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Initial performance of 'Rebo' wine grapes on different rootstocks and at various planting densities

Abstract – The objective of this work was to evaluate the influence of different rootstocks and planting densities on the initial performance of the yield and quality of the Rebo grapes cultivars grown in a high altitude region of the state of Santa Catarina, Brazil. An experimental design with randomized complete blocks was carried out in a 5×3 factorial arrangement. The treatments consisted of the combination of five rootstocks ('101-14 Mgt', 'IAC 572', 'Paulsen 1103', 'Harmony', and 'VR 043-43') with the 'Rebo' grape, and of three spacing between plants (1.0, 1.2, and 1.5 m). The evaluations took place during the 2018/2019 and 2019/2020 crop seasons. The initial yield variables and the physicochemical characteristics of the grapes were evaluated. The '101-14 Mgt' rootstock provided early shoots, and the 'VR043-43' and 'IAC 572' rootstocks the latest shoots. The '101-14 Mgt' and 'VR043-43' rootstocks provided a higher yield. Plant spacing at 1.0 and 1.2 m increased the initial yield of the vineyard. The '101-14 Mgt' and 'Harmony' rootstocks contributed to the lower total acidity of must. The initial performance of the yield and quality of 'Rebo' wine grape is favored by the '101-14 Mgt' rootstock at the planting densities of 1.0 to 1.2 m.

Index terms: *Vitis vinifera*, plant spacing, viticulture, yield parameters.

Desempenho inicial de uvas viníferas 'Rebo' sobre diferentes porta-enxertos e a várias densidades de plantio

Resumo – O objetivo deste trabalho foi avaliar a influência de diferentes porta-enxertos e densidades de plantio sobre o desempenho inicial da produtividade e da qualidade de uvas da cultivar Rebo, cultivada em região de alta altitude do estado de Santa Catarina, Brasil. Realizou-se um delineamento experimental de blocos ao acaso, em arranjo fatorial 5×3. Os tratamentos consistiram da combinação de cinco porta-enxertos ('101-14 Mgt', 'IAC 572', 'Paulsen 1103', 'Harmony' e 'VR 043-43') com a uva Rebo e de três espaçamentos entre plantas (1,0, 1,2 e 1,5 m). As avaliações ocorreram durante as safras 2018/2019 e 2019/2020. Avaliaram-se as variáveis produtivas iniciais e as características físico-químicas das uvas. O porta-enxerto '101-14 Mgt' apresentou a brotação mais precoce, e os porta-enxertos 'VR043-43' e 'IAC 572', as mais tardias. Os porta-enxertos '101-14 Mgt' e 'VR043-43' proporcionaram maior produtividade. Os espaçamentos de 1,0 e 1,2 m entre plantas aumentaram a produtividade inicial da vinha. Os porta-enxertos '101-14 Mgt' e 'Harmony' contribuíram para diminuir a acidez total do mosto. O desempenho inicial da produtividade e da qualidade da uva vinífera 'Rebo' é favorecido pelo porta-enxerto '101-14 Mgt' às densidades de plantio de 1,0 a 1,2 m.

Termos para indexação: *Vitis vinifera*, espaçamento entre plantas, viticultura, parâmetros produtivos.

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Introduction

Viticulture is practiced in different regions of the world. In Southern Brazil, the state of Santa Catarina has as traditionally producing regions the “Vale do Rio do Peixe” and “Vale da Uva Goethe” with a predominance of common and hybrid grapes (Caliari, 2018). However, new productive areas have emerged and received attention on the national scene, with the production of viniferous grapes, mainly in high altitude areas, between 900 to 1,400 m, due to the high quality of the elaborated wines (Malohlava et al., 2017).

A partnership between the Autonomous Province of Trento, through the Fondazione Edmund Mach/ Istituto San Michele all’Adige and the Empresa de Pesquisa Agropecuária e Extensão Rural Catarinense (Epagri), together with the Universidade Federal de Santa Catarina (UFSC), developed the project called “Technologies for the development of viticulture in Santa Catarina”, in order to characterize potential new regions for the viticulture in Santa Catarina (Porro & Stefanini, 2016). Therefore, 36 new Italian grape cultivars were introduced in the region, out of which five were selected for their best agronomic and enological performance. This fact makes it necessary to continue the research, in order to better characterize these five cultivars in the altitude regions of Santa Catarina, and to find ideal rootstocks for each one, adapting the planting density for these combinations.

These regions at high altitude provide unique characteristics to grapes produced in the terroir, allowing of complete maturation and, consequently, the elaboration of different still and sparkling wines. The Rebo grape cultivar, originated from Italy, showed favorable agronomic and enological potential for production in this terroir (Porro & Stefanini, 2016), with high levels of soluble solids, total monomeric anthocyanins, and total polyphenols, in addition to intermediate values of titratable acidity and yield (Brighenti et al., 2014).

The great influence of environmental conditions on the phenological and productive quality is characteristic of wine grape cultivars (Tomazetti et al., 2015), which can be influenced when combined with the rootstocks, as such condition can alter the vigor of the plants and, consequently, the quality of the grapes (Brighenti et al., 2010). In viticulture, the use of rootstocks is consolidated to confer resistance to different soil characteristics, such as pH, wet or poor drainage, dry and saline soils, among others, conferring also resistance to pests and soil diseases, as well as their control (Li et al., 2019).

In addition, the different canopy and rootstock combinations can influence the microclimate conditions of the vineyard, making it necessary to adjust the planting density (Santos, 2006). At the same time, planting density is directly linked to the yield of cultivation operations and to levels of productivity and, consequently, to the costs of cultivation operations (Caser et al., 2000).

The objective of this work was to evaluate the influence of different rootstocks and planting densities on the initial performance of the yield and quality of the Rebo grapes cultivars grown in a high altitude region of the state of Santa Catarina, Brazil.

Materials and Methods

The experiment was carried out in a vineyard installed in 2016, located in the municipality Água Doce, in the state of Santa Catarina, Brazil (at 1,250 m altitude), in the Villaggio Grando winery, during the 2018/2019 and 2019/2020 crop seasons. The plants were conducted in the form of a spreader with a pruning system in double Guyot, at 2.9 m spacing between rows and between plants, varying according to the treatment (1.0, 1.2, and 1.5 m). The climate of the region, according to the Köppen-Geiger’s classification, is the Cfb type (mesothermal, humid) without dry season, with a cool summer (Pessenti et al., 2019).

The experimental design was carried out in randomized complete blocks, in a 5×3 factorial arrangement (five rootstocks and three spacings), and four replicates, with two plants per plot. The treatments included the combination of five rootstocks ('101-14 Mgt', 'IAC 572', 'Paulsen 1103', 'Harmony', and 'VR 043-43') with the 'Rebo' canopy and three plant spacings (1.0, 1.2, and 1.5 m).

The phenological cycle was evaluated by observing the main stages after pruning (09/12/2018 and 08/27/2019 for the 2018/2019 and 2019/2020 crop seasons, respectively, in the beginning of sprouting (BBCH:07), in the full bloom (BBCH:65), and during the color change – “veraison” (BBCH:83), following the report by Lorenz et al. (1995). Monthly and weekly averages of precipitation and air temperature, as well as the accumulated cold hours, obtained by the meteorological station of Água Doce, located in the Villagio Grando winery, were provided by the Epagri/Ciram database.

The evaluation of the productive parameters was carried out in the 2018/2019 and 2019/2020 crop seasons, with the measurement of the following ones: number of bunches, counted individually in the marked plants and averaged per plant; the average bunch weight, obtained by the average weight of the bunches harvested per plant (g); production per plant, from the weighing of the bunches at the time of harvest (kg); and the estimated yield per hectare, by multiplying the production per plant by the number of plants per hectare (Mg ha^{-1}).

Harvestings were performed considering the point of maturation in relation to the content of soluble solids and acidity of berries, and they took place on 03/19/2019 and 03/04/2020, for the 2018/2019 and 2019/2020 crop seasons, respectively.

For the physicochemical parameters, the soluble solids content (°Brix) was determined in a digital bench refractometer with automatic temperature compensation (QUIMIS, Nova Instruments, WYA -2S, Piracicaba, SP, Brazil); pH was determined directly in the wort by pHmeter (Adwa, AD1030, São Paulo, SP, Brazil); and the total acidity (mEq L^{-1}) determinations were carried out by titrating the samples (Netter Toledo, 8603, China) with a standardized solution of NaOH 0.1N, adopting pH = 8.2 as the end point of the titration.

Data were subjected to the analysis of variance, normality was determined by the Shapiro-Wilk's test, and homoscedasticity, by the Bartlett's test. When the assumptions were not met, data transformation was performed. In the 2018/2019 crop season, the variable yield was transformed by the base 10 logarithm of value. In the 2019/2020 crop season, the TSS variable was transformed using the method of Box & Cox (1964).

When there was statistical significance, the data were unfolded and the means were compared by the Duncan's test, at 5% probability. The analyses were performed using the R 4.1.1 software (R Core Team, 2019), agricolae packages (Mendiburu, 2017), openxlsx 4.1.0 (Walker, 2018), ExpDes.pt 1.2.0 (Ferreira et al., 2018), and dplyr (Wickham et al., 2021).

Results and Discussion

The 2018/2019 crop season was marked by high rainfall throughout the reproductive period (Figure 1), and mild temperatures during grape ripening (Figure 2). The 2019/2020 crop season was characterized by a drought that preceded the sprouting, and constant rainfall together with mild temperatures during the grape ripening period. These characteristics are limiting factors for grapevine cultivation in high altitude regions of Southern Brazil (Brighenti et al., 2015), which requires the use of fungicide preventive applications for disease control (Brighenti et al., 2016).

The 'Rebo' sprouting occurred between 09/23/2018 and 09/05/2019, for the 2018/2019 and 2019/2020 crop seasons, respectively. Flowering was between 11/15/2018 and 10/26/2019, and the color change ("veraison") between 02/01/2019 and 01/19/2020, with an average of 180 days from the sprouting cycle until

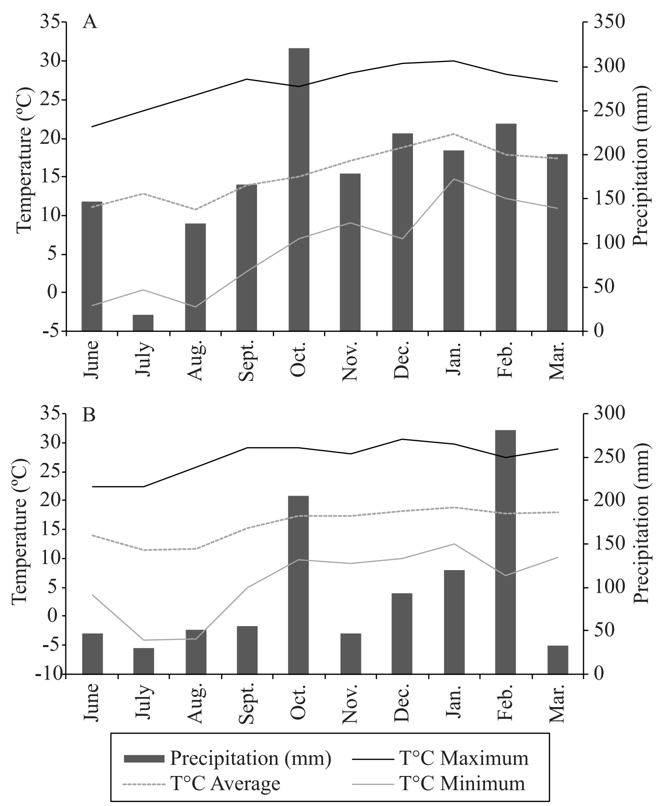

Figure 1. Monthly averages of air temperature and accumulated precipitation, in the municipality of Água Doce, in the state of Santa Catarina, Brazil, at 1,250 m altitude, during 'Rebo' grape (*Vitis vinifera*) crop seasons: A, 2018/2019; and B, 2019/2020

the harvest (Table 1). According to Brighenti et al. (2015), in its region of origin (San Michele All'Adige, Italy), 'Rebo' has an average of 150 days for the cycle from sprouting to maturity, and in the municipality of São Joaquim, in the state of Santa Catarina, Brazil, this cultivar shows 219 days for the same cycle.

The thermal sum of cold hours shows that the accumulated amount was 680 and 405 hours, respectively, in the 2018/2019 and 2019/2020 crop seasons (Figure 3). The reduction of the number of cold hours can cause problems such as breaking dormancy, uneven sprouting, and delay of the beginning of ripening, due to the displacement of the phases subsequent to sprouting (Pandolfo et al., 2008).

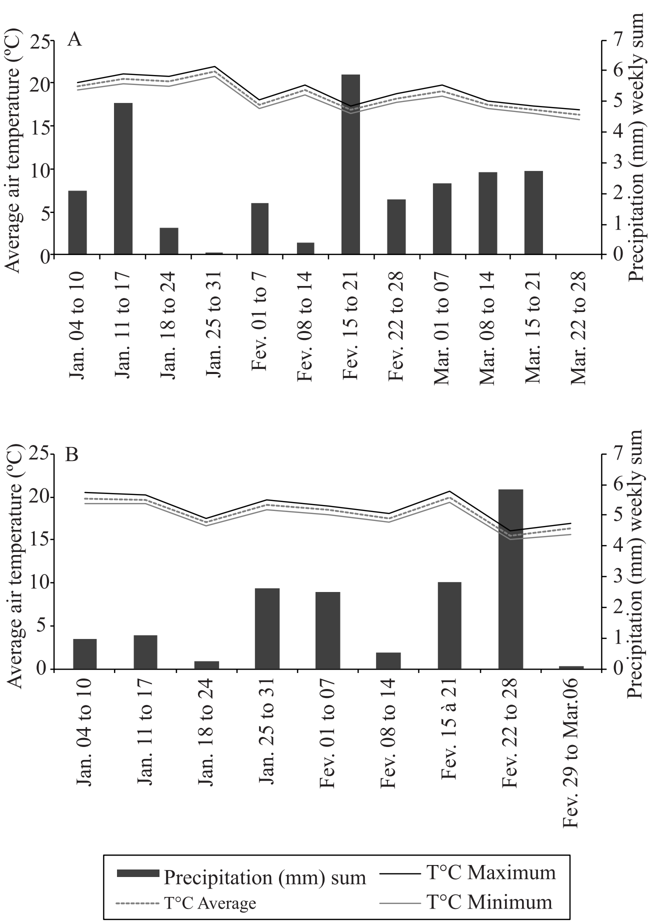

Figure 2. Weekly averages of air temperature and accumulated precipitation, in the municipality of Água Doce, in the state of Santa Catarina, Brazil, at 1,250 m altitude, during 'Rebo' grape (*Vitis vinifera*) crop seasons: A, 2018/2019; and B, 2019/2020.

The reduction of cold hours in the 2019/2020 crop season contributed to overcoming dormancy and anticipating pruning by 16 days, in comparison to the previous crop season (Table 2). First sproutings occurred on '101-14 Mgt' and 'Harmony' rootstocks, in both crops. In the 2018/2019 crop season, 'IAC 572' and 'Paulsen 1103' showed intermediate sprouting, and 'VR 043-43' the latest one. In the 2019/2020 crop season, there was no difference for sprouting of these rootstocks. However, this crop had a smaller sum in cold hours, leading to nonuniform sprouting. The adequate minimum limit for cold hours is 600, as values below this one affect yield and the period of economic exploration of the vineyard (Westphalen & Maluf, 2000).

Flowering also showed a difference, though in a shorter interval of days; the 2018/2019 crop season showed up to 4 days difference between the flowerings, as '101-14 Mgt' had 56 days from sprouting to flowering, while 'IAC 572' stood out with 52 days. Similar behavior was observed in the 2019/2020 crop season, as '101-14 Mgt' again was the last for flowering (56 days) and 'Paulsen 1103' was the first with 49 days after sprouting. In turn, color change ("veraison"), in the 2018/2019 season, occurred first in the most vigorous rootstocks, when 'Paulsen 1103' stood out with 74 days after the beginning of flowering, and 'Harmony', at 79 days. In the 2019/2020 season, 'VR 043-43' was the first to show color change (83 days),

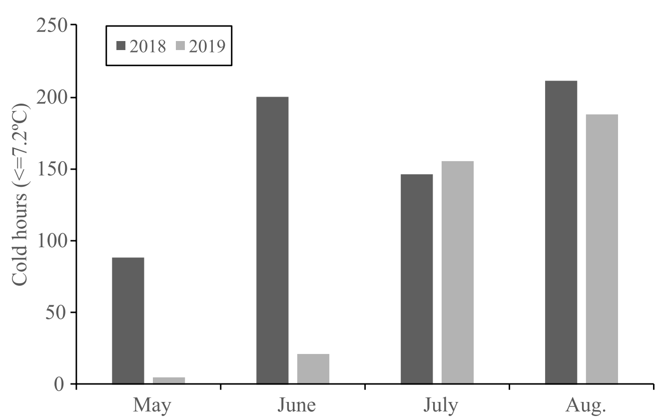

Figure 3. Monthly sum of cold hours, in the municipality of Água Doce, in the state of Santa Catarina, Brazil, at 1,250 m altitude, during 'Rebo' grape (*Vitis vinifera*) 2018/2019 and 2019/2020 crop seasons.

whereas 'Paulsen 1103' and '101-14 Mgt' had similar behavior, with color change 86 days after flowering.

Despite the difference for days from the beginning of the “veraison” to the harvest, grapes should be considered as being harvested together, regardless of the rootstock, since a general sampling of the area was performed, in order to optimize the activities in the winery, and the maturation period may be different among the rootstocks; to elucidate this issue, a physicochemical evaluation of must per rootstock was carried out. In a study on the effect of rootstocks on the evolution of Cabernet Sauvignon grape ripening, the '101-14 Mgt' rootstock interference was observed in both “veraison” and maturity stage (Miele & Rizzon, 2019). Vigorous rootstocks can prolong the vegetative

Table 1. Dates of phenological occurrences by rootstock for 'Rebo' grapes (*Vitis vinifera*) grown in a high-altitude region of the state of Santa Catarina, Brazil.

Rootstock[(1)]	Pruning	Sprouting	Flowering	“Veraison”	Harvest
			2018/2019 crop season		
101-14 Mgt	09/12/2018	09/18/2018	11/13/2018	01/29/2019	03/19/2019
Harmony	09/12/2018	09/22/2018	11/15/2018	02/02/2019	03/19/2019
IAC 572	09/12/2018	09/25/2018	11/17/2018	02/02/2019	03/19/2019
Paulsen 1103	09/12/2018	09/24/2018	11/15/2018	01/30/2019	03/19/2019
VR 043-43	09/12/2018	09/26/2018	11/18/2018	02/04/2019	03/19/2019
			2019/2020 crop season		
101-14 Mgt	08/27/2019	08/29/2019	10/25/2019	01/19/2020	04/03/2020
Harmony	08/27/2019	09/05/2019	10/26/2019	01/18/2020	04/03/2020
IAC 572	08/27/2019	09/07/2019	10/27/2019	01/20/2020	04/03/2020
Paulsen 1103	08/27/2019	09/07/2019	10/26/2019	01/20/2020	04/03/2020
VR 043-43	08/27/2019	09/08/2019	10/28/2019	01/18/2020	04/03/2020

[(1)]Averages of four replicates.

Table 2. Chronological duration (days) of the solstice-pruning (SP), pruning-sprouting (PS), sprouting-flowering (SF), flowering-“veraison” (FV), and “veraison”-harvest (VH) subperiods of 'Rebo' grape (*Vitis vinifera*) cultivated in a high-altitude region of the state of Santa Catarina, Brazil[(1)].

Rootstock	SP	PS	SF	FV	VH
			2018/2019 crop season		
101-14 Mgt	83[ns]	6d	56a	76bc	53a
Harmony	83	8c	55ab	79a	49bc
IAC 572	83	13ab	52c	78ab	50b
Paulsen 1103	83	12b	54abc	74c	52ab
VR 043-43	83	14a	53bc	78ab	46c
			2019/2020 crop season		
101-14 Mgt	67[ns]	3c	56a	86a	44abc
Harmony	67	8b	53b	84ab	46a
IAC 572	67	12a	50bc	85ab	43c
Paulsen 1103	67	11a	49c	86a	44bc
VR 043-43	67	12a	50bc	83 b	45ab

[(1)]Means followed by equal letters, lowercase in the column, do not differ from each other by Duncan’s test, at 5% probability. [ns]Nonsignificant.

cycle, thus slowing the accumulation of sugars in the berries (Brighenti et al., 2011).

Água Doce region is characterized by low temperature during the sprouting period, a factor that favors the occurrence of late frosts. In this sense, it is interesting to use rootstocks that delay the sprouting start. The most vigorous rootstocks ('IAC 572', 'Paulsen 1103', and 'VR 043-43') provided this effect. Evaluating the phenology of 'Merlot' on different rootstocks, Allebrandt et al. (2015) observed no difference for the beginning of sprouting; however, they noted the anticipation of flowering, when using the 'Paulsen 1103' rootstock in comparison with the '101-14 Mgt'.

In the 2018/2019 crop season, there was interaction between the treatment factors for the variables number of clusters, production per plant, and estimated yield. No differences were observed for bunch weight (Table 3).

Regarding the number of bunches, the highest averages were obtained in the smallest spacing, except for 'Harmony', which had the highest number of bunches at 1.5 m spacing. The smallest number of bunches for the largest spacing may be related to the vigor imparted by the rootstocks, which led to an imbalance between shoots and roots (Dalbó & Feldberg, 2019).

The production per plant was statistically different between rootstocks only when spacing at 1.2 m between plants was used, in which 'VR043-43' showed the highest production. The spacing at 1.0 m showed the highest number of curls for all grafts. For the first productive crop, this result may be related to a greater competition between environment and plant at the smaller spacing, since the plant uses its photoassimilates for vegetative production instead of bunches, which shows the importance of controlling the vegetative canopy for the adjustment of the relationship between source and drain (Santos, 2006; Panceri et al., 2018). This behavior affected the estimated yield that (in the case of raw values) had the highest averages at 1.0 m spacing between plants.

In the 2019/2020 crop season, the evaluation of production parameters did not show interaction between treatments, and only the isolated factors of rootstock and spacing were evaluated (Table 4).

Number of bunches did not differ significantly in relation to the rootstocks and spacing used. However, considering the raw values, the rootstocks '101-14 Mgt' and 'VR 043-43' showed four more bunches than the other rootstocks. Besides, these '101-14 Mgt' and 'VR 043-43' had the highest averages for bunch weight, and this fact reflected in the production per plant variables and estimated yield.

'Rebo' behavior at a high altitude region of the state of Santa Catarina, showed an average production of 17.10 clusters per plant, according to Brighenti et al. (2014). These authors also compared wine-growing regions and found an average of 32.80 clusters for 'Rebo' in Italy, and they associated the difference of production to a lower insolation and temperature in the subperiod between flowering and color change of the berries, when this cultivar was produced in São Joaquim (Brighenti et al., 2015).

In the evaluation of cluster weight, 'IAC 572' showed the lowest average, which affected the productive performance per plant, resulting in the lowest production. Very vigorous rootstocks, such as

Table 3. Production parameters of the 'Rebo' grape (*Vitis vinifera*) on different rootstocks, at various planting densities, in a high-altitude region of the state of Santa Catarina, Brazil, in the 2018/2019 crop season[(1)].

Rootstock	Number of clusters			Cluster weight (g)	Yield (Mg ha^{-1})			Production per plant (kg)		
	1.0 m	1.2 m	1.5 m		1.0 m	1.2 m	1.5 m	1.0 m	1.2 m	1.5 m
Harmony	12.2bAB	8.3bB	16.5aA	79.42a	3.8abA	2.07bcA	2.68aA	1.47aA	0.62bB	0.61aB
IAC 572	21.5aA	7.7bB	8.8bB	72.88a	2.5bA	2.75abA	1.60aA	1.67aA	0.55bB	0.70aB
Paulsen 1103	22.3aA	16.0aA	7.3bB	77.24a	4.2abA	1.06cB	1.34aB	1.55aA	0.37bB	0.58aB
VR 043-43	23.3aA	14.3abB	9.5abB	75.64a	6.1aA	5.25aA	0.50bB	1.76aA	1.33aB	0.36aB
101-14 Mgt	23.0aA	12.3abB	3.3bC	64.92a	6.9aA	2.70abB	0.36bC	1.99aA	0.94bB	0.36aB
Spacing	1.0 m	1.2 m	1.5 m	-	-	-	-	-	-	-
Cluster weight (g)	75.81^{ns}	76.16	70.23	-	-	-	-	-	-	-

[(1)]Means followed by equal letters, lowercase in the columns or uppercase in the rows, do not differ by Duncan's test, at 5% probability. ^{ns}Nonsignificant.

the 'IAC 572', can cause excessive growth of plants, tending to lead to floral abortion or bud dormancy, due to the lack of incidence of solar radiation (Dalbó & Feldberg, 2019). Brighenti et al. (2015) observed an average production per plant of 1.3 kg per plant for 'Rebo' grown in São Joaquim, in the state of Santa Catarina, Brazil, and 7.1 kg per plant when this cultivar was grown in San Michele All'Adige, Italy. Several environmental factors can affect yield, among which is the increase of altitude, either by the effect of lower bud fertility, or by reduction of the average weight of bunch (Porro & Stefanini, 2016).

Table 4. Production parameters of the Rebo grape (*Vitis vinifera*) cultivar on different rootstocks, at various planting densities, in a high-altitude region of the state of Santa Catarina, Brazil, in the 2019-2020 crop season[1].

Rootstock	Cluster weight (g)	Production per plant (kg)	Number of clusters	Yield (Mg ha^{-1})
Harmony	98.81b	1.49bc	14.38^{ns}	4.24bc
IAC 572	70.51c	1.17c	14.36	3.37c
Paulsen 1103	100.15b	1.54bc	14.92	4.51bc
VR 043-43	111.14ab	2.05ab	18.21	5.84ab
101-14 Mgt	122.61a	2.28a	18.42	6.69a
Spacing				
1.0 m	103.95^{ns}	1.70^{ns}	15.25^{ns}	5.85a
1.2 m	105.23	1.88	17.58	5.39a
1.5 m	94.48	1.59	15.50	3.65b

[1]Means followed by equal letters in the columns, do not differ by Duncan's test, at 5% probability. ^{ns}Nonsignificant.

Average yield of the 2019/2020 crop season was generally higher at 1.0 and 1.2 m spacing between plants. This result may be related to the higher number of plants per hectare, since no effect of the interaction between rootstocks and spacings was observed in this season.

It is important to consider that the plants have not yet reached their productive balance, since the data obtained express what occurred in the early years of the vineyard, and differences may occur when plants are mature, especially in relation to the more vigorous rootstocks, which take longer to reach adulthood, thus, this may be a trend for future behavior in the vineyard.

The physicochemical variables in the 2018/2019 crops season showed interaction between the treatments evaluated for pH and titratable acidity, whereas the total soluble solids content was not significant in this season. In the 2019/2020 crop season, the interaction was only observed for the soluble solids content. Titratable acidity and pH showed significance only in relation to rootstock (Table 5).

Although pH values in both vintages have differed statistically, this difference in practice is not enough to change the properties of the product. The appropriate pH value for winemaking is around 3.30, since must at low pH is protected from the action of oxidative enzymes, during the pre-fermentation phase (Rizzon & Miele, 2002).

Titratable acidity values for both vintages were suitable for winemaking. The initial acidity of the ripe grape should be between 90 and 110 mEq L^{-1},

Table 5. Means for pH, titratable acidity (TA), and total soluble solids (TSS) of the Rebo grape (*Vitis vinifera*) cultivar on different rootstocks, and at various planting densities, in a high-altitude region of the state of Santa Catarina, Brazil[1].

Rootstock	pH			TA			TSS	pH	TA	TSS		
	1.0 m	1.2 m	1.5 m	1.0 m	1.2 m	1.5 m				1.0 m	1.2 m	1.5 m
	2018/2019 crop season							2019/2020 crop season				
Harmony	3.17aB	3.24abA	3.20aAB	81.34bA	82.43bA	85.01bA	18.19^{ns}	3.50a	79.47cd	21.85aA	21.85aA	21.85aA
IAC 572	3.18aB	3.25aA	3.18aB	89.59aA	82.79bB	90.48aA	17.84	3.42b	91.09a	20.92aA	20.92cAB	20.92bB
Paulsen 1103	3.22aA	3.16cA	3.17aA	82.24bA	90.48aA	87.34abA	18.16	3.48a	82.21bc	20.17aA	20.17bcA	20.17aA
VR 043	3.16aA	3.17bcA	3.20aA	85.12bA	85.83bA	78.40cB	18.19	3.45ab	83.37b	21.65aA	21.65cA	21.65aA
101-14 Mgt	3.18aA	3.15cA	3.20aA	81.01bA	78.03cA	77.34cA	18.40	3.46a	78.56d	21.82aA	21.82abA	21.82aA
Spacing												
1.0 m	-	-	-	-	-	-	18.07^{ns}	3.48^{ns}	82.96^{ns}	-	-	-
1.2 m	-	-	-	-	-	-	18.28	3.45	82.09	-	-	-
1.5 m	-	-	-	-	-	-	18.11	3.46	83.31	-	-	-

[1]Means followed by equal letters, lowercase in the columns or uppercase in the rows, do not differ by Duncan's test, at 5% probability. ^{ns}Nonsignificant.

according to Conde et al. (2007). The 'IAC 572' rootstock had the highest averages for titratable acidity, and the lowest values of soluble solids. There is a tendency toward a decrease of soluble solids, when very vigorous rootstocks are used, such as the 'IAC' (Dalbó & Feldberg, 2019), which may be related to a possible competition between vegetative growth, induced by the rootstock and the supply of soluble solids in the more vigorous combinations, linked to the translocation of photoassimilates primarily for vegetative growth rather than accumulation in fruit (Pasa et al., 2012). Even so, this rootstock produced grapes with adequate levels of brix and acidity.

As to phenological periods, it was observed that the 'IAC 572' rootstock sprouted eight days after the earliest rootstock, therefore, it is possible that this rootstock had not reached the final stage of maturation when grapes were harvested. Brighenti et al. (2015) found an average of 20.2 °Brix for 'Rebo', in São Joaquim (Brazil) and in San Michele All'Adige (Italy). Porro & Stefanini (2016) found levels of total soluble solids above 21 °Brix, which is is a result close to those found in this study.

Rootstocks effect was also evidenced for the pH and titratable acidity variables, for which less vigorous rootstocks ('101-14 Mgt' and 'Harmony') were observed to have the greatest reduction of acidity. However, vigorous rootstocks tend to extend the fruit ripening period (Dalbó & Feldberg, 2019). This change may be related to the lengthening of the phenological cycle, since all grapes were harvested in the same date. Therefore, they could be at different levels of maturation because of the thickening of the canopy that resulted from the excess vigor, which led to less grape exposure to solar radiation and, consequently, to the delay of the ripening and reduction of volatile acids.

Conclusions

1. The initial performance of yield and quality of the 'Rebo' wine grape (*Vitis vinifera*) is favored by the '101-14 Mgt' rootstock at 1.0 to 1.2 m planting spacing.
2. The rootstock '101-14 Mgt' provides early shoots, and rootstocks 'VR043-43' and 'IAC 572' provide the latest ones.
3. The rootstocks '101-14 Mgt' and 'VR043-43' lead to higher yield.
4. Spacings at 1.0 and 1.2 m between plants increase the initial yield of the vineyard.
5. The rootstocks '101-14 Mgt' and 'Harmony' contribute to lower the total acidity of must.

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