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Agronomic performance of ‘BRS Melodia’ seedless table grape grafted onto different rootstocks

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ABSTRACT: The seedless table grape ‘BRS Melodia’ stands out for its pink color and the special flavor of red berries, which make for commercial classification as gourmet type grapes. Cultivation of this new table grape cultivar is expanding in the São Francisco Valley, in the Brazilian Northeast region. The aim of this study was to determine the effect of the rootstock on vigor, on yield components, and on physicochemical characteristics of ‘BRS Melodia’ grapes grown under the semi-arid tropical conditions of the São Francisco Valley. The experiment was carried out under irrigated cultivation in a commercial area in the municipality of Casa Nova, Bahia, Brazil, from 2021 to 2023. Treatments consisted of the rootstocks 101-14 MgT, IAC 313, IAC 572, IAC 766, Paulsen 1103, Ramsey, SO4, and Teleki 5C in a randomized block experimental design with four replications. There was no effect of the rootstock on the following variables: branch and leaf fresh matter, sprouting percentage, total soluble solids content (SS), titratable acidity (TA), and SS/TA ratio. ‘BRS Melodia’ grapevines had high vigor regardless of the rootstock used. The Ramsey rootstock led to reduced bud fertility compared to IAC 572 and IAC 766. As the vines advanced in age, the rootstocks IAC 572 and IAC 766 provided the highest yields and number of clusters per vine. The physicochemical characteristics of the ‘BRS Melodia’ grapes meet the standards required for commercialization on all the rootstocks used.

Key words: *Vitis vinifera* L., tropical grape growing, morpho-agronomic evaluation.

INTRODUCTION

Grafting has been practiced as a manner of vegetative propagation of grapevines (*Vitis vinifera* L.) for hundreds of years. However, the use of rootstocks in grape- and wine-growing began only in the middle of the 19th century, as at that time it was the only way of providing resistance to damage caused by the root system pest phylloxera (*Daktulosphaira vitifoliae* Fitch) (Arnold and Schnitzler 2020). The choice of the rootstock for each grape cultivar (scion) and edaphic and climatic conditions is very important, since other changes in management can be performed over the growing seasons of the grapevines, whereas the choice of the rootstock is definitive and performed in the phase of setting up the vineyard (Brighenti et al. 2021, Klimek et al. 2022, Migicovsky et al. 2021).

In Brazil, the São Francisco Valley is the main growing and exporting region of grapes (Ritschel et al. 2021). As it has semi-arid tropical conditions, control of water availability through irrigation, and pruning management, it is possible to obtain up to five consecutive crops every two years in this region (Leão and Silva 2018). Recently, in addition to the preference for seedless grapes, there is a market for grape cultivars to serve niche markets for gourmet fruit with exotic or special flavor. The seedless table grape ‘BRS Melodia’ has the differential characteristics of pink seedless berries and the special flavor of red berries (Maia et al. 2019). In Brazil, under semi-arid conditions, the table grape ‘BRS Ísis’, ‘BRS Vitória’, ‘Thompson

Seedless', and 'BRS Tainá' have exhibited quantitative and/or qualitative changes in morphoagronomic variables with the use of different rootstocks (Leão et al. 2016, 2020a, 2020b, 2020c, Martinez et al. 2017). The same situation occurred for 'Flame Seedless', 'Thompson Seedless', and 'Red Globe' under semi-arid conditions in Chile (Ibacache et al. 2016, Vijaya and Rao 2015), while in India, under the wet and dry tropical climate, 'Fantasy Seedless' and 'Thompson Seedless' also had differentiated agronomic performance in accordance with the rootstock used (Jogaiah et al. 2013, Somkuwar et al. 2015).

Considering that there are still no research results for recommending rootstock for the 'BRS Melodia', the aim of this study was to determine the effect of different rootstocks on vigor, yield components, and physicochemical characteristics of the young 'BRS Melodia' grapevines under tropical conditions of the Brazilian semi-arid region.

MATERIALS AND METHODS

Experimental area and plant material

The study was carried out in a commercial growing area in the municipality of Casa Nova, Bahia, Brazil (09º16'S, 40º54'W and 404 m altitude) in the first four grape production cycles in the 2021–2023 period. The four-cycle production was between July 2021 and Oct 2021, Dec 2021 and Apr 2022, May 2022 and Aug 2022, and Sept 2022 and Jan 2023, respectively.

According to the Köppen classification, the local climate is BSh type, hot and semi-arid, with annual rainfall ranging from 500 to 900 mm. The information about the monthly averages of air temperature (mean, maximum, and minimum), rainfall, and global solar radiation recording during the period under study at the automatic agricultural meteorological (weather) station of the Universidade Federal do Vale do São Francisco in Juazeiro, Bahia, is shown in Fig. 1.

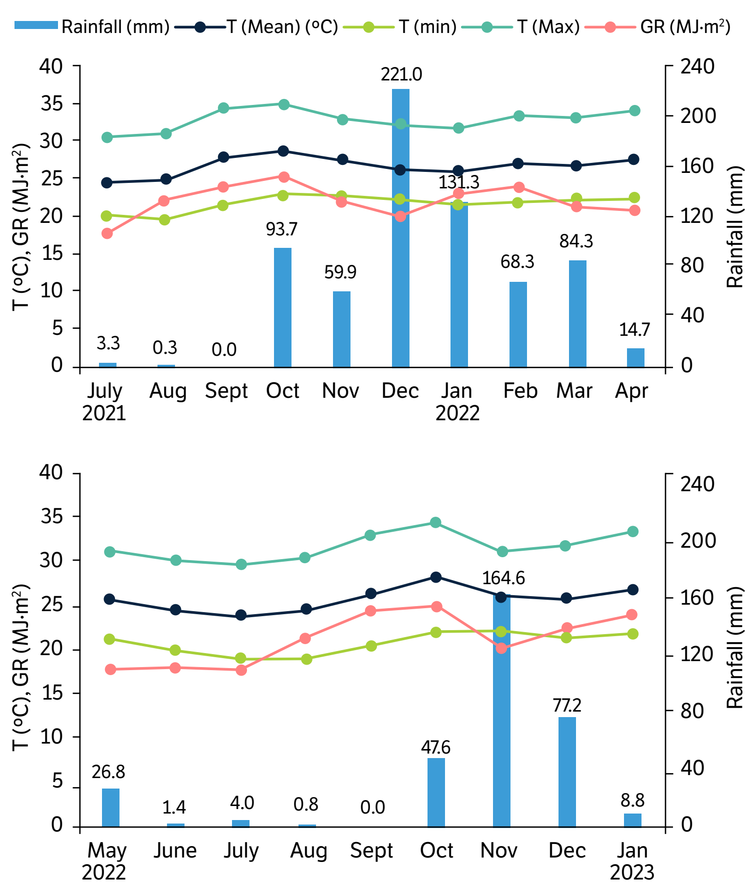

Figure 1. Monthly averages of rainfall (mm); mean, minimum, and maximum air temperature (T, in °C); and global solar radiation (GR, in MJ·m²) over the periods (a) from July 2021 to April 2022, and (b) from May 2022 to January 2023 in Juazeiro, Bahia, Brazil.

The grapevines of 'BRS Melodia' were planted on Sep. 10, 2020, in a trellis-type horizontal training system at a plant spacing of 3.5 m × 2.5 m, with one vine per plant pit and trained in a bilateral cordon canopy architecture. A mixed-type production pruning was adopted, with canes (five and seven buds) and spurs (two or three buds). Irrigation management was based on the evapotranspiration data obtained by the agricultural meteorological station at the location. Fertilization was performed through fertigation according to the nutritional needs observed in soil analysis. Weed control was through mechanical hoeing, while the main pests and diseases in the region were controlled through preventive chemical spraying.

Experimental design

The treatments consisted of eight rootstocks: 101-14 MgT, IAC 313, IAC 572, IAC 766, Paulsen 1103, Ramsey, SO4, and Teleki 5C. A randomized block experimental design was used with four replications in split plots, in which production cycles were considered as the main plot and rootstocks as split plots. The experimental unit was composed of four plants, with evaluation of one vine per plot.

Agronomic evaluation

The variables related to vigor and the yield components evaluated were as follows:

- Branch and leaf fresh matter (FM) collected during production pruning, determined using a digital balance, expressed in kg per plant;
- Stem diameter (SD), evaluated at a height of approximately 1.30 cm from the soil with the aid of a digital caliper, in mm;
- Percentage of bud sprouting (SP), using the Eq. 1:

$$SP\ (\%) = [(\text{no. of sprouts} / \text{no. of buds}) \times 100] \quad (1)$$

- Bud fertility index (FI), through the Eq. 2:

$$FI = (\text{no. of clusters} / \text{no. of buds}) \quad (2)$$

During harvest, yield, expressed in $t{\cdot}ha^{-1}$, was estimated by the Eq. 3:

$$Y = [(\text{production per vine, in kg}) \times (\text{no. of vine per hectare})] \quad (3)$$

The number of clusters per vine (NC) was determined. After that, five clusters per vine were collected to evaluate the following variables: cluster weight, expressed in g; cluster length and cluster width, using a ruler, expressed in cm. Ten berries from each cluster were used, for a total of 50 berries per plot, for evaluation of the following variables: berry weight, expressed in g; berry length and berry diameter, in mm; total soluble solids content (SS), in °Brix, measured using a digital refractometer with automatic temperature adjustment (ATAGO, Digital Pocket Refractometer, model PAL-1); titratable acidity (TA), determined using 0.1 M NaOH solution, expressed in g of tartaric acid.100 mL^{-1} (AOAC 2016); and ratio, obtained by the SS/TA ratio. All the variables were evaluated over four production cycles, except for SP, FM, and FI, which were evaluated over three production cycles.

Statistical analysis

The normal distribution of the data was evaluated using the Shapiro-Wilk's test. When normality of distribution was met, analysis of variance was performed using the F test. The data referring to the variables FM, Y, and NC did not show normal distribution and were adjusted using the $\sqrt{X}$ transformation, while for TA and cluster width $\sqrt{(X+1)}$ was used. The mean values of effects of cycles, rootstocks, and their interactions were compared using Tukey's test at the 5% probability level using the Sisvar computational program (Ferreira 2011).

RESULTS AND DISCUSSION

For the estimated yield and number of clusters per vine variables, there was significant interaction between the rootstock and the production cycle, with variation in yield among cycles only in the rootstocks IAC 572, IAC 766, and Paulsen 1103 (Table 1). In the third production cycle, the highest yield values were achieved, with the mean values of 22.84 t·ha^{-1} for IAC 572 and 23.96 t·ha^{-1} for IAC 766 standing out. In contrast, the lowest yield of the 'BRS Melodia' grapevines occurred on Paulsen 1103. The third production cycle occurred during the period of least rainfall (Fig. 1b), which contributed to better fruit set, as well as lower incidence of diseases, resulting in higher yield.

Table 1. Effect of the rootstock on yield and number of clusters per plant in the first four production cycles of the 'BRS Melodia' grapevine.

Rootstock	Yield (t·ha^{-1})				
	Cycle I	Cycle II	Cycle III	Cycle IV	Mean
101-14 MgT	8.63Aa	8.92Aa	7.45Abc	7.98Aa	8.24c
IAC 313	7.42Aa	7.64Aa	11.77Ab	10.64Aa	9.36bc
IAC 572	9.42Ba	12.07Ba	22.84Aa	9.46Ba	13.44ab
IAC 766	11.07Ba	13.62Ba	23.96 Aa	14.31ABa	15.74a
Paulsen 1103	8.20Aa	7.09ABa	2.97 Bc	12.08Aa	7.59c
Ramsey	8.34Aa	7.26Aa	5.14 Abc	8.05Aa	7.20c
SO4	8.08Aa	9.94Aa	5.83 Abc	10.84Aa	8.68c
Teleki 5C	6.25Aa	8.24Aa	7.79 Abc	8.88Aa	7.79c
Mean	8.42ns	9.35	10.97	10.28	9.76
CV (%)					19.97
Rootstock	Number of clusters per vine				
	Cycle I	Cycle II	Cycle III	Cycle IV	Mean
101-14 MgT	54.0Aa	55.0Aa	46.0Abc	72.0Aab	56.63c
IAC 313	48.0Ba	45.0Ba	61.0ABab	89.0Aab	60.38bc
IAC 572	62.0Ba	59.0Ba	101.0Aa	84.0ABab	76.19ab
IAC 766	60.0Ba	60.0Ba	95.0ABa	108.0Aa	82.44a
Paulsen 1103	54.0ABa	42.0BCa	24.0Cc	85.0Aab	51.06c
Ramsey	49.0ABa	44.0ABa	32.0Bbc	66.0Ab	47.69c
SO4	54.0ABa	49.0ABa	35.0Bbc	75.0Aab	53.19c
Teleki 5C	40.0Ba	49.0Ba	47.0Bbc	85.0Aab	55.25c
Mean	52.56B	51.00B	54.97B	82.88A	60.35
CV (%)					14.46

Means by the same lowercase letters in the column comparing rootstocks, and uppercase letters in the row comparing production cycles do not differ by Tukey's test ($p < 0.05$); ns: not significant; CV: coefficient of variation.

The results obtained differed from those observed in this same region for 'BRS Vitória' on different rootstocks, where there was no significant effect of rootstocks on grapevine yield; the grapevines achieved 22.0 t·ha^{-1} only from the fifth production cycle on (Leão et al. 2020b). The 'BRS Melodia' can reach mean yields of 25 t·ha^{-1} as of the second production cycle under tropical conditions when the grapevines remain at rest 60 to 70 days to restore reserves (Ritschel et al. 2021). In this study, the number of days of last harvest and next pruning between cycles was 42 days on average, according to the management practiced by the grower. Therefore, it is recommended a pruning schedule be established for the cultivar 'BRS Melodia' with two production cycles per year, and not the 2.5 cycles that was carried out in this study.

In addition, a smaller spacing between plants (2 m), as recommended by Maia et al. (2019) in growing 'BRS Melodia' in the Serra Gaúcha region in the state of Rio Grande do Sul, Brazil, under plastic covering, and during the validation studies made by Ritschel et al. (2021) in the São Francisco Valley may increase the yield in relation to the mean yields found in this study. Therefore, despite the differences in the rest period and differences in between-plant spacing, the use of the rootstocks IAC 572 and IAC 766 under favorable environmental conditions and suitable management made it possible to achieve values similar to that of the yield expected for 'BRS Melodia' during the third production cycle.

There was significant interaction between rootstocks and production cycles in the number of clusters per vine variable, with the IAC 572 and IAC 766 rootstocks standing out. They led to an increase in the number of clusters of 'BRS Melodia' grapevines in the last two production cycles, whereas 101-14 MgT remained stable throughout all crop seasons (Table 1). The rootstock Teleki 5C increased the number of clusters per plant only in the fourth production cycle (85), differing significantly from the previous cycles.

There is a trend towards an increase in the number of clusters as the plants age for most rootstocks. Leão et al. (2020c), studying 'BRS Ísis' under the conditions of the São Francisco Valley, also found a larger number of clusters from the fourth production cycle on, reaching averages of over 110 clusters per vine.

As previously mentioned in relation to yield, favorable weather conditions during the fourth production cycle promoted greater plant health and fruit setting (Fig. 1b). Koyama et al. (2020), upon carrying out a study with 'BRS Melodia' grafted onto IAC 572 in the subtropical climate of Marialva, in the state of Paraná, Brazil, with rainfall distributed throughout the year, obtained mean values ranging from 30.8 to 33.7 clusters per vine, values lower than those found in the present study. However, Ibacache et al. (2016) studied three cultivars of grapes, two of which are seedless–'Flame Seedless' and 'Thompson Seedless'–, on different rootstocks in semi-arid conditions in Chile and were not able to observe differences in the average of treatments after six growing cycles. Thus, the yield performance of grafted grapevines and their response to the rootstocks used depend on the interaction between the scion cultivar, rootstock, and environment.

Stem diameter and bud fertility index were affected by the rootstock in mean performance over the first four production cycles (Table 2). The rootstock IAC 572 had the largest mean stem diameter (35.01 mm), larger than that of Paulsen 1103, SO4, and 101-14 MgT. IAC 572 is characterized by high vigor, which induces the scion cultivars grafted onto it (Angelotti-Mendonça et al. 2018, Embrapa 2023a, Pimentel Junior et al. 2018), though this may be a characteristic restrictive to its use, since plants with very high vigor tend to decrease bud fertility and, consequently, fructification potential (Leão and Rodrigues 2015). However, under the conditions of this study, this trend was not observed, since the rootstock IAC 572 and IAC 766 led to an increase in the bud fertility index of 'BRS Melodia' grapevines in relation to Ramsey, and neither one differed from the other rootstocks studied.

The Percentage of Bud Sprouting was similar in all the treatments, with an overall mean (65.55%) a little below the ideal (≥ 70%), but the results do not diverge from those obtained by Leão and Pereira (2001), who studied the table grape cultivars 'Marroo Seedless' (67.5%), 'Arizul' (65.0%), 'Beauty Seedless' (63.6%), and 'Vênus' (63.0%) in the São Francisco Valley. Despite the differences about SD among the rootstocks, the branch and leaf FM, a variable often used for measuring canopy vigor, had similar measurements in all the rootstocks. According to Leão et al. (2020c), the vegetative development of the grapevine does not solely depend on the intrinsic characteristics of the rootstock, since under ideal conditions of water and nutrient supply, plant responses tend to be similar for this variable.

There was a significant effect of production cycles for all the variables related to vigor, bud fertility, and physical characteristics of the clusters (Table 2). The mean value of branch and leaf FM obtained in the second production cycle (9.73 kg per vine) was approximately two times higher than the values observed during the first and third cycles. The second production cycle exhibited greater vigor, measured both by branch and leaf FM and by SD, in relation to the first cycle, considering the greater age of the plants and, consequently, greater storage of carbohydrate reserves in older plants (Keller 2015). These higher values can also be explained by the longer rest time between the harvest of the first cycle and the production pruning of the second cycle (75 days). The reduction in branch and leaf FM in the third production cycle was due to the considerable incidence of diseases during the rest period, resulting in a significant decrease in relation to the previous cycle. The highest mean values for sprouting and bud fertility index were obtained in the second and fourth production cycles. Thus, it can be affirmed that sprouting and bud fertility are variables that are highly affected by the environmental conditions and management practices intrinsic to each production cycle. Leão et al. (2020c) also observed variations in sprouting (67.06–74.85%) and bud fertility (0.27–0.88) of the cultivar 'BRS Ísis' up to the fourth production cycle.

Table 2. Mean values for branch and leaf fresh matter per vine (FM), stem diameter (SD), sprouting (SP), bud fertility index (FI) (clusters sprout^{-1}), cluster weight (CW), cluster length (CL) and cluster width (CWd) of 'BRS Melodia' grapevines on different rootstocks over four production cycles in Casa Nova, BA, Brazil.

Rootstock	FM	SD	SP	FI	CW	CL	CWd
	kg	mm	%		g		cm
101-14 MgT	5.22^{ns}	29.15c	67.33ns	0.70ab	178.29ab	14.57bc	7.50bc
IAC 313	4.31	32.21abc	63.77	0.71ab	188.17ab	15.40abc	7.60abc
IAC 572	6.59	35.01a	66.70	0.85a	210.18ab	16.42ab	8.37a
IAC 766	5.96	32.78abc	61.07	0.85a	217.12a	16.68a	8.25ab
Paulsen 1103	5.19	30.78bc	69.26	0.64ab	174.35b	14.79abc	7.42bc
Ramsey	6.66	33.85ab	70.23	0.60b	175.79ab	14.24c	7.18c
SO4	5.46	29.47c	66.09	0.64ab	195.72ab	15.73abc	7.69abc
Teleki 5C	5.62	32.47abc	60.00	0.73ab	197.21ab	16.07abc	7.60abc
Mean	5.63	31.97	65.55	0.71	192.10	15.49	7.70
CV (%)	16.80	10.34	14.79	30.16	17.25	11.21	4.24
Cycle							
I	3.44b	18.99c	---	0.68b	200.95a	15.99a	8.24a
II	9.73a	32.60b	72.60a	0.91a	206.06a	13.53b	7.13b
III	3.71b	38.05a	53.59b	0.58b	200.21a	15.88a	7.82ab
IV	---	38.22a	70.48a	0.70ab	161.19b	16.54a	7.62ab
CV (%)	18.74	6.00	9.44	38.29	26.01	12.11	5.64

Mean values followed by the same lowercase letters in the column comparing rootstocks and production cycles do not differ from each other by Tukey's test ($p < 0.05$); ns: not significant; CV: coefficient of variation.

'BRS Melodia' grapevines grafted onto IAC 766 produced clusters with a mean weight of 217.12 g, values higher than those observed on the rootstock Paulsen 1103 (174.35 g), neither differing from the other treatments (Table 2). Regarding the physical characteristics of the clusters, the use of the rootstock IAC 766 led to gains in cluster length compared to Ramsey and 101-14 MgT, while on IAC 572 the clusters had greater width compared to those on the rootstocks Ramsey, Paulsen 1103, and 101-14 MgT. Under semi-arid conditions in Chile, when 'Thompson Seedless' were grown on Ramsey (Salt Creek), they also had heavier clusters compared to those grown on Paulsen 1103 (Ibacache et al. 2016). However, 'BRS Vitória', 'BRS Núbia', 'BRS Isis', and 'Niágara Rosada' grapevines in a tropical climate with a dry season in the winter grown on the rootstocks IAC 572 and IAC 766 did not exhibit significant differences in cluster weight. In contrast, the rootstock IAC 572 brought about clusters of 'BRS Vitória' with greater length and width (Campos et al. 2022).

In a Brazilian semi-arid climate, there were no significant differences for cluster weight, width, and length in the cultivars 'BRS Isis' and 'BRS Vitória' when grafted onto IAC 572 and IAC 766. However, the choice of other rootstocks, such as Harmony for 'BRS Ísis' or Paulsen 1103 for 'BRS Vitória', reduced the size of the clusters (Leão et al. 2020b, 2020c). These results once more show the important effect of the climate conditions and the management practices performed on each farm and growing location on the agronomic performance of the scion cultivar as a result of the rootstock. Clusters of 'BRS Melodia' should have a mean weight of around 200 g, a length of 16 cm, and width of 9 cm (Ritschel et al. 2021). Thus, the use of the rootstocks IAC 572 and IAC 766 was not only able to increase the yield of 'BRS Melodia', but also to promote the development of clusters with the size expected for this cultivar. The reduction in the size of the cluster during the second production cycle can be explained in part by the loss of leaf area and consequently lower storage of carbohydrate reserves in the plant, and this led to greater incidence of diseases due to greater rainfall in that period (Fig. 1a).

In relation to berry characteristics, there was a significant effect of the interaction between rootstocks and production cycles in berry diameter (Table 3). For most of the rootstocks, variations were not observed in berry diameter among the production cycles, except for IAC 572 and IAC 313. Berry diameter is an important variable, because berries with a minimum diameter of 17 mm are preferred in more demanding markets (Santos et al. 2013). The rootstocks IAC 572 and IAC 313 led to development of berries with a diameter within the values recommended for commercialization of 'BRS Melodia' grapes (16–17 mm) in the four production cycles evaluated (Ritschel et al. 2021). Similar to the results found in this study, other table grape cultivars, such as 'Flame Seedless' (Ibacache et al. 2016), 'Thompson Seedless' (Martinez et al. 2017), and 'BRS Vitória' (Leão et al. 2020b), also exhibited values of berry diameter suitable for commercialization for all the rootstocks studied.

Table 3. Berry diameter of 'BRS Melodia' grapevines over four production cycles.

Rootstock	Berry Diameter (mm)				
	Cycle I	Cycle II	Cycle III	Cycle IV	Mean
101-14 MgT	16.54Aa	16.26Aab	16.38Aa	16.69Aa	16.47ab
IAC 313	16.55ABa	15.54Bb	17.26Aa	16.81Aa	16.54ab
IAC 572	16.07Ba	16.61ABab	17.00ABa	17.18Aa	16.71ab
IAC 766	17.18Aa	17.13Aa	17.06Aa	16.37Aa	16.93a
Paulsen 1103	16.92Aa	15.98Aab	16.21Aa	16.40Aa	16.38ab
Ramsey	16.20Aa	15.92Aab	16.41Aa	16.55Aa	16.27b
SO4	16.15Aa	15.95Aab	16.52Aa	16.81Aa	16.36ab
Teleki 5C	16.70Aa	16.32Aab	16.66Aa	16.62Aa	16.57ab
Mean	16.54AB	16.21B	16.69Aa	16.68AB	16.53
CV (%)					3.29

Mean values followed by the same lowercase letters in the column comparing rootstocks and uppercase letters in the row comparing production cycles do not differ by Tukey's test ($p < 0.05$); CV: coefficient of variation.

'BRS Melodia' grapevines grafted onto IAC 572 and IAC 766 exhibited greater berry weight, differing significantly from the rootstocks 101-14 MgT, Paulsen 1103, SO4, and Ramsey (Fig. 2a). Berry length did not differ for most of the rootstocks, but IAC 572 resulted in longer berries compared to Paulsen 1103 and SO4 (Fig. 2b). Therefore, the rootstock IAC 572 not only led to an increase in the yield and number of clusters, but also increased berry size, which differs from what was observed in the cultivar 'BRS Vitória', in which greater berry weight and size were obtained in rootstocks that induced a smaller mean number of clusters (Leão et al. 2020c). Nevertheless, studies performed in other grapes, such as 'BRS Ísis', 'BRS Núbia', and 'Níagara Rosada', did not confirm this trend in responses, but showed results similar to those of this study, in which rootstocks that led to an increase in berry weight and size were also the ones that favored a larger mean number of clusters per plant (Campos et al. 2022, Leão et al. 2020b). The rootstocks IAC 572 and IAC 766 are known as tropical rootstocks because they result from crosses made with the species *Vitis caribaea*, which has enhanced rooting as a characteristic (Embrapa 2023a). Thus, genetic characteristics intrinsic to the rootstock, such as vigor and development of the root system, together with affinity between the scion cultivar × rootstock, can favor gains in yield components without this necessarily occurring to the detriment of response in other agronomic variables.

About berry morphology, the length/diameter proportion should be taken into consideration because it can add greater market value; consumers prefer elliptical or elongated berries (length > diameter) since they associate this shape with seedless grapes (Chitarra and Chitarra 2005, Mascarenhas et al. 2010). In spite of the variations observed among the rootstocks used, the berries of 'BRS Melodia' had an ellipsoid shape, in conformity with the standard desired by the market.

The mean value for total SS content did not differ significantly among the rootstocks (Table 4), but the production cycle had a decisive effect on the sugar content in the fruit. The second and fourth production cycles (harvest carried out on Apr. 7, 2022, and Jan. 5, 2023, respectively) favored the production of grapes with a lower total SS content on all the rootstocks, ranging from 14.95 to 18.08 °Brix. That occurred because the phase of fruit maturation and harvest coincided with the rainy periods (Figs. 1a and 1b), diluting the sugars in the fruit.

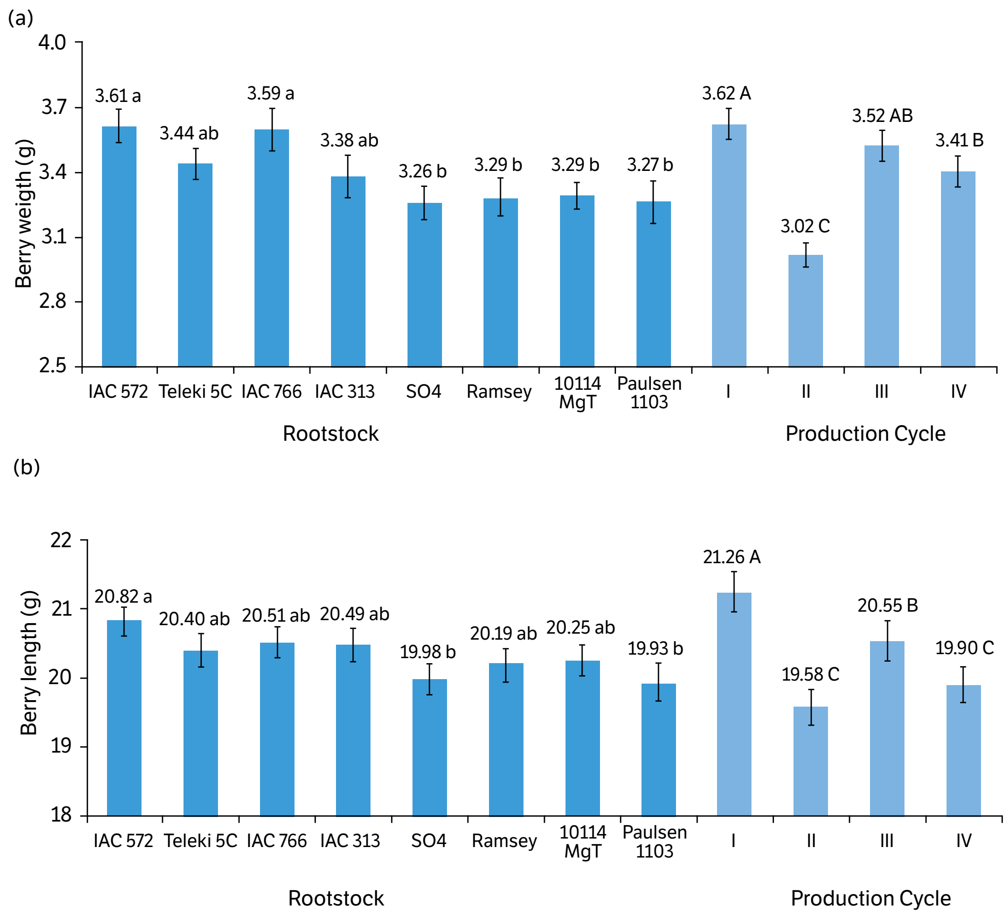

Figure 2. (a) Berry weight and (b) length of 'BRS Melodia' grapevines on different rootstocks over four production cycles.

Table 4. Soluble solids content of 'BRS Melodia' grapes over four production cycles.

Rootstock	Soluble solids content (ºBrix)				
	Cycle I	Cycle II	Cycle III	Cycle IV	Mean
101-14 MgT	19.43Bab	17.95Ca	21.95Aa	16.10Da	18.86ns
IAC 313	19.70Aab	17.83Ba	20.93Aab	15.58Ca	18.51
IAC 572	20.55Aa	18.08Ba	20.50Aab	15.68Ca	18.70
IAC 766	20.30Aab	17.95Ba	19.75Ab	14.95Ca	18.24
Paulsen 1103	18.85Bb	17.63Ba	21.43Aab	16.05Ca	18.49
Ramsey	19.58Bab	17.48Ca	21.30Aab	16.08Ca	18.61
SO4	19.60Bab	17.78Ca	21.93Aa	15.60Da	18.73
Teleki 5C	20.33Aab	17.73Ba	21.23Aab	16.35Ba	18.91
Mean	19.79B	17.80 C	21.13 A	15.80D	18.63
CV (%)					4.31

Mean values followed by the same lowercase letters in the column comparing rootstocks and uppercase letters in the row comparing production cycles do not differ by Tukey's test ($p < 0.05$); ns: not significant; CV: coefficient of variation.

The change in the time of production pruning to perform harvest in drier months tends to improve the chemical characteristics of the must, especially for SS content and acidity (Mota et al. 2010, Pedro Júnior et al. 2014). However, the market periods favorable to sale of grapes in the foreign market, which occur from September to December, also coincide with the beginning of the rainy period in this region (Embrapa 2023b). The mean values for total SS content in the cultivar

'BRS Melodia' were lower than those observed in the São Francisco Valley in other table grape cultivars, such as 'BRS Vitória' (19.51 °Brix), 'BRS Clara' (20.54 °Brix), and 'Thompson Seedless' (21.0 °Brix), but they were higher than those found in 'BRS Ísis' grapes (16.91 °Brix) (Leão et al. 2018, 2020b, 2020c, Martinez et al. 2017). According to Ritschel et al. (2021), 'BRS Melodia' grapes at the end of maturation do not need to reach total SS content greater than or equal to 19 °Brix since they have medium acidity and lack of astringency in the skin. Regardless of the variations among rootstocks and production cycles, all the total SS values obtained in this study were greater than the minimum content of 14 °Brix required for domestic and international consumption and commercialization (Benato 2003, Brasil 2002).

Grapes from the 'BRS Melodia' grapevine did not show variations for TA and the sugar/acid ratio (SS/TA) among the rootstocks (Figs. 3a and 3b), showing mean values of 0.485 g of tartaric acid in 100 mL of juice and an SS/TA ratio of 39.07. The value of TA, classified as moderate, is within the values reported for 'BRS Melodia' in the semi-arid environment and also in studies carried out in the South region of Brazil (Koyama et al. 2019, 2020, Maia et al. 2019, Ritschel et al. 2021). In addition, other table grape cultivars that are widely accepted in the market, such as 'BRS Vitória' and 'BRS Ísis', had similar values (Leão et al. 2016, 2020c). TA is directly associated with the process of fruit maturation and senescence, since the organic acids are metabolized to produce energy during the respiratory processes. For that reason, this variable is used in the SS/TA ratio (Takma and Korel 2017). Regardless of the rootstock and production cycle, the ratio had a medium value (39.07), which is considered suitable for fruit consumption and commercialization, since seedless grapes should have values ≥ 20 to be widely accepted on the commercial market (Benato 2003, Lima and Choudhury 2007).

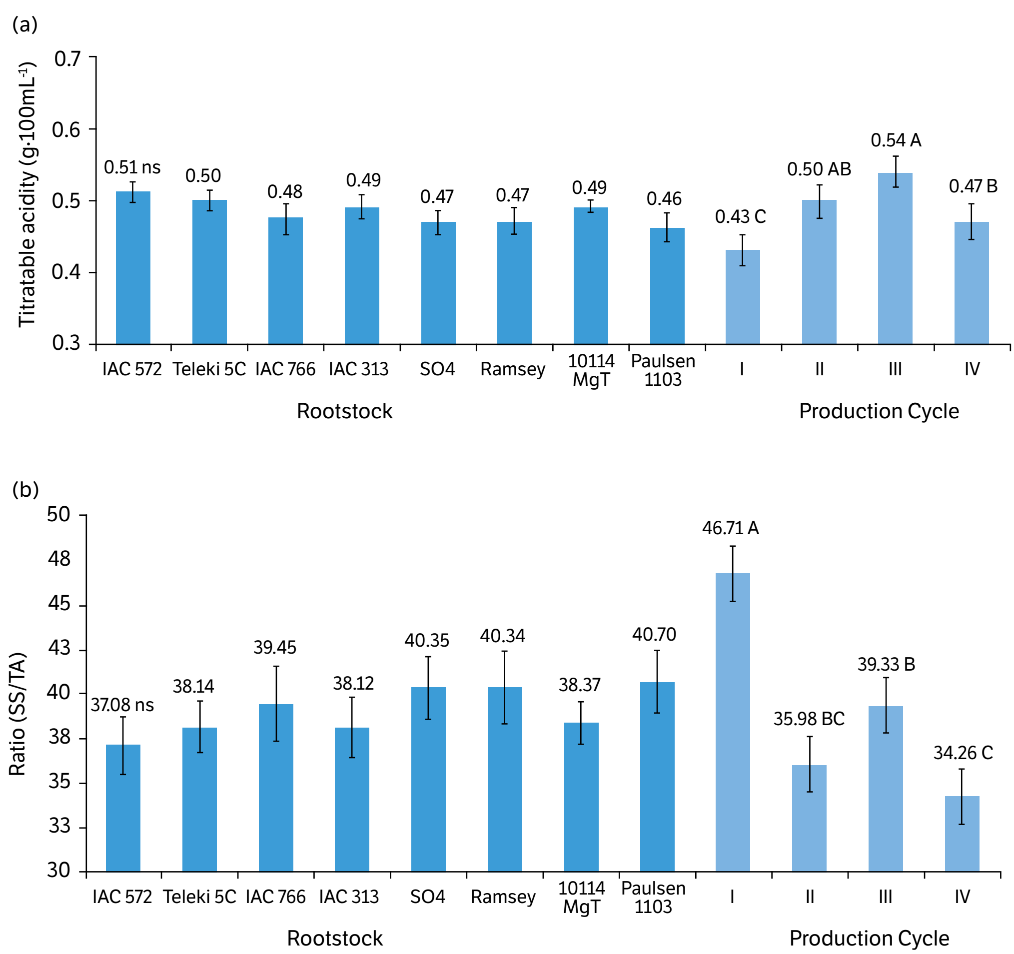

Figure 3. (a) Titratable acidity (TA) and (b) soluble solids content (SS)/TA ratio of berries of the 'BRS Melodia' grapevines on different rootstocks over four production cycles.

The chemical characteristics of the 'BRS Melodia' berries, as well as the physical characteristics, also varied over the production cycles under the semi-arid conditions of the São Francisco Valley. The first and third cycles provided for heavier and more elongated fruit, with higher SS/TA ratios, while the TA had the lowest values in the first and fourth cycles (Figs. 3a and 3b). The low values of TA may be related to the rains that occurred during the end of fruit maturation and at the time of harvest (Figs. 1a and 1b), resulting in dilution of the acid concentration, resulting from the increase in the water volume in the fruit (Lima 2009). Higher values for the SS/TA ratio, in turn, in the first and third production cycles were explained by the greater SS content in these cycles compared to the fourth production cycle (Table 4).

The effect of the production cycle factor was greater than the effect of the rootstock on the berry weight and length variables, with a trend of better responses during the drier cycles. These drier cycles had higher temperatures and sunlight, which favored plant health, an increase in photosynthetic rates, and accumulation of carbohydrates, resulting in an increase in berry weight and size. Changes commonly occur in the weight and size of grapes, considering that the management practices and climate variations of each crop season can lead to different responses (Costa et al. 2020, Koyama et al. 2020, Leão et al. 2020b, 2020c). In addition, despite the variations observed in the physicochemical characteristics of the berries over the production cycles, all the values observed are in accordance with those recommended for commercialization of table grapes and also with the characteristics described for the cultivar 'BRS Melodia' in the São Francisco Valley (Brasil 2002, Ritschel et al. 2021).

CONCLUSION

The rootstocks IAC 572 and IAC 766 should be recommended for grafting on the cultivar 'BRS Melodia' under similar edaphic and climatic conditions, because they led to increases in yield, bud fertility, and cluster and berry weight and size. There was no effect of the rootstock on vigor, TA, and the SS/TA ratio of the 'BRS Melodia' grapes.

CONFLICT OF INTEREST

Nothing to declare.

AUTHORS' CONTRIBUTION

Conceptualization: Leão, P. C. S.; **Investigation:** Oliveira, C. R. S., Leão, P. C. S., Silva, F. B. and Pontes, G. M. A.; **Funding Acquisition:** Leão, P. C. S.; **Supervision:** Leão, P. C. S. and Mendonça Junior, A. F.; **Writing – Original Draft:** Oliveira, C. R. S.; **Writing – Review and Editing:** Oliveira, C. R. S. and Leão, P. C. S.

DATA AVAILABILITY STATEMENT

All dataset were generated and analyzed in the current study.

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