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Productive performance and physicochemical quality of grapes for processing grown on different rootstocks

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Abstract – The objective of this work was to evaluate the productive performance and physicochemical characteristics of the Isabel Precoce, BRS Carmem, BRS Cora, and IAC 138-22 Máximo grape (*Vitis labrusca*) cultivars for juice grafted onto the 'IAC 572 Jales' and 'IAC 766 Campinas' rootstocks. A randomized complete block design, in a 4×2 factorial arrangement, was used. Productive performance was evaluated through: production per plant; yield; number of clusters per vine; and physical characteristics of clusters, berries, and rachis. The physicochemical characteristics of must composition were also determined through the content of soluble solids, reducing sugars, titratable acidity, maturity index, and pH. Since there was no significant interaction between cultivars and rootstocks for most of the evaluated characteristics, each factor was analyzed separately. The 'IAC 766 Campinas' rootstock provided a higher yield and more suitable physicochemical characteristics for the four cultivars. However, regardless of the rootstock used, cultivars BRS Carmem, IAC 138-22 Máximo, and Isabel Precoce were more productive than BRS Cora.

Index terms: *Vitis labrusca*, grape juice, hybrid grapes, tropical viticulture.

Desempenho produtivo e qualidade físico-química de uvas para processamento cultivadas em diferentes porta-enxertos

Resumo – O objetivo deste trabalho foi avaliar o desempenho produtivo e as características físico-químicas das cultivares de uva (*Vitis labrusca*) para suco Isabel Precoce, BRS Carmem, BRS Cora e IAC 138-22 Máximo, enxertadas sobre os porta-enxertos 'IAC 572 Jales' e 'IAC 766 Campinas'. Utilizou-se o delineamento em blocos ao acaso, em arranjo fatorial 4×2. O desempenho produtivo foi avaliado por meio de: produção por planta; produtividade; número de cachos por videira; e características físicas de cachos, bagas e engaços. Também foram determinadas as características físico-químicas da composição do mosto por meio do teor de sólidos solúveis, açúcares redutores, acidez titulável, índice de maturidade e pH. Como não houve interação significativa entre as cultivares e os porta-enxertos para a maioria das características avaliadas, cada fator foi analisado separadamente. O porta-enxerto 'IAC 766 Campinas' proporcionou maior produtividade e características físico-químicas mais adequadas às quatro cultivares. No entanto, independentemente do porta-enxerto utilizado, as cultivares BRS Carmem, IAC 138-22 Máximo e Isabel Precoce foram mais produtivas que BRS Cora.

Termos para indexação: *Vitis labrusca*, suco de uva, uvas híbridas, viticultura tropical.

Introduction

Grape juice has been gaining new consumers in Brazil due to its many health benefits. In the last ten years, the grape juice market grew 372% in the country. The state of Rio Grande do Sul produces 90% of the national beverage, which is equivalent to 125.4 million liters of ready-to-drink juice and 31 million kilograms of concentrate juice for the 2017/2018 season. The remaining 10% of the grape juice production is spread over the states of Santa Catarina, Mato Grosso, Bahia, Paraná, São Paulo, and Pernambuco (Ibravin, 2015).

In the state of São Paulo, the regions of Jundiai, São Miguel Arcanjo, and Jales are the main grape producers (Camargo et al., 2019). Traditionally, in the region of Jales, located in the northwest of the state, where a tropical climate predominates, most of the grapes produced are for in natura consumption (Maia et al., 2018). However, due to the increased demand for grape juice, winemakers are interested in expanding their business by adding value to grape, ensuring the production of quality grapes and juices.

The grape juice produced in Brazil is mostly made from non-vinifera cultivars (Mello, 2017). Considering the importance of grape juice production, Embrapa Uva e Vinho developed new grape cultivars to be grown in tropical areas of the country, among them: Isabel Precoce, a spontaneous somatic mutation of Isabel (Camargo, 2004); BRS Cora (Muscat Belly A × H. 65.9.14); BRS Violeta (BRS Rúbea × IAC 1398-21); and BRS Carmem (Muscat Belly A × H 65.9.14). All of these cultivars have been developed as alternatives for grape juice production in Brazil and have contributed to technological improvements, expansion of production, and competitiveness of Brazilian grape juice segments (Camargo & Maia, 2004; Camargo et al., 2008).

Another potential hybrid cultivar for grape juice production is IAC 138-22 Máximo ('Seibel 11342' × 'Syrah'), which was developed by the genetic improvement program of Instituto Agronômico (IAC) (Souza & Martins, 2002). Besides being used in winemaking, it has been recommended for juice production due to its high yield associated with a high amount of phenolic compounds and a high antioxidant activity in grape berries (Santos et al., 2011; Pedro Júnior et al., 2014; Silva et al., 2019).

In addition to tolerating some fungal diseases or having high yields, the cultivars developed by Embrapa show climate adaptability, as well as desired chemical and sensory attributes. However, grape yield and quality can be influenced by other factors, including the used rootstocks (Bascunán-Godoy et al., 2017; Silva et al., 2017). 'IAC 766 Campinas' and 'IAC 572 Jales' are among the most used rootstocks in viticulture in the state of São Paulo (Tecchio et al., 2018). However, with the introduction of new hybrids and *Vitis labrusca* L. grape cultivars intended for juice production, further studies are needed to obtain scientific data for the recommendation of rootstocks for these cultivars.

The objective of this work was to evaluate the productive performance and physicochemical characteristics of the Isabel Precoce, BRS Carmem, BRS Cora, and IAC 138-22 Máximo grape cultivars for juice grafted onto the 'IAC 572 Jales' and 'IAC 766 Campinas' rootstocks.

Materials and Methods

The experiment was conducted throughout three harvest seasons, from 2017 to 2019. The experimental vineyard was installed at Centro Avançado de Pesquisa Tecnológica do Agronegócio de Seringueira e Sistemas Agroflorestais of IAC, located in the municipality of Votuporanga, in the state of São Paulo, Brazil (20°20'S, 49°58'W, at 525 m above sea level). According to Köppen’s classification, the climate of the area is of the Aw type, humid tropical, with concentrated rains from October to March (Cepagri, 2017), an average annual rainfall of 1,449 mm, and an average annual temperature of 24.3°C. The soil is classified as an Argissolo Vermelho-Amarelo according to Sistema Brasileiro de Classificação de Solos (Santos et al., 2018), which corresponds to an Ultisol (Soil Survey Staff, 2014).

The experiment was carried out in a randomized complete block design with a 4×2 factorial arrangement (four cultivars × two rootstocks). The Isabel Precoce (*V. labrusca*), BRS Carmem (Muscat Belly A × H 65.9.14), BRS Cora (Muscat Belly A × H. 65.9.14), and IAC 138-22 Máximo ('Seibel 11342' × 'Syrah') cultivars were grafted onto the 'IAC 766 Campinas' (106-8 Mgt × *Vitis caribaea* DC.) and 'IAC 572 Jales' (*V. caribaea* × 101-14 Mgt) rootstocks. Five blocks were set up with four plants per plot.

The vineyard was planted in August 2013. The rootstocks were planted first and, then, the scion cultivars were grafted onto them in July 2014. The vines were trained on a unilateral cordon system in a vertical shoot position using iron wires located at 1.0, 1.3, 1.6, and 1.9 m above ground level and were spaced 2.0×1.1 m apart.

Furthermore, 18% polyethylene shading screens were installed to prevent bird attacks. For irrigation, micro-sprinklers were turned upside down and then suspended on the wire spreader, spaced at 3.0×2.0 m, with an average flow rate of 32 L h^{-1}, which covered 100% of the soil surface.

Pruning was performed on the following dates: 3/13/2017 in the first season, 2/27/2018 in the second season, and 3/2/2019 in the third season. Moreover, four to six buds were retained per cane, and 2.5% hydrogen cyanamide was applied to buds for uniform budburst.

The vines were harvested in June and July of each season, and the spurs were pruned in August of each year; this is a traditional practice carried out by viticulturists in the northwest region of the state of São Paulo in order to form new canes to be cane-pruned in the next season.

The number of clusters per vine was recorded and calculated at harvest to determine production per vine (kilogram per vine). Yield (Mg ha^{-1}) was estimated as a function of spacing (2.0×1.1 m) and production, considering a planting density of 4,545 vines per hectare.

To determine physical characteristics, ten representative clusters from each plot were used. Ten berries were collected from the top, middle, and bottom of each cluster (3:4:3), totaling 100 grape berries per plot. Then, the fresh weight (g) of clusters, berries, and rachis was obtained on a high-precision analytical balance. The length and width (cm) of the clusters were measured with a graduated ruler.

After the physical analyses, berries were crushed to obtain the grape must, which was used to evaluate soluble solids content, titratable acidity, pH, maturity index, and reducing sugars content. The content of soluble solids was measured using the PAL-1 digital refractometer (Atago Brasil, Ribeirão Preto, SP, Brazil), with results expressed in °Brix; titratable acidity was obtained by titrating sodium hydroxide solution (0.1 N NaOH) until the turning point, with results expressed in percentage of tartaric acid; pH was measured with the B274 pH meter (Micronal, Santo André, SP, Brazil); the maturity index was determined by the ratio between soluble solids content and titratable acidity; and the content of reducing sugars was considered the percentage of glucose. All analyses followed the methodology proposed by Instituto Adolfo Lutz (Zenebon & Pascuet, 2005).

The statistical analyses were based on the averages of the three harvest seasons. The data were subjected to the analysis of variance, in order to determine the effect of scion/rootstock combinations. Subsequently, Tukey's test, at 5% probability, was used to compare averages. All analyses were carried out with the SISVAR, version 5.4, software (Ferreira, 2011). Data of the 15 characteristics of the eight scion-rootstock combinations were also analyzed through principal component analysis (PCA) using the XLSTAT, version 19.4, software (Addinsoft, New York, NY, USA).

Results and Discussion

There was no significant effect of the interaction between cultivars and rootstocks for most assessed variables, except for the fresh weight of clusters and the soluble solid contents and pH of grape must.

However, the studied factors caused isolated effects. The highest number of clusters per vine was 36.80 for 'IAC 138-22 Máximo' and the lowest was 29.51 for 'BRS Carmem' (Table 1). Although fewer, the clusters of 'BRS Carmem' were heavier (Table 2), leading to a higher production of 3.68 kg per vine and a yield of 16.74 Mg ha^{-1}. Despite this, 'BRS Carmem' did not differ significantly from 'Isabel Precoce' and 'IAC 138-22 Máximo' regarding these traits.

Table 1. Number of clusters per vine, production, and yield of grape (*Vitis labrusca*) cultivars grafted onto two rootstocks for juice and wine production[1].

Cultivar	Number of clusters per vine	Production (kg per vine)	Yield (Mg ha^{-1})
BRS Carmem	29.51b	3.68a	16.74a
BRS Cora	31.23ab	2.68b	12.18b
IAC 138-22 Máximo	36.80a	3.42ab	15.55ab
Isabel Precoce	33.72ab	3.31ab	15.05ab
Rootstock			
'IAC 572 Jales'	29.27b	2.89b	13.11b
'IAC 766 Campinas'	36.36a	3.66a	16.65a
CV (%)	15.96	20.34	20.34

[1]Means followed by equal letters, lowercase in the columns, do not differ by Tukey's test, at 5% probability.

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The yield range for all cultivars was from 12.2 to 16.8 Mg ha^{-1}, similar to those obtained in traditional viticulture regions, whose production is destined for agroindustry (Tecchio et al., 2020). Under similar crop conditions, Silva et al. (2018) found that 'BRS Carmem' had a lower average yield of 6.6 Mg ha^{-1}, which represents 39% of the production in the present study. This difference can be attributed to pruning management, since those authors retained two buds per cane instead of six in the spur pruning system, as done here, which increased the production of clusters per vine. According to Camargo et al. (2008), 'BRS Carmem' should be cane-pruned by retaining six to eight buds per cane because the fruitfulness of the basal buds is lower.

Regarding the isolated effect of rootstocks on the productive characteristics of the vines, 'IAC 766 Campinas' induced a higher number of clusters per vine, production, and yield than 'IAC 572 Jales'. Although the latter is a vigorous rootstock and presents a high capacity for absorption and translocation of water and nutrients, which contributes to scion performance, vigorous rootstocks can cause an excessive vegetative growth in scions under favorable climate and soil conditions in detriment to productive traits (Alvarenga et al., 2002). Silva et al. (2018) obtained similar results when evaluating the same cultivars and rootstocks.

Regarding the physical characteristics of clusters, berries, and rachis, there was only a significant effect of the interaction between scions and rootstocks for cluster fresh weight (Table 2). In general, 'BRS Carmem' had the heaviest clusters of all as previously mentioned, with a significant effect of rootstock interaction, with 'IAC 572 Jales' inducing the greatest weight. Contrarily, 'BRS Cora' had the lowest cluster fresh weight, especially when grafted onto 'IAC 572 Jales'. Moreover, no significant effect of rootstocks on cluster weight was observed for 'Isabel Precoce' and 'IAC 138-22 Máximo'.

Table 2. Cluster fresh weight of grape (*Vitis labrusca*) cultivars grafted onto the 'IAC 572 Jales' and 'IAC 766 Campinas' rootstocks for juice and wine production[(1)].

Cultivar	Cluster weight (g)	
	'IAC 572 Jales'	'IAC 766 Campinas'
BRS Carmem	166.5aA	144.5aB
BRS Cora	85.06cB	106.9bA
IAC 138-22 Máximo	116.2bA	131.6aA
Isabel Precoce	95.25cA	106.9bA
CV (%)	10.01	

[(1)]Means followed by equal letters, lowercase in the columns and uppercase in the rows, do not differ by Tukey's test, at 5% probability.

The mean cluster weight was -11% for 'BRS Cora', 'IAC 138-22 Máximo', and 'Isabel Precoce', slightly lower than those found by Silva et al. (2018) for the same cultivars. However, these authors obtained -32% of clusters per vine. This result is indicative that the lower cluster fresh weight in the present study may be related to the greater strength of the sinks due to the number of clusters (Chaumont et al., 1994). In addition, the yield of the four assessed cultivars was 37% higher than those obtained by the aforementioned authors.

In terms of size, 'IAC 138-22 Máximo' had clusters with greater length and width, 'BRS Carmem' had clusters with a similar length, and 'Isabel Precoce' had small and compact clusters with 10.73 cm in length and 5.83 cm in width. The obtained values are similar to the average cluster length of 10.9 cm found for 'Isabel' by Assis et al. (2011).

In terms of fresh berry weight, 'Isabel Precoce' and 'BRS Cora' had larger and heavier berries, showing a mean of 3.00 and 3.05 g, respectively (Table 3). Under similar conditions, Silva et al. (2018) reported similar values of 3.19 g for 'Isabel Precoce' and of 3.12 g for 'BRS Cora'. Champagnol (1984) highlighted that the weight and size of grape berries are inherent characteristics of each cultivar, but may also be influenced by other factors, such as hormonal balance, amount of water absorbed, and sugar concentration.

The grape berries of IAC 138-22 Máximo showed a mean weight of 1.36 g, length of 1.44 cm, and width of 1.27 cm, which were lower than those of the other cultivars. This characteristic is important for cultivars destined for the production of juices and wines because small grape berries provide a better solute/solvent ratio, that is, the extraction of minerals, anthocyanins, and other phenolic compounds from grape skins becomes more efficient (Conde et al., 2007).

Regarding the fresh weight of the rachis, 'IAC 138-22 Máximo' had the highest mean of 5.12 g (Table 3). Rachis fresh weight is often disregarded in many studies, but this trait should be considered when grapes are destined for agroindustry since juice yield is influenced by the removal of the stem from the cluster during processing (Silva et al., 2018).

There was a significant effect of the interaction between rootstocks for cluster length, fresh berry weight, and rachis weight/cluster weight ratio (Table 3). The 'IAC 766 Campinas' rootstock induced grapes with longer clusters and heavier berries, as well as a lower rachis weight/cluster weight ratio.

For the physicochemical characteristics of the must, the titratable acidity of BRS Cora was 1.38% tartaric acid, a value significantly higher than that of the other cultivars (Table 4). In contrast, 'Isabel Precoce' and 'BRS Carmem' had the lowest mean acidity of 0.82 and 0.97% tartaric acid, respectively.

The obtained results differ from those reported by Ribeiro et al. (2012), who found a mean of 0.6% titratable acidity for 'Isabel Precoce' and of 1.01% for 'BRS Cora' under the conditions of the sub-middle region of the São Francisco Valley, a semiarid area; these different values may related to the environmental conditions at the vineyard, located in a hot semiarid zone, which caused a decrease in acidity and an increase in the soluble solids contents of the grapes. Despite the lower values, 'BRS Cora' showed a high titratable acidity as in the present study. Other authors also observed that this cultivar maintains high levels of acidity even in ripe grapes (Lima et al., 2014; Silva et al., 2018). According to Guerra (2003), grapes for juice must present an acidity from 0.5 to 0.9% tartaric acid to produce a good quality beverage. In the present study, all cultivars showed titratable acidity levels higher than the range indicated by the author, regardless of the rootstock. Therefore, it is interesting to mix the BRS Cora cultivar with others, which may balance acidity to meet the standards required for grape beverages, allowing the production of juices or wines of excellent quality.

The rootstocks individually affected titratable acidity. The grapes of the scions grafted onto 'IAC 572 Jales' were less acid (Table 4). On this same rootstock, the maturity index was the highest for 'Isabel Precoce', which also showed the highest content of reducing sugars, not differing significantly from 'BRS Cora' but from 'IAC 138-22 Máximo', with the lowest reducing sugars content.

Overall, the average values found for reducing sugars were higher than those obtained by Silva et al. (2018), except for 'IAC 138-22 Máximo'. The authors evaluated the same cultivars and found contents of 13.5% for 'Isabel Precoce', 13.3% for 'BRS Carmem', 12.7% for 'BRS Cora', and 11.4% for 'IAC 138-22 Máximo'.

There was a significant effect of the interaction between scion and rootstock for soluble solids content and pH in the grape must (Table 5). Regardless of the rootstocks, the highest soluble solids contents were obtained for: 'BRS Carmem' and 'BRS Cora' overall; and 'Isabel Precoce' when grafted onto 'IAC 766 Campinas'. The mean content of soluble solids for these grapes was 17.6 °Brix, a result superior to the 13.7°Brix for 'BRS Carmem' and 15.3°Brix for 'Isabel' found by Assis et al. (2011) in the state of Paraná, Brazil. This difference may be related to the different climatic conditions at the studied vineyards since temperatures are higher in the northwest of the state of São Paulo, enabling a greater sugar accumulation in grape berries.

The lowest content of soluble solids was obtained for 'IAC 138-22 Máximo' grafted onto 'IAC 572 Jales'

Table 3. Fresh weight of berries (BFW) and rachis (RFW), length and width of berries, and length and width of rachis of grape (*Vitis labrusca*) cultivars grafted onto two rootstocks for juice and wine production(1).

Cultivar	Length of rachis (cm)	Width of rachis (cm)	BFW (g)	Length of berries (cm)	Width of berries (cm)	RFW (g)	BFW/RFW (%)
BRS Carmem	12.69ab	7.10b	2.70b	1.86a	1.60a	3.55b	2.32c
BRS Cora	12.14b	7.15b	3.05a	1.97a	1.57b	2.14d	2.28c
IAC 138-22 Máximo	13.23a	7.99a	1.36c	1.44b	1.27c	5.12a	4.13a
Isabel Precoce	10.73c	5.83c	3.00a	1.86a	1.61a	2.74c	2.73b
Rootstock							
'IAC 572 Jales'	11.97b	6.90a	2.49b	1.80a	1.51a	3.47a	3.03a
'IAC 766 Campinas'	12.43a	7.13a	2.57a	1.76a	1.52a	3.31a	2.70b
CV (%)	5.53	5.77	3.88	6.45	1.66	10.61	10.38

(1)Means followed by equal letters, lowercase in the columns, do not differ by Tukey's test, at 5% probability.

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and 'IAC 766 Campinas', with an average of 15.55 and 16.21°Brix, respectively. Similar values were reported by Santos et al. (2011) in the region of Jundiaí, in the state of São Paulo. Regardless of the differences in soluble solids contents, all cultivars reached the minimum value required by Brazilian regulation, that is, 14°Brix for processing grapes into juices (Brasil, 2018).

Regardless of the used rootstocks, 'BRS Carmem', 'Isabel Precoce', and 'IAC 138-22 Máximo' showed a similar pH, with a mean of 3.2. 'BRS Cora' had the lowest pH when grafted onto both rootstocks, with a mean of 3.05 on 'IAC 572 Jales' and of 3.12 on 'IAC 766 Campinas'. In red grape beverages, pH is an important parameter because it is directly related to the stability of anthocyanins and, therefore, changes the color intensity of the drinks (Yamamoto et al., 2015). At harvest, the pH of the grape for processing must range from 3.1 to 3.3 (Rizzon et al., 2004). Therefore, the averages obtained in the present study are adequate and show that the quality of the must is within the required standards.

The PCA was applied over all analyzed variables in the eight scion/rootstock combinations, explaining 76.13% of data variation with two main components (Figure 1).

The first component explained 51.50% of data variation and was mainly associated with the physical characteristics of grape berries and rachis, as well as to the contents of soluble solids and reducing sugars. By analyzing the scores and loadings of this component, grapes from 'IAC 138-22 Máximo' had lower soluble solids and sugar contents than those of 'Isabel Precoce'

Table 4. Titratable acidity (TA), ratio between soluble solids and titratable acidity (SS/TA), and reducing sugars (RS) of the must of grape (*Vitis labrusca*) cultivars grafted onto two rootstocks for juice and wine production[(1)].

Cultivar	TA (%)	SS/TA	RS (%)
BRS Carmem	0.97c	18.83b	14.07b
BRS Cora	1.38a	13.80c	14.79ab
IAC 138-22 Máximo	1.17b	13.69c	10.75c
Isabel Precoce	0.82d	23.93a	15.08a
Rootstock			
'IAC 572 Jales'	1.05b	18.19a	13.52a
'IAC 766 Campinas'	1.12a	16.93b	13.82a
CV (%)	3.86	9.64	4.51

[(1)]Means followed by equal letters, lowercase in the columns, do not differ by Tukey's test, at 5% probability.

Table 5. Content of soluble solids and pH of the grape must of grape (*Vitis labrusca*) cultivars grafted onto the 'IAC 572 Jales' and 'IAC 766 Campinas' rootstocks for juice and wine production[(1)].

Cultivar	SS (°Brix)		pH	
	'IAC 572 Jales'	'IAC 766 Campinas'	'IAC 572 Jales'	'IAC 766 Campinas'
BRS Carmem	17.73aA	17.51aA	3.32aA	3.18abB
BRS Cora	17.61aA	17.35aA	3.05bB	3.12bA
IAC 138-22 Máximo	15.55cB	16.21bA	3.21aA	3.18abA
Isabel Precoce	16.64bB	17.79aA	3.18aA	3.21aA
CV (%)	2.60		1.11	

[(1)]Means followed by equal letters, lowercase in the columns and uppercase in the rows, do not differ by Tukey's test, at 5% probability.

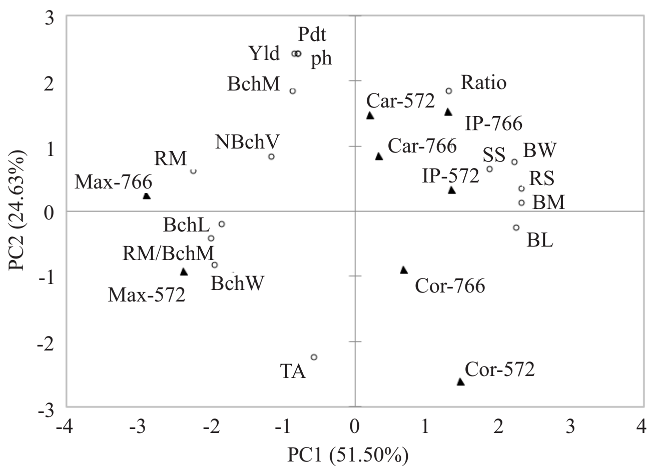

Figure 1. Principal component analysis of the productive and physicochemical characteristics of grapes (*Vitis labrusca*) grafted onto two rootstocks for juice production. NBchV, number of clusters per vine; BchM, fresh cluster weight; Yld, yield; Pdt, production; Ratio, ratio between soluble solids and titratable acidity (maturity index); SS, soluble solids; BW, berry width; RS, reducing sugars; BM, fresh berry weight; BL, berry length; TA, titratable acidity; BchW, cluster width; RM/BchM, rachis weight/cluster weight ratio; BchL, cluster length; and RM, fresh rachis weight. Evaluated cultivars: Car, BRS Carmem; Cor, BRS Cora; Max, IAC 138-22 Máximo; IP, Isabel Precoce; 572, IAC 572 Jales rootstock; and 766, IAC 766 Campinas rootstock.

and 'BRS Carmem', with higher soluble solids content and a lower titratable acidity, i.e., a higher maturity index. Furthermore, the berries of IAC 138-22 Máximo were smaller than those of the other cultivars.

The second component explained 24.63% of data variation. This component was associated with production variables, pH, acidity, ratio between soluble solids content and titratable acidity, and yield. Even in ripe fruits, 'BRS Cora' maintained high levels of titratable acidity and a low pH, besides presenting the greatest negative correlation with production and yield, especially when grafted onto 'IAC 572 Jales'. Moreover, Isabel Precoce and BRS Carmen showed a better maturity index due to their lower titratable acidity; these cultivars also had greater yield averages, regardless of the used rootstock.

Conclusions

1. For the BRS Carmem, BRS Cora, IAC 138-22 Máximo, and Isabel Precoce grape (*Vitis labrusca*) cultivars used for juice production, the ‘IAC 766’ rootstock induces a higher yield and more suitable physicochemical characteristics of the must.
2. Regardless of the rootstock used, cultivars BRS Carmem, IAC 138-22 Máximo, and Isabel Precoce are more productive than BRS Cora.
3. With the exception of IAC 138-22 Máximo, which shows a weak relationship between sugars and acids, all studied cultivars have physicochemical characteristics suitable for the production of juices.

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