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EVALUATION OF SOME CITRUS ROOTSTOCKS FOR "HERNANDINA" CLEMENTINE IN A HIGH-DENSITY PLANTING

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ABSTRACT

Vegetative growth, yield and fruit quality of "Hernandina" clementine (as newly introduced cultivar in Egypt) grafted on Sour orange (the most common rootstock), Cleopatra mandarin, Carrizo citrange and "Swingle" citrumelo were evaluated in a private farm at "Wady El-Mullak" region, Ismailia Governorate during 2004/2005 and 2005/2006 seasons.

"Hernandina" clementine trees budded on Carrizo citrange showed higher vegetative growth parameters (canopy circumference and diameter, tree volume) than those on Sour orange, "Swingle" citrumelo and Cleopatra mandarin rootstocks, except the tree height which was similar to those on other rootstocks (except Sour orange which was significantly lower). The highest affinity was found with Sour orange, followed by Cleopatra mandarin and Carrizo citrange without significant differences among them, while the lowest affinity was found with "Swingle" citrumelo.

Trees on Carrizo citrange produced higher yield than those on Sour orange, Cleopatra mandarin and "Swingle" citrumelo rootstocks. The trees grafted on Carrizo citrange had the highest average yield of the two seasons (29.51%, 24.55% and 13.55% over those on Cleopatra mandarin, Sour orange and "Swingle" citrumelo, respectively). Trees on Cleopatra mandarin showed a significant higher alternate bearing index (24.87%) as compared with those on other rootstocks.

Juice SSC, acidity, SSC/acid ratio and ascorbic acid contents were significantly affected by rootstock. The fruits from trees budded on Carrizo citrange showed the highest SSC, while those budded on Sour orange had the lowest SSC and highest acidity. The lowest maturity index was achieved by fruits from trees grafted on Sour orange as compared with those on the other rootstocks; however, the highest maturity index was clear in fruits from trees on Carrizo citrange and "Swingle" citrumelo rootstocks.

Considering the tree growth rate, scion/stock affinity, yield and fruit quality; Carrizo citrange and Cleopatra mandarin can be considered as the most promising rootstocks for 'Hernandina' clementine under the Egyptian conditions.

Keywords: Citrus; Clementine; Hernandina; Rootstocks; Tree vigor; Yield; Alternate bearing; Fruit quality

INTRODUCTION

Citrus is one of the most important fruit crops in Egypt. In 2006/2007 season, the cultivated area estimated by 382 027 fed., and produced 3 211

709 tons from which 796 000 tons were exported (Statistics of Egyptian Ministry of Agric.).

Recently, mandarin cultivars and hybrids have been introduced to Egypt and are spreading in the private sector orchards. Hernandina clementine derived as a spontaneous mutation of “Fina” clementine in 1966 in Spain, its maturity is delayed, but the internal maturity of fruit takes place before the external one by one month or more, with excellent characteristics (Bono *et al.*, 1995).

Selecting a suitable rootstock is one of the most important issues in the cultivation of citrus trees due to its effects on fruit size, weight and juice (Alirezanezhad and Ramin, 2004), as well as tree growth, yield and fruit quality (Filho *et al.*, 2007).

The common commercial rootstocks for mandarin cultivars are Sour orange and Cleopatra mandarin. Considering yield, growth and fruit quality, Carrizo citrange is suitable for Fairchild mandarin in the arid regions (Fallahi and Rodney, 1992). Most of the Egyptian citrus cultivars are budded on Sour orange rootstock. Although Sour orange was considered a satisfactory rootstock in several citrus-producing areas, it had to be replaced in some of these areas as a result of its susceptibility to citrus tristeza virus (Gregoriou and Economides, 1993).

For new varieties, suitable rootstocks for good production and fruit quality under the Egyptian conditions are unknown. 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 tree growth, yield and fruit quality of "Hernandina" clementine as a newly introduced cultivar in Egypt (Bassal, 2001) grafted on four commercial rootstocks (Sour orange, Cleopatra mandarin, Carrizo citrange and "Swingle" citrumelo).

MATERIALS AND METHODS

'Hernandina' clementine (*Citrus clementina* Hort. ex Tan.) was grafted on four commercial rootstocks namely; 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.) as previously described by Bassal (2007). During March 1999, uniform 1-year-old trees were planted in the field in a high-density planting (2x5 m apart i.e. 400 trees per fed.) in a private orchard at Wady El-Mullak region, Ismailia Governorate under drip irrigation system and received the same cultural practices.

In the fifth year after planting (2004), twelve trees per 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/plot and three replicates was used (Steel and Torrie, 1980).

In February of each season, tree height (m), canopy diameter in the two tree directions (m), canopy circumference (m), trunk girth (cm) at 10 cm

above and below the budding union were measured, then scion/stock girth ratio was calculated. The canopy volume (m^3) was calculated according to Wutscher (1995) as follow:

Tree volume = (Tree width^2 x Tree height)/4

In each season, at harvest time (3rd and 1st Jan.) the weight of harvested fruits per tree was recorded and the yield per feddan was calculated. Then, the ratio of yield to canopy volume (yield efficiency – Kg/m^3) and the average yield of two seasons per tree were also calculated. Alternate bearing index was calculated according to Georgiou and Gregoriou (1999) by dividing the difference between two successive crops by the sum of two successive crops x 100. 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% (Shawky *et al.*, 1976).

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/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 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 (SSC) was measured refractometrically; titratable acidity (TA) and ascorbic acid (Vit.C) were determined according to AOAC (1985), and then SSC/acid ratio was calculated.

Data obtained were statistically analyzed as randomize complete blocks design (Steel and Torrie, 1980) using analysis of variance procedures with the MSTAT-C statistical package (M-STAT, 1990) and means were separated by LSD test at 0.05 level.

RESULTS AND DISCUSSION

I- Vegetative growth

Tree height: The tree height of Hernandina clementine on all studied rootstocks in the 6th year after planting (YAP) was higher than those in the 5th YAP, regardless of rootstock (Table 1). However, the trees on all studied rootstocks had similar height in both seasons, except those budded on Sour orange, which had the lowest significant tree height as compared with those on the other studied rootstocks.

In this respect Georgiou (2000) on 'Nova' mandarin and (2002) on 'Clementine' mandarin reported that Sour orange, Carrizo citrange and "Swingle" citrumelo rootstocks had insignificant effect on canopy height. Similarly, Forner-Giner *et al.* (2003) stated that trees of 'Navelia' orange budded on Cleopatra mandarin and Carrizo citrange had statistically similar height.

Canopy diameter and tree volume: Canopy diameter and tree volume behaved the same minor in both seasons (Table 1). Trees budded onto Carrizo citrange had the highest diameter and volume, which were significantly differed than those of trees on the other studied rootstocks in both seasons, except the volume of trees budded on "Swingle" citrumelo in the 6th YAP which was statistically similar. The trees on Sour orange, "Swingle" citrumelo and Cleopatra mandarin showed no significant differences among them in both seasons with respect of the tree diameter and volume, except in the second one, the trees grafted on "Swingle" citrumelo were significantly bigger than those on Sour orange and Cleopatra mandarin.

These findings are in agreement with Forner-Giner *et al.* (2003), who revealed that trees of 'Navelina' orange on Carrizo citrange had a higher canopy volume than those on Cleopatra mandarin. On the contrary, Georgiou in 2000, on "Nova" mandarin and in 2002, on "Clementine" mandarin found that Sour orange rootstock induced the highest values of trees canopy volume and diameter as compared with those on Carrizo citrange and "Swingle" citrumelo. Also, Clemenules trees on Cleopatra mandarin had higher vegetative growth parameter than those on Carrizo citrange, as reported by García-Sánchez *et al.* (2006). Moreover, canopy volume of "Sunburst" mandarin trees budded on Cleopatra mandarin and "Swingle" citrumelo was similar, contrary to canopy volume of "Fallglo" mandarin trees on Cleopatra mandarin was about 100% larger than those budded on "Swingle" citrumelo (Filho *et al.*, 2007).

Table (1): Effect of some citrus rootstocks on the vegetative growth of "Hernandina" clementine.

Para. / Stocks	Tree height (m)	Canopy diameter (m)	Tree volume (m^3)	Canopy circum. (m)	Girth (cm)		Scion/stock girth ratio
					Scion	Stock	
	5th year after planting						
SO	2.12 b	2.62 b	3.63 b	7.88 b	28.83 a	33.00 b	0.87 a
CC	2.38 a	2.86 a	4.89 a	9.07 a	28.33 ab	33.67 b	0.84 a
SC	2.34 a	2.59 b	3.92 b	7.65 b	27.17 b	37.67 a	0.72 b
CM	2.34 a	2.50 b	3.67 b	7.01 c	25.50 c	31.67 b	0.81ab
6th year after planting							
SO	2.55 b	2.80 c	5.01 b	8.56 b	35.17 ab	39.67 b	0.89 a
CC	2.74 a	3.01 a	6.23 a	9.84 a	33.83 b	39.33 b	0.86 a
SC	2.79 a	2.89 b	5.85 a	8.40 b	36.50 a	50.50 a	0.72 b
CM	2.76 a	2.75 c	5.24 b	7.90 c	31.17 c	34.83 c	0.89 a

Means having the same letter (s) in each column are insignificantly different at 5% level, using LSD test. SO: Sour orange; CC: Carrizo citrange; SC: "Swingle" citrumelo; CM: Cleopatra mandarin.

Canopy circumference: Data in Table 1 revealed that in the 5th and 6th YAP, trees grafted on Carrizo citrange had the largest canopy circumference, which was significantly differed than that of trees on the other rootstocks in

both seasons. The trees on Cleopatra mandarin gave the smallest canopy circumference, while those on Sour orange and "Swingle" citrumelo were similar and were in between these two extremes. These results disagreed with those of Hassan *et al.* (2000), who stated that 'Baladi' mandarin trees on Sour orange had the lowest circumference as compared with those on Cleopatra rootstock.

Scion trunk girth: The data in Table 1 showed that the trees budded on Cleopatra mandarin had the lowest values of scion trunk girth in both seasons, while those budded on Sour orange and Carrizo citrange (in the 5th YAP) and Sour orange and "Swingle" citrumelo (in the 6th YAP) had the highest values. No significant differences in scion trunk girth were found between Sour orange and Carrizo citrange in both seasons, and between that of trees on Carrizo citrange and "Swingle" citrumelo, in the 5th YAP only. These results are in contrary with those obtained by Filho *et al.* (2007), who mentioned that trunk diameter of 'Fallglo' mandarin trees on Cleopatra mandarin was larger than that of trees on "Swingle" citrumelo; while the trees of 'Sunburst' mandarin budded on Cleopatra mandarin and "Swingle" citrumelo rootstocks were similar in this respect.

Stock trunk girth: The highest significant stock trunk girth was found in "Swingle" citrumelo rootstock in both seasons. On the other hand, insignificant differences were found among Sour orange, Carrizo citrange and Cleopatra mandarin in 5th YAP, while in the 6th YAP Cleopatra mandarin recorded the lowest value as compared with that on the other studied rootstocks.

Scion/Stock trunk girth ratio: The ratio between scion and rootstock trunk girth is used as a scion/rootstock affinity indicator, whereas values close to 1 are associated with very good affinity (Bisio *et al.*, 2000). The highest affinity for Hernandina clementine was found with the Sour orange (0.87 and 0.89), Carrizo citrange (0.84 and 0.86) and Cleopatra mandarin (0.81 and 0.89) in 2004 and 2005, respectively without significant differences among them (Table 1), while the lowest affinity was found with "Swingle" citrumelo (0.72 in both seasons), although, it was not significantly differed than that on Cleopatra mandarin in the 5th YAP.

These findings are in harmony with those of Georgiou (2002) on "Clementine" mandarin, who reported that the highest scion/stock trunk girth ratio was found with Sour orange and Carrizo citrange as compared with "Swingle" citrumelo, without significant difference. Moreover, Georgiou and Gregoriou (1999) on "Shamouti" orange, and Georgiou (2000) on "Nova" mandarin reported that the highest scion/stock girth ratio was found with Sour orange followed by Carrizo citrange and "Swingle" citrumelo, without significant differences between Carrizo and "Swingle" citrumelo. In addition, Hassan *et al.* (2000) mentioned that scion/stock trunk girth ratio of Valencia orange trees was higher on Sour orange rootstock followed by Cleopatra mandarin one.

II - Yield

In the 5th YAP, trees on Carrizo citrange produced a significant higher yield (22.6 t/fed) than those on all other rootstocks (76.56%, 34.52% and 15.31% over those on Cleopatra mandarin, Sour orange and "Swingle" citrumelo, respectively). The lowest yield (12.8 t/fed) was recorded for trees on Cleopatra mandarin, while trees on Sour orange and "Swingle" citrumelo were in between, with significant differences among them. In the 6th YAP, trees on Carrizo citrange and Cleopatra mandarin didn't significantly differ in yield, and produced the highest yield (21.7 and 21.3 t/fed, respectively), while those on Sour orange and "Swingle" citrumelo produced the lowest yields and the difference between them was insignificant (Table 2).

The average yield of the two seasons, either per tree or per feddan (Table 2) confirm the obtained data in the 5th YAP, whereas the trees grafted on Carrizo citrange had the highest average yield (29.51%, 24.55% and 13.55% over those on Cleopatra mandarin, Sour orange and "Swingle" citrumelo, respectively). However, trees on Cleopatra mandarin and Sour orange had the lowest average yield (17.1 and 17.8 t/fed, respectively), while the trees on "Swingle" citrumelo were in between these two extremes.

These results are agreed with those of the previous works, where the trees budded on "Swingle" citrumelo rootstock promoted higher yield than those on Cleopatra mandarin (Verdú, 1993 on "Clemenules" clementine, Zekri, 1997 on "Ambersweet" mandarin). Similar results were also obtained by Tuzcu *et al.* (2004), who reported that W. Navel orange trees grafted on Carrizo citrange produced the highest fruit yield and the lowest one was on Cleopatra mandarin; Al-Jaleel and Zekri (2004), also found that orange trees on Carrizo citrange were most productive than those on Cleopatra mandarin and "Swingle" citrumelo. In addition, Kaplankiran *et al.* (2005) on 'Okitsu' Satsuma and Demirkeser *et al.* (2005) on Valencia orange cleared that the highest yielding rootstock was Carrizo citrange, while Sour orange was the lowest yielding one. In other study, Georgiou (2002) on 'Clementine' mandarin reported that accumulative yields of trees on "Swingle" citrumelo were less than those on Sour orange and Carrizo citrange. On the other hand, Filho *et al.* (2007) mentioned that fruit yield of 'Fallglo' and 'Sunburst' mandarin trees was not affected by the rootstock.

Table (2): Effect of some citrus rootstocks on fruit yield of "Hernandina" Clementine.

Stocks	Fruit yield						ABI	Yield efficiency (Kg/m³ canopy)		
	5th YAP		6th YAP		Average					
	Tree (kg)	Fed. (ton)	Tree (kg)	Fed. (ton)	Tree (kg)	Fed. (ton)	%	5th YAP	6th YAP	Average
SO	42.1 c	16.8	46.7 b	18.6	44.4 c	17.8	5.21 b	11.59 a	9.33 b	10.45 a
CC	56.5 a	22.6	54.2 a	21.7	55.3 a	22.1	2.10 b	11.57 a	8.71 bc	10.12 ab
SC	49.0 b	19.6	48.4 b	19.4	48.7 b	19.5	2.32 b	12.55 a	8.29 c	10.42 a
CM	32.1 d	12.8	53.3 a	21.3	42.7 c	17.1	24.87 a	8.75 b	10.18 a	9.45 b

Means having the same letter (s) in each column are insignificantly different at 5% level, using LSD test. SO: Sour orange; CC: Carrizo citrange; SC: "Swingle" citrumelo; CM: Cleopatra mandarin; ABI: alternate bearing index.

The variability in tree production on all rootstocks probably reflects a tendency to alternate bearing. Trees on Cleopatra mandarin showed a significant higher alternate bearing index (24.87%); while no significant differences were detected among Sour orange, Carrizo citrange and "Swingle" citrumelo in this respect (Table 2). Georgiou and Gregoriou (1999) on 'Shamouti' orange demonstrated that alternate bearing index (ABI) was not significantly differed among rootstocks; while Carrizo citrange rootstock had the lowest ABI. Also, Filho *et al.* (2007) on 'Fallglo' and 'Sunburst' mandarin found that alternate bearing was not influenced by the rootstock.

Yield efficiency: Data presented in Table 2 showed that trees budded on Cleopatra mandarin had the lowest yield efficiency in the 5th YAP, but had the highest one in the 6th YAP, and this may be due to the higher alternate bearing. Trees budded on Sour orange, Carrizo citrange and "Swingle" citrumelo produced almost similar significant yield efficiency in both seasons, except in the 6th YAP in which the trees on Sour orange were significantly higher than those on "Swingle" citrumelo.

The average yield efficiency of two seasons showed that trees budded on Cleopatra mandarin had the lowest one; despite no significantly differed than those on Carrizo citrange. On the other hand, trees budded on Sour orange, Carrizo citrange and "Swingle" citrumelo show no significant differences among them.

In this respect Georgiou and Gregoriou (1999) on "Shamouti" orange and Georgiou (2002) on "Clementine" mandarin found that Sour orange, Carrizo citrange and "Swingle" citrumelo produced almost equal yield efficiency. In addition, Forner-Giner *et al.* (2003) on "Navelina" orange reported that trees on Carrizo and Cleopatra had similar yield efficiency and Filho *et al.* (2007) stated that "Sunburst" mandarin trees did not show any differences regarding to rootstocks for this variable.

III- Fruit quality

Fruit weight, volume, gravity, dimensions and shape were not significantly affected by rootstocks in both seasons of this study (Table 3). These results are in agreement with those of Gregoriou and Economides (1993) on "Ortanique" tangor, Georgiou and Gregoriou (1999) on "Shamouti" orange and Georgiou (2002) on "Clementine" mandarin, who reported that trees on Sour orange, Carrizo citrange and "Swingle" citrumelo produced similar fruits in weight and size. Also, Tuzcu *et al.* (2004) mentioned that the fruit weight of W. Navel orange on Sour orange was similar to that on Carrizo citrange and Cleopatra mandarin and Filho *et al.* (2007) found that fruit weight of 'Fallglo' mandarin was not affected by the rootstock. On the other hand, Georgiou (2000) on 'Nova' mandarin and Ali (2002) on 'Fremont' tangerine declared that the trees on Sour orange produced smaller and lighter fruit than those on Carrizo citrange and "Swingle" citrumelo.

Fruit colour (Hue angle), firmness, peel thickness and percentage and juice content: All these parameters showed no significant differences among rootstocks in both seasons of this study (Table 3). These results confirmed the results of Gregoriou and Economides (1993), who mentioned

that the fruit peel thickness and juice content of 'Ortanique' tangor showed no significant differences as affected by Sour orange, Carrizo citrange and "Swingle" citrumelo rootstocks. Similar trend was found by Tuzcu *et al.* (2004), who stated that the fruits of W. Navel orange from trees on Sour orange, Carrizo citrange and Cleopatra mandarin showed no significant differences in their juice content. Moreover, García-Sánchez *et al.* (2006) reported that peel thickness was not influenced by the rootstock. In addition, Filho, *et al.* (2007) mentioned that fruit juice content of 'Fallaglo' and 'Sunburst' mandarin was not affected by the rootstock, although García-Sánchez *et al.* (2006) found that fruits of 'Clemenules' mandarin on Carrizo citrange had higher juice percentage and lower peel percentage than those on Cleopatra mandarin. On the other hand, Tuzcu *et al.* (1999) on W. Navel orange, found that fruits with good colour were produced on citrange and mandarin rootstocks, while for Shamouti orange, fruits with the best colour were produced on citrange rootstock, and García-Sánchez *et al.* (2006) stated that trees of 'Clemenules' clementine on Carrizo citrange produced fruits with higher external colour index than those on Cleopatra mandarin. In the contrary; Ali (2002) mentioned that Fremont tangerine fruits on Sour orange had the best rind colour in comparison with those on Carrizo citrange.

Concerning SSC, the fruits from trees budded on Sour orange had the lowest SSC as compared with those on other rootstocks, while those from trees budded on Carrizo citrange showed the highest SSC in both seasons. The fruits from trees budded on "Swingle" citrumelo were higher in its content of SSC than those from trees budded on Cleopatra mandarin in the first season, but were similar in the second one and significantly higher than those from trees budded on Sour orange in both seasons (Table 3). These results are in concordance with those of Verdú (1993), who found that the Clemenules fruits on Cleopatra mandarin had SSC higher than those on Sour orange; El-Shafee (1999); Ali (2002) on Fremont tangerine and Tuzco *et al.* (2004) on W. Navel who stated that fruits on Carrizo citrange recorded the highest SSC. In the contrary, the trees grafted on Sour orange produced the highest SSC as compared with those on Carrizo citrange and "Swingle" citrumelo (Gregoriou and Economides, 1993 on "Ortanique" tangor); on Cleopatra mandarin and Carrizo citrange (Alirezanezhad and Ramin, 2004, on Grapefruit) and on Carrizo citrange (Kaplankiran *et al.*, 2005 on "Okitsu" Satsuma).

Juice acidity percentage: The highest percentage of juice acidity was showed by fruits from trees on Sour orange as compared with that on the other rootstocks in both seasons. Fruits from trees budded on Cleopatra mandarin contained a significantly higher acidity than those on "Swingle" citrumelo in the first season, but they were similar in the second one. No significant differences were detected between Carrizo citrange and "Swingle" citrumelo in this respect, in both seasons (Table 3).

Table (3): Effect of some citrus rootstocks on fruit quality of "Hernandina" Clementine.

Fruit properties	Rootstocks			
	Sour orange	Carrizo citrange	Swingle citrumelo	Cleopatra mandarin
2004/2005 season (5th YAP)				
Fruit weight (g)	145.8 a	145.8 a	135.4 a	141.7 a
Fruit volume (cm^3)	150.8 a	156.1 a	146.5 a	145.3 a
Fruit gravity (g/cm^3)	0.97 a	0.93 a	0.93 a	0.97 a
Fruit diameter (cm)	6.8 a	6.9 a	6.3 a	6.8 a
Fruit height (cm)	6.5 a	6.7 a	6.0 a	6.6 a
D/H	1.05 a	1.03 a	1.05 a	1.03 a
Hue angle	67.7 a	64.9 a	64.1 a	62.3 a
Lightness	57.1 a	56.1 a	54.1 a	56.0 a
Fruit firmness (g/cm^3)	106.0 a	94.9 a	101.9 a	106.6 a
Peel thickness (mm)	2.10 a	2.23 a	2.13 a	2.25 a
Peel (%)	20.4 a	18.5 a	19.0 a	22.2 a
Juice (%)	48.8 a	48.0 a	47.1 a	48.3 a
SSC (%)	10.2 c	11.1 a	11.2 a	10.9 b
Acidity (%)	0.83 a	0.70 bc	0.65 c	0.72 b
SSC/TA ratio	12.3 c	15.9 ab	17.7 a	15.2 b
Ascorbic acid (mg/100 ml juice)	19.49 a	19.76 a	19.31 a	17.09 a
2005/2006 season (6th YAP)				
Fruit weight (g)	119.3 a	136.1 a	113.9 a	129.0 a
Fruit volume (cm^3)	140.8 a	161.7 a	136.0 a	150.7 a
Fruit gravity (g/cm^3)	0.85 a	0.84 a	0.84 a	0.86 a
Fruit diameter (cm)	6.4 a	6.8 a	6.4 a	6.3 a
Fruit height (cm)	5.8 a	6.1 a	5.7 a	5.8 a
D/H	1.10 a	1.12 a	1.12 a	1.09 a
Hue angle	68.8 a	63.0 a	64.7 a	66.1 a
Lightness	45.8 a	50.8 a	47.9 a	49.6 a
Fruit firmness (g/cm^3)	104.5 a	100.9 a	97.5 a	99.1 a
Peel thickness (mm)	2.17 a	2.19a	2.19 a	2.18a
Peel (%)	19.9 a	20.5 a	21.3 a	21.3 a
Juice (%)	48.8 a	48.0 a	47.1 a	48.3 a
SSC (%)	11.5 c	12.3 a	11.9 b	11.8 b
Acidity (%)	0.72 a	0.63 b	0.63 b	0.66 b
SSC/TA ratio	16.0 c	19.6 a	19.1 a	18.0 b
Ascorbic acid (mg/100 ml juice)	21.60 b	24.00 a	21.69 b	23.27 a

Means having the same letter (s) in each row are insignificantly different at 5% level, using LSD test.

In this respect, Ali (2002) on Fremont tangerine found that the lowest percentage of juice acidity was found on Carrizo citrange in the first season and on Sour orange in the second one. In the contrary, Verdú (1993) found that fruits of "Clemenules" mandarin on "Swingle" citrumelo and Cleopatra mandarin rootstocks had higher acidity than those on Sour orange. On the

other hand, the results of El-Shafee (1999) on Fremont tangerine; Tuzcu *et al.* (2004) on W. Navel orange; Demirkeser *et al.* (2005) on 'Valencia' orange; Kaplankiran *et al.* (2005) on 'Okitsu' Satsuma mandarin and García-Sánchez *et al.* (2006) on 'Clemenules' mandarin demonstrated that the effects of the rootstocks on fruit juice acidity were not significant.

SSC/acid ratio (maturity index): The lowest maturity index was achieved by fruits from trees grafted on Sour orange as compared with those on the other rootstocks in both seasons (Table 3). The highest maturity index was clear in fruits from trees on Carrizo citrange and "Swingle" citrumelo rootstocks without significant differences between them in both seasons, while Cleopatra mandarin came in between these two extremes.

In this regard, Ali (2002) on Fremont tangerine found that the highest values of SSC/acid ratio were found on Carrizo citrange in the first season only; and García-Sánchez *et al.* (2006) reported that trees of Clemenules mandarin on Carrizo citrange produced fruits with a higher maturity index than those on Cleopatra mandarin. On the other hand, Currie *et al.* (2000) on “Miyagawa” Satsuma mandarin; Tuzcu *et al.* (2004) on W. Navel orange; Demirkeser *et al.* (2005) on 'Valencia' orange; and Kaplankiran *et al.* (2005) on 'Okitsu' Satsuma mandarin reported that the effects of rootstocks on SSC/acid ratio were not statistically significant.

Ascorbic acid juice content: No significant differences were found among the studied rootstocks in this respect in the 5th YAP; while in the 6th YAP the fruits from trees grow on Sour orange and "Swingle" citrumelo contained a significant lower ascorbic acid than those from trees grafted on Carrizo citrange and Cleopatra mandarin (Table 3).

Conclusion:

The results of this investigation showed that the rootstock had clear effect on tree size, yield, and fruit quality of 'Hernandina' clementine. Trees of 'Hernandina' clementine budded on Carrizo citrange had higher growth parameters and yield than those on the other rootstocks, and earlier in fruit maturity, with good affinity. Sour orange rootstock produced lower yield and retarded the fruit maturity. Considering all parameters; Carrizo citrange and Cleopatra mandarin can be considered the most promising rootstocks for 'Hernandina' clementine under the Egyptian conditions.

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تقييم سلوك اليوسفي كليمنتين "إرناندينا" على بعض أصول الموالح في زراعات عالية الكثافة

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يهدف هذا البحث إلى تحديد الأصل الأكثر ملائمة لليوسفي كليمنتين صنف "إرناندينا" حديث الزراعة في مصر. أجريت هذه الدراسة في مزرعة خاصة بمنطقة وادي الملاك بمحافظة الإسماعيلية باستخدام أربعة أصول موالح هي: النارنج (الأصل الأكثر شيوعا في مصر) - يوسفي كليوباترا - كاريزو سترانج - سوينجل سترويلو خلال موسمي ٢٠٠٤/٢٠٠٥ و ٢٠٠٥/٢٠٠٦, حيث تمت زراعة شتلات متجانسة مطعومة بهذا الصنف عمر سنة من كل أصل في الأرض المستديمة في شهر مارس ١٩٩٩ على مسافة ٢×٥ م تحت نظام الري بالتنقيط وقد خضعت جميع الأشجار لنفس المعاملات الزراعية.

في العام الخامس والسادس بعد الزراعة تم انتخاب ١٢ شجرة مطعومة على كل أصل من الأصول المختارة في تصميم قطاعات عشوائية كاملة (٣ مكررات كل منها ٤ أشجار) لإجراء هذه الدراسة.

وكانت أهم النتائج المتحصل عليها هي:

- أعطت الأشجار المطعومة على أصل الكاريزو سترانج أعلى مؤشرات للنمو الخضري (محيط وقطر النمو الخضري - حجم الشجرة) مقارنة بالأشجار المطعومة على كل من أصل النارنج والسترويلو واليوسفي كليوباترا، فيما عدا إرتفاع الشجرة والذى كان مماثلا للأشجار المطعومة على الأصول الأخرى (عدا أصل النارنج والذي كان أقل إرتفاعا). ومن حيث درجة التوافق بين هذا الصنف والأصول تحت الدراسة ، فقد وجد أن النارنج والكاريزو واليوسفي كليوباترا كانت متماثلة في هذا الشأن بينما لوحظت أقل درجة توافق مع أصل السترويلو.
- أشجار اليوسفي كليمنتين "إرناندينا" المطعومة على أصل الكاريزو سترانج أعطت أعلى محصول (٢٢.٦ و ٢١,٧ طن/فدان في كلا الموسمين على التوالي) مقارنة بالأشجار المطعومة على الأصول الأخرى تحت الدراسة. كما أعطت هذه الأشجار أعلى متوسط محصول في سنتي الدراسة (٢٩,٥١% و ٢٤,٥٥% و ١٣,٥٥% أعلى من الأشجار المطعومة على كل من اليوسفي كليوباترا والنارنج والسترويلو على التوالي)؛ من ناحية أخرى فقد أظهرت الأشجار المطعومة على أصل اليوسفي كليوباترا أعلى نسبة من تبادل الحمل (٢٤,٨٧%) مقارنة بالأشجار المطعومة على الأصول الأخرى.
- وجد أن معظم صفات جودة الثمار (الوزن – الحجم – الكثافة – الأبعاد – الشكل – اللون – الصلابة – سمك القشرة - نسبة العصير) لم تتأثر بنوع الأصل, بينما المحتوى من المواد الصلبة الذائبة الكلية والحموضة ونسبة المواد الصلبة الذائبة الكلية/الحموضة (مؤشر النضج) وحامض الأسكوربيك قد تأثرت معنويا بنوع الأصل؛ فالثمار المأخوذة من الأشجار المطعومة على أصل الكاريزو سترانج كانت هي الأعلى في محتواها من المواد الصلبة الذائبة الكلية, بينما كانت الثمار المأخوذة من الأشجار المطعومة على أصل النارنج منخفضة في محتواها من المواد الصلبة الذائبة الكلية وعالية الحموضة. وظهر أن أقل مؤشر نضج كان في ثمار الأشجار المطعومة على أصل النارنج مقارنة بالأصول الأخرى, بينما أعلى مؤشر نضج كان مع الثمار المأخوذة من الأشجار المطعومة على كل من أصل الكاريزو سترانج وسوينجل سترويلو.

على ضوء النتائج المتحصل عليها تحت ظروف هذه الدراسة ومع الأخذ في الاعتبار كل من معدل نمو الأشجار والتوافق بين الأصل والطعم والمحصول وجودة الثمار فإن أصل الكاريزو سترانج واليوسفي كليوباترا يمكن اعتبارهما من الأصول الواعدة لأشجار اليوسفي كليمنتين "ايرناندينا" تحت ظروف منطقة التل الكبير بمحافظة الإسماعيلية.