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Yield performance of new juice grape varieties grafted onto different rootstocks under tropical conditions

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ABSTRACT

The objective of this work was to evaluate the yield components and physicochemical characteristics of bunches and berries of new grape varieties for juice elaboration, which were ‘Isabel Precoce’ (*Vitis labrusca* L.) and the hybrids ‘BRS Carmem’, ‘BRS Cora’ and IAC 138-22 ‘Máximo’ grown onto ‘IAC 572’ and ‘IAC 766’ rootstocks under tropical conditions. The yield components (number of bunches and yield per vine, as well as productivity) and the physicochemical characteristics of the bunches and berries of the eight scion-rootstock combinations were evaluated in three seasons. All data were subjected to analysis of variance and principal components analysis. The varieties ‘Isabel Precoce’, ‘BRS Cora’ and IAC 138 22 ‘Máximo’ produced high fruit yield, with the number of bunches and yield per vine similar to one another and superior to those of ‘BRS Carmem’. Significant differences occurred among varieties in the physicochemical grape characteristics. ‘Isabel Precoce’ and ‘BRS Carmem’ grapes had balanced levels of sugar and acid content, and ‘BRS Cora’ presented large bunches and berries, reaching high soluble solids content despite the high acidity. IAC 138-22 ‘Máximo’ grape also had large bunches but small berries and limited potential in the accumulation of sugars. The ‘IAC 766’ rootstock resulted in the best performance across all four varieties evaluated, showing maximum results in terms of fruit yield and physicochemical quality attributes of grapes.

1. Introduction

Grapes are one of the world’s most commonly produced fruit crops. In addition to the increasing consumption of fresh grapes, in recent years, interest in products made from grapes has greatly increased, particularly in grape juices (FAO and OIV, 2017). The numerous health benefits may be part of the reason because these products are rich sources of phenolic compounds (phytochemicals with potential antioxidant activity) (Granato et al., 2016).

Almost any type of grape variety can produce grape juice. However, technological and economic constraints limit the varieties used. Some varieties are particularly dedicated to grape juice, such as ‘Concord’ (*Vitis labrusca* L.), which is cultivated in the United States of America and Brazil (FAO and OIV, 2017). However, in Brazil, the ‘Isabel’ (*V. labrusca*) is the primary raw material used for the elaboration of grape juices, despite limitations. ‘Isabel’ grapes confer low color intensity and low bioactive compounds content to grape juice (Lima et al., 2014). Additionally, these *V. labrusca* varieties are mostly planted in the subtropical and temperate areas of the country (Mello, 2017).

To meet the demands of producing grape juices in tropical conditions worldwide, breeding programs have been developing new interspecific hybrid grape varieties (*V. vinifera* × *V. labrusca*). The goal is to develop varieties that, in addition to having suitable characteristics for adapting to warmer environments, show high yield capacity, tolerance to the primary fungal diseases and produce grapes with good quality for juice production (Camargo and Maia, 2004). Thus, in addition to the ‘Isabel Precoce’, a spontaneous somatic mutation of the ‘Isabel’ (Camargo, 2004), the hybrid varieties ‘BRS Carmem’, ‘BRS Cora’ and IAC 138-22 ‘Máximo’ have been recently released.

In some tropical areas, because of the climate, more than one crop a year can be produced with high temperatures and a defined rainy season in the summer, the dry winter and the use of budburst stimulators. Therefore, programming the pruning according to demands of industry is possible (Camargo et al., 2012).

Several factors can influence grapevine yield and grape quality, which include the use of grafting. Extensively used in viticulture,

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grafting is an effective technique for controlling soilborne diseases and for overcoming abiotic stresses (Ibacache et al., 2016; Jin et al., 2016). Additionally, many studies report that different rootstocks affect the duration of phenological stages, canopy structure, growth, yield and fruit quality (Bascunán-Godoy et al., 2017; Koundouras et al., 2008; Silva et al., 2017).

The scion-rootstock relationship is extremely specific, depending on affinity and compatibility of the combination and the soil and climatic adaptation (Vrsic et al., 2015). Thus, the ideal scion-rootstock combination is very important in a production system. Currently, in tropical conditions, varieties of *V. vinifera* table grapes are cultivated onto 'IAC 572', considered of high vigor. However, with the introduction of new hybrids and *V. labrusca* grape varieties intended for juice production, further studies are required to achieve useful scientific data for use in rootstock recommendations for these varieties.

In this context, the objective of this work was to evaluate the yield components and physicochemical characteristics of bunches and berries of new juice grape varieties (*V. labrusca* and hybrids) grown onto 'IAC 572' and 'IAC 766' rootstocks under tropical conditions.

2. Materials and methods

2.1. Experimental location and growing conditions

The study was conducted in an experimental vineyard located in Votuporanga, São Paulo State, Brazil (latitude 20°20′S, longitude 49°58′W; elevation 525 m), during three consecutive seasons performed within two years (2015–2016). According to the Köppen classification, the climate is type Aw, *i.e.*, tropical climate with dry winter. An automatic meteorological station (Campbell Scientific®, Logan, UT, EUA) installed in the experimental area recorded meteorological conditions during the study period. The mean temperature was 24.1 °C, the minimum average was 16.6 °C, and the maximum average was 31.7 °C. The average annual rainfall was 1495 mm, with a tendency for concentrated rainfall in the summer months. The soil was classified as Argissolo Vermelho-Amarelo (equivalent to Ultisol, USDA soil taxonomy) according to previously published criteria (Embrapa, 2006).

The experiment was established in the winter of 2013 when the rootstocks were planted, and the scions were grafted in the winter of 2014. The vines were trained on a unilateral cordon system (1 m above the soil) in a vertical shoot positioning by means of iron wires and spaced 2.0 × 1.1 m apart (4545 vines per hectare).

During the trials, all the cultural practices regarding fertilization, weed control, and pest and disease management were conducted as standard regional cultivation practices. The entire vineyard was covered with polyethylene screen with 18% shading, to protect against bird attack. The irrigation of the plants was performed with a micro sprinkler system, as described by Conceição et al. (2017).

Regular crop pruning was performed in February and August 2015 and July 2016, and the grapes were harvested in June and December 2015 and December 2016, respectively. For all seasons, vines were cane pruned to leave one to two nodes, as well the usual cultivation practices in the region. Subsequently, 5% hydrogen cyanamide was applied to the buds to induce and standardize the sprouting.

2.2. Treatments and experimental design

One *Vitis labrusca* L., 'Isabel Precoce', and three hybrid grape varieties, 'BRS Carmem' (Muscat Belly A × H 65.9.14), 'BRS Cora' (Muscat Belly A × H. 65.9.14) and IAC 138-22 'Máximo' (Seibel 11342 × Syrah), were grown onto the rootstocks 'IAC 766' Campinas (106-8 Mgt × *V. caribaea*) and 'IAC 572' Jales (*V. caribaea* × 101-14 Mgt).

A completely randomized block design in a two-factor arrangement (factorial scheme 4 × 2) with five replicates was used as the statistical model. The factors evaluated consisted of four scions and two rootstocks. The plot consisted of four vines, with a total of 20 vines per treatment (scion-rootstock combination).

2.3. Harvest and measurements

The plots were harvested at full maturity stage of the grapes. At harvest, the number of bunches per vine and their masses were recorded to estimate the yield per vine (kg) and productivity (t ha^{-1}).

The physical measurements of the grapes were assessed by determining the bunch mass (g), length (cm) and width (cm) in a sample of 10 bunches per plot collected at harvest of each season, which were also used to measure the rachis mass (g). For berry mass (g), length (cm) and width (cm), 10 berries were collected from each bunch, totaling 100 berries per plot. The number of berries per bunch was estimated using the relation [(bunch mass − rachis mass)/berry mass]. The ratio rachis mass/bunch mass was calculated and expressed as a percentage.

For the chemical evaluations of the berries, pH, soluble solids (SS), titratable acidity (TA), maturation index (SS/TA) and reducing sugars were determined. The pH of the grape must was determined directly by a potentiometer (Tecnal®, Piracicaba, SP, Brazil). The SS was determined using a digital refractometer with automatic temperature compensation (Reichert®, r^{2}i300 model, Buffalo, NY, EUA), and the result is expressed in units of °Brix. TA was determined through the titration of the grape must with a 0.1 N NaOH solution in a semi-automatic titrator, adopting the end-point at pH = 8.2, and the result is expressed in percent of tartaric acid (OIV, 2011). The reducing sugars were determined according to the Somogy-Nelson colorimetric method (Nelson, 1944). The absorbance values at 535 nm were compared with those of a calibration curve of glucose in a UV/vis spectrophotometer (BEL Photonics®, Piracicaba, SP, Brazil), and the results are expressed in percent of glucose.

2.4. Statistical analysis

Means of the three seasons were subjected to analysis of variance (*two-way* ANOVA) to determine the effect of scions and rootstocks and their interaction, and then means were compared by Tukey's test ($p < 0.05$) using the SISVAR version 5.4 statistical program (Lavras, MG, Brazil). Additionally, data of the eight scion-rootstocks, including 17 traits, were analyzed *via* XLSTAT statistical software version 19.4 (Addinsoft, NY, USA). Principal component analysis (PCA) was applied to all productive and physicochemical attributes, which were also evaluated by Pearson's correlation.

3. Results and discussion

All data represent an average of three seasons performed within two years (2015/2016). Statistically significant variations were not detected among the seasons.

No significant interaction ($p > 0.05$) was detected between scions and rootstocks for all yield components (Table 1) and physicochemical characteristics evaluated (Tables 2 and 3). Thus, both factors (scions and rootstocks) were analyzed separately.

3.1. Yield components

Analyzing the isolated effect of the canopy varieties on the yield components, 'Isabel Precoce', 'BRS Cora' and IAC 138-22 'Máximo' presented a number of bunches that were similar to one another, with an average of 26 bunches per vine. This value was approximately 2.3-fold higher than that found on 'BRS Carmem' vines (Table 1).

The number of bunches per vine was the variable that most contributed to the yield, which was verified by the high positive and significant correlation (r) between those characteristics ($r = 0.91$, $p < 0.01$; data not shown). Similar results are found by others for *V. vinifera* grape varieties (Bascunán-Godoy et al., 2017; Ibacache et al., 2016).