Australian Journal of Crop Science AJCS

Aust J Crop Sci. 19(03):284-291 (2025) | ISSN:1835-2707
https://doi.org/10.21475/ajcs.25.19.03.p288

Table grape 'BRS Vitória' yield performance, vigor, and quality as influenced by rootstocks in a subtropical region

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Received: ***17/10/2024***

Revised: ***17/11/2024***

Accepted: ***28/01/2025***

Abstract: Given the growth of vine orchards to new areas and the need for diversification of scion and rootstock combinations in subtropical sites, selecting the right rootstock can bring significant benefits to the scions. Thus, the current study sought to determine the impact of rootstocks 'IAC 572' Jales, 'IAC 766 Campinas' and '1103 Paulsen' on the productive performance, vigor, and quality of 'BRS Vitória' grapevines grown under subtropical circumstances. The experimental design was a randomized block design, with three treatments (rootstocks), seven blocks, and three plants per plot, for a total of 63 grapevines. Over three summer seasons (2020, 2021, and 2022), production and vigor components (number of clusters per vine, production per vine, productivity, and pruning mass), physical-chemical properties of clusters and berries (number of berries, fresh mass, length, and width of clusters and berries, soluble solids, pH, titratable acidity, and maturity index, as well as the quantities of bioactive chemicals in the berries (phenols, flavonoids, and anthocyanins), were all assessed. The rootstocks had a significant influence on the majority of the factors studied. The results showed that increasing vigor of rootstock increased vine yield while decreasing the quantity of soluble solids and bioactive chemicals in grapes. The 'IAC 572' rootstock increased vigor and productivity, whereas grapes from plants grafted onto '1103P' exhibited higher amounts of soluble solids, phenols, flavonoids, and anthocyanins. Overall, the 'BRS Vitória' cultivar demonstrated high yield and quality. As a result, extending cultivation in subtropical locations emerges as an effective solution to meet the growing demand for seedless grapes.

Keywords: grafting; subtropical viticulture; seedless grapes; hybrid grapes; bioactive compounds.

Introduction

The demand for seedless grapes in Brazil has increased significantly over the previous decade. In this light, it is worth noting that the cultivars Superior Seedless, Crimson Seedless, and Thompson Seedless are increasingly being replaced by new hybrid and national cultivars, owing to their adaptability, productivity, and commercial quality—all of which are very desirable by customers. Notable cultivars include 'BRS Ísis' and 'BRS Vitória', which are well-received in the home market and among the most exported grape varieties in the country (Mello and Machado, 2022).

'BRS Vitória', a seedless black grape, is popular in Brazilian viticulture because to its delicious taste, high soluble solids content, and increased productivity. It also has good vigor, bud fertility, and resistance to mildew and berry cracking (Maia et al. 2012). One noteworthy characteristic is that it has lower production costs due to fewer pesticide and labor needs, resulting in higher economic returns for grape growers and more sustainable production (Maia et al. 2018). Although traditionally grown in Brazil's semi-arid tropical climate, 'BRS Vitória' is highly adaptable to many climates (Maia et al., 2012), making it a viable option for subtropical and temperate countries.

In São Paulo's key viticulture districts, cultivating 'BRS Vitória' in the Northwest is gaining popularity as a profitable production diversification option. However, being a cultivar introduced in 2013, more research in these places is needed, particularly on critical practices such as the use of appropriate rootstocks.

Grafting is essential in viticulture, offering a consistently effective and successful strategy in major viticultural countries for treating numerous pathogens affecting grape root systems, most notably phylloxera (Granett et al., 2001) and nematodes (Ferris et al., 2012). Furthermore, rootstocks play an important role in enabling vine cultivation even in adverse soil conditions such as high salinity (Dunlevy et al., 2022), water deficit or drought (Serra et al., 2013), nutrient deficiency (Livigni et al., 2019), and toxic element excess (Cançado et al., 2009). Beyond these advantages, research indicates that rootstocks can influence a variety of vine

characteristics, including vegetative vigor (Li et al., 2019), productivity (Tecchio et al., 2020), physicochemical quality (Silva et al., 2018), bioactive compound levels (Cheng et al., 2017), and phenological cycle duration (Callili et al., 2023). Thus, selecting a rootstock that is well-suited to the scion cultivar is critical for effective grape growing.

Before choosing a rootstock, it's crucial to consider compatibility and interaction with the scion cultivar, as well as adaptation to climatic circumstances (Vrsic et al., 2015; Leão et al., 2020a). Furthermore, the rootstock's vigor on the above-ground component must be evaluated, since studies demonstrate that this parameter is intimately linked to grape productivity and quality (Jones et al., 2009; Ibacache et al., 2016). Thus, investigations using rootstocks in specific production settings are critical and can provide direct recommendations to grape growers.

Brazil currently offers various rootstock cultivars, each with unique characteristics and recommendations. Notable possibilities include 'IAC 572 Jales', 'IAC 766 Campinas', and '1103 Paulsen'. 'IAC 572' and 'IAC 766' are popular in subtropical and tropical regions, whereas '1103P' is the most commonly used rootstock in temperate Brazilian environments (Tecchio et al., 2018; Viana et al., 2018). There is limited study on 'BRS Vitória' in subtropical and temperate settings, despite studies assessing it in conjunction with popular table grape cultivars in Brazil (Feldberg et al., 2007; Leão et al., 2019; Leão et al., 2020a; Callili et al., 2022a). Thus, the current study sought to determine the effect of the rootstocks 'IAC 572', 'IAC 766', and '1103P' on the productive performance, vigor, and quality of the 'BRS Vitória' grapevine in subtropical conditions.

Results and Discussion

Production components, vegetative vigor, and physical attributes of clusters and berries

Grapevine rootstocks differed significantly ($p < 0.05$) in terms of productivity, with 'IAC 572' outperforming 'IAC 766' and '1103P' by 23% and 51%, respectively (Table 1). In terms of vine vigor, 'IAC 572' produced a larger pruning mass than 'IAC 766' and '1103P', with values of 3.63, 2.31, and 1.58 kg vine^{-1}, respectively (Table 1). Pearson correlation analysis (data not given) suggests that pruning mass has a significant impact on vine productivity ($r = 0.99$). Mota et al. (2009) found that 'IAC 572' increased vigor and productivity in 'Niagara Rosada' and 'Bordô'. These results confirm prior research that shows that higher vigor provided by the rootstock leads to increased vine productivity (Jones et al., 2009; Rizk-Alla et al., 2011; Ibacache et al., 2016).

According to Bascunán-Godoy et al. (2017), the vigor given by rootstocks on the canopy can be a significant role in determining vine yield. These authors underline that higher yields in vines grown on rootstocks that promote greater vigor are linked to increased light collection by the canopy. Furthermore, rootstocks differ in terms of water and nutrient uptake (Jin et al., 2016); that is, the greater the capacity for nutrient absorption and translocation, the higher the biomass accumulation in the aboveground part, and thus the greater the productivity of grapevines (Tecchio et al., 2019). Lower productivity was found in vines grafted onto '1103P', which is also related to the quantity of clusters per vine ($r = 0.91$). 'BRS Vitória' grafted onto 'IAC 572' and 'IAC 766' produced 84 and 81 clusters per vine, respectively, whilst those grown on '1103P' produced 70 clusters per vine (Table 1). Leão et al. (2020b) found that vines grafted onto '1103P' had more clusters than those grafted onto 'IAC 572', with 104 against 86. However, this variable had no effect on the output of 'BRS Vitória' in semi-arid tropical environments. Rootstocks' vigor had a substantial impact on cluster physical features. Pruning mass had a strong positive connection with the quantity of berries per cluster ($r = 0.98$), cluster mass ($r = 0.99$), cluster length ($r = 0.99$), and cluster width ($r = 0.93$). 'BRS Vitória' grafted onto 'IAC 572' produced more berries per cluster (70.75) and a larger cluster mass (332.74 g) than 'IAC 766' and '1103P'. Compared to '1103P', 'BRS Vitória' grown on 'IAC 572' had longer clusters (16.32 vs. 15.47 cm), wider clusters (8.37 vs. 7.31 cm), heavier berries (4.51 vs. 4.14 g), and wider berries (1.87 vs. 1.77 cm) (Table 2). Although rootstocks had a substantial effect in this investigation, Leão et al. (2020b) showed no variation in productivity of 'BRS Vitória' grown under semi-arid tropical conditions (BSwh). This suggests that the effect of rootstock on vine characteristics is inextricably linked to the cultivation site's soil and climatic circumstances. Furthermore, tests undertaken using these rootstocks in combination with other table grape cultivars produce significant diversity in results. Grafting 'Niagara Rosada' (Bruna and Back, 2015), 'BRS Clara' (Leão et al., 2019), 'Crimson Seedless', and 'Superior Seedless' (Feldberg et al., 2007) onto '1103P' resulted in better productivity than 'IAC 572', which contradicted the findings of the current study (Table 1). However, both rootstocks had no effect on the productivity of 'BRS Ísis' (Leão et al., 2020a). As a result, it is clear that the affinity and interaction between rootstock and scion cultivars are highly unique and vary depending on how they are grown.

The enhanced productive performance of vines grafted onto 'IAC 572' is attributed to the rootstock's increased vigor, better adaptation to the *Cfa* climate and Red Latosol, and better interaction with 'BRS Vitória' under these cultivation conditions. Furthermore, regardless of the rootstock employed, 'BRS Vitória' demonstrated good productive performance under subtropical conditions, yielding more than 25 t/ha.

Chemical composition and bioactive compounds

There was no change in the chemical composition of grapes between rootstocks for TA, pH, and maturity index, with average values of 0.51%, 3.48, and 37.7, respectively (Table 3). According to Maia et al. (2012), the raspberry flavor of 'BRS Vitória' grapes is enhanced when the SS/TA ratio ranges between 20 and 30, values lower than those obtained in this study. This may be ascribed primarily to the grapes' mild acidity. The fruit's flavor is mostly determined by the sugar-to-acid ratio (SS/TA), and high values of this index are coveted in the local market. According to Bleinroth (1993), the SS/TA ratio is a better indicator of fruit quality than isolated sugar or acidity measurements, and it should be equal to or greater than 20 for table grapes. However, because of its convenience, the isolated measurement of SS concentration is the most

Table 1. Yield and vigor components of the 'BRS Vitória' vine grafted onto distinct rootstocks in subtropical climates.

Yield and vigor components	Rootstocks			
	'IAC 572 Jales'	'IAC 766 Campinas'	'1103 Paulsen'	*p*-value
Yield per vine (kg vine^{-1})	23.87 ± 3.72 a	19.37 ± 1.34 b	15.80 ± 1.65 b	> 0.01
Productivity (t ha^{-1})	39.81 ± 6.20 a	32.27 ± 2.23b	26.27 ± 4.48 b	> 0.01
Number of clusters per vine	84.18 ± 8.45 a	81.78 ± 3.84 a	70.24 ± 9.53 b	> 0.01
Pruning mass (kg vine^{-1})	3.63 ± 0.98 a	2.31 ± 0.30 b	1.58 ± 0.20 b	> 0.01

Values are shown as the mean (three seasons) ± standard deviation (n = 7). Values denoted by various letters show significant differences (Tukey test; p < 0.05).

Table 2. Physical characteristics of 'BRS Vitória' vine clusters and berries grafted onto distinct rootstocks in subtropical climates.

Clusters and berries characteristics	Rootstocks			
	'IAC 572 Jales'	'IAC 766 Campinas'	'1103 Paulsen'	p-value
Number of berries per cluster	70.75 ± 3.67 a	67.10 ± 3.62 b	63.47 ± 4.31 c	> 0.01
Clusters mass (g)	332.47 ± 11.76 a	302.27 ± 12.01 b	273.90 ± 16.47 c	> 0.01
Clusters length (cm)	16.32 ± 0.51 a	15.87 ± 0.41 ab	15.47 ± 0.40 b	> 0.01
Clusters width (cm)	8.37 ± 0.27 a	8.20 ± 0.17 ab	7.81 ± 0.34 b	> 0.01
Berries mass (g)	4.51 ± 0.19 a	4.38 ± 0.14 a	4.14 ± 0.13 b	> 0.01
Berries length (cm)	2.40 ± 0.04	2.40 ± 0.03	2.34 ± 0.02	0.05
Berries width (cm)	1.87 ± 0.09 a	1.82 ± 0.10 ab	1.77 ± 0.01 b	> 0.05

Values are shown as the mean (three seasons) ± standard deviation (n = 7). Values denoted by various letters show significant differences (Tukey test; p < 0.05).

Table 3. Chemical compositions and bioactive compounds of 'BRS Vitória' vines grown on different rootstocks in subtropical climates.

Chemical compositions and bioactive compounds	Rootstocks			
	'IAC 572 Jales'	'IAC 766 Campinas'	'1103 Paulsen'	*p*-value
Titratable acidity (%)	0.52 ± 0.03	0.50 ± 0.04	0.51 ± 0.04	0.63
pH	3.46 ± 0.04	3.49 ± 0.06	3.49 ± 0.05	0.37
Soluble solids (°Brix)	16.99 ± 0.47 b	18.08 ± 0.86 ab	19.08 ± 0.85 a	> 0.01
maturity index (SS/TA)	34.38 ± 3.97	39.40 ± 6.11	39.32 ± 4.40	0.17
Total phenols (mg 100 g^{-1})	190.67 ± 22.78 b	213.46 ± 8.27 ab	226.70 ± 4.40 a	< 0.05
Total flavonoids (mg 100 g^{-1})	19.40 ± 1.78 b	19.62 ± 1.38 b	25.07 ± 0.85 a	< 0.01
Anthocyanins (mg 100 g^{-1})	81.98 ± 4.54 b	97.09 ± 7.41 b	181.29 ± 12.19 a	< 0.01

Values are shown as the mean (three seasons) ± standard deviation (n = 7). Values denoted by various letters show significant differences (Tukey test, p < 0.05).

commonly utilized quality criterion among grape growers.

The SS content of 'BRS Vitória' grapes grafted onto '1103P' was significantly higher than that of 'IAC 572' (19.08 against 16.99 °Brix) (Table 3). This is mostly due to the increased vigor generated by 'IAC 572', since a strong negative association was discovered between SS and pruning mass (r = -0.99), number of berries (r = -1.00), cluster mass (r = -1.00), berry mass (r = -0.99), and, as a result, production (r = -0.99). When grafted onto 'IAC 572', 'Niagara Rosada' and 'Bordô' displayed the similar behavior, with stronger vigor and lower SS content than 'IAC 766' and '1103P''(Mota et al., 2009). In 'BRS Vitória' cultivated in the BSwh climate, there was no difference in SS content (19.4 °Brix) between these same rootstocks (Leão et al., 2020b), values higher than those obtained in this study (Table 3), due to the conditions that occur in the semi-arid tropical climate, i.e., low precipitation and high temperature during the harvest period, which favor SS accumulation.

Figure 1 shows that there was a high rainfall index in the time preceding the harvest (December), which was unfavorable for SS accumulation. However, regardless of the rootstock, the values found are within the international guidelines for commercialization. The minimal SS content of table grapes is 14 to 17.5 ºBrix, depending on the cultivar and growth conditions. Furthermore, when compared to 'Niagara Rosada', the most popular table grape cultivar in subtropical Brazilian regions, 'BRS Vitória' has a greater SS content, which is appealing to customers. Callili et al. (2022b) found 15.6 °Brix in 'Niagara Rosada' grapes grown in similar climates. It is also worth noting that 'BRS Vitória' is resistant to berry cracking (Maia et al., 2012), making cultivation possible even in areas with considerable precipitation.

'BRS Vitória' grafted onto '1103P' has more total phenols, flavonoids, and monomeric anthocyanins (Table 3). Similar to SS, phenolic chemicals and vine vigor components showed a strong negative connection. Other research have confirmed the effect of rootstocks on the content of phenolic compounds in grapes, and vegetative vigor is regarded as an essential determinant in the concentration of some bioactive compounds (Silva et al., 2017; Silva et al., 2019; Callili et al., 2022b). The variation in phenolic compound levels could be attributed to changes in secondary metabolism in response to biotic or abiotic stimuli as light, temperature, altitude, soil type, water, microbial interactions, nutritional status, pathogenesis, wounds, defoliation, and phytohormones.

Table 4. Factor loadings, eigenvalues, and the proportion of variance associated with two principal components (PC) of the yield, physicochemical, and biochemical properties of the combination of 'BRS Vitória' grape with 'IAC 572', 'IAC 766', and '1103P' rootstocks.

Traits	PC1	PC2
YldV	0.998	0.066
Pdt	0.998	0.062
NCV	0.934	-0.358
CM	1.000	0.015
CL	1.000	0.019
CW	0.978	-0.209
NBC	1.000	0.001
BM	0.993	-0.116
BL	0.950	-0.312
BW	0.995	-0.098
PrngM	0.987	0.158
TA	0.562	0.827
pH	-0.875	-0.484
SS	-1.000	-0.021
SS/TA	-0.860	-0.510
Phnl	-0.989	-0.148
Flvn	-0.881	0.472
Anth	-0.927	0.376
Eigenvalue	16.108	1.892
Variability (%)	89.491	10.509
Cumulative %	89.491	100.000

Trait abbreviation: number of clusters per vine [NCV], number of berries per cluster [NBC], yield per vine [YldV], productivity [Pdt], pruning mass [PrngM], cluster mass [CM], cluster length [CL], cluster width [CW], berry mass [BM], berry length [BL], berry width [BW], pH [pH], soluble solids [SS], titratable acidity [TA], maturity index [SS/TA ratio], phenols [Phnl], flavonoids [Flvn], anthocyanins [Anth].

However, the most likely factor impacting phenolic compound content is high vigor (Downey et al., 2006).
The highest difference between rootstocks was found in anthocyanin content. 'BRS Vitória' grapes grown on '1103P' contain higher levels of anthocyanins than 'IAC 766' and 'IAC 572', at 181.29, 97.09, and 81.98 mg per 100 g, respectively (Table 3). Suriano et al. (2016) found that rootstocks have a direct effect on grape anthocyanin levels. Anthocyanins are molecules that contribute to fruit pigmentation; hence, larger amounts encourage a more intense color in the berries, making them more appealing to consumers. Furthermore, these chemicals are extremely attractive due to their antioxidant characteristics, which give a variety of health benefits to humans (Haminiuk et al. 2012).

Principal component analysis (PCA)

Principal Component Analysis (PCA) was used to analyze all variables in the cultivar BRS Vitória grafted onto the rootstocks 'IAC 572', 'IAC 766', and '1103P'. Two principal components (PC) accounted for the experiment's variability (Table 4 and Figure 2). PC1 accounted 89.49% of the overall variability, effectively distinguishing the examined rootstocks, particularly 'IAC 572' from '1103P'. Except for titratable acidity, all other variables significantly influenced the separation of these rootstocks. Variables with high positive loadings included yield, productivity, morphological qualities of clusters and berries, and pruning mass. Variables with high negative loadings included pH, soluble solids, phenolic compounds, anthocyanins, and flavonoids. PC1 scores and loadings indicate that 'BRS Vitória' grafted onto 'IAC 572' has a greater yield, which is favorably connected with higher physical qualities of clusters and berries. When 'BRS Vitória' was grafted onto '1103P', the berries had a higher concentration of soluble solids and beneficial substances. The adoption of the rootstock 'IAC 766' resulted in lesser titratable acidity.

Material and Methods

Treatments, experimental design, experimental site and cultivation conditions

The grape cultivar 'BRS Vitória' (CNPUV 681-29 x 'BRS Linda') is in its 4th, 5th, and 6th production cycles. It was grafted onto the rootstocks 'IAC 572 Jales' [(*Vitis caribaea* x (*Vitis riparia* x *Vitis rupestris* 101-14)], 'IAC 766 Campinas' (Riparia do Traviú x *Vitis caribaea*), and '1103 Paulsen' (*Vitis berlandieri* x *Vitis rupestris*). The experimental design was a randomized block design, with three treatments (rootstocks), seven blocks, and three plants per plot, for a total of 63 grapevines.
The study was done in an experimental vineyard located in São Manuel, State of São Paulo, Brazil (22° 46'S, 48° 34'W, and 773 m height), throughout three consecutive summer seasons (2020–2022). According to the Köppen classification, the climate is *Cfa*, which means subtropical with a hot summer. The average minimum temperature throughout grapevine production cycles, which run from July to December, was 16.4°C in 2020, 15.9°C in 2021, and 16.1°C in 2022. Meanwhile, the average maximum

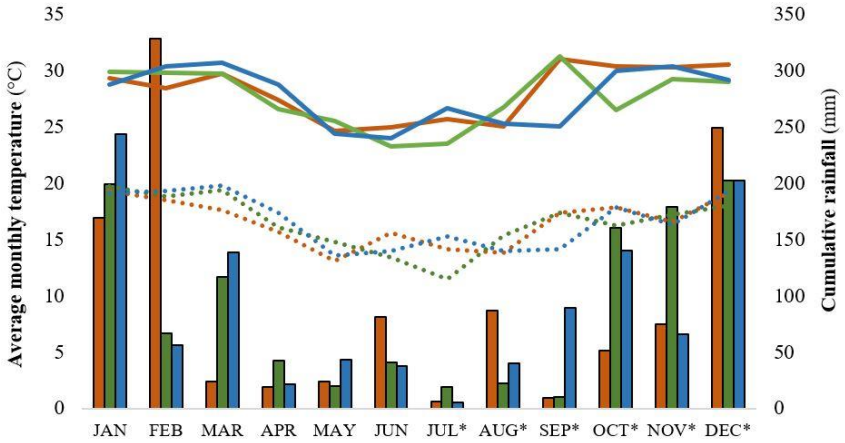

Figure 1. Climate data for the experimental location in 2020, 2021, and 2022 (including mean temperature and total rainfall). *Production time. The lines represent the minimum and maximum temperatures, and the bars show the total amount of precipitation. The hues orange, green, and blue represent 2020, 2021, and 2022, respectively.

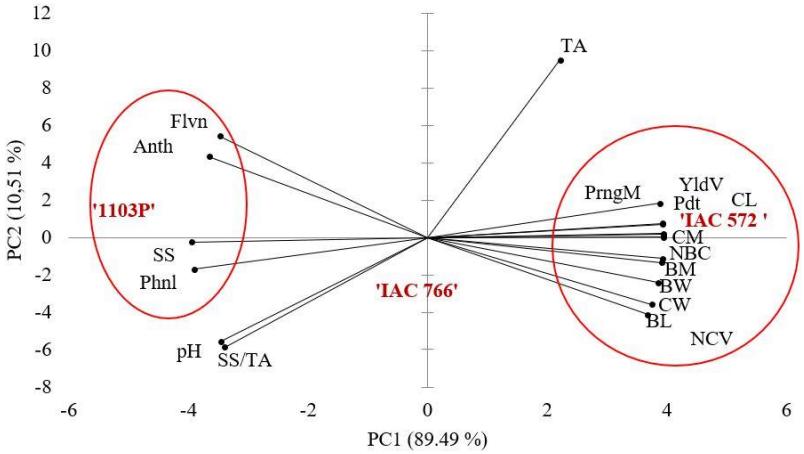

Figure 2. Plot showing the main component analysis of 18 yield and quality traits for the 'BRS Vitória' grape combined with 'IAC 572', 'IAC 766', and '1103P' rootstocks. Trait abbreviation: number of clusters per vine [NCV], number of berries per cluster [NBC], yield per vine [YldV], productivity [Pdt], pruning mass [PrngM], cluster mass [CM], cluster length [CL], cluster width [CW], berry mass [BM], berry length [BL], berry width [BW], pH [pH], soluble solids [SS], titratable acidity [TA], maturity index [SS/TA ratio], phenol [Phnl], flavonoid [Flvn], anthocyanins [Anth].

temperature for 2020, 2021, and 2022 was 28.8°C, 27.7°C, and 27.7°C, respectively. The total rainfall in 2020, 2021, and 2022 was 477 mm, 593 mm, and 543 mm, with a concentration in the summer months (Figure 1). A graph of precipitation, temperature, and relative humidity during the three summer seasons has been provided to provide a thorough environmental profile.

Embrapa criteria (2018) identified the soil in the trial region as Red Latosol (equal to Oxisols in USDA soil taxonomy). Rootstock cuttings were planted in August 2018, with a row spacing of 3.0 m and a plant spacing of 2.0 m, yielding a grapevine density of 1,667 per hectare. The scion cultivar was grafted in July 2019 using the "cleft graft" method, which ensures excellent compatibility and success. A "Y" system with a metal structure and eucalyptus-treated posts was utilized to support and train the vines. Irrigation was done with microsprinklers, which ensured an adequate supply of water during the growth season. To protect against hail and bird attacks, the experimental vineyard was covered with 18% shade polyethylene mesh.

All cultural procedures, including fertilizer, plant growth regulators, shoot thinning, leaf removal, shoot positioning, cluster thinning, and phytosanitary control, were carried out in accordance with the recommendations made by Maia et al. (2016). Pruning for the 2020, 2021, and 2022 production cycles occurred on July 22, August 5, and July 14, respectively (winter pruning). During pruning, one to two buds were preserved per spur, and 2.5% hydrogen cyanamide was used to induce and standardize bud break.

Fruits were picked at full maturity, which means they had soluble solids and titratable acidity levels appropriate for the 'BRS Vitória' cultivar in subtropical climates (Maia et al., 2012). In addition, berry color and texture were evaluated while selecting the optimal harvest period.

Production components and vine vigor

At harvest, the number of clusters per vine was counted, and the weight of each cluster was used to calculate vine production. Productivity (t ha^{-1}) was evaluated using vine production and planting spacing, with a planting density of 1,667 plants per hectare. To estimate vine vigor, biomass accumulation from shoots (kg vine-1) was measured. During the pruning step, the total fresh mass of shoots from each experimental plot was determined.

The percentage of dry mass of the shoots was then assessed in samples of three per plot. Thus, the accumulation of shoot biomass was determined by multiplying the sample data of the dry mass percentage by the total fresh mass of the shoots.

Physical characteristics of clusters and berries

For physical features of clusters and berries, 10 clusters were chosen from each plot and their fresh mass (g), width (cm), and length (cm) were measured. The number of berries in each cluster was also quantified.

Chemical composition of grape must

The chemical properties of the berries were evaluated, including titratable acidity (TA), pH, soluble solids (SS) concentration, and maturity index. TA was measured by titrating the berry must with 0.1 N NaOH at a pH of 8.2, and the result was reported as a percentage of tartaric acid (%). The pH was determined by directly reading the grape must using a pH meter (Tecnal®, model Tec-5, Piracicaba, SP, Brazil). The SS content was evaluated by direct refractometry of the grape must with a digital refractometer (Reichert®, model r2i300, Depew, NY, USA), and the maturity index was calculated using the SS/TA ratio.

Bioactive compounds

The total phenol content was determined using the Folin-Ciocalteau reagent (Singleton and Rossi, 1965), and the results were represented in mg equivalent of gallic acid (mgEAG) per 100 g. The total flavonoid content was calculated using Popova et al. (2004), and the results were represented in mg equivalent of quercetin (mgEQ) per 100 g. The differential pH method (Giusti and Wrolstad, 2001) was used to estimate the total monomeric anthocyanin content, which was expressed in mg of malvidin-3-glucoside per 100 g.

Statistical analyses

Statistical analyses were performed using the average values obtained from the three production cycles. The results were treated to analysis of variance (ANOVA) to identify the influence of rootstocks, and mean comparisons between treatments were performed using the Tukey test at a 5% probability level, with the statistical program SISVAR version 5.7. Data from 18 characteristics were analyzed using principal component analysis (PCA) in XLSTAT version 19.4, which also calculated Pearson correlation to investigate the link between the evaluated variables.

Conclusions

Throughout the three harvests, all three rootstocks had a direct impact on the productivity, vigor, and quality of 'BRS Vitória' grapes. There is an obvious distinction between 'IAC 572' and '1103P' when compared to 'IAC 766'. 'BRS Vitória' grafted onto 'IAC 572' has the best commercialization characteristics, i.e., higher vigor and productivity, after accounting for the number of clusters per vine, number of berries per cluster, yield per vine, productivity, pruning mass, cluster mass, cluster length, cluster width, berry mass, berry length, and berry width. When looking for fruit with more bioactive compounds, grafting onto '1103P' is recommended, as berries have higher levels of soluble solids, phenolic compounds, flavonoids, and anthocyanins under similar growth circumstances.

Acknowledgment

To the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for financial support (2020/12152-3), and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the Doctoral Scholarship (140830/2020-0), Research Productivity Grant (process no 307377/2021-0), and aid granted (406355/2018-5).

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