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Comparative Study of The Yield and Fruit Quality of Salustiana Orange Cv. Grafted on Some Citrus Rootstocks

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TO evaluate the effect of the three citrus rootstocks: Sour orange, Rough lemon and Cleopatra mandarin on yield and fruit quality of Salustiana orange (*Citrus sinensis* L. Osbeck) trees a study was conducted during the two successive seasons of 2018 and 2019. The experimental trees were 12-year-old and grown in sandy soil in Wadi El-Natron region, Behira Governorate, Egypt. The obtained results indicated the Salustiana orange trees budded on Rough lemon had greater the yield / tree, fruit weight, size, fruit dimensions, pulp and peel weights/ fruit as well as peel thickness than those on Cleopatra mandarin and sour orange. Juice TSS percentage and TSS/ acid ratio of fruits for trees budded on sour orange were higher than those on rough lemon and Cleopatra mandarin. Juice volume/ fruit for trees budded on sour orange were smaller than those budded on rough lemon and Cleopatra mandarin. While, total acidity percentage was higher in fruits of trees budded on rough lemon than those of Cleopatra mandarin. Seed number and weight/ fruit of trees budded on rough lemon reached 10.38 & 11.12 and 6.45 & 10.30 folds its values on sour orange in the both seasons. The corresponding values for trees budded on Cleopatra mandarin trees were 6.98 & 10.59 and 6.35 & 10.15 folds, respectively. This indicates that rootstock type may affect fertility of reproductive organs of Salustiana flowers, especially ovules.

Keywords: Citrus, Salustiana orange, Rootstocks, Yield, Fruit quality.

Introduction

Citrus fruits are cultivated worldwide due to its adaptation to various environmental conditions (Shireen et al., 2018). Salustiana cultivar is one of common orange group belonging to sweet orange (*Citrus sinensis* (L.) Osbeck) species. This cultivar originated as a bud mutation in Spain. Its fruit is middle to large in size, commercially seedless with middle rind thickness, being quite easy to remove, though sometimes it can break easily (Davies and Albrigo, 1994). The Salustiana is pleasant to eat, with good sweetness, lots of juice and a mild flavour, though can be a little acid if picked at the wrong time. Moreover, are a mid-season fruit which can be left on the tree for 2-3 months without noticeable quality deterioration, though they are prone to softness.

Rootstocks chosen is a main factor for citrus growing success. The rootstocks give anchorage to the tree, rootstock is also responsible for uptake and translocation of water and nutrients, storage of photosynthates and synthetic of growth regulators such as cytokinines and gibberelline making the scion part more tolerable (Bellini et al., 2014). Since the root system of citrus trees develops from the rootstock, the rootstock has direct effect on tree size, precocity, fruit production and maturity through complex inter relationship between the roots and tree canopy (Richardson et al., 2003 and Kumar et al., 2018). Moreover, the rootstock increases scion ability to tolerate some unsuitable soil conditions such as pH, salinity and drought, beside fungal and viral diseases (Davies and Albrigo, 1994). Rootstocks have played a vital role in the fruit industry, and effect on more than 20 horticultural scion

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characters including: tree health and size, root system distribution and depth, low temperature tolerance, adaptability to some unsuitable soil conditions, nematodes and diseases resistance as well as tree yield, fruit quality and nutrient status (Legua et al., 2014; Somkuwar et al., 2015; Tietel et al., 2020). The effect of rootstocks on fruit quality incidences such as fruit volume, weight, rind thickness, juice content, TSS and acidity percentages of scion cultivars have been reported by many researchers (Mehrotra et al., 2000; Zekri and Al-Jaleel, 2004; Al-Jaleel et al., 2005; Ramin and Alirezanezhad, 2005; Muhtaseb and Ghnaim, 2006 and Ahmed et al., 2007). Ghnaim (1993), Georgiou and Georgiou (1999) and Muhtaseb and Ghnaim (2006) stated that fruit size, weight, rind thickness, juice content, Brix and total acids of Shamouti orange fruits were affected by rootstock type. Similar trends were reported on other sweet orange cultivars (Wheaton et al., 1991 & 1995).

The previous works have shown that citrus rootstocks impact inversely on scion growth such as environmental and soil conditions (Forner-Giner et al., 2014; Chahal and Gill, 2015). The chosen of appropriate graft is essential for the production of fruits because of effects physiological both scion and rootstock relations of each other (Sharma et al., 2015), minerals uptake (Toplu et al., 2012 and Hayat et al., 2019), vigor and yield behavior (Mallick et al., 2019 and Martins et al., 2020).

This study carried out to evaluate the effect of some different rootstocks citrus as Sour orange, Rough lemon and Cleopatra mandarin rootstocks on yield, physical and chemical fruit characteristics of Salustiana sweet orange trees.

Materials and Methods

This work was carried out on randomly picked ripe fruit samples in the first week of December in 2018 and 2019 seasons from similar mature Salustiana orange budded on three rootstocks namely: Rour orange, Rough lemon and Cleopatra mandarin and grown in sandy soil of the citrus orchard in Wadi El-Natron region, Behira Governorate, Egypt. The trees received similar cultural practices in respect of irrigation, fertilization, pest management and weeding. This investigation was planned to study the effect of the previous rootstocks on tree yield as well as physical and chemical characteristics of Salustians orange fruits. Yield/ tree (kg) was recorded by weighing the total number of fruits/ tree at the time of harvesting. Thereafter, 60 fully ripen fruits were randomly selected from the obtained fruits from three trees budded on each rootstock. The collected fruit samples of each rootstock were randomly divided to four replicates (15 fruits for each). The following parameters were recorded: average fruit weight (g), size (cm^3) and fruit dimensions (height and width, cm). Thereafter, 10 fruits from each replicate were manually peeled to estimate pulp and peel weight/ fruit (g), peel thickness (mm), seed number and weight/ fruit, also pulp and peel moister percentages. The remained 5 fruits were peeled for juice extraction. After filtering the extracted juice, average juice volume/ fruit (cm^3) was estimated. Also, total soluble solids percentage (TSS) was determined using hand Refractometer and titretable acidity percentage as citric acid by titration against 0.1 N sodium hydroxide (A.O.A.C., 2006). TSS/acid ratio was also calculated.

The obtained data were statistically analyzed according to the randomized complete block design with 3 replicatesand differences between means were compared using LSD at 5 % level according to Snedecor and Cochran (1980). Mean value and stander deviation (SD) for variables were calculated .

Results and Discussion

Yield components and fruit dimensions

The effect of rootstock type on yield/ tree, fruit weight, size and dimensions of Salustiana orange cv. is presented in Table 1, and differed significantly among the tested rootstocks. Trees budded on rough lemon rootstock gained the highest yield/tree (89.80 & 96.31 kg), the highest fruit weight (214.70 & 251.68 g) and size (238.26 & 280.23 cm^3), followed by those trees budded on Cleopatra mandarin. Whereas, trees budded on sour orange recorded the least yield/ tree (62.86 & 65.66 kg), fruit weight (188.2 & 190.31 g) and size (203.53 & 211.24 cm^3) in the first and second season, respectively. The average increases in yield of trees budded on Rough lemon and Cleopatra mandarin were higher than those on sour orange by 42.86 & 9.53% in the first season and 46.68 & 11.74% in the second season, respectivelt. However, fruit weight of Salustiana orange cv. budded on all rootstocks, ranged in the two seasons between 188.2 - 251.68 g, while size ranged between 203.53 -280.23 cm^3. Fruit height and diameter followed the same trend in both seasons.

These results are in line with those reported by Zekri and Al-Jaleel (2004), Muhtaseb and Ghnaim (2006), Ahmed et al. (2007), Castle et al., (2010), Shafieizargar et al. (2012) and Hifny et al. (2013). They found that orange, mandarin and grapefruit trees budded on rough lemon, Volkamer lemon and macrophylla rootstocks produce heigher yields and fruits than those on sour orange, citron and trifoliate orange ones.

Fruit physical characteristics

Data in Table 2 clearly show that values of physical characteristics of Salustiana sweet orange fruits were significantly affected by rootstock type. The highest fruit pulp and peel weights (163.26 & 183.52 g for fruit pulp and 59.48 & 59.47 g for peel) were recorded for trees budded on Rough lemon budded trees, while the lowest values (131.47 & 133.63 g for pulp and 55.28 & 46.23 g for peel) were recorded for trees budded on Cleopatra mandarin in the first and second seasons, respectively.

Peel thickness was significantly affected by the tested rootstocks in both seasons. The thickest peel (5.56 & 4.84 mm) was recorded for fruits of trees budded on rough lemon. The other two rootstocks recorded equal statistically values (4.64 & 4.69 mm) in the first season and (3.83 & 3.97 mm) in the second one for trees budded on Sour orange and Cleopatra mandarin, respectively. This means that rough lemon rootstock produces fruits with thicker peel, while Sour orange produces fruits with thinner peel and Cleopatra mandarin came in between in this respect.

The larger juice volume/ fruit was extracted from fruits of trees budded on Cleopatra mandarin rootstock (128.08 cm^3/ fruit) in the first season and those on Rough lemon rootstock (180.27 cm^3/ fruit) in the second one. The least juice volume/ fruit (108.45 & 147.06 cm^3/ fruit) was found in fruits of trees budded on sour orange in the two studied seasons, respectively.

The obtained findings are in full agreement with those previously reported by Mehrotra et al. (2000), Zekri and Al-Jaleel (2004), Al-Jaleel et al. (2005), Ramin and Alirezanezhad (2005), Garcia–Sanchez et al. (2006), Muhtaseb and Ghnaim (2006), Ahmed et al. (2007), Bassal (2009) and Yildirim et al. (2010).

Fruits of trees budded on Rough lemon and Cleopatra mandarin trees contained the highest seed number and weight without significant difference between them for seed weight/ fruit. While, those trees budded on sour orange contained the least values. Seed number and weight/ fruit of trees budded on Rough lemon reached 10.38 & 11.12 and 6.45 & 10.30 folds its values on Sour orange in the both seasons.

TABLE 1. Influence of different rootstocks on yield/ tree and its components as well as fruit dimensions of Salustiana sweet orange fruits during 2018 and 2019 seasons .

Rootstock	Yield/ tree (kg)	± (%)	Fruit weight (g)	Fruit size (cm^3)	Fruit height (cm)	Fruit diameter (cm)
First season (2018)						
Sour orange	62.86c±1.32	-	188.2c±1.96	203.53c±1.60	6.80c±0.04	6.94c±0.03
Rough lemon	89.80a±1.51	+42.86	214.70a±2.70	238.26a±5.24	7.23a±0.01	7.19a±0.01
Cleopatra mandarin	68.85b±1.10	+9.53	194.53b±1.74	213.56b±1.70	7.07b±0.01	7.02b±0.02
LSD at 0.05	0.48	-	2.49	0.56	0.04	0.05
Second season (2019)						
Sour orange	65.66c±1.25	-	190.31c±2.05	211.24c±1.89	6.72c±0.01	6.90b±0.08
Rough lemon	96.31a±0.99	+46.68	251.68a±2.24	280.23a±1.92	7.20a±0.01	7.36a±0.03
Cleopatra mandarin	73.37b±1.02	+11.74	209.88b±1.86	235.18b±1.82	6.83b±0.02	6.85b±0.03
LSD at 0.05	1.37	-	0.89	0.29	0.03	0.06

± (%) = increase or decrease (%) in relation to Sour orange.

TABLE 2. Influence of different rootstocks on some physical characteristics of Salustiana sweet orange fruits during 2018 and 2019 seasons.

Rootstock	Pulp weight/ fruit (g)	Peel weight/ fruit (g)	Peel thickness (mm)	Juice volume (cm^3/fruit)	Seed No./ fruit	Seed weight/ fruit (g)
First season (2018)						
Sour orange	139.64b±0.86	55.55b±0.43	4.64b±0.14	108.45c±1.57	0.87c±0.02	0.20c±0.01
Rough lemon	163.26a±0.68	59.48a±0.22	5.56a±0.06	117.34b±2.50	9.03a±0.25	1.29a±0.01
Cleopatra mandarin	131.47c±1.35	55.28b±0.62	4.69b±0.09	128.08a±2.15	6.07b±0.02	1.27a±0.01
LSD at 0.05	0.86	0.49	0.13	1.27	0.31	0.03
Second season (2019)						
Sour orange	157.32b±1.09	47.15b±0.73	3.83b±0.09	147.06c±2.00	1.32c±0.02	0.20c±0.01
Rough lemon	183.52a±0.67	59.47a±0.55	4.84a±0.11	180.27a±1.75	14.68a±0.02	2.06a±0.01
Cleopatra mandarin	133.63c±2.45	46.23c±0.66	3.97b±0.05	155.17b±1.75	13.98b±0.07	2.03a±0.02
LSD at 0.05	3.01	0.52	0.16	0.44	0.06	0.05

The corresponding values for trees budded on Cleopatra mandarin were 6.98 & 10.59 and 6.35 & 10.15 folds, respectively. This indicates that rootstock type may affect fertility of reproductive organs of Salustiana flowers, especially ovules. This point of study was of no previous reports in the available literature.

Fruit chemical characteristics

Table 3 show the effect of tested rootstocks on TSS percentage, total acidity percentage, TSS/ acid ratio, pulp and peel moister percentages in the first and second experimental seasons.

Fruit juice of trees budded on Sour orange contained the highest TSS percentage and TSS / acid ratio (12.93 & 13.03% and 17.10 & 21.60), followed by those budded on Cleopatra mandarin (10.43 & 12.83% and 12.77 & 17.04) in both seasons, respectively. While that of trees budded on Cleopatra mandarin were lower values (10.43 & 11.97% and 10.13 & 16.32) in the first and second seasons, respectively. Juice TSS percentage in fruit juice of Salustiana on Sour orange grafted trees was larger than those on Rough lemon and Cleopatra mandarin by 1.19 & 1.24 and 1.02 & 1.09% in both seasons, respectively.

Fruit juice of trees budded on Sour orange contained the least acidity percentage (0.76 & 0.60%), while those trees budded on Cleopatra mandarin (1.03 & 0.75%) in the first season and second one contained the highest acidity percentage without significant differences between it and Rough lemon rootstock in the second season only.

The previous results are in agreement with those reported by Davies and Albrigo (1994), Zekri and Al-Jaleel (2004), Al-Jaleel et al. (2005), Muhtaseb and Ghraim (2006) and Castle (2010). But, Economides (1976) reported that TSS percentage in fruit juice of grapefruit Marsh on Cleopatra mandarin was more than its value on Sour orange and Rough lemon rootstocks.

The highest (91.56 & 90.10%) and lowest (88.20 & 88.17%) pulp moisture percentage were recorded for trees budded on Cleopatra mandarin and Sour orange in the first and second seasons, respectively. Moisture percentage in fruit pulp of trees budded on Rough lemon came in between in both seasons. Peel moisture percentage was significantly affected by rootstocks in the second season only. Peel moisture percentage of Salustiana orange ranged between 69.42 - 73.78%, and between 69.77 - 74.42% in the two seasons.

TABLE 3. Influence of different rootstocks on some chemical characteristics of Salustiana sweet orange fruits during 2018 and 2019 seasons.

Rootstock	TSS (%)	Total acidity (%)	TSS/ acid ratio	Pulp moister (%)	Peel moister (%)
First season (2018)					
Sour orange	12.93a±0.06	0.76c±0.01	17.10a±0.42	88.20c±0.26	69.42a±0.50
Rough lemon	10.90b±0.06	0.85b±0.02	12.77b±0.32	90.22b±0.36	76.95a±0.85
Cleopatra mandarin	10.43c±0.10	1.03a±0.05	10.13c±0.19	91.56a±0.54	73.78a±5.51
LSD at 0.05	0.06	0.02	0.41	0.58	NS
Second season (2019)					
Sour orange	13.03a±0.11	0.60b±0.01	21.60a±0.19	88.17b±0.45	69.77c±0.21
Rough lemon	12.83b±0.05	0.73a±0.01	17.04b±0.18	89.04b±0.83	71.85b±0.21
Cleopatra mandarin	11.97c±0.05	0.75a±0.01	16.32c±0.40	90.10a±0.49	74.42a±0.50
LSD at 0.05	0.11	0.02	0.48	1.01	0.51

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Conflict of interest

No conflicts of interest during this research

Reffrences

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دراسة مقارنة لمحصول وجودة ثمار صنف البرتقال سالوستيانا المطعوم على بعض أصول الموالح

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أجريت هـــذه الدراسة خلال موسمين متتاليين ٢٠١٨ و ٢٠١٩ علي أشجار البرتقال صنف سالوستيانا عمر ١٢ عام ومطعومة علي ثلاثة أصول من الموالح هي : النارنج ، الليمون المخرفش ويوسفي كليوباترا ومنزرعة في تربة رملية في منطقة وادي النطرون بمحافظة البحيرة ، مصر. لتقييم تأثير هذه الأصول على محصول وجودة الثمار. أوضحت النتائج المتحصل عليها أن أشجار البرتقال سالوستيانا المطعومة على الليمون المخرفش كانت أكبر في متوسط المحصول / شجرة ووزن وحجم وارتفاع وقطر ووزن اللب والقشرة / ثمرة وكذلك سمك القشرة من تلك المطعومة علي كل من أصل يوسفي كليوباترا والنارنج. وكانت نسبة المواد الصلبة الذائبة ونسبة المواد الصلبة الذائبة إلى الحموضة في عصير ثمار الأشجار المطعومة علي النارنج أكبر من تلك الموجودة علي الليمون المخرفش ويوسفي كليوباترا. وكان حجم العصير / ثمرة لثمار الأشجار المطعومة على النارنج أقل من مثيلتها علي الليمون المخرفش ويوسفي كليوباترا. بينما كانت نسبة الحموضة الكلية في ثمار الأشجار المطعومة على الليمون المخرفش أكبر منها في يوسفي كليوباترا. بلغ عدد البذور ووزنها / ثمرة في ثمار الأشجار المطعومة على الليمون المخرفش ١٠,٣٨ و ١١,١٢ & ٦,٤٥ و ١٠,٣٠ ضعف قيمتها في النارنج في كلا الموسمين. وكانت القيم المقابلة لثمار الأشجار المطعومة على أصل يوسفي كليوباترا ٦,٩٨ و ١٠,٥٩ & ٦,٣٥ و ١٠,١٥ ، على التوالي. ويشير هذا إلى أن نوع الأصل قد يؤثر على خصوبة الأعضاء الجنسية في أزهار السالوستيانا خاصة البويضات.

الكلمات الدالة: الموالح ، البرتقال سالوستيانا ، الأصول ، المحصول ، جودة الثمار.