REVISTA BRASILEIRA DE FRUTICULTURA
Published by the Brazilian Society of Fruit Crops
ISSN 0100-2945

Crop Production

Original Article - Edited by: Luis Eduardo Correa Antunes

Phenology, thermal demand, and maturation development of the 'BRS Vitória' grape cultivated on different rootstocks in subtropical conditions

Daniel Callili[1], Camilo André Pereira Contreras Sánchez[1], Olivia Pak Campos[1], Débora Cavalcante dos Santos Carneiro[1], Ana Carolina Barduzzi Scudeletti[1], Marco Antonio Tecchio[1]

[1] Faculdade de Ciências Agronômicas/UNESP, Botucatu-SP, Brazil.
Corresponding author: daniel_callili@hotmail.com

Abstract: The purpose of this study was to assess how 'IAC 572', 'IAC 766', and 'Paulsen 1103' rootstocks affected the duration of phenological phases, thermal demand, and chemical evolution throughout production cycle of the 'BRS Vitória' table grape cultivated in subtropical conditions. The duration of the following phenological stages was measured in days after pruning throughout two production seasons: budburst, flowering, setting, veraison, and harvest date. The thermal demand was determined using the degree-day concept. Titratable acidity, pH, soluble solids, and the maturation index were all measured throughout berry maturation. In general, the rootstocks 'IAC 572' and 'IAC 766' increased vine precocity in comparison to 'Paulsen 1103' during the early phenological phases. However, the vines grafted on 'Paulsen 1103' were earlier in the later phases, that is, at the veraison and at the harvest date, when compared to those grafted on the rootstocks 'IAC 572' and 'IAC 766'. Under subtropical conditions, the total cycle period of the 'BRS Vitória' vine varied from 131 to 143 days, with thermal demands ranging from 1,545 to 1,725 DD. In comparison to the 'IAC 572' and the 'IAC 766', the 'Paulsen 1103' supplied the berries with a higher accumulation of soluble solids and a higher maturation index.

Index Terms: seedless grape; table grapes; subtropical viticulture; grafting; chemical analysis.

Revista Brasileira de Fruticultura, v.45, e-999 DOI: https://dx.doi.org/10.1590/0100-29452023999
Received 30 Aug, 2022 • Accepted 16 Nov, 2022 • Published Jan/Feb, 2023.

Fenologia, demanda térmica e evolução da maturação da uva ‘BRS Vitória’ cultivada sobre diferentes porta-enxertos em condições subtropicais

Resumo: Objetivou-se avaliar o efeito dos porta-enxertos ‘IAC 572’, ‘IAC 766’ e ‘Paulsen 1103’ quanto à duração dos estádios fenológicos, à demanda térmica e à evolução química ao longo do ciclo de produção da uva ‘BRS Vitória’, cultivada em condições subtropicais. Durante dois ciclos de produção, foi quantificado, em dias após a poda, a duração das fases fenológicas: brotação, pleno florescimento, frutificação, início da maturação e data de colheita. A demanda térmica total foi calculdada utilizando-se do conceito de graus-dias. Durante a maturação das bagas, foram avaliados o pH, a acidez titulável, os teores de sólidos solúveis e o índice de maturação. De maneira geral, nos estádios fenológicos iniciais, os porta-enxertos ‘IAC 572’ e ‘IAC 766’ promoveram precocidade às videiras em relação ao ‘Paulsen 1103’. Contudo, nas fases finais, ou seja, no ínicio da maturação e na colheita, as videiras enxertadas sobre o ‘Paulsen 1103’ foram mais precoces quando comparadas às cultivadas sobre os porta-enxertos ‘IAC 572’ e ‘IAC 766’. A duração completa do ciclo da videira ‘BRS Vitória’, em condições subtropicais, variou de 131 a 143 dias, com demandas térmicas variando de 1.545 a 1.725 GD. O ‘Paulsen 1103’ propiciou às bagas maior acúmulo de sólidos solúveis e maior índice de maturação em relação ao ‘IAC 572’ e ao ‘IAC 766’.

Termos para indexação: uva sem semente; uva para mesa; viticultura subtropical; enxertia; análises químicas.

Introduction

Grapes are among the most produced and sold fruits in Brazil (AGRIANUAL, 2020), and due to the country’s diverse climatic conditions, Brazilian viticulture has a notable range of cultivars and production processes. According to Mello and Machado (2021), 46.7% of the 1,416,398 tons of grapes produced in Brazil in 2020 were processing grapes, while 53.3% were table grapes.

In the table grapes market, there has been a substantial increase in demand for seedless grapes over the previous decade, and from 2006 to 2017, the participation of seedless grape cultivars increased from 7% to 30% of total table grapes sold at CEAGESP in São Paulo. Given the current situation, it is crucial to note that this new consumer behaviour has encouraged many producers to engage in the production of seedless grapes, particularly the new Embrapa cultivars ‘BRS Ísis’ and ‘BRS Vitória’ (MAIA et al., 2018).

Based on its agronomic qualities, such as succulent consistency, high concentration of soluble solids, high fertility, strong yield, mildew tolerance, and cheap production cost, the black grape cultivar ‘BRS Vitória’ has gained popularity among consumers and grape grower (MAIA et al., 2016; MAIA et al., 2018).

The ‘BRS Vitória’ vine is mostly planted in the São Francisco Valley’s sub-medium zone, under hot semi-arid (BSh) (MELLO and MACHADO, 2021). However, due to its extensive edaphloclimatic adaptability (MAIA et al., 2012) and expanding consumer demand, it is a promising choice for seedless grape production in temperate and subtropical climates.

According to Maia et al. (2012), the duration of the production cycle ranges from 90 to 135 days, depending on soil and climate conditions. However, in addition to the cultivation site conditions, other factors, like as the rootstock utilized, can have a direct impact on the duration of the production cycle (TECCHIO et al., 2013) and the agronomic features of the vines (SILVA et al., 2018; LEÃO et al., 2020a).

'IAC 572 Jales', 'IAC 766 Campinas', and 'Paulsen 1103' are among the most widely used rootstocks in Brazil. Because of its resistance to fusariosis, 'Paulsen 1103' is the most extensively used rootstock in Rio Grande do Sul; also, its cultivation has increased substantially in the São Francisco Valley's Submedium. 'IAC 572', on the other hand, presents high vigour, excellent roots, and adaptability to sandy or clayey soils. 'IAC 766', which is well suited to subtropical environments, has excellent roots and vigour (LEÃO and SILVA, 2018; TECCHIO et al., 2018). It is crucial to note, however, that while selecting the optimal rootstock, the affinity between rootstock and scion must be addressed (TECCHIO et al., 2020).

In terms of phenology and thermal demand, these rootstocks were investigated in combinations with different grape cultivars, including 'Niagara Rosada' (CALLILI et al., 2022), 'Cabernet Sauvignon' (MIELE, 2019), 'Vênus' (TECCHIO et al., 2019a), 'Merlot' (ALLEBRANDT et al., 2015), 'Bordô', 'BRS Carmen', 'Concord' (BARROS et al., 2015), 'Isabel' and 'Rubea' (SATO et al., 2008). However, it should be noted that no research have been conducted to assess the impact of rootstocks on the phenology and thermal requirements of the 'BRS Vitória' vine, particularly in a subtropical climatic location.

Phenology and thermal demands studies are critical for viticulture since understanding the duration of each phenological stage allows grape grower to prepare for prospective harvest dates, periods of maximum labor demand, as well as cultural and phytosanitary management. Furthermore, they can provide an indicator of the region's climatic potential for grape production. Similarly, understanding the chemical changes that occur during berry maturity is a powerful tool since it allows you to determine the perfect time for harvest, that is, when the best balance of soluble solids and acidity occurs.

Thus, the purpose of this study was to assess the influence of rootstocks on the duration of phenological phases and thermal demand of the vines, as well as to confirm the chemical changes of the 'BRS Vitória' grape cultivated under subtropical conditions.

Material and methods

The experimental design consisted of randomized blocks with seven blocks and three vines per plot for a total of 63 vines in the experimental area. The cultivar BRS Vitória (CNPUV 681-29 x 'BRS Linda') was grafted on the following rootstocks 'IAC 572 Jales' ((*Vitis caribaea* x (*Vitis riparia* x *Vitis rupestris* 101-14)), 'IAC 766 Campinas' (Riparia do Traviú x *Vitis caribaea*) and 'Paulsen 1103' (*Vitis berlandieri* x *Vitis rupestris*).

The research was conducted during the 2020 and 2021 crop seasons at an experimental vineyard in São Manuel, São Paulo, Brazil (22°46'35''S and 48°34'08''W; at an altitude of 773 m). Red Latosol soil was identified in the experimental region (EMBRAPA, 2018). The Köppen classification classifies the climate as *Cfa*, which means subtropical with hot summers.

Between July and December of the experiment, the minimum average temperature was 16.4°C in 2020 and 15.9°C in 2021, while the maximum average temperature was 28.8°C in 2020 and 27.7°C in 2021. The cumulative rainfall in this timeframe was 477 mm in 2020 and 593 mm in 2021, with a tendency for precipitation to be concentrated in the summer months (Figure 1). During the ripening of the grapes, the minimum average temperature was 17.1°C in 2020 and 17.9°C in 2021 and the maximum average temperature was 29.8°C in 2020 and 29.3°C in 2021. The cumulative rainfall in this period in 2020 was 106.6 mm and in 2021 it was 288.2 mm (Figure 2).

The rootstock cuttings were planted in August 2018, and the scion grafting was completed in July 2019. The row spacing was 3.0 m and the vine spacing was 2.0 m (density of 1,667 vines per hectare). Vines were trained in an Open Gable or Y training system, with a me-

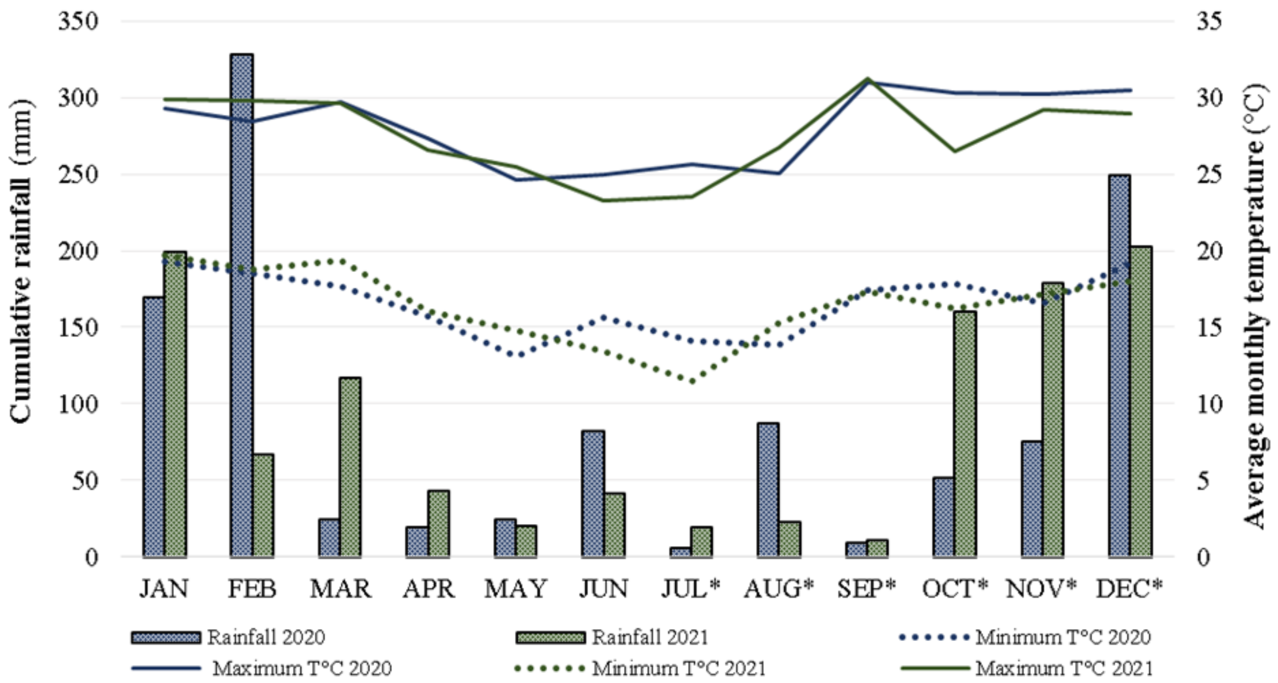

Figure 1. Meteorological data (temperature and cumulative rainfall) from the experimental site in 2020 and 2021. São Manuel, State of São Paulo, Brazil. *Productive period. The bars represent the total amount of rain, while the lines represent the minimum and maximum temperatures.

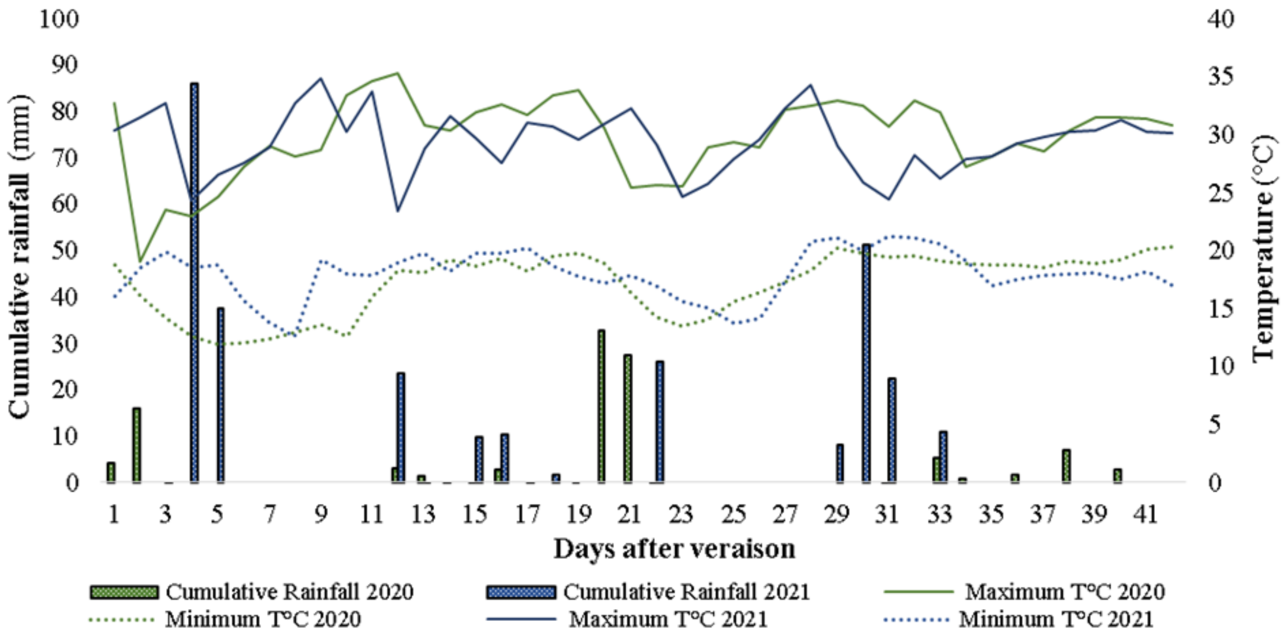

Figure 2. Meteorological data (temperature and cumulative rainfall) from the experimental site during the ripening of 'BRS Vitória' grape in 2020 and 2021. São Manuel, State of São Paulo, Brazil.

tallic framework. Micro sprinklers were implemented for the watering system. A polyethylene screen with 18% shading was installed for bird and hail protection. Phytosanitary control, fertilization, plant regulators, pruning, defoliation, secondary shoot removal, shoot trimming, and bunch thining were all carried out in line with the recommendations provided by Maia et al. (2016).

On July 22 and August 5, respectively, winter pruning for the 2020 and 2021 seasons was accomplished where one or two buds per spur were retained and 2.5% hydrogen cyanamide was applied after pruning to promote and standardize budburst. After budburst, the bud load was standardized with about 60 branches per vine.

The main phenological stages of the vines, that is, pruning to budburst, full-bloom, setting, veraison, and harvest date (full maturartion) were all quantified (Figure 3) using the criteria suggested by Coombe (1995). Visual observations were done thrice a week to assess the length of each phenological stage in days after pruning (DAP).

The grape harvest dates were chosen when the berries reached roughly 19°Brix, as recommended by Maia et al (2012). However, when the berries did not achieve 19° Brix, the harvest date of the grapes was calculated according to the maturation curve, that is, when the content of soluble solids and titratable acidity stabilized in the interval between two samplings. Samplings were conducted up to 42 days following veraison since the berries began to exhibit signs of decay after this time.

To assess the heat demand in degree-days (DD), the total of the pruning to harvest dates was computed using the following Winkler (1965) equation: DD = Σ (average temperature- 10° C) × days after pruning.

Grape maturity curves were developed based on the progression of the grapes' titratable acidity (TA), soluble solids (SS), pH, and maturation index (SS/TA). For this aim, 10 bunches per experimental plot were randomly selected and analyzed during veraison, that is, when the berries began to change color. Berries were harvested from selected bunches and assessed every 7 days following veraison, i.e. at 0, 7, 14, 21, 28, 35,

Figure 3. Characterization of phenological stages: budburst (A), full-bloom (B), setting (C), veraison (D) and harvest (E) of the 'BRS Vitória' grapevine.

and 42 days (coinciding, respectively, with 99, 106, 113, 120, 127, 135 and 142 DAP, and at 102, 109, 116, 123, 130, 137 and 144 DAP, of the 2020 and 2021 seasons).

TA was obtained by titrating with 0.1 N NaOH to the pH = 8.2 equivalence point (results expressed as percentage of tartaric acid). The SS was calculated using direct refractometry of grape must in a digital refractometer (Reichert®, model r2i300, USA), and the findings were represented in °Brix. The pH was evaluated using a Tecnal® potentiometer, model r2i300.

Statistical analyses were carried out over two production seasons (2020 and 2021). To identify the impacts of rootstocks, all data were treated to analysis of variance. The Tukey test (5% probability) was used to compare averages for phenology and thermal demands, and a regression analysis was used to examine the impact of rootstocks on the chemical development of the grapes during ripening, using the SISVAR® statistical software, version 5.6. (Lavras, MG, Brazil).

Results and discussion

The rootstocks had a significant influence ($p < 0,05$) on the duration of the assessed phenological phases in both production seasons (Table 1).

In general, 'Paulsen 1103' had a late behaviour effect in the early phenological stages, that is, from pruning to budburst, full-bloom, and setting, when compared to the following rootstocks 'IAC 572' and 'IAC 766'. The intervals from pruning to budburst were around 15 to 21 days in both production seasons. The vines were in full bloom between 40 and 48 DAP, while the setting was between 44 and 57 DAP (Table 1).

In terms of veraison, there was no significant difference between the assessed rootstocks in the first season, with an average of 98.4 DAP between treatments. In the second production cycle, however, vines grafted on 'IAC 572' (102.8 DAP) emerged at veraison substantially later than those grafted on 'IAC 766' (99.4 DAP) and 'Paulsen 1103' (98.8 DAP) (Table 1).

In terms of the production cycle, that is, the duration from pruning to harvest date of 'BRS Vitória', 'Paulsen 1103' induced an early precocity of 7 days in the first season when compared to 'IAC 572', with values of 131.1 and 138.4 DAP, respectively. In the second season, vines grafted on 'Paulsen 1103' (132.0 DAP) were 7 and 11 days sooner than vines growing on 'IAC 766' (139.4 DAP) and 'IAC 572' (143.4 DAP), respectively (Table 1).

Table 1. Phenological stages (DAP) and thermal demands (DD) of 'BRS Vitória' grapevine grafted on 'IAC 572 Jales', 'IAC 766 Campinas' and 'Paulsen 1103' rootstocks in two production seasons.

Phenological stages and thermal demands	Seasons	Rootstocks			
		IAC 572 Jales	IAC 766 Campinas	Paulsen 1103	*p*-value
Budburst	I	17.33 ± 1.80 b	18.69 ± 2.27 b	21.09 ± 1.25 a	< 0.01
	II	15.42 ± 1.02 b	16.00 ± 1.02 b	17.42 ± 0.52 a	< 0.01
Full-bloom	I	45.27 ± 1.22 c	47.07 ± 0.49 b	48.66 ± 0.73 a	< 0.01
	II	40.00 ± 1.00 b	41.14 ± 1.07 ab	42.57 ± 0.98 a	< 0.01
Setting	I	50.00 ± 0.82 c	52.85 ± 1.03 b	57.00 ± 1.30 a	< 0.01
	II	44.28 ± 0.76 b	45.14 ± 1.07 b	46.57 ± 0.76 a	< 0.01
Veraison	I	99.89 ± 1.41	97.85 ± 1.37	97.71 ± 0.76	0.16
	II	102.85 ± 1.34 a	99.42 ± 0.67 b	98.85 ± 1.01 b	< 0.01
Harvest	I	138.42 ± 3.40 a	134.00 ± 3.78 ab	131.14 ± 2.75 b	< 0.01
	II	143.42 ± 0.98 a	139.42 ± 6.60 a	132.00 + 3.42 b	< 0.01
Full cycle demands	I	1,651.4 ± 50.53 a	1,588.0 ± 54.45 ab	1,545.7 ± 28.51 b	< 0.01
	II	1,725.7 ± 12.2 a	1,662.7 ± 80.2 a	1,572.8 ± 41.7 b	< 0.01

Mean ± standard deviation (n = 7) is used to express the data. On the same line, values preceded by the same letter were similar by Tukey test.

Alvarenga et al. (2002) also reported that 'Paulsen 1103' afforded the grape 'Niagara Rosada' more precocity than 'IAC 572' and 'IAC 766'. Rootstocks' effect may be connected to their vigour, nutrient storage, and water uptake for vine photosynthesis, which helps in the absorption of stocks required for nutrition (BARROS et al., 2015). However, it is vital to note that rootstock effect is directly tied to scion genotype and adaptability to soil and climatic conditions.

Few investigations have been conducted on the duration of the phenological phases of the vine 'BRS Vitória' under subtropical environments. According to Maia et al. (2016), the cycle duration varies from 130 to 135 days in the Northwest of São Paulo, the North of Minas Gerais, and the North of Paraná. Borges et al. (2017) discovered that the 'BRS Vitória' cycle lasted 130 days in the summer crop in a *Cfa* climate, the same as in the current study. As a result, comparable values were discovered in the current investigation, with variations depending on rootstock and production cycle (Table 1).

In comparison to other studies that evaluated the duration of the phenological stages of other table grape cultivars in a subtropical climate, the duration of the pruning cycle at the harvest date of 'BRS Vitória' verified in this study was slightly earlier than 'BRS Ísis' (AHMED et al., 2019) and 'Niagara Rosada' (CALLILI et al., 2022).

With regard to thermal demand, Maia et al. (2012) stated that the vines' thermal demand to complete the cycle is 1,511 DD. Borges et al. (2017) reported that the thermal demand in the summer crop and in subtropical circumstances was 1,679 DD. The thermal demand 1,545.7 to 1,651.4 DD in the first season and from 1,572.8 to 1,725.7 DD in the second season in the current study (Table 1). According to Silva et al. (2008), the duration of the phenological phases of the vines might vary depending on the scion genotype and climatic circumstances in each location, or even within the same region, owing to seasonal climatic fluctuations throughout the year.

All in all, it should be recognized that phenology information is critical in the planning of vineyard operations, as well as in the forecast of harvest dates and marketing. As a result, evaluating elements that might affect vine phenology, such as rootstocks, is critical for Brazilian viticulture.

According to the Figure 4, the chemical changes that occurred during berry maturity followed the predicted pattern, with a rise in SS, pH, and maturation index and a decrease in TA, and quadratic regression models were fitted for all assessments and treatments.

According to Maia et al. (2012), the 'BRS Vitória' grape should be harvested when the berries reach at least 19° Brix, a point when there is an excellent balance of sugar and acidity, bestowing a very distinguishable raspberry taste without astringency in the bark. Figure 4b shows that the berries of the vines grafted on 'Paulsen 1103' and 'IAC 766' reached 19°Brix about 30 days after veraison in the first season, and the highest attained from these treatments was around 21°Brix. Berries on vines planted on rootstock 'IAC 572', on the other hand, attained 19° Brix just 42 days after veraison.

Only the berries of the vines planted on 'Paulsen 1103' achieved 19° Brix in the second season, whereas the maximum SS content reached by the rootstock 'IAC 766' was 17.8° Brix and by the 'IAC 572' was 16.3° Brix (Figure 4b). Lower quantities of SS were possibly found in the berries of vines grafted on 'IAC 572' in both seasons due to the higher robustness that this rootstock imparts to the vines (ALVARENGA et al., 2002; MOTA et al., 2009). Excessive vegetative vigour can create a microclimate with high humidity and low radiation, producing more shadowing to the bunches and preventing the buildup of soluble solids in the berries. Several studies have found that the vegetative and reproductive balance of rootstocks to vines has a signif-

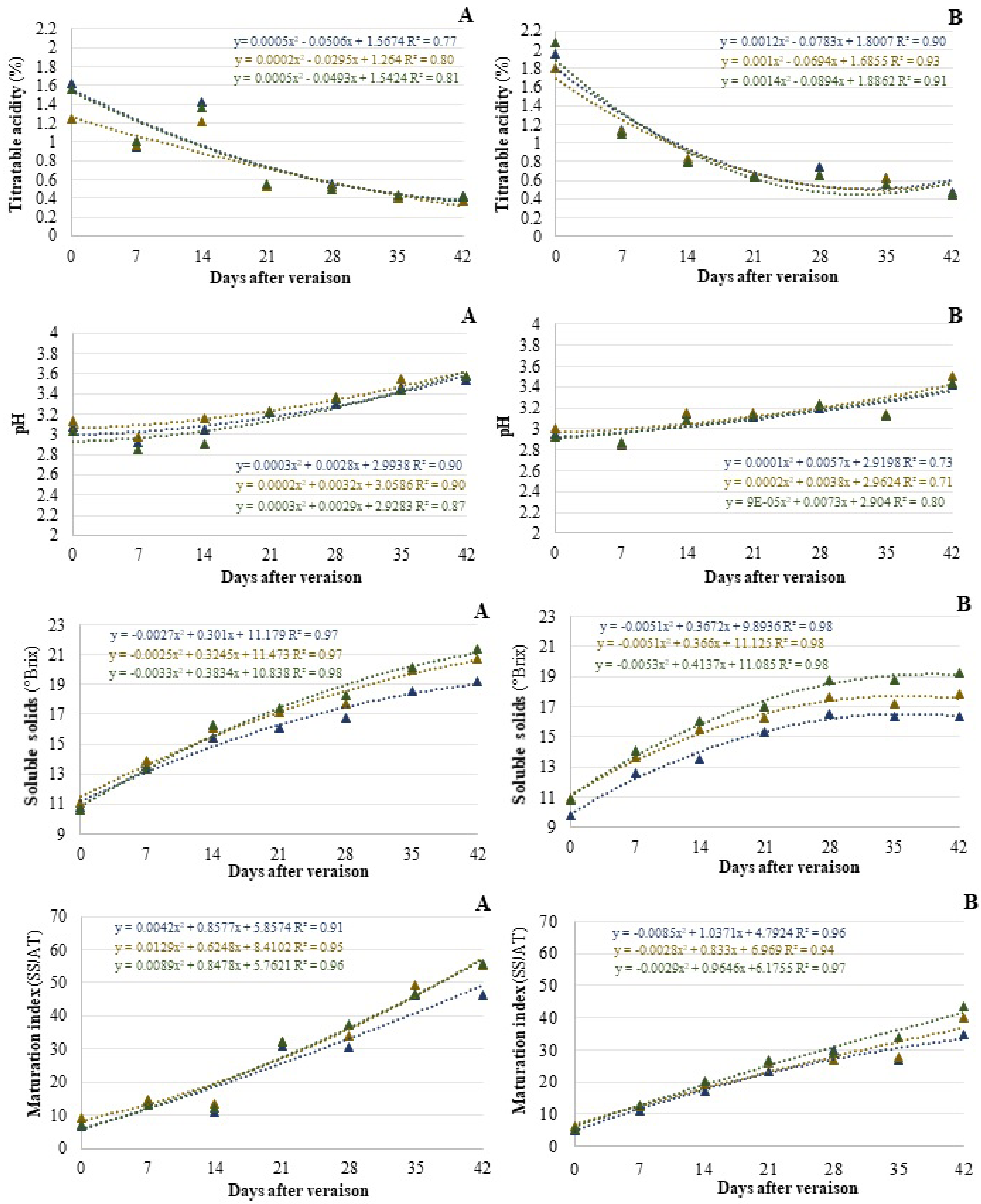

Figure 4. Development of titratable acidity, pH, soluble solids and maturation index during the ripening of 'BRS Vitória' grape grown in 2020 (A) and 2021 (B). The rootstocks 'IAC 572', 'IAC 766' and 'Paulsen 1103' are represented by the colors blue, gold and green, respectively.

icant impact on grape quality (SATISHA et al., 2010; BRIGHENTI et al., 2011; JIN et al., 2016). According to Bascunán-Godoy et al. (2017), rootstocks may have a direct influence on the scion's photosynthetic activity; additionally, they have different capacities for absorption and translocation of water and nutrients (MARTÍNEZ-BALLESTA et al., 2010), which can affect the chemical composition of the grapes.

In studies conducted using 'Niagara Rosada' in Cwb climate, Alvarenga et al. (2002) and Mota et al. (2009) showed that 'IAC 572' gave a lower concentration of SS than 'Paulsen 1103' and 'IAC 766'. In contrast, Leão et al. (2020b) reported no significant difference in the accumulation of soluble solids in the 'BRS Vitória' grape among 'IAC 572', 'IAC 766', and 'Paulsen 1103' in semi-arid climatic conditions. As well as Leão et al. (2019), who found that these rootstocks had no effect on the chemical quality of the 'BRS Clara' grape, demonstrating that the affinity and interaction between rootstocks and scion is specific (TECCHIO et al., 2022). and may differ based on the cultivation site's soil and climatic conditions (VRŠIČ et al., 2015).

Another significant finding was that, independent of rootstock, the berries in the first season had greater levels of SS, higher pH, and lower acidity than in the second season (Figure 4), demonstrating the effect of climate fluctuations at each harvest. Leão et al. (2020a) argue that seasonal climate fluctuations have a greater impact on vine agronomic traits than rootstocks.

The grape matures during the sunniest time of year, when the temperature rises, causing a higher concentration of sugars and a decrease in acidity owing to the breakdown of organic acids (SANTANA et al., 2008). Furthermore, excessive precipitation during the ripening phase lowers the quantities of soluble carbohydrates in the fruit (MANDELLI et al., 2008). Due to the larger precipitation during berry maturation, especially in the time leading up to harvest date, roughly 30 days following veraison, there was a lesser buildup of SS in 2021 compared to 2020 (Figure 2). However, it is underlined that the berries met the minimal requirement needed by international marketing regulations, which vary from 14 to 17.5ºBrix for table grapes depending on cultivar and growing circumstances.

In the current study, greater maturity index values were detected in the berries of vines grafted on 'Paulsen 1103' and 'IAC 766' in both seasons (Figure 4). The SS/TA ratio provides a more accurate assessment of the fruits than separate measurements of sugars or acidity and a high value is desirable for the domestic market, which should be equivalent to or more than 20 for table grapes (BLEINROTH, 1993). According to Maia et al. (2012), the grape is best for eating when the SS/TA ratio is between 20 and 30 in cv. BRS Vitória. It was found that vines grafted on 'Paulsen 1103' and 'IAC 766' reached this range earlier than vines grafted on 'IAC 572' rootstock in both cycles. In this case, it is critical to emphasize that the precocity provided by these rootstocks promotes various benefits to the grape grower, including agility in product sale and a reduction in the risk of fruit loss in the field.

Conclusions

The rootstocks altered the duration of the phenological phases of 'BRS Vitória,' with the rootstock 'Paulsen 1103' providing the vines with more precocity.

The cycle from pruning to harvest date for cv. BRS Vitória was 131 to 143 days in subtropical conditions, with thermal demands ranging from 1,545 to 1,725 DD.

'Paulsen 1103' induced berries with greater soluble solids content and good balance between SS/TA earlier in both seasons. 'IAC 572', on the other hand, was the rootstock that promoted lower soluble solids content and a longer delay in berry maturation.

Acknowledgment

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

References

AGRIANUAL. **Anuário da agricultura brasileira**. São Paulo: Informa Economics FNF, 2020. 480p.

AHMED, S.; ROBERTO, S.R.; SHAHAB, M.; COLOMBO, R.C.; SILVESTRE, J.P.; KOYAMA, R.; SOUZA, R.T. Proposal of double-cropping system for 'BRS Isis' seedless grape grown in subtropical area. **Scientia Horticulturae**, New York, v.251, p.118-26, 2019.

ALLEBRANDT, R.; MARCON FILHO, J.L.; BEM, B.P.; WÜRZ, D.A.; BRIGHENTI, A.F.; KRETZSCHMAR, A.A.; RUFATO, L. Fenologia da variedade Merlot produzida sobre três porta-enxertos em elevadas altitudes de Santa Catarina. **Revista Brasileira de Viticultura e Enologia**, Bento Gonçalves, n.7, p.36-43, 2015.

ALVARENGA, A.A.; REGINA, M.A.; FRÁGUAS, J.S.; CHALFUN, N.N.; SILVA, A.L. Influência de porta-enxerto sobre o crescimento e produção da cultivar de videira 'Niagara Rosada' (*Vitis labrusca* L. x *Vitis vinifera* L.) em condições de solo ácido. **Ciência e Agrotecnologia**, Lavras, p.1459-64, 2002. Edição especial**.**

BARROS, L.B.; MARGOTI, G.; FOWLER, J.G.; MIO, L.L.M.; BIASI, L.A. Thermal requirement and phenology of different cultivars of *Vitis labrusca* on different rootstocks. **Semina: Ciências Agrárias**, Londrina, v.36, n.4, p.2433-42, 2015.

BASCUNÁN-GODOY, L.; FRANCK, N.; ZAMORANO, D.; SANHUEZA, C.; CARVAJAL, D.E.; IBACACHE, A. Rootstock effect on irrigated grapevine yield under arid climateconditions are explained by changes in traits related to light absorption of the scion. **Scientia Horticulturae**, New York, v.218, p.284-92, 2017.

BLEINROTH, E.W. Determinação do ponto de colheita. *In*: GORGATTI NETO, A.; GAYET, J.P.; BLEINROTH, E.W.; MATTALO, M.; GARCIA, E.; GARCIA, A.E.; ARDITO, E.F.G; BORDIN, M. **Uva para exportação**: procedimentos de colheita e pós-colheita. Brasília, DF: EMBRAPASPI/FRUPEX, 1993. p.20-21 (Publicações Técnicas FRUPEX, 2).

BORGES, W.F.S.; KOYAMA, R.; SILVA, G.B.; SHAHAB, M.; SOUZA, R. T.; ROBERTO, S.R. Phenological characterization and thermal demand of 'BRS Vitoria' seedless grape grown in subtropical área. **Agronomy Science and Biotechnology**, Londrina, v.3, n.1, p.25-8, 2017.

BRIGHENTI, A.F.; RUFATO, L.; KRETZCHMAR, A.A.; SCHLEMPER, C. Desempenho vitivinícola da Cabernet Sauvignon sobre diferentes porta-enxertos em região de altitude de Santa Catarina. **Revista Brasileira de Fruticultura**, Jaboticabal, v.33, n.1, p.96-102, 2011.

CALLILI, D.; SILVA, M.J.R.; SANCHEZ, C.A.P.C.; WATANABE, C.Y.; MACEDO, B.M.P.; DOMINGUES NETO, F.J.; TEIXEIRA, L.A.J.; TECCHIO, M.A. Rootstock and potassium fertilization, in terms of phenology, thermal demand and chemical evolution, of berries on Niagara Rosada grapevine under subtropical conditions. **Bragantia**, Campinas, v.81, p.e2022, 2022.

COOMBE, B.G. Growth Stages of the Grapevine: Adoption of a system for identifying grapevine growth stages. **Australian Journal of Grape and Wine Research**, Adelaide, v.1, p.104-10, 1995.

EMBRAPA. **Sistema brasileiro de classificação de solos**. Rio de Janeiro: Centro Nacional de Pesquisa de Solos, 2018. p.353.

JIN, Z.X.; SUN, T.Y.; SUN, H.; YUE, Q.Y.; YAO, Y.X. Modifications of 'Summer Black' grape berry quality as affected by the different rootstocks. **Scientia Horticulturae**, New York, v.210, p.130-7, 2016.

LEÃO, P.C.S.; LIRA, M.M.C.; MORAES, D.S.; SILVA, E.R. Rootstocks for table grape BRS Clara in the São Francisco Valley, Northeast Brazil. **Acta Horticulturae**, Leuven, n.1248, p.381-5, 2019.

LEÃO, P.C.S.; NASCIMENTO, J.H.B.; MORAES, D.S.; SOUZA, E.R. Yield components of the new seedless table grape 'BRS Ísis' as affected by the rootstock under semi-arid tropical conditions. **Scientia Horticulturae**, New York, v.263, n.109114, 2020a.

LEÃO, P.C.S.; NASCIMENTO, J.H.B.; MORAES, D.S.; SOUZA, E.R. Rootstocks for the new seedless table grape 'BRS Vitória' under tropical semi-arid conditions of São Francisco Valley. **Ciência e Agrotecnologia**, Lavras, v.44, p.e025119, 2020b.

LEÃO, P.C.S.; SILVA, D.J. Cultivo da videira no semiárido nordestino. *In*: PIO, R. (org.). **Cultivo de fruteiras clima temperado em regiões subtropicais e tropicais**. 2.ed. Lavras: UFLA, 2018. p.587-625.

MAIA, J.D.G.; RITSCHEL, P.S.; CAMARGO, U.A.; SOUZA, R.T.; FAJARDO, T.V.M.; NAVES, R.L.; GIRARDI, C.L. '**BRS Vitória'**: nova cultivar de uva de mesa sem sementes com sabor especial e tolerante ao míldio. Bento Gonçalves: Embrapa Uva e Vinho, 2012. 12p. (Comunicado Técnico, 126).

MAIA, J.D.G.; RITSCHEL, P.S.; LAZZAROTTO, J.J. A viticultura de mesa no Brasil: produção para o mercado nacional e internacional. **Territoires du Vin**, Dijon, v.9, p.1-9, 2018.

MAIA, J.D.G.; RITSCHEL, P.S.; SOUZA, R.T.; GARRIDO, L.R. **'BRS Vitória' - uva para mesa, sem sementes, de sabor especial e tolerante ao míldio**: recomendações agronômicas para a região de Campinas, São Paulo. Bento Gonçalves: Embrapa Uva e Vinho, 2016. 28p. (Comunicado Técnico, 129).

MANDELLI, F.; MIELE, A.; RIZZON, L.A.; ZANUS, M.C. Efeito da poda verde na composição físico-química do mosto da uva Merlot. **Revista Brasileira de Fruticultura**, Jaboticabal, v.30, n.3, p.667-74, 2008.

MARTÍNEZ-BALLESTA, M.C.; ALCARAZ-LÓPEZ, C.; MURIES, B.; MOTA-CADENAS, C.; CARVAJAL, M. Physiological aspects of rootstock-scion interactions. **Scientia Horticulturae**, New York, v.127, p.112-8, 2010.

MELLO, L.M.R.; MACHADO, C.A.E. **Vitivinicultura brasileira**: panorama 2020. Bento Gonçalves: Embrapa Uva e Vinho, 2021. 18p. (Comunicado Técnico, 223).

MIELE, A. Rootstock-scion interaction: 6. Phenology, chilling and heat requirements of Cabernet Sauvignon grapevine. **Revista Brasileira de Fruticultura**, Jaboticabal, v.41, n.6, p. e-446, 2019.

MOTA, R.V.; SOUZA, C.R.; FAVERO, A.C.; SILVA, C.P.C.; CARMO, E.L.; FONSECA; A.R.; REGINA, M.A. Produtividade e composição físico-química de bagas de cultivares de uva em distintos porta-enxertos. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v.44, n.6, p.576-82, 2009.

SANTANA, M.T.A.; SIQUEIRA, H.H.; LACERDA, R.J.; LIMA, L.C.O. Caracterização físico-química e enzimática de uva 'patrícia' cultivada na região de Primavera do Leste - MT. **Ciência e Agrotecnologia**, Lavras, v.32, n.1, p.186-90, 2008.

SATISHA, J.; SOMKUWAR, K.G.; SHARMA, J.; UPADHYAY, A.K.; ADSULE, P.G. Influence of rootstocks on growth yield and fruit composition of Thompson seedless grapes grown in the Pune region of India. **South African Journal of Enology and Viticulture**, Stellenbosch, v.31, n.1, 2010.

SATO, A.J.; JUBILEU, B.S.; SANTOS, C.E.; BERTOLUCCI, R.; SANTOS, R.; CARIELO, M.; GUIRAUD, M.C.; FONSECA, I.C.B.; ROBERTO, S.R. Fenologia e demanda térmica das videiras Isabel e Rubea sobre diferentes porta-enxertos na região norte do Paraná. **Semina: Ciências Agrárias**, Londrina, v.29, n.2, p.283-92, 2008.

SILVA, F.C.C.; VIANA, A.P.; SILVA, M.G.O.; OLIVEIRA, J.G.; GOMES FILHO, A. Caracterização química e determinação dos estádios fenológicos de variedade de videiras cultivadas no norte fluminense. **Revista Brasileira de Fruticultura**, Jaboticabal, v.30, n.1, p.38-42, 2008.

SILVA, M.J.R.; PAIVA, A.P.M.; PIMENTEL JUNIOR, A.; SÁNCHEZ, C.A.P.C.; CALLILI, D.; MOURA, M.F.; LEONEL, S.; TECCHIO, M.A. Yield performance of new juice grape varieties grafted onto different rootstocks under tropical conditions. **Scientia Horticulture**, New York, v.241, p.194-200, 2018.

TECCHIO, M.A.; HERNANDES, J.L.; PAIOLI-PIRES, E.J.; TERRA, M.M.; MOURA, M.F. Cultivo da videira para mesa, vinho e suco. *In*: PIO, R. (org.). **Cultivo de fruteiras clima temperado em regiões subtropicais e tropicais**. 2.ed. Lavras: UFLA, 2018, p.512-84.

TECCHIO, M.A.; MOURA, M.F.; PAIOLI-PIRES, E.J.; TERRA, M.M. Efeito do porta-enxerto e da época de poda na duração das fases fenológicas e no acúmulo de graus-dia pela videira 'Niagara Rosada'. **Revista Brasileira de Fruticultura**, Jaboticabal, v.35, n.4, p.1073-80, 2013.

TECCHIO, M.A.; SILVA, M.J.R.; PAIVA, A.P.M.; MOURA, M.F.; TERRA, M.M.; PAIOLI-PIRES, E.J.; SARITA, L. Phenological, physicochemical, and productive characteristics of 'Vênus' grapevine onto rootstocks. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v.54, p.e00335, 2019a.

TECCHIO, M.A.; SILVA, M.J.R.; CALLILI, D.; HERNANDES, J.L.; MOURA, M.F. Yield of white and red grapes, in terms of quality, from hybrids and Vitis labrusca grafted on different rootstocks. **Scientia Horticulturae**, New York, v.259, n.108846, 2020.

TECCHIO, M.A.; SILVA, M.J.R.; SANCHEZ, C.A.P.C.; CALLILI, D., VEDOATO, B.T.F.; HERNANDES, J.L.; MOURA, M.F. Yield performance and quality of wine grapes (*Vitis vinifera*) grafted onto different rootstocks under subtropical conditions. **Bragantia**, Campinas, v.81, p.e1622, 2022.

VRŠIČ, S.; PULKO, B.; KOCSIS, L. Factors influencing grafting success and compatibility of grape rootstocks. **Scientia Horticulturae**, New York, v. 181, p.168-73, 2015.

WINKLER, A.J. **Viticultura**. México: Compañia Editorial Continental, 1965. 792p.