.2	a	26.5	a	33.5	a	22.3	a	26.8	a
8	3.21	a	3.29	a	3.44	a	3.37	a	3.33	a	20.9	b	22.9	a	22.8	b	19.6	a	21.4	b
10	3.17	a	3.18	a	3.51	a	3.37	a	3.31	a	26.6	a	20.9	b	33.0	a	22.2	a	25.6	a
12	3.27	a	3.20	a	3.48	a	3.34	a	3.32	a	26.6	a	19.5	b	31.5	a	16.7	b	23.4	a
13	3.19	a	3.21	a	3.46	a	3.35	a	3.30	a	23.6	a	23.7	a	35.6	a	16.6	b	24.8	a
15	3.16	a	3.27	a	3.40	a	3.35	a	3.30	a	18.7	b	25.3	a	23.0	b	14.8	b	20.4	b
16	3.23	a	3.22	a	3.41	a	3.32	a	3.30	a	24.4	a	18.7	b	25.5	b	21.7	a	22.5	a
17	3.15	a	3.22	a	3.41	a	3.35	a	3.28	a	21.7	b	22.9	a	19.9	b	16.5	b	20.2	b
18	3.18	a	3.24	a	3.41	a	3.34	a	3.29	a	23.7	a	24.0	a	30.5	a	16.4	b	23.6	a
19	3.08	a	3.13	a	3.42	a	3.31	a	3.23	a	18.8	b	16.3	b	21.2	b	16.2	b	18.1	b
CV (%)	2.7		2.2		1.9		1.7		2.1		15.4		15.6		21.5		13.5		21.8	

[(1)]Means with different letters, in the columns, indicate significant differences, by the Scott-Knott test, at 5% probability. SS/TA ratio, soluble solids/titratable acidity ratio.

lowest-SS levels in all evaluated seasons. The values obtained in the present work are in agreement with those verified for American grape cultivars grown in Brazil (Werle et al., 2008).

For TA, a variation among clones was observed in different seasons, and clone 7 stood out among those that showed the lowest-TA concentrations; the clone 19, however, was among those that produced grapes with the highest levels of TA (Table 3). The average values for TA (0.71% tartaric acid) are higher than the obtained ones for the same clones in Minas Gerais (0.52% tartaric acid) by Miotto et al. (2014). Higher temperatures are related to higher-acid degradation; therefore, the higher-acidity levels obtained in Santa Catarina are considered as related to the occurrence of lower temperatures during grape maturation.

The average value of pH must was 3.30, and no differences were observed among the clones in all evaluated seasons (Table 3). Miotto et al. (2014) obtained similar results in the state of Minas Gerais.

The SS/TA ratio is used to determine the ideal harvest timing of grapes, since it represents the balance between sugar and acidity contents, which are directly linked to fruit flavor and, consequently, to juice quality (Sato et al., 2009). In the average of four evaluated seasons, only the clone 19 did not reach values equal to or higher than 20, while the clones 3, 7, 10, 12, 13, 16, and 18 had SS/TA values higher than 22.

The highest-average concentrations of total anthocyanins and total polyphenols was observed in the clone 8, followed by the clones 12 and 15 that produced grapes with total anthocyanin concentrations above 900 mg L^{-1}, and total polyphenols concentrations above 1,000 mg L^{-1} (Table 4).

In the present study, the size of berries was not determinant for their phenolic composition, since no differences were found between the average values of total polyphenols and anthocyanins among the clones that produced smaller (7) and larger (18) berries.

In general, high yields may impair grape maturation due to competition for photoassimilates between clusters (Malinovski et al., 2016). When evaluating the 'Bordô' grape clones in Minas Gerais, Miotto et al. (2014) observed that high yields did not negatively affect the must composition or the skin anthocyanin concentrations. In the present study, the high yields of the clone 13 reduced the accumulation of phenolic compounds in the skin, as it showed on average the lowest concentrations, with 705.0 and 813.0 mg L^{-1} of anthocyanins and total polyphenols, respectively. However, when 'Bordô' anthocyanins and polyphenols concentrations are observed in other Brazilian regions (Toaldo et al., 2013, 2015), it is noticed that the values presented by clone 13, although statistically lower than other clones, did not cause any loss in grape quality destined to production of juice or table wine.

Table 4. Phenolic maturity of 'Bordô' (*Vitis labrusca*) clones, during the 2014 and 2015 crop seasons, in Tangará, in the region of Vale do Rio do Peixe, in Santa Catarina state, Brazil[1].

Clone	2011	2012	2014	2015	Average	2011	2012	2014	2015	Average
	Total anthocyanins (mg L^{-1})					Total polyphenols (mg L^{-1})				
3	865.2 c	868.1 d	710.2 c	763.5 f	852.1 d	997.1 c	1051.2 c	870.6 c	1160.3 c	1019.1 c
7	689.3 f	705.2 g	654.6 d	988.3 d	759.6 f	893.3 d	894.3 e	825.6 c	930.3 e	886.3 e
8	999.5 a	1161.8 a	764.8 b	1533.1 a	1114.3 a	1281.5 a	1358.6 a	955.5 b	1700.2 a	1323.5 a
10	871.7 c	892.4 c	729.4 c	1062.6 d	889.8 c	950.7 d	1016.9 d	862.5 c	1140.1 d	992.6 d
12	889.3 c	907.5 c	714.6 c	1097.8 c	902.4 c	1036.2 c	1076.5 c	872.3 c	1183.2 c	1042.5 c
13	705.2 f	700.4 g	577.8 e	838.4 e	705.3 g	769.8 f	822.5 f	718.2 d	945.4 e	813.1 f
15	914.6 b	996.3 b	841.2 a	1142.8 b	973.0 b	1105.3 b	1201.2 b	1037.5 a	1290.4 b	1158.3 b
16	723.9 f	735.6 f	697.2 c	786.9 f	735.3 f	834.9 e	890.6 e	858.7 c	885.6 f	867.4 e
17	839.5 d	843.9 d	679.1 c	1041.1 d	850.2 d	967.9 d	999.0 d	863.8 c	1107.2 d	984.8 d
18	740.0 f	713.4 f	618.4 d	856.5 e	732.7 f	878.0 e	877.4 e	748.9 d	978.2 e	871.9 e
19	790.3 e	805.5 e	864.6 a	769.2 f	807.3 e	948.2 d	1007.7 d	1070.4 a	905.6 f	983.7 d
CV (%)	9.1	6.7	12.1	21.0	3.1	14.7	15.3	12.1	21.3	2.5

[1]Means with different letters, in the columns, indicate significant differences, by the Scott-Knott test, at 5% probability.

Conclusion

The clones 13 and 16 ('Paco' and 'Bocaina') of the 'Bordô' grape are the most suitable for cultivation in the wine production region of Vale do Rio do Peixe, in Santa Catarina state, Brazil, as they show the highest yields, production stability, and grapes with adequate quality for wine and juice elaboration.

Acknowledgments

To the team of Empresa de Pesquisa Agropecuária de Minas Gerais (Epamig) located in Caldas, MG, Brazil, for the valuable research on clonal selection and production of 'Bordô' plant clones; and to Vinícola Panceri and Mr. Luiz Panceri, for the kind permission for the use of the experimental areas and for all support during the evaluations.

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Received on June 28, 2017 and accepted on October 20, 2017