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Initial performance of own-rooted and budded 'Sunraycer' nectarine plants

Abstract – The objective of this work was to evaluate the performance in the field of 'Sunraycer' nectarine plants when own rooted and budded onto 13 clonal rootstocks. For this, flowering, flushing, fruit maturity, vigor, and production were assessed. The time span between the end of flowering and the harvest period was shorter for 'Sunraycer' budded onto the 'G x N.9', 'Santa Rosa', and 'Ishtara' rootstocks. 'Flordaguard' and 'Ishtara' induced the largest and smallest canopy sizes, respectively. 'Flordaguard' resulted in the greatest production, and 'Cadaman', in the lowest. Own-rooted 'Sunraycer' plants produce heavier fruits and can be an alternative to growers.

Index terms: *Prunus*, flowering, flushing, production, vigor.

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Desempenho inicial de nectarineiras 'Sunraycer' autoenraizadas e sobre porta-enxertos

Resumo – O objetivo deste trabalho foi avaliar o desempenho em campo de nectarineiras 'Sunraycer' autoenraizadas e sobre 13 porta-enxertos clonais. Para tanto, foram avaliados florescimento, brotação, maturidade dos frutos, vigor e produção. O intervalo entre o final do florescimento e a época da colheita foi menor para 'Sunraycer' sobre os porta-enxertos 'G x N.9', 'Santa Rosa' e 'Ishtara'. 'Flordaguard' e 'Ishtara' induziram o maior e o menor volume de copa, respectivamente. 'Flordaguard' resultou na maior produção, e 'Cadaman', na menor. Plantas 'Sunraycer' autoenraizadas produzem frutos de maior massa e podem ser uma alternativa para os produtores.

Termos para indexação: *Prunus*, florescimento, brotação, produção, vigor.

In Brazil, seeds of unknown genetic origin, scrapped from canning industries, are the most commonly used source of rootstocks for peach [*Prunus persica* (L.) Batsch.] propagation, resulting in uneven stands of low-quality seedlings, with low growth rates (Mayer et al., 2017). The use of clonal rootstocks may be advantageous for stone fruit production if they can provide vigor control, yield increase, and adaptation to environmental conditions, without problems of scion/rootstock incompatibility (Mestre et al., 2015). However, only a few studies have focused on the performance of clonal rootstocks and of own-rooted peach plants in the field.

Among the nectarine [*Prunus persica* (L.) Batsch.] cultivars, Sunraycer stands out. It was developed by the University of Florida and is an early bearer, with a low chill requirement of 275 chill hours and a good fruit quality (Sherman et al., 1995).

The objective of this work was to evaluate the performance in the field of 'Sunraycer' nectarine plants when own rooted and budded onto 13 clonal rootstocks.

Flowering, flushing, fruit maturity, vigor, and production were assessed. Own-rooted 'Sunraycer' plants were compared with those budded onto the following clonal rootstocks: 'Flordaguard' (*P. persica* x *Prunus davidiana* Franch.); 'Cadaman' (*P. persica* x *P. davidiana*); 'Barrier' (*P. persica* x *P. davidiana*); 'G x N.9' (*P. persica* x *Prunus dulcis* D.A.Webb); 'Ishtara' [(*Prunus cerasifera* Ehrh. x *Prunus salicina* Lindl.) x (*P. cerasifera* x *P. persica*)]; 'Santa Rosa' (*P. salicina*); and 'Okinawa', 'Tsukuba-1', 'Tsukuba-2', 'Tsukuba-3', 'Nemared', 'México Fila 1', and 'I-67-52-4' (*P. persica*). Most of these rootstocks are resistant to nematodes, and 'Santa Rosa' is also resistant to waterlogging.

'Sunraycer' nursery trees were produced at the nursery of the Frutplan company, located in the municipality of Pelotas, in the state of Rio Grande do Sul, Brazil. Herbaceous cuttings of the rootstocks and the scion were collected from three-year-old mother plants. The plants were budded by inverted T-budding on January 2014 and were then planted at Escola Superior de Agricultura Luiz de Queiroz, in the municipality of Piracicaba, in the state of São Paulo, Brazil (22º42'30"S, 47º38'30"W, at 546 m altitude), in July 2014, in a 6.0x3.0-m spacing, with 555 trees per hectare, without supplemental irrigation, being conducted as recommended by the crop management guidelines for peach trees (Aguiar et al., 2014). The local climate is Cwa, according to the Köppen-Geiger classification, humid subtropical, with a dry winter, a hot summer, and a low number of chill hours below 7.2ºC (Figure 1). The soil is a clayey to very clayey Nitossol Vermelho eutrófico (Santos et al., 2018), i.e., a red eutrophic Oxisol.

All nursery trees were trained in a vase (open-center) system and evaluated during 2015 and 2016. Canopy volume (V) was determined using the formula: $V = \pi \times a \times b \times h/3$ (Schiaffino & Radice, 2009), where a and b are the canopy radius in perpendicular and parallel directions to the plant row, respectively; and h is plant height, measured with a ruler from the insertion point of the first limb, before winter pruning in both years.

In 2016, the following variables were assessed: full bloom date and final date of flowering, considered as $\geq$ 50% and $\leq$ 5% open flowers, respectively; initial and final date of sprouting, determined at the green-tip and fully-open bud stages, respectively; initial and final date of fruit harvest, when the first and the last fruit of each plot were picked; number of fruits per plant; mean fruit weight (g), calculated from the quotient between total fruit weight and total fruit number harvested from each plot; fruit yield (kilogram per plant), estimated from mean fruit weight (kg) and number of fruits per plant; and yield efficiency (kg m^{-3}), calculated from the ratio between fruit yield (kilogram per plant) and canopy volume (cubic meter per plant).

The experiment was conducted in a randomized complete block design, with 14 treatments with four single-tree replicates. Data were subjected to the analysis of variance (Anova), and means were compared by the least significant difference test at 5% probability, using the SAS software, version 9.3 (SAS Institute Inc., Cary, NC, USA). For some variables, the original data were transformed in order to meet Anova assumptions, as indicated in Table 1.

The time span between the end of flowering and the end of the harvest period was of 78 days for 'Sunraycer' budded onto the 'G x N.9' and 'Santa Rosa' rootstocks, and of 64 days on 'Ishtara', which were considered the shortest periods (Table 1); however, these three rootstocks induced an extended flowering period. These results confirm the early-maturation habit of the 'Sunraycer' nectarine. 'Sunraycer' nectarines were harvested from October 3 to October 18, a period of low fruit offer.

In 2015, the 'Flordaguard' and 'Ishtara' rootstocks induced the largest and the smallest canopy volume in 'Sunraycer' nectarine plants, respectively. Similar results were obtained in 2016, when the 'Tsukuba-1' rootstock also induced a large canopy volume (Table 1). Other authors, however, did not find any difference in canopy volume among combinations of Maciel and Chimarrita peach cultivars budded onto the 'Flordaguard' and 'Okinawa' rootstocks (Comiotto et al., 2013). 'Ishtara' was always among the less invigorating rootstocks (Salvador et al., 2014), and may be recommended for higher-density plantings.

The fruit yield of 'Sunraycer' nectarine plants was low, both when own rooted and when budded onto the different clonal rootstocks (Table 1), which might be explained by the lack of enough chill accumulation to

break bud dormancy at the experimental site (Figure 1 B). An annual chill requirement of 275 hours, with air temperatures between 0 and 7.2ºC, has been defined for 'Sunraycer' nectarine plants (Sherman et al., 1995); however, this condition must be reconsidered, since higher air temperatures, between 10 and 15ºC, were reported to be enough for overcoming the bud dormancy of 'Turmalina' peach trees grown in Pelotas, in the state of Rio Grande do Sul (Chavarria et al., 2009). During both experimental years, flowering took place after the accumulation of a given number of hours with air temperatures below 15ºC, totaling

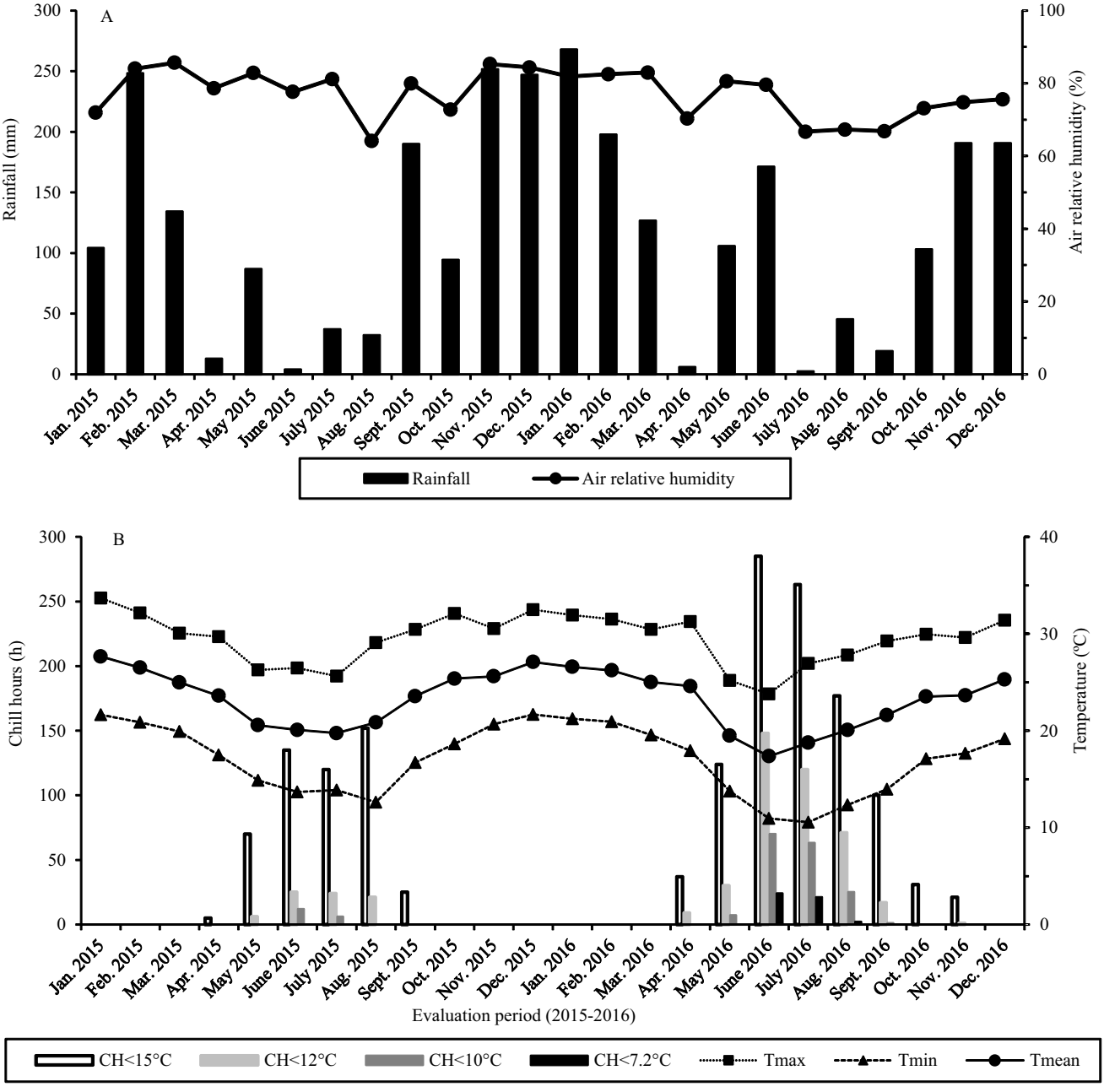

Figure 1. Mean monthly rainfall and air relative humidity (A); and chill hours (CH) below 15, 12, 10, and 7.2ºC, as well as maximum (Tmax), minimum (Tmin), and mean (Tmean) air temperatures (B) in 2015 and 2016. Data were collected by the automated meteorological station located at Escola Superior de Agricultura Luiz de Queiroz, in the municipality of Piracicaba, in the state of São Paulo, Brazil.

Table 1. Initial (ID) and final dates (FD) of flowering, sprouting, and harvest, as well as time span between the end of flowering and the end of harvest (EF to EH), canopy volume, fruit number per plant (FN), fruit weight (FW), fruit yield (FY), and yield efficiency (YE), of own-rooted and budded 'Sunraycer' nectarine (*Prunus persica*) plants, in the municipality of Piracicaba, in the state of São Paulo, Brazil[1].

Treatment	Dates of phenological events in 2016						EF to EH	Canopy volume (V, m³)		FN	FW (g)	FY (kg per plant)	YE (kg m^{-3})
	Flowering		Sprouting		Harvest								
	Full bloom	FD	ID	FD	ID	FD		2015[2]	2016[2]	2016[2]	2016[2]	2016[3]	2016[4]
Barrier	July 1	July 19	July 1	Aug. 23	Oct. 3	Oct. 18	91	4.58abcd	3.55cde	34.75b	61.13b	2.82abcd	0.794abcd
Cadaman	July 1	July 19	July 1	Sept. 5	Oct. 3	Oct. 18	91	4.87abc	3.92bcde	15.00c	51.40b	0.69e	0.176f
G x N.9	July 1	Aug. 1	July 1	Sept. 5	Oct. 3	Oct. 18	78	5.09ab	4.10abcde	41.00ab	50.65b	1.98cd	0.483bcde
México Fila 1	July 1	July 14	July 1	Aug. 15	Oct. 3	Oct. 18	96	4.66abcd	4.76abc	33.50bc	67.00b	2.11bcd	0.443bcde
I-67-52-4	July 1	July 19	July 1	Sept. 5	Oct. 3	Oct. 18	91	3.63bcde	5.24ab	35.00b	53.25b	1.87cd	0.357def
Tsukuba-1	July 1	July 11	July 1	Aug. 15	Oct. 3	Oct. 18	99	3.18def	6.37a	69.00ab	52.18b	4.38ab	0.688abcd
Tsukuba-2	July 1	July 19	July 1	Aug. 15	Oct. 3	Oct. 18	91	3.13def	2.97de	62.50ab	55.20b	3.00abc	1.010a
Tsukuba-3	July 1	July 14	July 1	Sept. 5	Oct. 3	Oct. 18	96	3.35cdef	4.08bcde	47.50ab	51.98b	2.04bcd	0.500abcd
Santa Rosa	July 1	Aug. 1	July 1	Aug. 23	Oct. 3	Oct. 18	78	2.66ef	4.18abcd	28.25bc	36.90c	1.02de	0.244ef
Flordaguard	July 1	July 14	July 1	Sept. 5	Oct. 3	Oct. 18	96	5.43a	5.99a	107.00a	51.10b	5.36a	0.895abc
Nemared	July 1	July 19	July 1	Sept. 5	Oct. 3	Oct. 18	91	3.87abcde	4.60abc	36.75b	52.08b	2.00bcd	0.435cde
Ishtara	July 1	Aug. 15	July 1	Sept. 5	Oct. 3	Oct. 18	64	1.95f	2.87e	51.50ab	53.46b	2.82abcd	0.983ab
Okinawa	July 1	July 11	July 1	Aug. 23	Oct. 3	Oct. 18	99	3.79bcde	4.36abc	34.00bc	49.80b	1.72cd	0.394cde
Own-rooted	July 1	July 19	July 1	Sept. 5	Oct. 3	Oct. 18	91	5.19ab	4.42abc	34.50bc	115.40a	2.86abc	0.647abcd
p-value								<0.0001	0.01	0.0652	<0.0001	0.048	0.0075
CV (%)								27.82	8.49	18.18	11.86	12.02	10.35

[1]Means followed by equal letters, in the columns, do not differ by the least significance difference test, at 5% probability. Original data were transformed by: $\hat{y} = \log_{10}(y)^{(2)}$, $\hat{y} = y^{-0.6(3)}$, and $\hat{y} = y^{0.2(4)}$.

482 hours in 2015 and 446 hours in 2016. Therefore, that temperature threshold may be considered when calculating chill accumulation to overcome the bud dormancy of 'Sunraycer' nectarine plants under local conditions.

Other factors also affected flowering and fruit set. One was the occurrence of low relative air humidity levels at bloom, which may desiccate pollen grains and reduce stigma receptiveness and fruit set (Nava et al., 2009). The others included: a weak vegetative flushing at the end of flowering and the beginning of fruit set, reducing photoassimilate availability to support fruit set and growth; a irregular flowering, caused by no hydrogen cyanamide application on the dormant flower buds and the growing regime under rainfed conditions.

'Flordaguard' induced a higher yield, being similar to the 'Tsukuba-1', 'Tsukuba-2', and 'Ishtara' rootstocks (Table 1). Own-rooted plants had the largest mean fruit weight, which overpassed the values found by Della Bruna & Moreto (2011) in the South of Brazil for the 'Sunraycer' nectarine budded onto 'Okinawa'; therefore, those plants may represent a new potential business option for the grower. It should be noted that plant performance is not only influenced by the evaluated genotype and year of study, but also by the climatic and soil conditions at the growing site (Nava et al., 2009).

The 'Cadaman' and 'Santa Rosa' rootstocks induced the lowest yield and yield efficiency, while 'Okinawa' also performed poorly regarding productivity (Table 1). The 'Tsukuba-2' rootstock induced a higher yield efficiency of 1.010 kg m^{-3}, compared with 'Cadaman', which showed the lowest value of 0.176 kg m^{-3}, but did not differ significantly from 'Barrier' (0.794 kg m^{-3}), 'Tsukuba-1' (0.688 kg m^{-3}), 'Tsukuba-3' (0.500 kg m^{-3}), 'Flordaguard' (0.895 kg m^{-3}), 'Ishtara' (0.983 kg m^{-3}), and the own-rooted plants (0.647 kg m^{-3}). Likewise, Mestre et al. (2015) verified that 'Big Top' nectarine plants budded onto low-invigorating rootstocks had a similar yield efficiency to those budded onto more invigorating ones. 'Flordaguard', 'Tsukuba-1', 'Tsukuba-2', 'Ishtara', and the own-rooted plants had an outstanding performance for most of the production-related variables.

The 'Flordaguard' rootstock stands out in terms of tree vigor and fruit yield, whereas the standard 'Okinawa' rootstock is not suitable for the Sunraycer nectarine cultivar and may be replaced by other rootstocks. Own-rooted 'Sunraycer' nectarine plants produce heavier fruits and can be an alternative to growers, especially since, in Piracicaba, this nectarine is harvested from October 3 to October 18, a period of low fruit offer. These results, however, should be further confirmed in future studies with mature trees.

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