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Growth, yield and fruit quality of 'Marisol' clementine grown on four rootstocks in Egypt

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ABSTRACT

To evaluate the most appropriate rootstocks for mandarin production in Egypt, vegetative growth, yield and fruit quality of 'Marisol' clementine (as newly introduced cultivar in Egypt) grafted on Sour orange (the common rootstock), Cleopatra mandarin, Carrizo citrange and 'Swingle' citrumelo were evaluated under the Egyptian conditions during 2004/2005 and 2005/2006 seasons. Trees were grown in a private farm at 'Wady El-Mullak' region, Ismailia Governorate (Latitude, 30°36′ N; longitude, 32°14′ E; Altitude, 10 m above sea level).

'Marisol' clementine trees budded on Sour orange showed higher vegetative growth parameters (canopy circumference and diameter, tree volume, scion trunk girth) than trees on Carrizo citrange, 'Swingle' citrumelo and Cleopatra mandarin rootstocks, except the tree height which was shorter than those on Carrizo citrange and 'Swingle' citrumelo (in the first season) or similar (in the second season), while the trees budded on Cleopatra mandarin were the shortest. The highest affinity was found with the Sour orange, followed by Cleopatra mandarin and Carrizo citrange, while the lowest affinity was found with 'Swingle' citrumelo.

Trees on Sour orange produced the higher yield than those on Cleopatra mandarin, 'Swingle' citrumelo and Carrizo citrange rootstocks. The trees on Sour orange had the highest average yield of two seasons (26.36%, 19.51% and 17.6% over those on Cleopatra mandarin, Carrizo citrange and 'Swingle' citrumelo, respectively); however, those budded on Cleopatra mandarin had the lowest one. Trees on all rootstocks exhibited relatively little alternate bearing index, and the trees on Carrizo citrange significantly showed lower alternate bearing index.

Fruit weight, volume, dimensions and shape, peel thickness and percentage, rag percentage and juice content were not significantly affected by rootstock. However, fruit gravity, colour, firmness and juice TSS, acidity, TSS/acid ratio and ascorbic acid contents were significantly affected by rootstock. Sour orange produced fruits with high gravity, firmness and acidity and low fruit colour, TSS and TSS/acid ratio, indicating that Sour orange retarded fruit maturity and, therefore, it is not recommended as a rootstock for this cultivar (whereas its fruit maturation is extra early), despite of its high fruit production. While, Carrizo citrange produced fruits with low gravity, firmness and acidity and best colour, high TSS and TSS/acid ratio, followed by Cleopatra mandarin and 'Swingle' citrumelo rootstocks. Carrizo citrange, Cleopatra mandarin and 'Swingle' citrumelo can be considered as suitable rootstocks for 'Marisol' clementine under the Egyptian conditions.

1. Introduction

All citrus varieties in Egypt are mainly budded on Sour orange rootstock. However, Sour orange rootstock had to be replaced in some areas as a result of its susceptibility to citrus tristeza virus (Gregoriou and Economides, 1993). The rootstock may influence several aspects of citrus growth and development, including yield, fruit quality, and tolerance to stress caused by biotic and abiotic factors (Filho et al., 2007).

'Marisol' clementine is a mutation of 'Oroval' clementine detected in 1970 in Spain. The tree is very vigorous with vertical growth habit, high productive and early production. The fruit has a good size with acidic juice, puffing when the peel develop into orange colour. The fruit maturation is extra early and can be harvested from mid-September for degreening, with green-orange coloration (Bono et al., 1995; Aznar, 1999).

The common commercial rootstocks for mandarin cultivars are Sour orange and Cleopatra mandarin (Fallahi and Rodney, 1992).

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Trees of 'Clemenules' clementine budded on Cleopatra mandarin were shorter than those on Troyer citrange and the last were shorter than those on 'Swingle' citrumelo (Verdú, 1993), also 'Valencia' orange on Cleopatra mandarin had the smallest canopy comparing with other rootstocks (Zekri, 2000), while Filho et al. (2007) reported that Cleopatra mandarin induced the most vigorous growth in 'Fallglo' mandarin as compared to trees on 'Swingle' citrumelo.

Fruits of 'Fairchild' mandarin budded on Carrizo citrange had the highest TSS, considering yield, growth and fruit quality, Carrizo citrange is suitable for 'Fairchild' mandarin in the arid regions (Fallahi and Rodney, 1992). In addition, Ali (2002) reported that the highest juice percentage and the best rind colour of 'Fremont' fruits were from trees budded on Sour orange, while Carrizo citrange had the highest TSS.

There is only limited information concerning rootstock effects on 'Marisol' clementine performance. The rootstocks used in this study were chosen according to the earlier or promising performance in other areas and with other citrus cultivars. Thus, this study was carried out to evaluate the vegetative growth, yield and fruit quality of 'Marisol' clementine as newly introduced cultivar in Egypt (Bassal, 2001) budded on four commercial rootstocks (Sour orange, Cleopatra mandarin, Carrizo citrange and 'Swingle' citrumelo).

2. Materials and methods

The used rootstocks were Sour orange (*C. aurantium* L.), Cleopatra mandarin (*C. reshni* Hort. ex Tan.), Carrizo citrange (*C. sinensis* (L.) Osb. X *Poncirus trifoliat*a (L.) Raf.) and 'Swingle' citrumelo (*C. paradisi* Macf. X *Poncirus trifoliat*a (L.) Raf.).

Seeds of Sour orange and Cleopatra mandarin were locally obtained from selected healthy trees, while seeds of Carrizo citrange and 'Swingle' citrumelo were obtained from Valencia Agriculture Research Institute (IVIA)–Spain. The seeds were sown in the spring of 1997 in artificial soil mix (sand + peat moss, 2:1 v/v) in a screenhouse and the seedlings were transplanted into plastic bags during June of the same year.

The seedlings were budded in spring 1998 by buds taken from virus-free trees of 'Marisol' clementine (*C. clementina* Hort. ex Tan.) grown in multiplication block under screenhouse raised from budwood obtained from (IVIA), Spain in 1994. The scions of all trees were of the same clonal strain.

During March 1999, uniform 1-year-old trees were planted in the field in a high-density planting, in a private orchard at 'Wady El-Mullak region', Ismailia Governorate (Latitude, 30°36′ N; longitude, 32°14′ E; Altitude, 10 m above sea level). The trees were 2 m × 5 m apart (400 trees per fed.) under drip irrigation system and received the same cultural practices.

In the fifth year after planting (2004), twelve trees on each rootstock were chosen and labeled for this study, which carried out during two successive seasons (2004/2005 and 2005/2006). A randomized complete blocks design with four-trees per plot and three replicates was used (Steel and Torrie, 1980).

In November of each season, tree height, canopy diameter in the two tree directions (to obtain the average diameter), canopy circumference, trunk girth at 10 cm above and below the budding union were measured, and scion/stock girth ratio was calculated. The canopy volume (m^3) was calculated according to the equation reported by Wutscher (1995) as follow: Tree volume = (Tree diameter^2 × Tree height)/4

The weight of harvested fruits per tree was recorded at harvest time every season (1st and 3rd Nov., respectively), and then the fruit production per feddan was calculated. The ratio of yield to canopy volume (yield efficiency – (Kg/m^3) and the average yield of two seasons per tree were also calculated. The alternate bearing habit was estimated according to the equation suggested by Shawky et al. (1976) as follows:

Alternate bearing index = 100 X Differences between two consecutive yields/sum of two yields. If the index is more than 50%, this means that the tree in alternate bearing, while the tree is in regular bearing if this index is less than 50%.

Samples of twelve fruits per replicate were randomly collected at harvest date for determination the physical and chemical characteristics. Fruit weight, volume, diameter (D) and height (H) were determined. Gravity (g/cm^3) and fruit shape index (D/H) were calculated. Fruit firmness (g/cm^2) was measured (3 readings per each fruit) by Lfra texture analyzer instrument using a penetrating cylinder of 1 mm in diameter. Fruit colour was measured by a Hunter colorimeter type (Dp-9000) for estimation of '*L*', '*a*' and '*b*' values; colour values as Hue angle was calculated according to McGuire (1992) and Voss (1992).

Peel thickness was measured, and the juice was extracted by a rotary extractor, then the peel and juice percentages (w/w) were calculated. Soluble solids content (TSS) was measured refractometrically; titratable acidity (TA) and ascorbic acid (Vit.C) were determined according to AOAC (1985), and then TSS/acid ratio was estimated.

Data recorded in all seasons were statistically analyzed as randomize complete blocks design (Steel and Torrie, 1980) using the MSTAT-C statistical package (M–STAT, 1990) and means were separated by LSD test ($P < 0.05$).

3. Results and discussion

3.1. Vegetative growth

Tree height: In the 5th year after planting (YAP) the trees of 'Marisol' clementine budded on Carrizo citrange and 'Swingle' citrumelo were significantly higher than those on Sour orange and Cleopatra mandarin (Table 1). The shorter trees were those on Cleopatra mandarin and Sour orange, and did not significantly differ from each other. In the 6th YAP the trees on Cleopatra mandarin showed the lowest tree height, and the trees on Sour orange, Carrizo citrange and 'Swingle' citrumelo were significantly equal.

These results agreed with the findings of Verdú (1993), who reported that trees of 'Clemenules' clementine on Cleopatra mandarin were shorter than those on Troyer citrange and 'Swingle' citrumelo. While trees on Cleopatra mandarin had higher vegetative growth parameters than trees on Carrizo citrange (García–Sánchez et al., 2006) and trees on 'Swingle' citrumelo (Filho et al., 2007) in 'Fallglo' mandarin.

Canopy diameter: Trees grafted onto Sour orange showed the highest values of canopy diameter in both seasons. The trees on Carrizo citrange, 'Swingle' citrumelo and Cleopatra mandarin were similar and the difference among them was insignificant in both seasons (Table 1).

Similar results were reported by Georgiou (2000) on 'Nova' mandarin and (2002) on 'Clementine' mandarin, who stated that Sour orange induced the highest values of canopy diameter as compared with Carrizo citrange and 'Swingle' citrumelo.

Tree volume: The trees budded onto Sour orange had the highest volume, which was significantly differed from those on other studied rootstocks in both seasons, except Carrizo citrange in the first season only, which was equal (Table 1). The trees budded on Carrizo citrange had statistically similar volume to those budded on 'Swingle' citrumelo and Cleopatra mandarin in both seasons. While, trees budded on Cleopatra mandarin were significantly smaller than those budded on 'Swingle citrumelo' in the second season only.