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# EFFECT OF FOUR CITRUS ROOTSTOCKS ON GROWTH, FLOWERING, YIELD AND FRUIT QUALITY OF VALENCIA ORANGE CULTIVAR

BY

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## ABSTRACT

The present study was carried out during seasons of 2001 and 2002, to evaluate Valencia orange (*C. Sinensis* L. Osbeck) trees budded on four citrus rootstocks, i.e. Cleopatra mandarin (C.M.), Sour orange (S.O.), Rangpur lime (R.L.) and Volkamer lemon (V.L.). The experimental trees were grown in a newly reclaimed sandy soil at the orchard of EL-Kassasin Horticulture Research Station, Ismaila Governorate Egypt. The evaluation programe considered the major characteristics of vegetative growth, scion projection area, root spread area and their ratio, yield and fruit quality. The considered parameters were mostly of significant responses among Valencia orange cv. and the four studied rootstocks. The study proved the superiority of Volkamer lemon rootstock for Valancia orange trees, as compared with the other tested rootstocks. On the contrary, Rangpur lime rootstock seemed to be the worst one for Valencia orange trees under the experimental conditions.

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**Keywords**: Citrus rootstocks (Cleopatra mandarin, Sour orange, Rangpur lime and Volkamer lemon)-Valencia orange cv.-Vegetative growth-Yield-Fruit quality.

## INTRODUCTION

It is well known that rootstock greatly affect numcrous growth and fruiting parameters of the borne cultivar. In this concern the change in canopy diameter and plant height for Persian lime, was more vigorous in trees on *C. volkameriana* than those on Cleopatra mandarin (Valbuena, 1996). Abo El-Komsan (1998) found that Rough lemon and Sour orange rootstocks were the best compatible for Ruby, Marsh and Thompson grapefruit cultivars. Iriarte-Martel *et al.*, (1999) and Ibrahim, (2000) found that the greatest tree height and canopy volumes of Balady mandarin and Valencia orange were obtained with Cleopatra mandarin and *C. volkameriana* rootstocks.

Abd alla *et al.*, (1978) found that fruits of Washington Navel orange trees on Sour orange had the highest juice vitamin C. than those on Rough lemon and baladi lime. Baldry *et al.*, (1982) found that fruits of Valencia orange trees on

*C. volkameriana* had lower ascorbic acid content. Monteverde *et al.*, (1988) found that *C. volkameriana* induced the best mean fruit weight for Valencia orange.. Monteverde (1989) reported that the smallest fruits of Valencia orange were produced on Cleopatra mandarin rootstock, and that juice percentage of Valencia orange was high on Cleopatra mandarin and *C. volkameriana*. Whereas, the T.S.S. / acid ratio of Valencia orange was high on *C. volkameriana*, Sour orange, Cleopatra mandarin and Carrizo citrange. Gregoriau and Economides (1994) noticed that the cumulative yields of Valencia orange trees on Raugh lemon and *C. Volkamerima* rootstocks were significantly higher than those of trees on the other rootstocks. They added that rootstock had no enough effects on fruit quality. Tuzcu *et al.*, (1999) noted that the highest yields of Washington Navel orange were obtained from trees on Carizzo citrange and *C. volkameriana*, while both the citranges positively affected fruit quality. *C. volkameriana*, Sour orange and *C. junos* all negatively affected fruit quality. In Moro blood orange, the best yields were obtained from trees on *C. volkameriana*, while the best fruit quality was obtained from trees on the citranges. Sour orange and *C. junos* negatively affected both yield and fruit quality of Moro blood orange.

Thus, the present study dealt with the effect of four citrus rootstocks i.e C.M., S.O., R.L. and V.L. on growth, compatibility %, flowering habit, yield and fruit quality of the Valencia orange cv. through 2001 & 2002 seasons.

## MATERIALS AND METHODS

**General consideration:**

The present study was carried out in Kassasine Horticulture Research Station, Ismailia Governorate, Egypt during 2001/2002 and 2002 / 2003 seasons. Nine-years-old Valencia orange (V.O.) *(Citrus sinensis L.* Osbeck) trees, budded on 4 citrus rootstocks namely: Cleopatra mandarin (C.M.) *(Citrus reticulata*, Blanco); Sour orange (S.O.) (*Citrus aurantium* Lime.); Rangpur lime (R.L) (*Citrus limonia*, Osbeck) and Volkamer lemon (V.L.) (*Citrus volkameriana*, Tan & Pesq.). Trees were planted in a newly reclaimed sandy soil (Soil and irrigation water analysis are presented in table (1) (A, B, C and D) in September 1994, at 5m apart and they received the same traditional horticulture practices including, fertilization, irrigation, pruning and pest control.

However, the present experiment comprises V.O. cv. and 4 rootstoks where each combination was replicated three times with 3 trees for each replicate. Thus, 36 trees of V.O. cv. budded on 4 different rootstock, were experimented in a complete randomized block design.

**Morphological characteristics:**

**Tree vigour measurements:**

In February and November of each season, the following measurements were carried out: Tree height (m); canopy diameter (m) (average in- row and cross- row diameter); canopy circumference(m), tree canopy volume ($m^3$) (calculated according to the equation reported by Morse and Robertson (1987). Canopy volume= 0.5236 x HD2, Where H= tree height (m) and D = canopy

diameter (m). Trunk circumference was measured at 5 cm above and below the bud union and used to calculate the scion / rootstock circumference ratio (Compatibility %).

**Mutual effect between scion and rootstocks on canopy area, root system area, canopy area / root system area ratio, scion fresh weight and scion dry weight.**

In Feb. of the 1st growing season and Nov. in the 2nd growing one, three trees from each scion / rootstock combination, were utilized.

Horizontal spread (in meters) of scion canopy and root system of the studied rootstocks were measured in 8 directions and the average was considered as a diameter of tree canopy projection area. Root system horizontally spread from the trunk of the studied trees were measured in 8 directions and the average was considered as a diameter of a circle in which the roots were spread. Thereafter, the ratio between scion canopy area and root system spread area was calculated in Nov.2002. In addition, the scion canopy fresh weight and dry weight were determined in the same date.

**Vegetative growth flushes:**

The current growth cycles which developed on the studied trees throughout the season were counted every year to compare the intensity of vegetative growth between spring (March-May), summer (June-August) and autumn (September-November) flushes.

**Flowering period, yield and fruit quality:**

**Flowering:**

In both seasons, dates of beginning, full and ending of blooming for each tree were recorded. Also duration of bloom /day was calculated.

**Yield**:

Yield as fruits weight / tree was recorded at the harvesting time in both seasons (the third week of January in the first season (2002), and the fourth week of January in the second season (2003).

**Fruit quality:**

A sample of 25 fruits of each individual tree was taken randomly at harvesting time to determine the physical and chemical properties as follows:

**Fruit physical properties:**

1 Fruit weight (g).
2 Pulp weight (g).
3 Fruit height and diameter (cm) using a vernier callipper.
4 Fruit shape inedex: as height / diameter ratio.
5 Peel thickness (mm) using a vernier callipper
6 Juice volume (ml per fruit).

**Fruit chemical properties.**

1. **Total soluble solids percentage** (T.S.S. %) was determined by using karl zeiss hand refractometer.
2. **Total acidity percentage:** was determined in fruit juice as percentage of anhydrous citric acid by titration with standard 0.01 N sodium hydroxid solution and phenolphthalein 1% as indicator according to A.O.A.C. (1984).
3. **Total soluble solids / acid ratio:**
4. **Ascorbic acid (Vitamin c) content:** was determined by using 2, 6 - dichlorophenol indophenol and 2% oxalic acid. Ascorbic acid was calculated as milligrams per 100 ml of juice (A.O.A.C.1984).
5. **Statistical analysis:** The obtained results were statistically analysed using analysis of variance and Duncan's multiple range tested was used to differentiate means Snedecor and Cochran (1980).

## RASULTS AND DISCUSSIONS

**Effect of different citrus rootstocks on some morphological characteristics of scion:**

**Tree height**:

Table (1) reveals that in 1st season Volkamer lemon (V.L.) rootstock induced the tallest trees (2.01 & 2.26 m) in Feb. and Nov. respectively, followed by those on Rangpur lime (R.L.) rootstock (1.93 & 2.15 m). Whereas the shortest trees were produced by both Sour orange (S.O.) rootstock (1.84 & 2.07m), and Cleopatera mandarin (C.M.) rootstock (1.83 & 2.01 m) in Feb. and Nov. respectively.

Concerning, the second season, V.L.(2.32 & 2.44m) and R.L. (2.25 & 2.38 m) rootstocks had recorded the tallest trees in Feb. and Nov., respectively. Whereas S.O.(2.11 & 2.29) and C.M.(2.15 & 2.23) rootstocks had induced the shortest trees of V.O. trees in Feb. and Nov. respectively.

**Canopy diameter:**

The highest canopy diameter of V.O. trees was recorded on V.L. rootstock (2.15 & 2.31 m) in Feb. and Nov. in the First season, respectively, followed by those on R.L. rootstock (2.04 & 2.19). Whereas, the smallest canopy diameter was shown on S.O. rootstock (1.87 & 2.06 m) in Feb. and Nov. respectively.

In the second season, the greatest canopy diameter of V.O. trees was recorded on V.L. rootstock (2.38 & 2.48 m) in Feb. and Nov. respectively, followed by those on R.L. rootstock.(2.24 & 2.36). Whereas, the smallest canopy diameter was shown on S.O. rootstock (2.14 & 2.28 m) in Feb. and Nov. respectively.

**Canopy circumference:**

The data showed that the highest canopy circumference of V.O. trees was shown on V.L. (6.96 & 6.86m). and R.L. (6.43 & 6.58) rootstocks in Feb. and Nov., respectively, whereas the lowest canopy circumference was found on S.O. (5.66 & 5.80 m) and C.M. (5.92 & 6.03 m) rootstocks in Feb. and Nov. in the first season.

Table (1) : Soil and irrigation water analyses of the experimental orchard:

A. Soil mechanical analysis, $CaCo_3$%, organic matter, EC ( mmhos /cm) and pH.

| Soil depth | Soil mechanical analysis | | | Soil texture | $CaCo_3$ % | Organic matter % | EC Mmhos /cm | PH |
|---|---|---|---|---|---|---|---|---|
| ( cm ) | Sand % | Clay % | Silt % | | | | | |
| 0-30 cm | 83 | 14 | 3 | Sand | 2 | 0.16 | 0.42 | 7.9 |
| 30-60cm | 90 | 9 | 1 | Sand | 1.7 | 0.13 | 0.39 | 8.6 |
| 60-90cm | 94 | 5 | 1 | Sand | 1.6 | 0.07 | 0.37 | 8.9 |

B. Soil soluble ions, m. meq /L.

| Soil depth | Cations ( meq. / L ) | | | | Anions (meq. / L) | | | |
|---|---|---|---|---|---|---|---|---|
| (cm) | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $SO_4^{=}$ | $Cl^{-}$ | $HCO_3^{-}$ | $CO_3^{=}$ |
| 0-30 cm | 0.6 | 0.7 | 0.41 | 0.18 | 0.98 | 0.75 | 0.24 | 0 |
| 30-60cm | 0.8 | 0.5 | 1.09 | 0.11 | 0.82 | 0.80 | 0.40 | 0 |
| 60-90 cm | 0.7 | 0.3 | 0.87 | 0.12 | 1.00 | 0.60 | 0.90 | 0 |

C. Soil macro and micronutrients content :

| Soil depth | ( meq / L ) | | | | | |
|---|---|---|---|---|---|---|
| (cm) | N | P | K | Fe | Zn | Mn |
| 0-30 cm | 54 | 4 | 80 | 1.4 | 0.11 | 0.61 |
| 30-60 cm | 29 | 2 | 88 | 1.6 | 0.03 | 0.54 |
| 60-90 cm | 18 | 3 | 112 | 1.5 | 0.02 | 0.60 |

D . Chemical analysis of the irrigation water .

| pH | E.C. | Salinity | Cations m.eq./L | | | | Anions (meq./L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | m.mohs/cm | PP$^{m}$ | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $SO_4^{=}$ | $Cl^{-}$ | $HCO_3^{-}$ | $CO_3^{=}$ |
| 7.5 | 1.12 | 716.8 | 3.2 | 1 | 1.32 | 0.22 | 0.27 | 0.82 | 0.21 | 0.0 |

In the second season, the highest canopy circumference of V.O. trees was recorded on V.L.(6.98 & 7.12m) and R.L. (6.66 & 6.78 m) rootstocks in Feb. and Nov. respectively. Whereas the lowest canopy circumference was noticed on S.O. (5.89 & 6.06 m) and C.M. (6.13 & 6.56 m) rootstocks in Feb. and Nov. in the second season.

**Canopy volume ($m^3$):**

Results cleared that, V.L. rootstock induced the significantly largest canopy volume of V.O. trees (4.86 & 6.13 $m^3$) in Feb. and Nov., respectively in the first season as compared with other tested rootstocks. Whereas, the smallest canopy volume were produced on both C.M. (3.64 & 4.77$m^3$) and S. O. (3.36 & 4.59 $m^3$) rootstock in Feb. and Nov., respectively in the first season,. In the second season, the highest canopy volume was recorded by V.L. (6.88 & 7.85$m^3$) rootstocks. Whereas the lowest canopy volume was resulted by S.O. (5.05 & 6.23 $m^3$) and C.M. (5.25 & 5.90 $m^3$) rootstocks.

**Scion / rootstock compatibility percent:**

In the first season, V.O. trees had significantly higher compatibility percentage on both V.L. (94.32 & 95.79 %) and S.O. (93.74 & 94.362%) rootstocks in Feb. and Nov., respectively compared with those budded on C.M. which gave the lowest significant compatibility percentage (88.75 & 89.10 %) in Feb. and Nov. respectively.

In the second season, V.L rootstock showed the highest compatibility percentage (96.18 & 96.73%) in Feb. and Nov., respectively without significant difference than S.O. (94.68 & 95.33 %) in Nov. only. While the lowest compatibility percentage was recorded by both. C.M. (91.26 & 92.59%) and R.L. (92.90 & 93.47 %) rootstocks in Feb. and Nov.

The obtained findings are in agreement with those reported by Valbuena (1996) that *C. Volkmeriana* was generally considered the best rootstocks for Valencia orange in terms of tree height, canopy volume and cropping

**Canopy area ($m^2$):**

As shown in table (2) the canopy area of V.O. trees was significantly highest on V.L. rootstock (3.62 & 4.83 $m^2$) in the first and second seasons without significant differences than R.L. rootstock (3.26 $m^2$) in the first seasons only. The smallest canopy area of V.O. trees was recorded on S.O. rootstock (2.74 & 4.08 $m^2$) in the first and second seasons, respectively.

**Root system spread area ($m^2$):**

Data revealed that, V.L. rootstock recorded the significantly highest root spread area (6.96 & 7.98 $m^2$) in the first and second seasons, respectively. But C.M. rootstock recorded the lowest roots spread area (4.78 & 6.02 $m^2$) in the two seasons, without significant differences than R.L. (5.10 & 6.60 $m^2$) rootstock in the first season only. While S.O. rootstock came inbetween (6.01 & 7.22 $m^2$) in the two tested seasons.

**Canopy/ root system area ratio:**

Concerning canopy/ roots area ratio for V.O. trees, it is obvious that R.L. rootstock induced the highest canopy / roots area ratio (63.92 & 66.21%) in the first season, and C.M. rootstock recorded the greatest ratio (62.34 & 68.94 %) in the second season without significantly differences between them in the two studied seasons. While the lowest canopy / roots area ratio recorded by S.O. rootstock (45.59 & 56.51%) in the first and second seasons, respectively without significant differences than V.L. rootstock (52.01 & 60.53%) in both seasons.

**Scion fresh weight (kg):**

Results indicated that V.O. trees on V.L. rootstock showed the significantly highest scion fresh weight (19.67 kg) without significant differences than R.L. rootstock (19.33 kg) as compared with other tested rootstocks. Whereas, C.M. rootstock produced the significantly lowest scion fresh weight (15.01 kg) as compared with other tested rootstocks.

**Scion dry weight (kg):**

V.L. rootstock induced the significantly highest scion dry weight (11.45 kg) as compared with other tested rootstock except R.L. rootstock (11.07kg). Whereas C.M. rootstock produced the significantly lowest scion dry weight (9.22 kg) compared with other tested rootstocks.

The obtained findings are in agreement with those reported by Valbuena (1996) that *C. volkameriana* was generally considered the best rootstock for Valencia orange in terms of tree growth and cropping.

**Vegetative growth Flushes**:

Data in table (3) clear the effect of some citrus rootstocks on the number of shoots/tree in different vegetative growth flushes of Valencia orange trees in 2001 and 2002 seasons. The tested citrus rootstocks and growth flushes significantly affected shoots number per tree in the two experimental seasons.

Concerning the first season, it is obvious that the highest shoots number per tree (89.67) was recorded on V.L. rootstock followed by those on R.L. (89.22) without significant difference between them. The lowest shoots number per tree (73.11 & 75.05) was gained on C.M. and S.O. rootstocks, respectively without significant difference between them and regardless of growth flush.

As for the effect of growth flush, one can noticed that the highest shoots number per tree (140.67) was recorded for spring flush, whereas the significantly lowest number (45.09) was deteted for autumn flush. While summer flush shoots number per tree (59.54) came in-between regardless of rootstock.

The interaction between the used rootstocks and growth flushes was significant in most cases during the first season., and it could be noticed that R.L. rootstock with spring flush (154.67) achieved the significantly highest shoots number per/ tree, opposite to S.O. rootstock in autumn flush.

**Table (2) : Effect of different citrus rootstocks on some morphological characteristics (Tree height , Canopy diameter , Canopy circumference , Canopy Volume and compatibility(%) of Valencia orange tree in 2001 and 2002 seasons .**

| Rootstocks / Characteristics | Tree height ( m) | | | | Canopy diameter (m) | | | | Canopy circumference (m) | | | | Canopy Volume ( m3) | | | | compatibility (%)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2001 | | 2002 | | 2001 | | 2002 | | 2001 | | 2002 | | 2001 | | 2002 | | 2001 | | 2002 | |
| | Feb. | Nov. | Feb. | Nov. | Feb. | Nov. | Feb. | Nov. | Feb. | Nov. | Feb. | Nov. | Feb. | Nov. | Feb. | Nov. | Feb. | Nov. | Feb. | Nov. |
| C. M. | 1.83A | 2.01A | 2.15A | 2.23A | 1.95AB | 2.13AB | 2.16A | 2.29A | 5.92A | 6.03AB | 6.13A | 6.56B | 3.64AB | 4.77A | 5.25A | 5.90A | 88.75A | 89.10A | 91.26A | 92.59BA |
| S.O. | 1.84A | 2.07AB | 2.11A | 2.29AB | 1.87A | 2.06A | 2.14A | 2.28A | 5.66A | 5.80A | 5.89A | 6.06A | 3.36A | 4.59A | 5.05A | 6.23A | 93.74 B | 94.62BC | 94.68B | 95.33 BC |
| R. L. | 1.93AB | 2.15BC | 2.25BC | 2.38BC | 2.04BC | 2.19B | 2.24AB | 2.36A | 6.43B | 6.58BC | 6.66B | 6.79C | 4.21 B | 5.37AB | 5.91B | 6.94B | 93.23AB | 92.70B | 92.90A | 93.47 AB |
| V.L. | 2.01B | 2.26C | 2.32C | 2.44C | 2.15C | 3.31C | 2.38B | 2.48B | 6.69C | 6.86C | 6.98C | 7.12D | 4.86C | 6.13B | 6.88C | 7.85C | 94.32B | 95.79C | 96.18C | 96.7 BC |

**Table (3) : Mutual effect between Valencia orange scion and rootstocks on canopy area, root system area , canopy area / root system area ratio , scion fresh weight and scion dry weight in 2001 /and 2002 season .**

| Characteristics / Rootstocks | Canopy area ( m2) | | Root system area ($m^2$) | | Canopy area/ root system area ratio | | Scion fresh weight (kg) | Scion dry weight (kg) |
|---|---|---|---|---|---|---|---|---|
| | Feb. 2001 | Nov. 2002 | Feb. 2001 | Nov. 2002 | Feb. 2001 | Nov. 2002 | Nov. 2002 | Nov. 2002 |
| C.M. | 2.98AB | 4.15A | 4.78A | 6.02A | 62.34 BC | 68.94 B | 15.00 A | 9.22 A |
| S . O. | 2.74A | 4.08A | 6.01B | 7.22C | 45.59 A | 56.51 A | 17.16 B | 10.84 B |
| R . L. | 3.26BC | 4.37A | 5.10A | 6.60B | 63.92 C | 66.21 B | 19.33 CD | 11.07 CD |
| V . L. | 3.62C | 4.83B | 6.96C | 7.98D | 52.01 A | 60.53 AB | 19.67 D | 11.45 D |

Means having the same letter (s) in a column are not significant at 5 % level

C. M. = Cleopatera mandarin , S.O. = Sour orange ,R. L. = Rangpur lime , V.L. = Volkamer lemon

Regarding the effect of rootstocks in the second season, it is clear that the significantly highest shoot number per tree was found on R.L. (97.77) and V.L. (96.99) rootstocks. Whereas the significantly lowest number (82.89 & 83.91) was gained on both C.M and S.O. rootstocks, respectively.

As for the growth flush effect, data indicated that the significantly highest shoots number per tree (151.83) was recoded for spring flush, whereas the significantly lowest number was shown by both summer flush and autumn flush (59.47 & 59.88), respectively.

The interaction between the used rootstocks and growth flushes was significant in most cases during the second seasons. The significantly highest shoots number per tree was achieved by R.L. rootstock in spring flush while the significantly lowest number was recorded by S.O. rootstock in summer flush.

The obtained findings are in line with those reported by Abo-El Komsan, (1998) who working on some citrus cvs budded on different citrus rootstocks, and found that number of shoots was generally formed in the spring flush compared to those in summer and autumn.

**Effect of different citrus rootstocks on blooming characteristics:**

**Date of beginning bloom:**

Data in table (4) clear that, Sour orange rootstock considered as a control in such study, when budding V.O trees on other tested rootstocks had delayed the dates of beginning bloom than the control. Meanwhile, V.L rootstock delayed such date for V O trees by 6 & 4 days in the 1st and 2nd season, respectively. Whereas, R.L. achieved, 5 & 4 days delay. C.M rootstock resulted 1 & 2 days delay than the control in the 1st and 2nd season, respectively.

**Date of full bloom:**

Data clearly indicated that R.L rootstock delayed the data of full bloom in V.O. trees by 5 day in the 1st season but it advanced such date by one day in the 2nd one. V.L. rootstock, however, delayed the full bloom date by 4 days in the 1st reason only, whereas C.M rootstock delayed such date by one day in the second season only. The two latter rootstocks had no effect on blooming dates in the other season.

**Date of ending bloom:**

As shown in table (4) both R.L and V.L rootstocks delayed the date of ending bloom of V.O. trees in both seasons than the control (S.O rootstock) such delay were 5 & 3 days and 6 & 2 days in the 1st and 2nd seasons, respectively. On the other hand, C.M. rootstock took another trend, where it delayed the date of ending bloom by one day in the 1st seasons but it advanced such sate by one day in the 2nd one.

**Duration of bloom:**

V.O. trees budded on S.O rootstock exhibit blooming period of 20 & 19 days (fro $m^2$/4 & 30/3 to 21/4 & 17/4 in the 1st and 2nd seasons, respectively).

Both C.M. and V.L. rootstocks advanced such period in the 2nd season only by 2and 3 days, respectively and they were without effect in the 1st one. On the other hand, R.L. rootstock, delayed the full bloom period by one day in the 1st season but it advanced such period by 2 days in the 2nd one

Variations in dates of the beginning and end of bloom as well as blooming duration in different citrus species and cultivars were reported by Minessy *et al.*, (1965) who mentioned that, different citrus varieties and species differ in beginning, end and duration of bloom.

**Effect of different citrus rootstocks on yield and fruit quality of scion:**

Data in table (5) clear the effect of some citrus rootstocks on tree yield and some physical characteristics of Valencia orange fruits.

**Yield (kg / tree):**

It is evident from these results that average tree yield for V.O. trees was considerably higher on V.L. rootstock (26.23 & 30.18 kg) compared with those on C.M. rootstock (17.75 & 21.67 kg) in the first and the second seasons, respectively. In addition tree yield of V.O. on R.L. rootstock (24.75 & 29.18 kg) was significantly higher compared with those on S.O. rootstock (19.25 & 24.50 kg) in both two seasons, respectively.

The obtained results are in harmony with those found by Tuzcu *et al.*, (1994) on Washington Navel orange. They found that the highest yields were obtained from trees on *C. Volkameriana*.

**Fruit weight (gm):**

The significantly highest V.O. fruit weight was recorded on R.L. rootstock (261.6 & 251.03 gm) in the first and the second season, respectively. Whereas the significantly lowest value was shown on C.M. (214.3 & 213.01 gm).

**Pulp weight (gm):**

Sour orange rootstock induced the significantly lowest pulp weight (127.9 & 140.7 gm) compared with other rootstocks in the two seasons. Whereas V.O. fruits on R.L. rootstock recorded the significantly highest pulp weight in the first season only (164.08 gm), and without significant difference than V.L. (151.68 gm) and C.M. (150.5 gm) rootstocks in the second season only.

**Fruit height (cm):**

The greatest fruit height was recorded by V.L. (7.83 & 8.03 cm) and the lowest value was detected on C.M. (6.61 & 6.89 cm) rootstocks in the first and the second season, respectively

**Fruit diameter (cm):**

The greatest fruit diameter of V.O. fruits was recorded by those on V.L. rootstock (8.01 & 7.86 cm) in the first and second seasons, respectively. Whereas, the lowest diameter was shown by S.O. rootstock (7.43 & 7.54 cm) without significant difference than those on R.L rootstock (7.53 cm) in the second season only.

Table (4) : Effect of different citrus rootstocks on number of shoots / tree in different vegetative growth flushes of Valencia orange trees in 2001 and 2002 seasons.

| Growth flush / Rootstocks | Season 2001 | | | | Season 2002 | | | |
|---|---|---|---|---|---|---|---|---|
| | Spring | Summer | Autumn | Means | Spring | Summer | Autumn | Means |
| C. M. | 125.5de | 49.17ab | 44.67a | 73.11A | 138.33b | 51.17a | 59.17a | 82.89A |
| S.O. | 140.5ef | 46.33ab | 38.33a | 75.05A | 143.17b | 48.00a | 60.57a | 83.91A |
| R. L. | 154.67g | 61.33 b | 51.67ab | 89.22BC | 168.5b | 63.7a | 61.10a | 97.77C |
| V.L. | 142.0f | 81.33c | 45.67a | 89.67C | 157.3b | 75.00a | 58.67a | 96.99BC |
| Means | 140.67C | 59.54B | 45.09A | - | 151.83B | 59.47A | 59.88A | - |

Table (5) : Effect of different citrus rootstocks on blooming characteristics of Valencia orange trees in 2001 and 2002 seasons.

| Rootstocks | Date of begining bloom | | | | Date of full bloom | | | | Date of ending bloom | | | | Duration of bloom /day | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date | | Delay or * advance than control in days | | Date | | Delay or * advance than control in days | | Date | | Delay or * advance than control in days | | Date | | Delay or * advance than control in days | |
| | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 |
| C. M. | 1 / 4 | 28/ 3 | -1 | -2 | 10/ 4 | 4 / 4 | 0 | -1 | 20/ 4 | 18/4 | -1 | +1 | 20 | 21 | 0 | +2 |
| S.O.* | 2 / 4 | 30/ 3 | 0 | 0 | 10/ 4 | 5 / 4 | 0 | 0 | 21/ 4 | 17/4 | 0 | 0 | 20 | 19 | 0 | 0 |
| R. L. | 28/ 3 | 26/ 3 | -5 | -4 | 5 / 4 | 6 / 4 | -5 | +1 | 16/ 4 | 14/4 | -5 | -3 | 19 | 21 | -1 | +2 |
| V.L. | 27/ 3 | 26/ 3 | -6 | -4 | 6 / 4 | 5 / 4 | -4 | 0 | 15/ 4 | 15/4 | -6 | -2 | 20 | 22 | 0 | +3 |

Means having the same letter (s) in a column are not significant at 5 % level

C. M. = Cleopatera mandaria , S.O. = Sour orange , R. L. = Rangpur lime , V.L. = Volkamer lemon

*control = S.O.

**Fruit shape index:**

It is shown from the obtained results that V.O. fruits specially on R.L. and V.L. rootstocks differ in their shape from season to another. Such difference may be due to the environmental and nutritional factors rather than rootstock effect.

**Peel thickness (mm):**

The significantly highest and lowest peel thickness were recorded by V.L. (4.3 & 4.15 mm) and S.O. (3.7 & 3.65mm) rootstocks in the first and the second season, respectively.

The obtained data are in agreement with those of Monteverde (1989), who reported that fruit peel thickness of Satsuma, Valencia, orange, Parent Navel orange and grapefruit was greatest on *C.Volkameriana* compared than those on others tested rootstocks

**Juice volume (ml/ fruit):**

Fruit juice volume was significantly higher on R.L. rootstock, (114.63 & 115.75 mml) and significantly lower on S.O. rootstock (98.50 & 102.5ml) in the first and second season, respectively.

**Chemical properties of fruits:**

**Total soluble solids % (T. S.S. %):**

As shown in table (6), the significantly highest T.S.S. percentage of V.O. juice were obtained on S.O. rootstock (10.62 & 10.83 %) in both seasons respectively but the lowest values were recorded on R.L. rootstock (9.20 & 9.65 %) in the first and the second seasons, respectively.

These results are in agreement with those obtained by Monteverde (1989); who found that T.S.S. percentage of fruits from Genoa EETA lemon, Valencia orange were highest on Sour orange.

**Total acidity:**

Valencia orange fruit juice acidity percentage was significantly higher on V.L. rootstock (1.08 & 1.06 %) in the first and the second seasons, respectively. Whereas, the lowest significant juice acidity percentage were recorded by S.O. (0.99 & 1.01 %) and R.L. (1.01 & 0.99 %) rootstocks in the first and the second seasons, respectively.

**T.S.S. / acid ratio:**

T.S.S./ acid ratio in fruit juice was highly significant in those on S.O. rootstock (10.73 & 10.72 %) in the first and the second seasons, respectively. Whereas, the lowest values were recorded by those on V.L. rootstock (9.08 & 9.27 %) in the first and the second seasons, respectively.

These results are in agreement with those found by Monteverde (1989) who reported that, the T.S.S/ acid ratio of Valencia orange was high on *C .Volkameriana*, Sour orange and Cleopatera mandorin.

**Table (6) : Effect of different citrus rootstocks on tree yield and some physical characteristics of Valencia orange fruits in 2001 and 2002 seasons.**

| Character / Rootstocks | Yield / tree (Kg) | | Fruit Weight (gm) | | Pulp weight (gm) | | Fruit height (cm) | | Fruit diameter (cm) | | Fruit shape index | | Peel thickness (mm) | | Juice volume / fruit (ml) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 |
| C . M. | 17.75A | 21.67A | 214.3A | 213.01A | 141.6B | 150.5AB | 6.61A | 6.89A | 7.72B | 7.61AB | 0.85 A | 0.9 A | 3.9B | 3.81B | 107.11B | 105.0B |
| S .O. | 19.25B | 24.50 B | 219.7 A | 219.86 B | 127.9 A | 140.7 A | 7.62 CD | 7.86 AB | 7.43 A | 7.54 A | 1.02 D | 1.04 BC | 3.7 A | 3.65 A | 98.50 A | 102.5 A |
| R . L. | 24.75C | 29.18 CD | 261.6 C | 257.83 D | 164.8 D | 159.53 B | 7.54 BC | 7.93 B | 7.96 C | 7.53 A | 0.95.B | 1.05 CD | 4.1 C | 3.96 C | 114.63 D | 115.75 D |
| V . L. | 26.23D | 30.18 D | 245.5 B | 246.71 C | 149.6 C | 151.68 B | 7.83 D | 8.03 B | 8.01 D | 7.86 C | 0.97 BC | 1.02 DB | 4.3 D | 4.15 D | 111.88 C | 111.5 C |

**Table (7) : Effect of different citrus rootstocks on some fruit chemical properties of Valencia orange trees in 2001 and 2002 seasons.**

| Rootstocks | T . S . S % | | Acidity % | | T.S.S / Acid Ratio | | Ascorbic acid content mg / 100 ml juice | |
|---|---|---|---|---|---|---|---|---|
| | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 | 2001 | 2002 |
| C. M. | 9.63 A | 9.96 A | 1.02 A | 1.04 BC | 9.44 B | 9.68 A | 35.72 AB | 37.50 AB |
| S.O. | 10.62 B | 10.83 B | 0.99 A | 1.01 A | 10.73 C | 10.72 B | 40.63 C | 39.85 B |
| R. L. | 9.20 A | 9.65 A | 1.01 A | 0.99 A | 9.11 A | 9.75 AB | 34.08 A | 36.63 A |
| V.L. | 9.81 AB | 9.83 A | 1.08 B | 1.06 C | 9.08 A | 9.27 A | 36.15 B | 37.09 A |

Means having same letter (s) in a column are not significant at 5 % level.

C. M. = Cleopatera mandarin, S.O. = Sour orange, R. L. = Rangpur lime , V.L.= Volkamer lemon

**Ascorbic acid content (mg/100.ml juice):**

Valencia orange fruit Ascorbic acid content was significantly the highest from trees budded on S.O. rootstock (40.63 & 39.85). While the lowest content was recorded by R.L. rootstock (34.08 & 36.63). The difference between Ascorbic acid content for V.O. fruit on C.M. and V.L. rootstocks was insignificant. Such results are in agreement with those obtained by Abd-alla *et al.*, (1978) who found that Ascorbic acid content was highest in fruits juice of Washington Navel orange trees on Sour orange rootstock. Also the results are in harmony with that found by Baldry *et al.*, (1982) who stated that ascorbic acid content was lowest in fruit juice of Valencia orange tree on C.*Volkamarian* rootstocks.

In conclusion, one can say that, Volkamer lemon rootstock is the best and promosing rootstock for Valencia orange trees under Ismailia Governorate conditions because it achieved the tallest trees, highest canopy diameter, highest canopy circumferance, largest canopy volume, highest compatibility percentage, highest canopy area, highest root spread area, highest scion fresh weight, highest scion dry weight and shoots number per tree. Also it gained the highest average tree yield, highest fruit juice volume, greatest fruit height, greatest fruit diameter, lowest peel thickness, highest T.S.S. and highest ascorbic acid content.

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# تأثير أربعة أصول موالح على النمو والتزهير والمحصول وجودة الثمار للبرتقال الفالنشيا

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أجريت هذه الدراسة خلال موسمي ٢٠٠١، ٢٠٠٢م لتقييم أشجار البرتقال الفالنشيا المطعومة على أربعة أصول موالح هي اليوسفي كليوباترا والنارنج والليمون الرانجبور والليمون الفولكامريانا، والمنزرعة في أرض رملية حديثة الاستصلاح بمزرعة محطة بحوث البساتين بالقصاصين محافظة الإسماعيلية جمهورية مصر العربية. واعتمد برنامج التقييم على تقدير معظم صفات النمو الخضري ومساحة انتشار الجذور والنسبة بينهما. كذلك تم تقدير المحصول وجودة الثمار وكانت معظم النتائج معنوية بين طعم البرتقال الفالنشيا والأصول تحت الدراسة والتي أسفرت عن تفوق اصل الليمون الفولكامريانا كأصل للبرتقال الفالنشيا تحت ظروف محافظة الإسماعيلية مقارنة بالأصول الأخرى وعلى العكس من ذلك كان أصل الليمون الرانجبور أقل ملائمة للبرتقال الفالنشيا تحت ظروف هذه التجربة.