Preliminary Results on Agronomic Behavior of Table Grapes on Different Rootstocks in Brazilian Cerrado Conditions

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Summary

Studies are necessary to understand the productive behavior of grape cultivars on different rootstocks, in regions where their cultivation is potentially favorable. Thus, the objective of this work was to evaluate the influence of the combination of canopy x rootstocks on production, fruit quality, thermal requirement and maturation curve of table grape cultivars, in brazilian Cerrado conditions. A randomized block design was adopted, with five repetitions. The studied combinations were composed by the rootstocks IAC 766 'Campinas' and IAC 572 'Jales' under the cultivars 'BRS Vitória', 'BRS Núbia', 'BRS Isis' and 'Niágara rosada'. Each cultivar was evaluated in isolation according to the two rootstocks. The cultivar 'BRS Vitória' showed higher productivity on the rootstock IAC 766 and greater development of bunches and berries on the IAC 572. This cultivar presented a thermal requirement of 1419 Degrees-Day from pruning until harvest. The 'BRS Núbia' cultivar showed higher productivity on the IAC 572 rootstock. The thermal requirement for 'BRS Núbia' to complete its cycle was 1725 Degrees-Day. The cultivar "BRS Isis" on the rootstock IAC 572 showed higher values of productivity, yield and number of bunches per plant. The IAC 766 'BRS Isis' rootstock showed a thermal requirement of 1958 Degrees-Day. For IAC 572, 2079 Degrees-Day were required. The rootstocks evaluated did not influence the productive and physical-chemical characteristics of the cultivar 'Niágara rosada', the thermal requirement was 1622 Degrees-Day, for both rootstocks.

Key words

Vitis ssp., tropical viticulture, evolution of maturation, degrees-day

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Introduction

Viticulture has stood out in Brazil as an important activity for small producers, providing its sustainability, associated with rural tourism. Being an important source of jobs and enterprises, aimed both at the production of table grapes and for processing (Tecchio et al., 2014a). Wine production is an activity highly influenced by the climate, which is important in defining the potential of the regions (Martins et al., 2017). When it is desired to grow grapes in regions where their cultivation is little known, it is necessary to carry out agronomic studies to know the productive behavior of the chosen cultivars, in addition to their behavior on the rootstocks used in the region (Sato et al., 2009).

In most producing regions, vines are propagated by grafting a canopy cultivar onto a rootstock (Miele et al., 2009; Borges et al., 2014). Among the characteristics that can be affected by the rootstock, we highlight the resistance to pests and soil diseases, productivity, berry size and chemical composition of the fruit, such as sugar content, organic acids and anthocyanins (Sabbatini and Howell, 2013). Rootstocks can also increase the vigor of their roots, in addition to reducing the predisposition to infection by pathogens that affect the root system (Pedro Júnior et al., 2011). Among the various existing rootstocks, the IAC 766 'Campinas' (Riparia do Traviú x *Vitis tiliifolia* Humb. & Bonpl. ex Roem. & Schult.) and the IAC 572 'Jales' (*V. tiliifolia* x 101-14 Mgt) stand out, which are known to bring greater productivity to cultivars crown grafted onto them (Pommer and Maia, 2003).

Between 2012 and 2013, the Genetic Improvement Program for Vine, maintained by Embrapa Uva e Vinho, launched three new table grape cultivars, two apyrenic and one with seeds. 'BRS Vitória' is a black table grape cultivar, without seeds, showing excellent agronomic behavior, high bud fertility and tolerance to downy mildew, the main disease of the vine in Brazil. 'BRS Isis' is a seedless red table grape, also tolerant to mildew, presenting high yields, naturally large fruits and uniform color, in the absence of chemical treatments. BRS Nubia is a table grape with seed, black in color and neutral in flavor. It presents high yield and presents large fruits (24 × 34 mm) with crunchy pulp. These cultivars have wide climatic adaptation, high productive potential, high quality fruits and less management requirements (Ritschel et al., 2015).

The grape cultivar 'Niágara rosada' has medium vigor and medium resistance to fungal diseases and its characteristics of color, aroma and flavor please most consumers. The area cultivated with 'Niágara rosada' had a great expansion in the state of São Paulo, even in the 1930s, giving rise to table viticulture in Brazil. The lower susceptibility to fungal diseases, the ease of handling and the low cost of production in relation to fine grapes enable better income for the producer (Hernandes and Pedro Júnior, 2015). It is the reason why its planting has been expanding to several traditional regions in the cultivation of the vine. It has also been the main alternative in places where viticulture has been introduced, such as the States of Rio de Janeiro, Goiás and Mato Grosso do Sul (Maia and Camargo, 2012a).

The knowledge of an evolution model of the grape's maturation and of the relationship between the development of the vine and the climatic conditions, is an important tool for the viticulturists to know better the cultivars with which they wish to work. This knowledge can be used to: improve the management of agricultural practices, harvest scheduling, regionalization of crops, in addition to forecasting the quality of the fruits of a harvest (Boliani and Pereira, 1996; Sato et al., 2009; Denega et al., 2010).

Knowing the physical characteristics, related to yield, and chemicals, which define the flavor and suitability for fresh or processed grape markets, for particular growing conditions, allows to highlight attributes that may be specific to a region (Ribeiro et al., 2012). Therefore, the objective of this work was to evaluate the influence of rootstocks on yield, on the physical-chemical characteristics and on the evolution of maturation in table grape cultivars, grown in brazilian Cerrado conditions.

Materials and Methods

The experiment was carried out in the experimental area of the School of Agronomy, Federal University of Goiás (16° 35' S, 49° 16' O and altitude of 725m), Goiânia, Goiás, Brazil. The regional climate, according to the Köppen-Geiger classification, is Aw type (Tropical with dry season in winter) (Alvares et al., 2013; Cardoso et al., 2014). The soil was classified as a Latossolo Vermelho distrófico (Santos et al., 2013) (Oxisol). Climatic records were obtained during the conduct of the experiment from a climatic station located 270 m from the test site (Fig. 1).

The vineyard was planted in a 2.0 x 2.5 m spacing between plants and between lines, respectively, in the trellis type conduction system, with a micro sprinkler irrigation system, using emitters with a flow of 55 L h^{-1}, spaced 2.5 m, with 100% wet area. The grafting, of the "fork" type in the field, was performed on August 29, 2016, of the canopy cultivars: 'BRS Vitória', 'BRS Núbia', 'BRS Isis' and 'Niágara rosada' on the rootstocks IAC 766 Campinas and IAC 572 Jales.

Before carrying out the production pruning, soil sampling was carried out in the 0 - 0.20 m deep layer, with the objective of recommending fertilization. The chemical and physical analysis of the soil, presented the following values: pH ($CaCl_2$) = 5,9; organic matter = 10 g kg^{-1}; P Mehlich = 6 mg dm^{-3}; Al = 0.0 cmolc dm^{-3}; H + Al = 1,5 cmolc dm^{-3}; K = 0,35 cmolc dm^{-3}; Ca = 3,4 cmolc dm^{-3}; Mg = 1,5 cmolc dm^{-3}; cation exchange capacity = 6,75 cmolc dm^{-3}; base saturation = 78%; clay = 310 g kg^{-1}; silt = 180 g kg^{-1} and sand = 51 g kg^{-1}.

The first production pruning was carried out on May 22, 2017, leaving 5 to 8 buds per offshoot, with subsequent application of 6% hydrogenated cyanamide (Dormex®) in the last three buds of each stick. The fertilization consisted of the application of 60 g $plant^{-1}$ of P_2O_5 (Yoorim Master®) ten days before pruning, in furrows distant 50 cm from the plant stem. Fifteen days after pruning, 20 g $plant^{-1}$ Nitrogen (ammonium sulfate) was applied without incorporation.

To evaluate the effect of the canopy x rootstock combination, a randomized block design was used, with two treatments, in five replications, each replication being a plant. IAC 766 'Campinas' and IAC 572 'Jales' rootstocks were studied under the crowns 'BRS Vitória', 'BRS Núbia', 'BRS Isis' and 'Niágara rosada'. Each canopy cultivar was considered an assay, due to the particular characteristics of each cultivar.

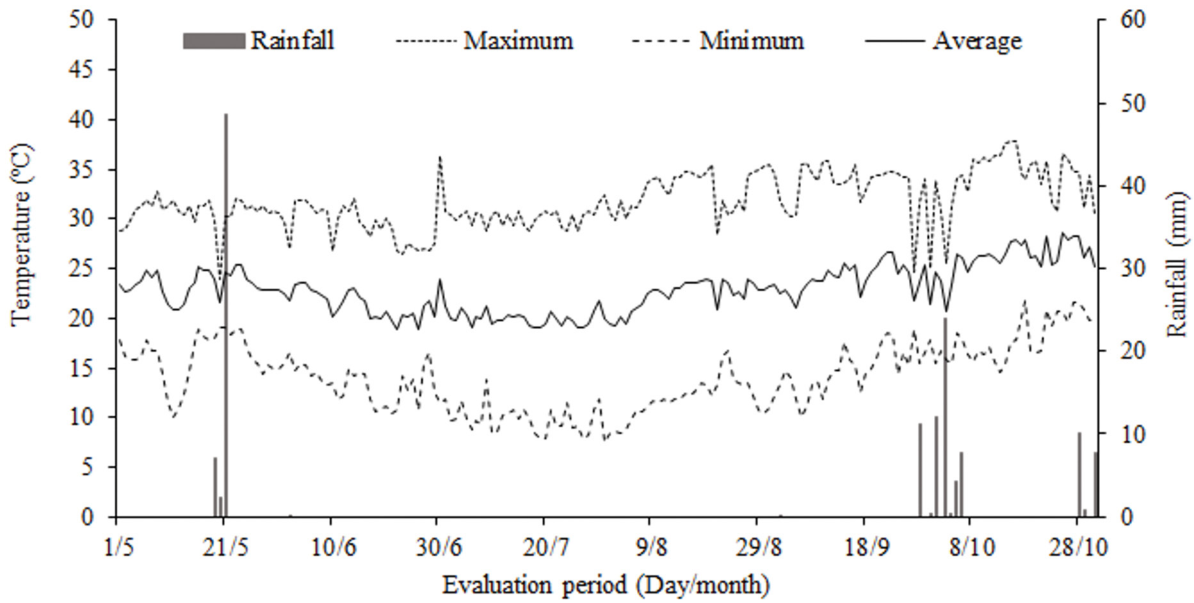

Figure 1. Rainfall, maximum, minimum and average temperature, during the period of conduction of the experiment, from May to October 2017.

The maturation evolution was monitored by sampling eighteen berries per plot, weekly, from the beginning of maturation. Six berries were collected per bunch (two in each portion: basal, median and apical of the bunch), in three plants per cultivar, for purposes of chemical analysis performed in triplicate. The must was obtained through manual pressing of the berries, and evaluated in each sample: the content of soluble solids (SS), expressed in ºBrix, by means of a portable optical refractometer with a scale of 0-32 ºBrix; pH by bench pot; titratable acidity (TA), determined by neutralization titration, by titrating 5 g of pulp and diluted in 95 ml of distilled water, with a standardized solution of NaOH at 1 mol L^{-1} N and turning point at pH between 8.1 to 8.2 (AOAC, 2012), the result being expressed in g of tartaric acid 100 mL^{-1} of juice. The maturation index was obtained by the ratio between soluble solids and titratable acidity (SS/TA) (AOAC, 2012).

At harvest, all bunches of five plants from each cultivar were counted (bunches $plant^{-1}$) and weighed and the value obtained divided by the number of plants, thus determining the average yield per plant (kg $plant^{-1}$). To estimate productivity (t ha^{-1}), the average yield per plant was multiplied by the number of plants per hectare. In a sample of five bunches per plant (repetition), the bunch weight (g) was determined by weighing on an analytical scale of 0.5 g precision and the bunches length and diameter (cm), with the aid of a graduated ruler. Six berries were removed from three bunches, totaling eighteen berries per parcel, to determine the mass (g), length (mm) and berry diameter (mm), the mass obtained by weighing on an analytical scale of 0.01 g of precision, and the dimensions with the aid of a digital caliper. With the values of these variables, the values of the length/diameter ratio of the berry were obtained.

To characterize the thermal requirements of each cultivar, the sum of Degrees-Day from pruning to harvest was used. The minimum and maximum temperature data were collected in an automatic meteorological station, and the calculation of the daily thermal accumulation was determined using the Degree-Day method, according to the equations proposed by Villa Nova et al. (1972) (Equations 1 and 2):

$$DD = \left(\frac{Tmax - Tmin}{2}\right) + (Tmin - Tb) \qquad \text{When Tmin > Tb} \qquad \text{Eq. 1}$$

$$DD = (Tmax - Tb)^2 / 2(Tmax - Tmin) \qquad \text{When Tmin} \leq \text{Tb} \qquad \text{Eq. 2}$$

where: DD is Degrees-Day; Tmax is the maximum temperature of the day; Tmin is the minimum temperature of the day; Tb is the base temperature of the crop, in this case 10ºC, considered for the entire vegetative cycle (Neis et al., 2010; Maia et al., 2014; Radünz et al., 2015; Abreu et al., 2016).

The data were subjected to analysis of variance and the mean values, compared by the Tukey's HSD test at 5% significance level, to compare the two rootstocks. For data on the evolution of maturation, analysis of variance and polynomial regression analysis were performed as a function of the number of Degrees-Day after the beginning of maturation.

Results and Discussion

'BRS Vitória'

It was observed, for the cultivar 'BRS Vitória', that there was an increase in the number of bunches per plant, when it was grafted on IAC 766, while the length and diameter of bunch and berry diameter were favored by grafting on IAC 572 (Table 1). The differences found are explained mainly by the formation of the plants, which was more adequate on IAC 766 rootstock, giving a greater number of productive branches in the first cycle. In addition, the smaller number of bunches per plant in the IAC 572 rootstock favored the greater development of these and of the berries.

Table 1. Average values and standard deviation for variables related to yield and physicochemical characteristics of the bunches of the 'BRS Vitória' grape cultivar, grafted on two rootstocks

Variables	IAC 766	IAC 572	F	CV
	Average ± SD	Average ± SD		
Yield (kg plant^{-1})	0.713 ±0.37	0.499 ± 0.19	ns	44.10
Productivity (t ha^{-1})	1.43 ±0.739	0.99 ± 0.383	ns	46.00
Bunches plant^{-1}	4.00 ±1.00	1.00 ± 0.00	**	28.28
Bunch weight (g)	170.81 ±47.46	170.0 ± 16.26	ns	20.25
Bunch length (cm)	11.25 ±1.4	13.00 ± 0.50	**	16.58
Bunch diameter (cm)	7.47 ±1.5	7.88 ± 1.40	**	24.79
Berry weight (g)	2.37 ±0.11	3.73 ± 1.11	ns	25.92
Berry diameter (BD) (mm)	14.31 ±0.31	16.27 ± 1.04	*	4.91
Berry height (BH) (mm)	18.61 ±0.20	20.47 ± 1.45	ns	5.37
BD/BH	0.77 ±0.02	0.80 ± 0.01	ns	0.00
Soluble solids (SS) (ºBrix)	20.00 ±0.89	19.00 ± 0.29	ns	3.23
pH	3.51 ±0.09	3.64 ± 0.02	ns	2.28
Titratable acidity (TA)[1]	0.62 ±0.10	0.58 ± 0.05	ns	14.00
Maturation index (SS/TA)	33.00 ±3.96	34.00 ± 3.38	ns	10.95

Note: SD = standard deviation; ns = non-significant; ** significant ($P < 0.01$); *significant ($P < 0.05$). CV = coefficient of variation. [1](g of tartaric acid 100 mL^{-1})

In general, the formation of productive branches after grafting was not satisfactory in both rootstocks, which resulted in a low productivity of 1,43 t ha^{-1} and 997 kg ha^{-1} of grapes, for IAC 766 rootstocks and IAC 572, respectively (Table 1). In the region of Petrolina – Pernanbuco, Brazil, Leão and Lima (2016) obtained 18.7 t ha^{-1} already in the first yield cycle. According to Maia et al. (2014) the productivity of this cultivar can exceed 30 t ha^{-1}, but in regions where it is possible to obtain two annual crops, it is recommended to adjust the productivity to 16 to 24 t ha^{-1} cycle^{-1}, in order to obtain a quality product.

The 'BRS Vitória' cultivar had a 119-day cycle and a thermal requirement of 1419 Degrees-Day from pruning to harvest, for both rootstocks evaluated (Fig. 2). According to Maia et al. (2014) the average thermal sum estimated for 'BRS Vitória' is 1511 Degrees-Day of pruning to harvest. Leão and Lima (2016) evaluated four production cycles of the 'BRS Vitória' cultivar in Petrolina-PE, from pruning to harvest, and observed a variation in the cycle from 95 to 114 days, depending on the harvest date predicted by the viticulturist, which classified as an early cultivar. In the North of Minas Gerais the cycle varies from 100 to 110 days, in the Northwest of the State of São Paulo the cycle is from 110 to 125 days, in the central regions of the State of São Paulo and in the North of Paraná State, the cycle lasts around 130 to 135 days (Maia et al., 2012b; 2014).

The beginning of maturation of the 'BRS Vitória' cultivar began at 91 days after pruning (1043 Degrees-Day) and the evolution of maturation was adjusted for second degree equations, however there was no difference between rootstocks (Fig. 2A, 2B and 2D). At harvest time, 119 days after pruning, for the soluble solids (SS) content, an average of 20 and 19 ºBrix were recorded, respectively, for rootstock IAC 766 and IAC 572 (Table 1). The minimum content of soluble solids for table grapes can vary from 14.0 to 17.5 ºBrix, according to international marketing standards. Leão and Lima (2016) observed that the levels of soluble solids in the ripe grapes of this cultivar vary between 19 and 22.5 °Brix. 'BRS Vitória' has high glucometric potential, reaching up to 23 °Brix (Maia et al., 2016).

There was interaction for titratable acidity between rootstocks as a function of the Degree-Day, in the evolution of maturation (Fig. 2C). The IAC 766 rootstock showed lower values of acidity in the first and second evaluation (1043 and 1137 Degrees-Day), from the third evaluation on the acidity values did not show significant difference. According to Leão and Lima (2016) for the cultivar 'BRS Vitória', the titratable acidity (TA) of the berries must be in the range between 0.6 and 0.8 g of tartaric acid 100 mL^{-1} at the time of harvest. In the experimental conditions, 0.52 and 0.68 g of tartaric acid 100 mL^{-1} were found, respectively, for rootstock IAC 766 and IAC 572 (Table 1).

The SS/TA ratio provides a good evaluation of fruits, being more representative than the isolated measurement of sugars or acidity and must be equal to or greater than 20 for table grapes (Bleinroth, 1993). In the experimental conditions, a high SS/TA ratio of 33 and 34 was observed for rootstock IAC 766 and IAC 572, respectively (Table 1) with linear growth throughout maturation (Fig. 2D), which means a high potential for acceptability by consumers (Maia et al., 2012b).

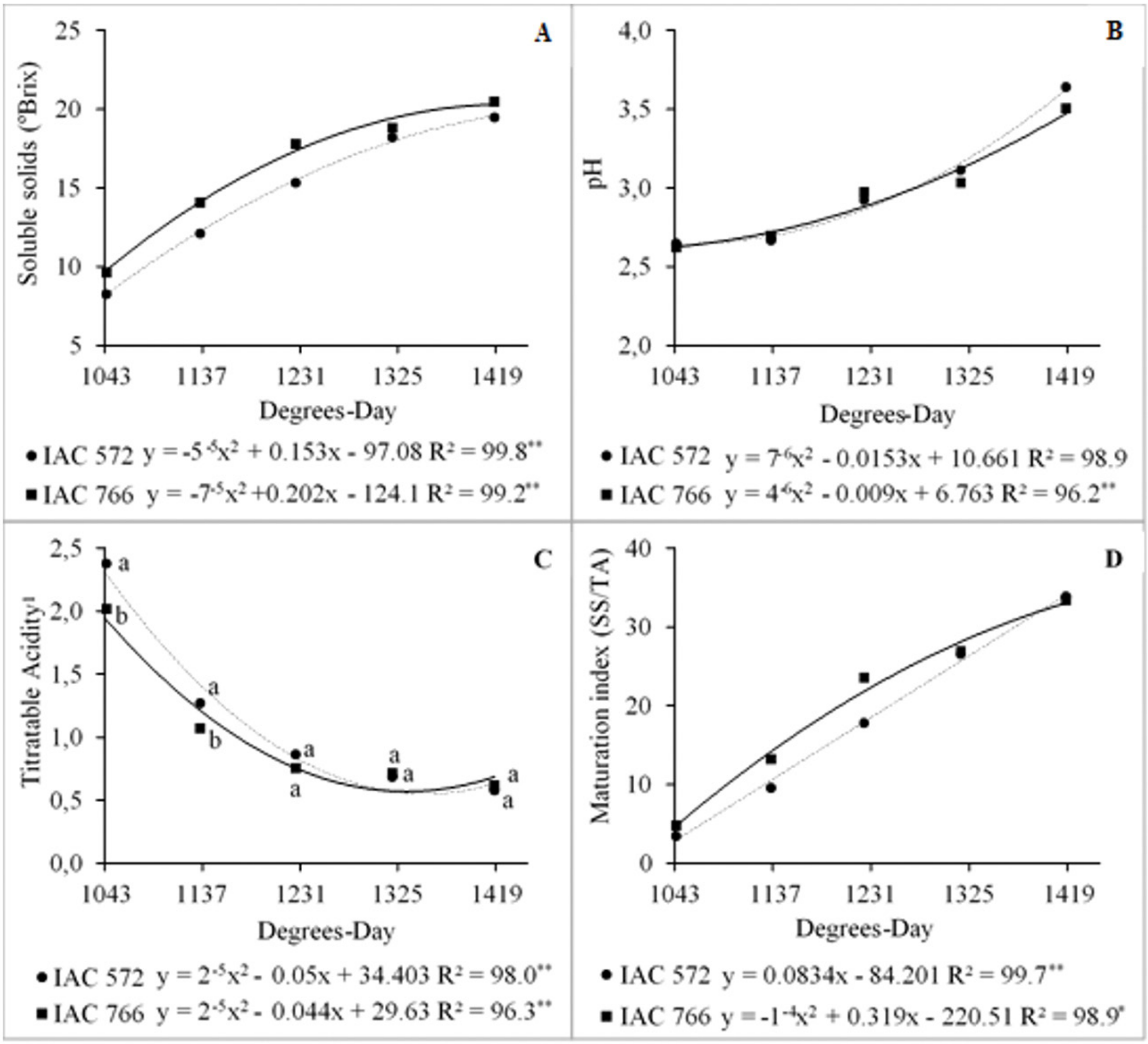

Figure 2. Relationship between physical-chemical characteristics and degree-days accumulated from the beginning of maturation for the 'BRS Vitória' grape cultivar, grafted on two rootstocks

Note: values marked with the same letter within the same Degrees-Day evaluation are not significantly different according to Tukey's HSD test ($P < 0.05$). [1](g of tartaric acid 100 mL^{-1})

'BRS Núbia'

For the cultivar 'BRS Núbia', yield averages, productivity, number of bunches per plant and berry mass were significantly higher for the IAC 572 rootstock (Table 2). This rootstock provided good vigor in the development of plants after grafting, which favored the formation of productive branches. A different result was found by Moraes et al. (2017) evaluating this cultivar under five rootstocks, in Petrolina-PE, in the second production cycle, in which there were no significant differences for the variables of productivity and quality of the grape.

According to Ritschel et al. (2015) the average mass of bunches, from 'BRS Núbia', is 450 g, which allows yields around 30 t ha^{-1}. However, under experimental conditions, the average bunch mass was 320 g and 274 g, the productivity of 1.36 t ha^{-1} and 0.76 t ha^{-1} of grapes, for rootstocks IAC 766 and IAC 572, respectively (Table 2). Moraes et al. (2017) also observed low productivity of 7.6 t ha^{-1} in Petrolina-PE, in the second production cycle. According to the authors, the low results obtained are possibly due to failures in the management of the plants, which led to problems such as the occurrence of pests and poor development and vigor of the plants. Rego et al. (2015) evaluated the 'BRS Núbia' during the fourth and fifth production cycles, in the Middle of the São Francisco Valley, and observed an average yield per plant of 14.21 and 17.76 kg, respectively, which corresponded to estimated yields of 27.0 and 33.8 t ha^{-1} in each harvest.

The thermal requirement for 'BRS Núbia' to complete its cycle was 1725 Degrees-Day, for both rootstocks evaluated (Fig. 3), a value higher than that estimated by Maia et al. (2013) of 1500 Degrees-Day. The production cycle, from pruning to harvest, was 140 days. According to Maia et al. (2013) 'BRS Núbia' is a cultivar with a medium production cycle (from budding to the end of maturation), whose duration can vary from 115 days, in regions of tropical climate in the semiarid Vale do São Francisco, up to 135 days, in regions subtropical and northern Paraná.

Table 2. Average values and standard deviation for variables related to yield and physicochemical characteristics of the bunches of the 'BRS Núbia' grape cultivar, grafted on two rootstocks

Variables	IAC 766	IAC 572	F	CV
	Average ± SD	Average ± SD		
Yield (kg plant^{-1})	0,679 ±0,56	3,80 ±2,02	*	64,25
Productivity (t ha^{-1})	1.36 ±1.12	7.59 ±4.04	*	65,11
Bunches plant^{-1}	2,00 ±0,82	13,20 ±6,14	**	56,82
Bunch weight (g)	320 ±145,09	274,00 ±67,61	ns	36,58
Bunch length (cm)	15,90 ±6,80	10,60 ±5,90	ns	50,35
Bunch diameter (cm)	9,70 ±5,90	7,00 ±1,30	ns	20,29
Berry weight (g)	7,17 ±0,74	9,34 ±1,03	*	11,07
Berry diameter (BD) (mm)	23,14 ±0,96	24,34 ±3,40	ns	11,83
Berry height (BH) (mm)	28,20 ±1,21	28,48 ±1,56	ns	4,50
BD/BH	0,82 ±0.02	0,86 ±0,15	ns	14,12
Soluble solids (SS) (°Brix)	18,00 ±1,41	18,31 ±0,48	ns	5,96
pH	3,02 ±0.06	3,04 ±0.05	ns	1,90
Titratable acidity (TA)[1]	0,51±0.01	0,52 ±0.04	ns	7,90
Maturation index (SS/TA)	35,07 ±2,40	35,27 ±3,95	ns	9,38

Note: SD = standard deviation; ns = non-significant; ** significant ($P < 0.01$); *significant ($P < 0.05$). CV = coefficient of variation. [1](g of tartaric acid 100 mL^{-1})

There was a difference of seven days between the beginning of maturation for rootstocks, where IAC 572 started at 105 days after pruning (1225 Degrees-Day) and IAC 766 at 112 days (1325 Degrees-Day) but completed the cycle at the same time (Fig. 3). The evolution of maturation was adjusted for second degree equations (Fig. 3), however there was no interaction with the rootstocks. At harvest time, for the soluble solids (SS) content, an average of 18 °Brix was registered for both rootstocks IAC 766 and IAC 572 (Table 2). The SS/TA parameter showed a different behavior among the rootstocks, with the evolution of the maturation of the berries. For IAC 572 there was a linear adjustment, while for IAC 766 the equation adjustment was quadratic (Fig. 3), and at the end of the evaluations both reached an average of 35, considered a high value (Table 2). In the São Francisco Valley Submediate, the average content of soluble solids in the berries of this cultivar varies from 17° Brix to 19° Brix, while the titratable acidity is about 0.60 g to 0.80 g of tartaric acid/100 mL, which therefore, it can reach an average for SS/TA of 26 (Leão and Lima, 2017).

'BRS Isis'

The variables related to productivity showed a significant difference, between rootstocks, for the cultivar 'BRS Isis'. The IAC 572 rootstock provided higher values of productivity (18,92 t ha^{-1}), yield (9,46 kg plant^{-1}) and number of bunches per plant (35,8) (Table 3). For these plants, better crown formation was observed, compared to plants under IAC 766, which provided a greater number of productive branches and, consequently, greater yield. As it is a vigorous cultivar, with exuberant vegetative development during formation, 'BRS Isis' has strong apical dominance, therefore requiring adequate management for the formation of plants, it has as a characteristic high bud fertility, presenting 2 to 3 bunches per branch, enabling an average productivity of 26 t ha^{-1} (Ritschel et al., 2013).

In the experimental conditions was found, 19.27 and 19.42 °Brix, 0.39 and 0.36 g of tartaric acid 100 mL^{-1}, respectively, for rootstock IAC 766 and IAC 572 (Table 3). These values are in agreement with those reported by Ritschel et al. (2015). According to these authors, the sugar content of 'BRS Isis' can reach from 16 to 21 °Brix, depending on the climatic condition during the maturation phase, presenting low acidity of 0.34 to 0.55 g of tartaric acid 100 mL^{-1}, resulting in a ratio between SS/TA from 38 to 47. Under experimental conditions, values of 49.94 and 53.89 were observed for the ratio between SS/TA, respectively, for rootstock IAC 766 and IAC 572 (Table 3). The soluble solids content and SS/TA ratio were adjusted for linear equations (Fig. 4A and 4D), while the titratable acidity was adjusted for quadratic equations, for the two rootstocks (Fig. 4C). The pH values showed a significant difference between the rootstocks (Table 3). In Fig. 4B, it is possible to observe the relative pH variation, and it is not possible to adjust polynomial equations until the second order, which would reflect the behavior similar to that of titratable acidity, in an inverse way.

The maturation of the bunches of the cultivar 'BRS Isis' was different among the rootstocks (Fig. 4).

Table 3. Average values and standard deviation for variables related to yield and physicochemical characteristics of the bunches of the 'BRS Isis' grape cultivar, grafted on two rootstocks

Variables	IAC 766	IAC 572	F	CV
	Average ± SD	Average ± SD		
Yield (kg plant^{-1})	3.04 ±1.53	9.46 ±1.86	**	27.25
Productivity (t ha^{-1})	6.08 ±3.05	18.92 ±3.73	**	27.24
Bunches plant^{-1}	11.40 ±5.37	35.8 ±10.03	**	34.10
Bunch weight (g)	264.05 ±65.58	269.90 ±40.28	ns	20.38
Bunch length (cm)	17.00 ±2.80	18.40 ±3.10	ns	16.49
Bunch diameter (cm)	9.30 ±0.90	9.90 ±1.50	ns	12.71
Berry weight (g)	4.59 ±0.56	5.56 ±0.55	ns	10.96
Berry diameter (BD) (mm)	17.25 ±0.28	18.08 ±0.47	ns	2.17
Berry height (BH) (mm)	24.41 ±0.64	26.32 ±1.21	ns	3.82
BD/BH	0.71 ±0.01	0.69 ±0.02	ns	2.42
Soluble solids (SS) (°Brix)	19.27 ±0.67	19.42 ±0.37	ns	2.78
pH	3.67 ±0.06	2.92 ±0.19	**	4.31
Titratable acidity (TA)[1]	0.39 ±0.02	0.36 ±0.03	ns	6.95
Maturation index (SS/TA)	49.94 ±2.77	53.89 ±4.72	ns	7.45

Note: SD = standard deviation; ns = non-significant; ** significant ($P < 0.01$); *significant ($P < 0.05$). CV = coefficient of variation. [1](g of tartaric acid 100 mL^{-1})

From pruning to maturation in IAC 766, the thermal requirement was 1958 Degrees-Day, a cycle of 154 days. For IAC 572, 2078 Degrees-Day were required, 161 days after pruning, values higher than those reported by Ritschel et al. (2013). It was observed that for plants grafted on IAC 572 there was greater canopy vigor, consequently, the bunches received less incidence of sunlight, which may have favored the delay in maturation (Drissi et al., 2009). According to Ritschel et al. (2013) 'BRS Isis' is a late-cycle cultivar (from budding to the end of maturation), whose duration can vary between 116 and 126 days, in regions of semi-arid tropical climate (Vale do Submédio São Francisco), up to 135 and 145 days, in regions of humid tropical climate (northwest of São Paulo). The thermal requirement of 'BRS Isis' estimated in Curaçá-Bahia and Jales-São Paulo, from pruning at the end of maturation was 1800 Degrees-Day and from budding to the end of maturation it was 1675 Degrees-Day.

'Niágara rosada'

The two rootstocks evaluated did not significantly influence the productive and physical-chemical characteristics of the 'Niágara rosada' grape (Table 4). High values of the variation coefficient are noted for the variables of production, productivity and number of bunches per plant. This is due to the uneven shape of the canopy in the IAC 766 rootstock. Less vigor and deficient formation of the definitive branches were also observed, these plants presented on average two bunches per plant, while the plants on the IAC 572 rootstock showed nine bunches per plant (Table 4).

Tecchio et al. (2014b) evaluating the 'Niágara rosada' grafted on various rootstocks, in the trellis conduction system, found that IAC 572 provided greater productivity and dry matter mass from the bunches and favored greater extraction of nutrients from the soil. According to Hartmann and Kester (1990), the most vigorous rootstocks have greater nutrient absorption and translocation capacity, which contribute to greater canopy development. Pimentel Junior (2017) observed different results in a 'Niágara rosada' vine, in the spreader and bilateral conduction system, where the IAC 766 rootstock anticipated the phenological stages, increased the number of branches per plant, as well as increased the yield and productivity. The thermal requirement for the cultivar 'Niágara rosada' to complete its cycle was 1622 Degrees-Day, with a productive cycle of pruning until a harvest of 133 days, for both rootstocks evaluated (Fig. 5). Bruna and Back (2015) reported 1430 Degrees-Day, from the beginning of sprouting to harvest, for 'Niágara rosada', cultivated in the south of Santa Catarina, in which there were also no significant differences for the different rootstocks studied. Quadratic regression models were adjusted for the content of soluble solids in the IAC 572 rootstock (Fig. 5A) and for pH and titratable acidity in the two rootstocks (Fig. 5B and 5C). For the content of soluble solids, in the IAC 766 rootstock (Fig. 5A), and the SS/TA ratio (Fig. 5D), a positive linear behavior was observed for both rootstocks. There was an interaction between the number of Degrees-Day and the rootstocks, for the variable titratable acidity, where IAC 572 was inferior to IAC 766 in the second evaluation (1420 Degrees-Day), whereas in the other evaluations there was no there was a significant difference (Fig. 5C).

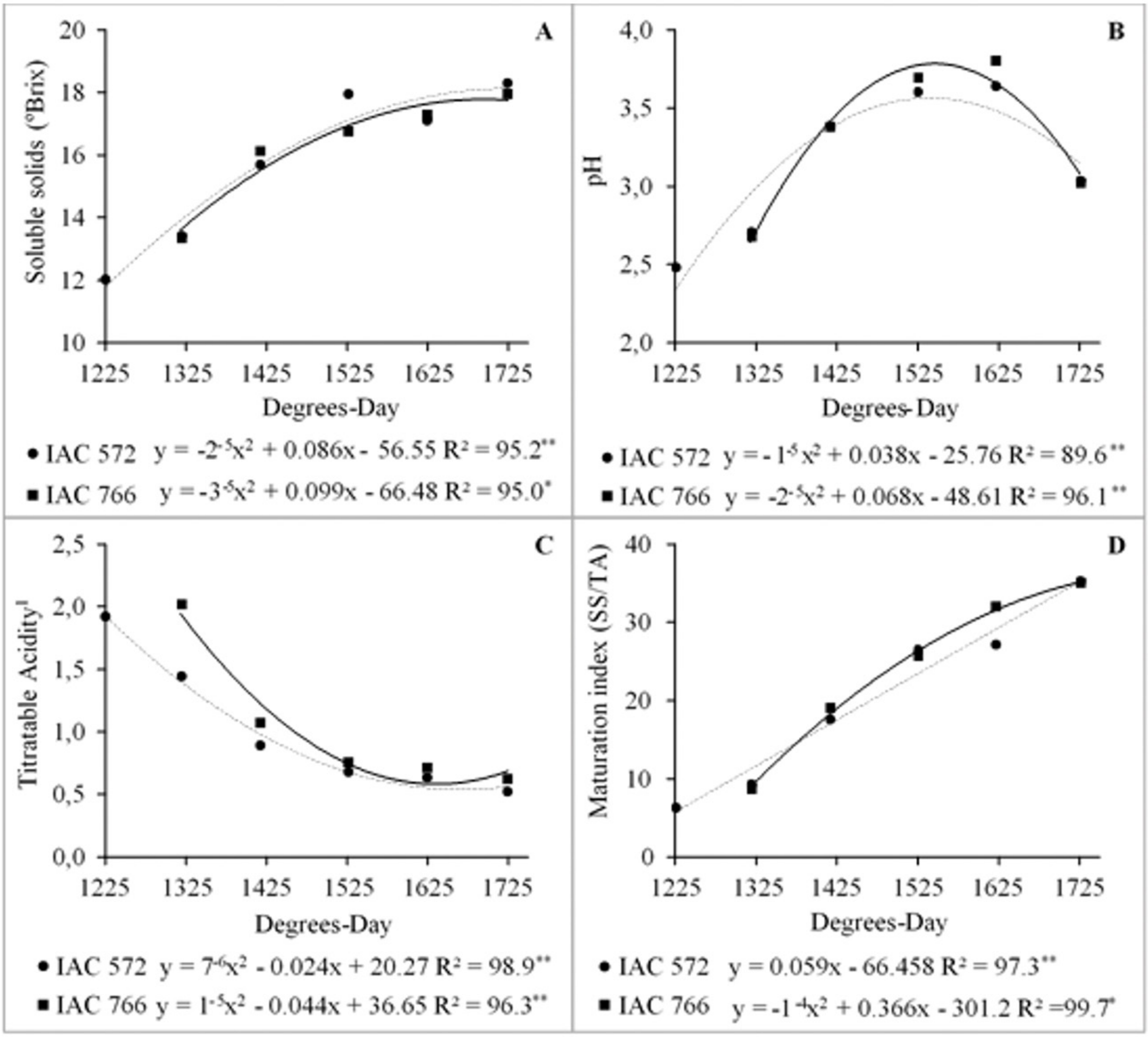

Figure 3. Relationship between physical-chemical characteristics and degree-days accumulated from the beginning of maturation for the 'BRS Núbia' grape cultivar, grafted on two rootstocks

Note: values marked with the same letter within the same Degrees-Day evaluation are not significantly different according to Tukey's HSD test ($P < 0.05$). [1](g of tartaric acid 100 mL^{-1})

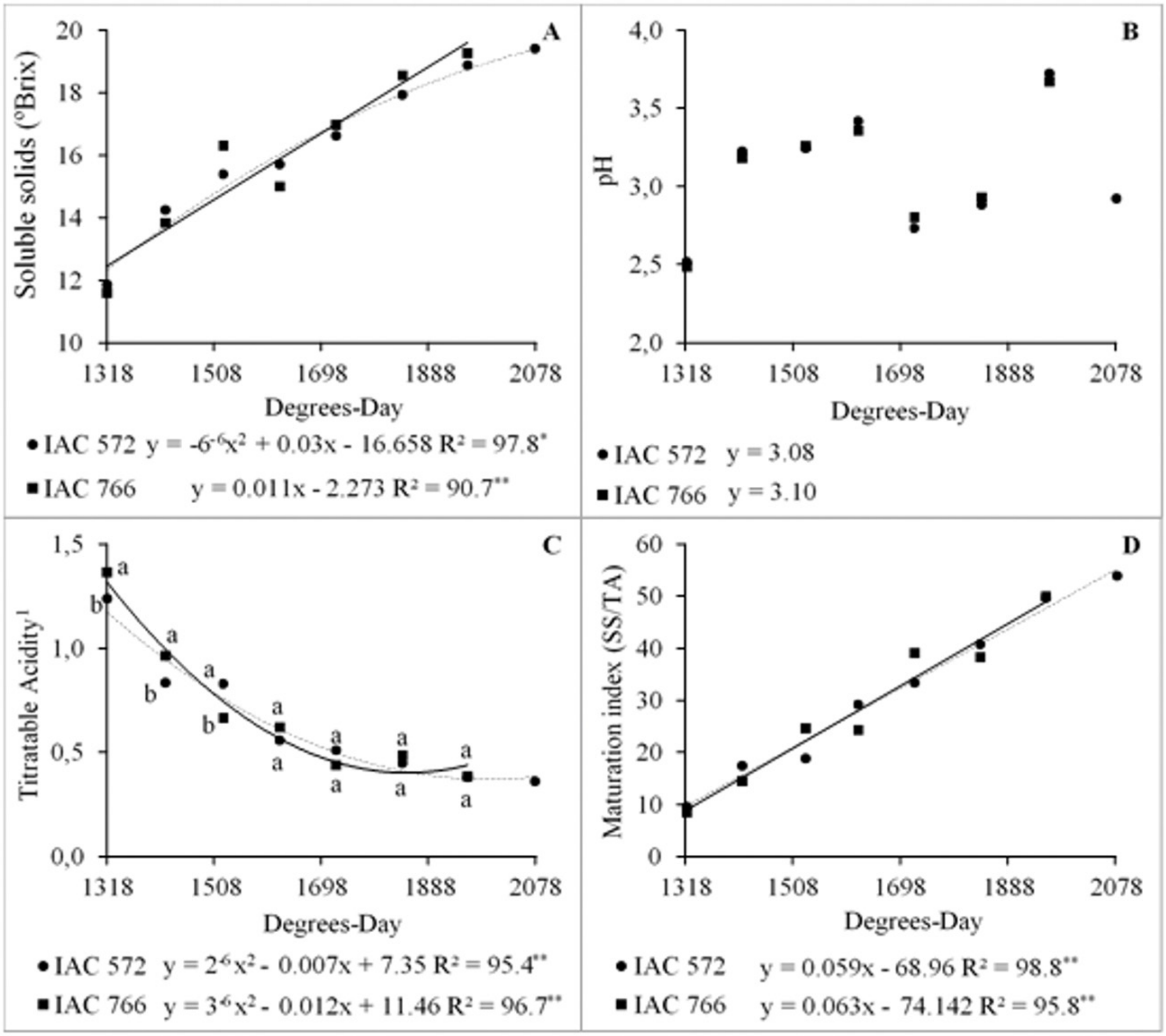

Figure 4. Relationship between physical-chemical characteristics and degree-days accumulated from the beginning of maturation for the 'BRS Isis' grape cultivar, grafted on two rootstocks

Note: values marked with the same letter within the same Degrees-Day evaluation are not significantly different according to Tukey's HSD test ($P < 0.05$). [1](g of tartaric acid 100 mL^{-1})

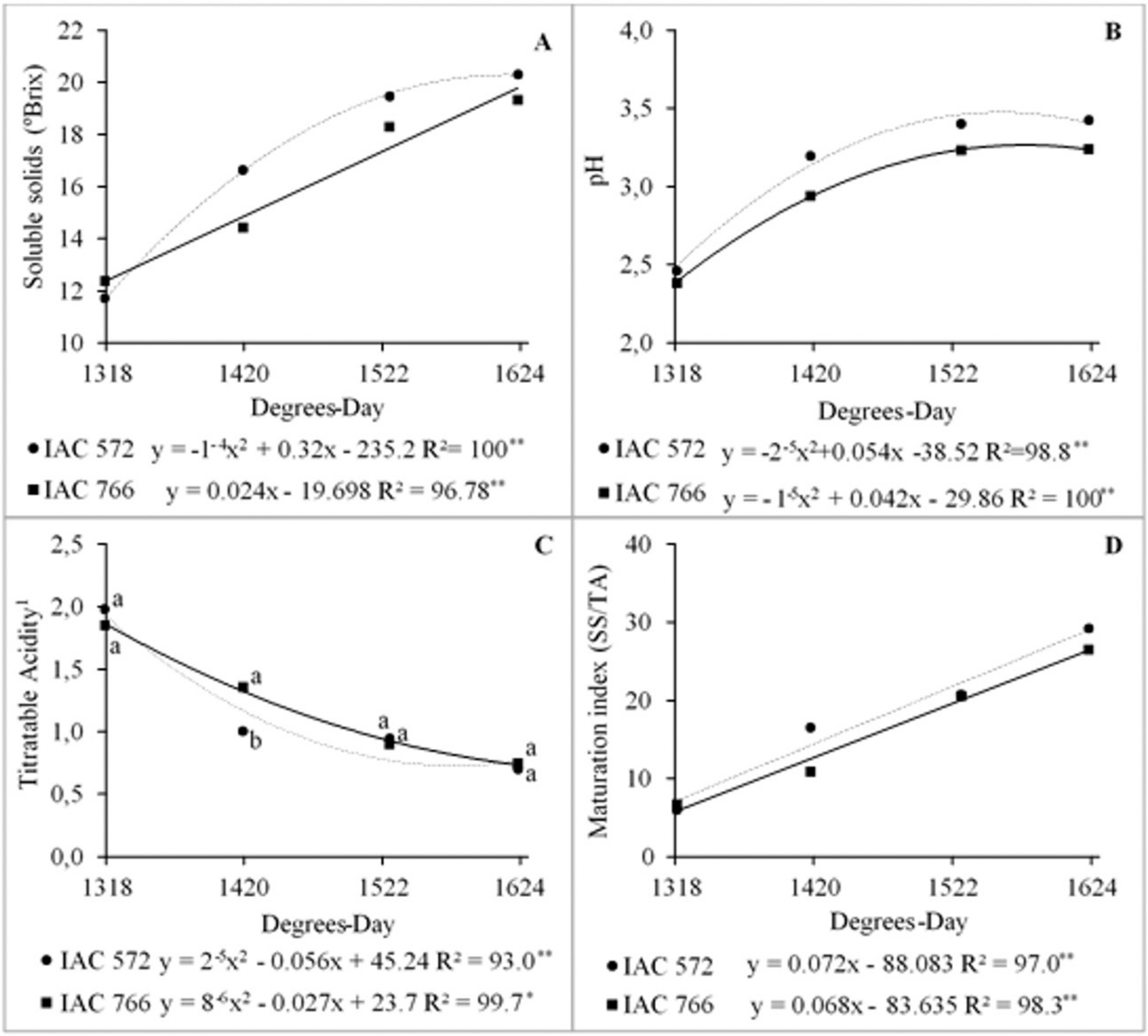

Figure 5. Relationship between physical-chemical characteristics and degree-days accumulated from the beginning of maturation for the 'Niágara rosada' grape cultivar, grafted on two rootstocks

Note: values marked with the same letter within the same Degrees-Day evaluation are not significantly different according to Tukey's HSD test ($P < 0.05$). [1](g of tartaric acid 100 mL^{-1})

Table 4. Average values and standard deviation for variables related to yield and physicochemical characteristics of the bunches of the 'Niágara rosada' grape cultivar, grafted on two rootstocks

Variables	IAC 766	IAC 572	F	CV
	Average ± SD	Average ± SD		
Yield (kg plant^{-1})	0.290 ±0.16	0.910 ±1.09	ns	126.42
Productivity (t ha^{-1})	0.58 ±0.32	1.82 ±2.18	ns	123.41
Bunches plant^{-1}	2.40 ±1.14	9.00 ±9.54	ns	114.58
Bunch weight (g)	118.08 ±35.86	94.97 ±49.68	ns	37.46
Bunch length (cm)	12.30 ±2.00	12.7 ±1.40	ns	14.29
Bunch diameter (cm)	6.50 ±0.70	7.5 ±1.50	ns	17.14
Berry weight (g)	3.35 ±0.19	3.29 ±0.41	ns	9.57
Berry diameter (BD) (mm)	16.45 ±1.36	17.41 ±0.59	ns	6.23
Berry height (BH) (mm)	18.24 ±0.63	17.89 ±1.07	ns	4.77
BD/BH	0.90 ±0.09	0.97 ±0.03	ns	7.44
Soluble solids (SS) (°Brix)	19.33 ±1.15	20.31 ±0.82	ns	5.05
pH	3.24 ±0.01	3.43 ±0.12	ns	2.74
Titratable acidity (TA)[1]	0.75 ±0.12	0.70 ±0.10	ns	14.73
Maturation index (SS/TA)	26.50 ±5.32	29.25 ±3.92	ns	16.69

Note: SD = standard deviation; ns = non-significant; ** significant ($P < 0.01$); *significant ($P < 0.05$). CV = coefficient of variation. [1](g of tartaric acid 100 mL^{-1})

Conclusions

The cultivar 'BRS Vitória' showed higher productivity on the rootstock IAC 766 and greater development of bunches and berries on the IAC 572. This cultivar had a 119-day cycle and a thermal requirement of 1419 Degree-days from pruning until harvest.

The cultivar 'BRS Núbia' showed higher productivity on the rootstock IAC 572. The thermal need for 'BRS Núbia' to complete its cycle was 1725 Degrees-Day, with productive cycle, from pruning to 140-day harvest.

The cultivar 'BRS Isis' on the rootstock IAC 572 showed higher values of productivity, yield and number of bunches per plant. On the rootstock IAC 766 the 'BRS Isis' presented thermal need 1958 Degrees-Day with cycle de154 days. For IAC 572, 2079 Degrees-Day were required, 161 days after pruning.

The rootstocks evaluated did not influence the productive and physical-chemical characteristics of the cultivar 'Niágara rosada'. The production cycle from pruning to harvest was 133 days and the thermal requirement was 1622 Degrees-Day, for both rootstocks.

The cultivars 'BRS Vitória', 'BRS Núbia', 'BRS Isis' and 'Niágara rosada' are recommended for cultivation in the region.

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