J. Agric. Sci. Mansoura Univ., 31 (5): 3041 - 3054, 2006

EVALUATION OF TWO CITRUS ROOTSTOCKS UNDER KAFR EL-SHEIKH CONDITIONS:
b- EVALUATING VOLKAMER LEMON "*C.Volkameriana*" AS ROOTSTOCK FOR WASHINGTON NAVEL ORANGE CULTIVAR UNDER KAFR EL-SHEIKH CONDITIONS.

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ABSTRACT

This study was carried out during 2001 and 2002 seasons on 8 – year old Washington navel orange trees budded on Volkamer lemon and Sour orange rootstocks to evaluate vegetative and root growth, Yield, Fruit quality, leaf and root mineral contents and ability of the two rootstocks to tolerate salinity, concentration of some heavy metals of root,leaf,rind,peel and juice of the fruit.

The obtained results showed that, Volkamer lemon produced the highest values of tree size, tree height, shoot length, number of leaves per shoot, trunk cross-sectional area "TCSA cm^2" and leaf area than those recorded on Sour orange rootstock.

Volkamer lemon rootstock also, produced the highest values of root growth i. e. root length, root density and root dry weight at different depths (30, 60 and 90 cm) and distances (50, 100 and 150 cm) from tree trunk comparing with those of Sour orange rootstock.

Washington navel orange tree on Volkamer lemon rootstock had lower Na and Cl ions in their leaves and roots but had higher levels of proline, carbohydrate and chlorophyll a, b and its total value than those recorded on Sour orange rootstock.

Fruit set was higher on Volkamer lemon than that on Sour orange rootstock. This result may due to fruit dropped in May, June and July on Volkamer lemon which was less than on Sour orange rootstock.

Washington navel orange on Volkamer lemon gave the highest yield as kg/tree and yield efficiency as kg/cm^2 of TCSA as well as weight kg/m^3 of tree canopy volume compared with the corresponding values on Sour orange.

The tested fruits contained higher values of TSS with less acidity(%) on Sour orange than both values on Volkamer lemon rootstock.On the other hand, fruit taken from trees on Volkamer lemon recorded higher values of fruit length, diameter, volume, weight, juice volume and rind thickness when compared with those recorded on Sour orange rootstock

Leaf N, K, Ca, Mg, Fe, Mn, Zn and Cu contents were higher on Volkamer lemon rootstock than those on Sour orange rootstock.

Root N, P, K, Fe, and Cu contents were also higher on Volkamer lemon rootstock.On the contrary root Ca, Mg, Mn and Zn values were significantly lower in concentrations on Sour orange rootstock than these on Volkamer lemon roots.

Additionally, trees on Sour orange rootstock contained higher of Pb, Cd, Se, Ni and Cr, in their leaves, roots fruit peel and fruit juice than those on Volkamer lemon rootstock.

INTRODUCTION

The rootstock is one of the most important factors to cultivate more new citrus varieties in the new reclaimed areas in Egypt. The influence of rootstock on scion was investigated by many workers. They reported results

on : (a) tree size and growth. (b) nutrients status of trees Etman (1982) and Mansour *et al.* (1993). (c) yield and fruit quality Mehrotra *et al.* (1999). (d) resistance to gummossis, treisteza and other diseases (Louzada, 1992) and (e) tolerance to drought, salinity and cold.

So, this study aimed to evaluate and compare Volkamer lemon and sour orange as rootstocks for Washington navel orange under inviromental conditions of Kafr El-Sheikh (unbudded) Seedlings of both tested roots tocks were also included in this study.

MATERIALS AND METHODS

The present study was carried out at the Experimental Farm of Sakha Agriculture Research Station, Kafr El–Sheikh Governorate during 2001 and 2002 seasons, on 8 - years old Washington navel orange trees budded on two citrus rootstocks, i.e., Volkamer lemon (*C. Volkameriana*) and Sour orange (*C. aurantium*). In addition, three seedlings trees of each stock were also included in these evaluation and comparison. The trees are grown in clay soil and spaced at 5x5 meter in a complete randomized block design with three trees plot replicated three times for a total of nine trees per rootstock. Mechanical and chemical analysis of the experimental soil was done as shown in Table (a).

Table (a): Mechanical and chemical analysis of the field soil.

Mechanical				Chemical			Available PPM			DTPA extractable PPM.				
Sand %	Silt %	Clay %	Texture	pH	EC	OM %	N	P	K	Fe	Zn	Pb	Ni	Cd
9.65	32.15	58.20	clay	7.97	3.35	1.90	18.53	7.78	73.47	20.09	9.97	0.48	0.74	0.19

In both seasons all trees received the following fertilizer, 300 gm/tree ammonium sulphate in March, 450 gm/tree ammonium sulphate in June, 200 gm/tree ammonium nitrite and 200 gm/tree potassium sulphate in August, All trees were irrigated at intervals of 10- 15 days in summer and 15 – 20 days in winter.

In this study four branches of 2 inches in diameter were selected and tagged on each tree. The vegetative growth parameters were measured in terms of tree height, shoot length, number of leaves per shoot, trunk cross-sectional area "TCSA cm^{2}" and leaf area. Tree Canopy volume was calculated according to the formula: 0.5238x tree height x diameter square (Turell, 1946).

During September, root samples were taken from four directions at distances of 50, 100 and 150 cm., from tree trunk. Samples were obtained by a method described by Ellis & Bornes (1971) using an auger 10-cm in diameter and 30 cm length. The soil samples were washed through 1.0-cm mesh to separate roots from soil. All root parameters, i.e, length cm/auger, root density as number of roots/auger and root dry weight gm/auger were measured according to Newman (1960). These measurements will help to evaluat root density and distribution under tested experimental soil conditions.

The number of flowers on the tagged branches per tree was counted through the blooming season, then fruit set was calculated as a percentage to initial number of flowers. Numbers of dropping fruits were also counted during

the period from May 10th to July 30th in both seasons to determine the percentage of dropped fruits.

At harvest time, in December yield as weight Kg/tree, Kg/cm^2 TSCA and Kg/m^3 of tree canopy were determined in both seasons. Fruit quality characters were also determined as: fruit length, fruit diameter, fruit volume, fruit weight, rind thickness, juice volume, T.S.S, acidity, T.S.S/acid ratio and ascorbic acid in 100 ml juice according to (A. O. A. C. 1970).

Fresh leaf samples were taken from each replicate to determine chlorophyll according to Moran (1982). Total carbohydrate was determined in 0.5-g fine powder leaf sample according to Dubois *et al.* (1956). Leaf proline content was determined according to Bates *et al.* (1973).

During September of both 2001 and 2002 leaf sample of 50 leaves as well as samples from feeder roots were washed and oven dried at 65-70 °C to constant weight. The dried leaves and roots were grounded and digested with H_2SO_4 and H_2O_2 according to Evenhuis & DeWaard (1980). Total nitrogen was determined by microkjeldahl Gunning method A.O.A.C. (1970). Phosphorus was determined by colorimeter, potassium by using Flame photometer according to Chapman & Pratt (1978) Ca, Na and Mg by the versenate method Johanson & Ulrich (1959). Fe, Zn, Mn, Cu, Pb, Cd, Se, Ni and Cr were determined using perking Elmer atomic absorption spectrophotometer, according to Black (1965) and Brigs & Crock (1986). Chloride was determined by silver nitrate methods due to Brown & Jackson (1955). All obtained data were statistically analyzed according Snedecor & Cochran (1967).

RESULTS AND DISCUSSION

1- Vegetative growth:

Data presented in Table (1) show that tree size and growth vigour were significantly affected by the tested rootstock. Washington navel orange on Volkamer lemon rootstock produced the larger tree size and the higher tree height comparing with those recorded on Sour orange. In this respect, the seedling of both rootstocks Volkamer lemon and Sour orange gave the largest tree height (cm) comparing with Washington navel budded on the same rootstocks in both seasons. Moreover, trunk cross sectional area (TCSA) of Washington navel orange on Volkamer lemon rootstock was higher than that recorded on Sour orange rootstock with significant differences between them in both seasons. Also, average leaves number per shoot and leaf area were also significantly higher on Volkamer lemon rootstock in both seasons. Besides, average shoot length gave the longest values on Volkamer lemon rootstock followed by that on Sour orange rootstock with significant differences between them in both seasons. Moreover, Volkamer lemon and Sour orange seedlings gave the longest values of shoot length when compared with Washington navel orange on both rootstocks. These results are in agreement with those of Mansour *et al.* (1993), Abou-Rawash *et al.* (l995) and Mehrotara *et al.* (1999).

2- Root system:

Data in Table (2) show the fibours root length at 50, 100 and 150 cm from tree trunk of Volkamer lemon and Sour orange rootstocks as affected by

Washington navel oranges secion in both seasons. It was clear that, root length was significantly longer in Volkamer lemon than that on Sour orange rootstock. In this respect, Volkamer lemon and Sour orange seedlings had the longest root length especially at 50 and 100 cm from tree trunk and at different soil depth of 30, 60 and 90 cm as compared with Washington navel orange on the same rootstocks. Beside, the results indicated that fibrous root length had less values when the distance from tree trunk was increased from 50 to 150 cm. This relationship was also true with increasing soil depth from 30 to 90 cm. Similar results are reported by Hassan (1983) and Saad- Allah *et al.* (1985 a, b).

Table (1): Vegetative growth parameters of Washington navel orange trees on Volkamer lemon and Sour orange rootstocks and corresponding values of both seedling rootstocks in 2001 – 2002 seasons.

Rootstock	Tree height, m	Canopy Volume, m^3/tree	* TCSA, cm^2	Average shoot length, cm	Leaves number/shoot	Leaf area, cm^2
2001 Season						
Washington navel/C. Volkameriana	2.60	8.50	67.7	13.9	10.7	16.3
Washington navel/Sour orange	2.30	7.40	51.6	12.8	10.3	16.1
C. Volkameriana/seedling rootstock	2.88	6.60	47.3	33.4	20.0	19.8
Sour orange/seedling rootstock	2.65	5.37	41.7	34.2	19.8	19.4
L.S.D 5%	0.27	0.66	2.63	1.07	0.70	0.27
2002 Season						
Washington navel/C. Volkameriana	2.80	9.30	63.6	14.6	11.0	15.3
Washington navel/Sour oragne	2.50	8.10	55.2	13.5	9.4	14.4
C. Volkameriana/seedling rootstock	3.18	8.14	48.7	34.2	18.8	20.3
Sour orange/seedling rootstock	3.66	7.04	43.5	36.6	19.2	19.7
L.S.D 5%	0.11	0.63	1.58	1.88	1.07	0.28

* TCSA (trunk cross sectional area)

Table (2): Fibrous root length (cm) of Sour orange and Volkamer lemon rootstocks as affected by Washington navel scion and corresponding values of both seedling rootstocks in 2001-2002 seasons.

Rootstock	30 cm depth	60 cm depth	90 cm depth	30 cm depth	60 cm depth	90 cm depth
	2001 Season			2002 Season		
50 cm from tree trunk						
Washington navel/C. Volkameriana	7.1	7.7	3.6	9.1	10.9	5.6
Washington navel/Sour oragne	5.7	8.5	2.8	7.6	8.9	2.4
C. Volkameriana/seedling rootstock	24.7	13.5	8.1	22.7	13.9	9.3
Sour orange/seedling rootstock	12.8	9.3	5.5	12.5	10.5	6.5
L.S.D 5%	0.55	1.24	0.38	2.12	2.47	0.48
100 cm from tree trunk						
Washington navel/C. Volkameriana	11.1	8.4	2.3	15.9	10.9	3.6
Washington navel/Sour oragne	4.0	5.9	1.2	5.6	9.3	1.7
C. Volkameriana/seedling rootstock	18.4	6.8	4.2	16.4	7.2	4.6
Sour orange/seedling rootstock	8.6	4.7	2.3	8.5	5.4	2.5
L.S.D 5%	0.61	0.49	0.42	1.57	1.28	0.50
150 cm from tree trunk						
Washington navel/C. Volkameriana	10.0	8.2	2.4	11.4	11.3	4.2
Washington navel/Sour oragne	5.2	5.0	1.6	8.0	7.4	3.4
C. Volkameriana/seedling rootstock	12.7	4.5	1.6	10.9	4.8	2.1
Sour orange/seedling rootstock	6.7	3.3	1.1	7.8	3.9	1.8
L.S.D 5%	0.75	0.46	0.44	2.01	1.39	0.95

Auger soil sample = 2356 cm^3

As for root density the data in Table (3) show that, root density as number of fibrous roots/auger of budded Volkamer lemon and Sour orange rootstocks with Washington navel orange and unbudded seedling rootstocks. It is clear that, root density was significantly promated on Volkamer lemon than that on Sour orange rootstock. The first counted more number fibrous roots than the second in both seasons. These results were true at different soil depths at (30, 60 and 90 cm) from tree trunk in both seasons

Table (3): Fibrous root density (number of roots/auger *) of Sour orange and Volkamer lemon rootstocks as affected by Washington navel scion and corresponding values of both seedlings rootstocks in 2001-2002 seasons.

Rootstock	30 cm depth	60 cm depth	90 cm depth	30 cm depth	60 cm depth	90 cm depth
	2001 Season			2002 Season		
50 cm from tree trunk						
Washington navel/C. Volkameriana	12.73	13.65	6.34	17.46	18.72	18.72
Washington navel/Sour orange	5.28	5.01	1.30	7.22	7.65	2.19
C. Volkameriana/seedling rootstock	43.39	23.69	14.16	43.25	23.66	13.51
Sour orange/seedling rootstock	11.89	8.02	4.94	11.82	9.00	5.84
L.S.D 5%	1.14	1.17	0.94	2.39	3.20	2.18
100 cm from tree trunk						
Washington navel/C. Volkameriana	14.66	14.77	4.16	26.96	16.35	5.11
Washington navel/Sour orange	3.34	5.24	2.10	4.44	7.20	1.60
C. Volkameriana/seedling rootstock	28.85	11.88	7.29	27.72	10.78	6.46
Sour orange/seedling rootstock	6.99	4.17	2.05	6.81	4.13	2.30
L.S.D 5%	2.11	1.23	0.37	1.70	2.57	0.26
150 cm from tree trunk						
Washington navel/C. Volkameriana	17.78	14.52	4.27	24.02	18.89	5.86
Washington navel/Sour orange	4.84	4.27	1.47	6.54	5.40	2.11
C. Volkameriana/seedling rootstock	22.36	7.93	2.83	22.66	7.95	2.85
Sour orange/seedling rootstock	6.19	2.79	0.99	6.33	2.84	1.10
L.S.D 5%	1.51	1.46	0.27	2.67	2.36	0.29

Auger soil sample = 2356 cm^3

Concerning seedling rootstocks, the highest root density as fibrous root was found on Volkamer lemon seedling rootstock comparing with that recorded for Sour orange seedling rootstock with significant differences between them in both seasons. These results agree with those obtained by Dawood (1996) and El-Sayed, Somaia (1999) under Kafr El-Sheikh conditions.

Also, data presented in Table (4) show the fibrous root dry weight(gm) of Volkamer lemon and Sour orange rootstocks at 50, 100 and 150 cm from tree trunk and at different soil depths of 30, 60 and 90 cm as affected by Washington navel orange variety.

It is clear from Table (7) that, Volkamer lemon and Sour orange rootstocks gave similar values of root dry weight in both seasons, meanwhile, Volkamer lemon seedling rootstock gave the highest values of root dry weight than that recorded on Sour orange seedling rootstock with significant differences between them in both seasons (Table 4). These results agree with those obtained by Saad- Allah *et al.* (1985 b) and Allurwar and Parihar (1992).

Table (4): Fibrous root dry weight (gm/auger *) of Sour orange and Volkamer lemon rootstocks as affected by Washington navel scion and corresponding values of both seedling rootstocks in 2001-2002 seasons.

rootstock	30 cm depth	60 cm depth	90 cm depth	30 cm depth	60 cm depth	90 cm depth
	2001 Season			2002 Season		
50 cm from tree trunk						
Washington navel/C. Volkameriana	1.00	0.95	0.24	1.38	1.29	0.35
Washington navel/Sour oragne	1.00	0.95	0.24	1.38	1. 30	0.35
C. Volkameriana/seedling rootstock	3.95	2.15	1.29	3.94	2.16	1.29
Sour orange/seedling rootstock	2.24	1.15	0.94	2.25	1.53	0.93
L.S.D 5%	0.07	0.04	0.02	0.03	0.05	0.06
100 cm from tree trunk						
Washington navel/C. Volkameriana	1.78	1.21	0.26	0.90	1.24	0.24
Washington navel/Sour oragne	1.79	1.21	0.26	0.99	1.36	0.27
C. Volkameriana/seedling rootstock	2.62	1.08	0.66	2.53	1.10	0.66
Sour orange/seedling rootstock	1.51	0.79	0.39	1.52	0.78	0.38
L.S.D 5%	0.06	0.03	0.02	0.07	0.05	0.04
150 cm from tree trunk						
Washington navel/C. Volkameriana	1.62	1.32	0.29	1.14	1.00	0.35
Washington navel/Sour oragne	1.62	1.32	0.28	1.26	1.10	0.38
C. Volkameriana/seedling rootstock	2.03	0.72	0.26	2.10	0.76	0.26
Sour orange/seedling rootstock	1.17	0.53	0.19	1.21	0.58	0.20
L.S.D 5%	0.29	0.08	0.01	0.04	0.24	0.01

Auger soil sample = 2356 cm^3

3- Fruit set, fruit drop, yield and yield efficiency :

As shown in Table (5) the results indicated that, fruit set percentage on Volkamer lemon rootstock was higher than that recorded on Sour orange rootstock. However, the differences between them was significant in the first season only. Similar result was obtained by Kitat *et al.* (1973).

Also, results indicated that, fruit drop percentage of Washington navel orange on Volkamer lemon was lower than that recorded on Sour orange. The differences were not significant, except fruit drop percentage in July in both seasons (Table 5). Similar conclusions were obtained by Abbas (1997) on Washington navel orange.

Data of Yield as(kg/tree) in Table (5) showed that, Washington navel orange on Volkamer lemon had significantly higher yield than on Sour orange rootstock. This result was true in both seasons. On the other hand, the yield of Washington navel orange was less in the second season when compared with the first one. Conclusively Washington navel orange tree produced more yield on Volkamer lemon than on Sour orange rootstock. These results agree with those obtained by Mehrotra *et al.* (1999) and Chohan *et al.* (2000) on sweet orange when tested as a scion

Also yield efficiency as Kg/cm^2 trunk cross - sectional area (TCSA), or Kg/m^3 of tree canopy volume on Volkamer lemon rootstock was significantly higher when compared with that on Sour orange rootstock in both seasons. These results are in accordance with those obtained by Mehrotra *et al.* (1999).

Table (5): Fruit set, dropping and yield of Washington navel orange trees on Volkamer lemon and Sour orange rootstocks and corresponding values of both seedling rootstocks in 2001-2002 seasons.

Rootstock	Fruit Set %	Fruit drop			Yield Kg/ tree	Yield efficiency	
		May %	June %	July %		Kg/cm² TCSA	Kg/m³ canopy volume
2001 Season							
Washington navel/C.Volkameriana	27.5	24.2	19.7	18.1	67.5	0.99	7.94
Washington navel/Sour orange	23.4	24.5	20.1	20.3	46.3	0.96	6.66
C. Volkameriana/seedling rootstock	36.0	21.5	20.0	20.2	24.8	0.52	3.75
Sour orange/seedling rootstock	26.9	29.6	25.0	26.6	23.5	0.56	4.37
L.S.D 5%	2.76	1.72	1.59	2.02	6.09	0.02	0.10
2002 Season							
Washington navel/C. Volkameriana	28.6	24.9	22.6	16.8	54.4	0.85	5.84
Washington navel/Sour orange	26.0.	26.0	23.2	18.3	32.8	0.59	4.04
C. Volkameriana/seedling rootstock	33.1	20.4	19.3	19.0	23.9	0.49	2.93
Sour orange/seedling rootstock	24.2	27.3	23.2	24.1	23.4	0.53	3.32
L.S.D 5%	2.74	2.31	NS	1.30	1.17	0.04	0.14

4- Fruit quality:

It is clear from Table (6) that the tested rootstocks had a significant effect on most fruit characters in this study, i, e. fruit length, diameter, volume, weight and juice volume recorded the highest values when the fruit are taken from trees on Volkamer lemon comparing with those on Sour orange rootstock. On the contrary, peel thickness was thickner in the fruit taken from tree on Volkamer lemon rootstock than that measured for the fruits on Sour orange rootstock.The analysis of juice recorded higher TSS and lower acidity% in the fruits taken from trees on Sour orange rootstock when compared with those on Volkamer lemon rootstock in both seasons. On the other hand, T.S.S/acid ratio was significantly lower on Volkamer lemon rootstock than that on Sour orange rootstock. Vit. C was higher in the juice taken from fruits on Volkamer lemon than that on Sour orange without significant differences between them in both seasons. These findings are in accordance with those obtained by Davies & Albrigo (1994) they reported that, C. Volkameriana generally induced high yields, but produced relatively poor fruit quality, fruits with less TSS characterized by high acidity and coarse peel.

5- Root and leaf Na and Cl contents:

Data in Table (7) revealed that, Na and Cl presented in the roots of Volkamer lemon were lower in both seasons than those determined on Sour orange rootstock with significant differences except Na in both seasons. On the other hand, Sour orange seedlings had higher content of Na and Cl when compared with Volkamer lemon seedlings with significant differences between them in both seasons. Moreover, Sour orange and Volkamer lemon seedlings had higher Na and Cl in their roots when compared with Washington navel orange on the same rootstocks in both seasons (Table 7).

These results agree with the findings of Combrink *et al.* (1995) they studied seedlings of Troyer citrange, Citrus Volkameriana, Carrizo citrange and Rough lemon which were tested for salaine irrigation water. They reported that, Volkameriana was the most tolerant to chloride when compared with the other tested rootstocks.

Leaf Na and Cl contents of Washington navel orange were significantly higher on Sour orange as compared with those on Volkamer lemon in both seasons. In this respect leaves of Sour orange seedlings had higher content of Na and Cl than that on Volkamer lemon ones with significant differences between them in both seasons.

Table (6): Fruit quality of Washington navel trees on Volkamer lemon and Sour orange rootstocks and corresponding values of both seedling rootstocks in 2001 and 2002 seasons.

Rootstock	Fruit length, cm	Fruit diameter, cm	Fruit volume, cm^3	Fruit weight, g	Rind thickness mm	Juice volume cm3/fruit	T.S.S %	Acidity %	T.S./acid ratio	Vitamin Cmg/100 ml juice
2001 Season										
Washington navel/C.Volkameriana	8.0	8.0	265.0	181.4	6.5	108.0	9.51	1.35	7.04	39.0
Washington navel/Sour orange	7.4	7.7	222.5	175.2	5.0	96.7	10.63	1.12	9.49	38.2
C. Volkameriana/seedling rootstock	6.8	6.5	126.8	116.8	4.2	44.6	8.60	4.68	1.83	38.0
Sour orange/seedling rootstock	5.5	4.5	154.8	145.9	5.2	56.0	9.24	5.46	1.69	31.4
L.S.D 5%	0.07	0.28	3.39	6.05	1.32	6.99	1.08	0.15	0.57	4.11
2002 Season										
Washington navel/C.Volkameriana	8.7	8.7	284.7	194.9	6.3	116.0	9.21	1.31	7.03	44.5
Washington navel/Sour orange	8.0	8.3	239.6	188.7	5.1	104.1	10.37	1.07	9.69	40.2
C. Volkameriana/seedling rootstock	6.8	6.6	126.8	116.5	5.3	44.1	8.30	4.86	1.71	35.6
Sour orange/seedling rootstock	5.7	4.6	154.8	141.5	6.3	54.9	9.13	5.33	1.71	30.0
L.S.D 5%	1.2	0.96	6.30	6.11	1.1	3.76	0.38	0.21	0.75	2.20

6- Some leaf organic substances :

It is clear from Table (7) leaf chlorophyll a, b and its total content had higher values on Volkamer lemon rootstock than that on Sour orange rootstock in both seasons. Similar results were reported by El-Sayed (1999).

Total carbohydrate, C/N ratio and proline content were higher in leaves of Washington navel orange tree on Volkamer lemon than those recorded on Sour orange rootstock in both seasons (Table 7). Similar results were reported by Azab (1995) and El-Sayed (1999)

Finely, it could be concluded that Washington navel orange tree on Volkamer lemon rootstock had higher leaf, total carbohydrate %, C/N ratio and proline level, on the other hand, low values of Na and Cl ions as shown in (Table 7) than these on Sour orange rootstock. These results mean that Volkamer lemon rootstock probably had the ability to tolerate salinity and alkaline stress under Kafr El-Sheikh conditions than Sour orange rootstock according to the tested indicators used in these study.

Table (7): Root and leaf content of Na and Cl, and some organic substances in leaf of Washington navel orange trees on Volkamer lemon and Sour orange rootstocks and in leaves of both unbudded seedling rootstocks and corresponding values of both seedling rootstocks in 2001 and 2002 seasons.

Rootstock	Root		Leaf		Chlorophyll			Total carbohydrate	Proline
	Na %	Cl %	Na %	Cl %	a	b	Total		
2001 seasons									
Washington navel/C. Volkameriana	0.220	0.159	0.050	0.060	44.8	23.3	68.1	11.3	0.47
Washington navel/Sour orange	0.220	0.167	0.300	0.070	44.7	22.1	66.9	11.0	0.32
C. Volkameriana/seedling rootstock	0.223	0.148	0.152	0.200	50.4	18.9	69.3	14.9	0.63
Sour orange/seedling rootstock	0.240	0.162	0.161	0.220	49.7	19.0	68.7	17.0	0.52
L.S.D 5%	0.020	0.004	0.030	0.026	2.51	2.80	N.S	1.70	0.04
2002 seasons									
Washington navel/C. Volkameriana	0.223	0.153	0.030	0.070	43.6	21.4	65.0	11.1	0.48
Washington navel/Sour orange	0.225	0.177	0.250	0.080	37.3	18.5	55.8	10.7	0.39
C. Volkameriana/seedling rootstock	0.222	0.163	0.152	0.200	51.9	19.9	71.8	15.2	0.67
Sour orange/seedling rootstock	0.239	0.179	0.162	0.210	48.9	19.8	68.7	17.4	0.55
L.S.D 5%	0.003	0.004	0.020	0.039	1.27	0.58	1.89	1.48	0.05

7- Leaf and root mineral content:

Data in Table (8) revealed that, N, P, K,Ca and Mg contents in the leaves of Washington navel orange on Volkamer lemon were higher in both seasons than those determined on Sour orange rootstock with significant differences in all cases, except P. The result also indicated that, Fe, Mn, Zn and Cu levels in leaves of Washington navel orange were higher on Volkamer lemon rootstock than those on Sour orange. The differences were also significant between them in both seasons. On the other hand, Volkamer lemon seedlings had high of P, K, Ca, Mg, Fe, Zn and Cu but had low N and Mn contents when compared with Sour orange seedlengs (Table 8). Similar results were reported by Mansour *et al.* (1993), Abou-Rawash *et al.* (1995) and El-Sayed (1999).

Also, data in Table (9) show, root mineral contents of Volkamer lemon and Sour orange rootstocks as affected by Washington navel orange. Its effect as scion was clear on Volkamer lemon rootstock which gave higher values of leaf N, P, K, Fe and Cu contents than those determined for Sour orange rootstock. On the contrary, Ca, Mg, Mn and Zn were higher on Sour orange rootstock than those recorded on Volkamer lemon rootstock. Sour orange seedlings had higher contents of N, P, K, Mg, Mn and Zn than those on Volkamer lemon seedlings, but lower Ca and Fe than Volkamer lemon seedlings (Table 9).

Table (8): Leaf mineral content of Washington navel orange trees budded on Volkamer lemon and Sour orange rootstocks and in leaves of both unbudded seedling rootstocks in 2001 and 2002 seasons.

Rootstock	N %	P %	K %	Ca %	Mg %	Fe ppm	Mn pm	Zn Ppm	Cu ppm
2001 Season									
Washington navel/C. Volkameriana	2.69	0.16	1.98	3.95	0.63	119.0	48.7	31.1	12.5
Washington navel/Sour orange	2.22	0.17	1.66	3.73	0.53	134.6	31.2	27.5	11.7
C. Volkameriana/seedling rootstock	2.47	0.20	1.33	3.56	0.65	134.1	34.5	55.3	12.8
Sour orange/seedling rootstock	2.56	0.19	1.37	3.52	0.56	115.0	44.5	45.0	13.0
L.S.D 5%	0.10	0.02	0.46	0.25	0.08	10.4	6.88	2.8	N.S
2002 Season									
Washington navel/C. Volkameriana	2.96	0.15	1.96	3.89	0.60	120.3	48.0	31.0	10.0
Washington navel/Sour orange	2.40	0.16	1.83	3.65	0.44	136.6	31.3	28.0	9.5
C. Volkameriana/seedling rootstock	2.42	0.21	1.36	3.55	0.57	132.0	35.6	56.6	14.0
Sour orange/seedling rootstock	2.51	0.19	1.32	3.51	0.48	123.0	45.5	45.5	13.5
L.S.D 5%	0.25	0.03	0.30	N.S	0.04	6.2	4.4	5.2	1.4

Table (9): Root mineral content of Sour orange and Volkamer lemon rootstocks as affected by Washington navel orange scion and in roots of both seedling rootstocks and corresponding values of both seedling rootstocks in 2001 and 2002 sesons.

Rootstock	N %	P %	K %	Ca %	Mg %	Fe ppm	Mn pm	Zn Ppm	Cu ppm
2001 Season									
Washington navel/C. Volkameriana	1.65	0.22	1.00	1.48	0.25	92.0	25.0	30	8.9
Washington navel/Sour orange	1.45	0.20	0.90	1.56	0.27	88.5	24.8	33	7.6
C. Volkameriana/seedling rootstock	1.34	0.18	0.88	1.49	0.24	224	68.0	70	11.0
Sour orange/seedling rootstock	1.45	0.19	0.91	1.45	0.27	184	87.0	91	16.8
L.S.D 5%	0.11	N.S	0.08	N.S	N.S	6.7	4.5	4.4.	1.8
2002 Season									
Washington navel/C. Volkameriana	1.67	0.20	0.98	1.59	0.26	87	29	26	8
Washington navel/Sour orange	1.55	0.18	0.78	1.68	0.28	85	33	25	7
C. Volkameriana/seedling rootstock	1.46	0.18	0.86	1.48	0.24	225	71	69	11
Sour orange/seedling rootstock	1.44	0.20	0.51	1.46	0.26	185	92	88	18
L.S.D 5%	0.11	N.S	0.08	0.07	0.02	3.8	5.1	2.6	3.3

8- The concentrations of some heavy metals :

Data in Table (10) show that, Pb, Cd, Se, Ni and Cr contents in leaves, roots, fruit peel and fruit juice of Washington navel orange budded on Volkamer lemon rootstock were lower than those on Sour orange rootstock with significant differences between them in most parameters.

This result was true in both seasons. The concentrations of different heavy metals were always higher in roots than that in leaves. This result was true for Washington navel orange on both rootstocks. Conclusively, Volkamer lemon as rootstock probably had the ability to absorb and transport lower quantities of most heavy metals when compared with Sour orange rootstock which enhance their absorption and translocation of these elements.

Table (10): Concentrations of some heavy metals in leaf, root, fruit peel and fruit juice of Washington navel orange on Volkamer lemon and Sour orange and in the same parts of both seedling rootstocks in 2001and2002 seasons.

Rootstocks	Pb, ppm	Cd, ppm	Se, ppm	Ni, ppm	Cr, ppm
2001 season					
	Leaf				
Washington navel/C. Volkameriana	2.47	4.05	4.82	6.14	5.17
Washington navel/Sour orange	3.07	3.00	5.33	6.94	4.89
C. Volkameriana/seedling rootstock	2.96	2.11	2.38	1.78	1.46
Sour orange/seedling rootstock	2.18	2.73	3.66	2.94	2.09
L.S.D 5%	.0.55	0.32	0.49	0.46	0.39
	Root				
Washington navel/C. Volkameriana	3.59	5.38	4.95	5.80	5.15
Washington navel/Sour orange	3.66	4.26	5.22	6.96	5.13
C. Volkameriana/seedling rootstock	4.33	4.33	8.99	4.94	7.41
Sour orange/seedling rootstock	5.62	5.62	11.65	5.50	7.63
L.S.D 5%	0.45	0.50	0.41	0.49	0.41
	Fruit Peel				
Washington navel/C. Volkameriana	0.022	0.018	0.038	0.021	0.045
Washington navel/Sour orange	0.028	0.019	0.035	0.022	0.055
C. Volkameriana/seedling rootstock	0.017	0.018	0.019	0.015	0.047
Sour orange/seedling rootstock	0.025	0.031	0.027	0.022	0.061
L.S.D 5%	0.003	0.002	0.003	0.004	0.003
	Fruit Juice				
Washington navel/C. Volkameriana	0.0029	0.0015	0.0021	0.0051	0.0045
Washington navel/Sour orange	0.0026	0.0013	0.0024	0.0058	0.0048
C. Volkameriana/seedling rootstock	0.0023	0.0013	0.0017	0.0022	0.0033
Sour orange/seedling rootstock	0.0035	0.0021	0.0022	0.0059	0.0065
L.S.D 5%	0.0002	0.0001	0.0001	0.0004	0.0002
2002 season					
	Leaf				
Washington navel/C. Volkameriana	3.67	3.40	5.08	6.53	6.03
Washington navel/Sour orange	3.72	3.44	5.24	6.90	6.35
C. Volkameriana/seedling rootstock	2.74	2.19	2.55	1.82	1.56
Sour orange/seedling rootstock	2.28	2.56	3.78	2.05	2.40
L.S.D 5%	0.35	0.94	0.26	0.83	0.30
	Root				
Washington navel/C. Volkameriana	4.09	5.57	5.11	5.87	5.70
Washington navel/Sour orange	3.85	5.00	5.83	7.01	5.49
C. Volkameriana/seedling rootstock	8.36	4.38	9.08	4.17	7.74
Sour orange/seedling rootstock	5.89	5.65	11.77	5.61	7.90
L.S.D 5%	0.34	0.49	0.54	1.25	0.39
	Fruit Peel				
Washington navel/C. Volkameriana	0.023	0.017	0.032	0.018	0.044
Washington navel/Sour orange	0.026	0.018	0.032	0.019	0.053
C. Volkameriana/seedling rootstock	0.015	0.017	0.019	0.013	0.045
Sour orange/seedling rootstock	0.021	0.032	0.026	0.021	0.059
L.S.D 5%	0.006	0.005	N.S	N.S	N.S
	Fruit Juice				
Washington navel/C. Volkameriana	0.0030	0.0017	0.0020	0.0057	0.0050
Washington navel/Sour orange	0.0027	0.0014	0.0023	0.0057	0.0051
C. Volkameriana/seedling rootstock	0.0024	0.0010	0.0016	0.0021	0.0035
Sour orange/seedling rootstock	0.0032	0.0019	0.0042	0.0058	0.0064
L.S.D 5%	N.S	0.0002	0.0003	0.0013	0.0010

Conclusion

It could be concluded that Washington navel orange on Volkamer lemon produced the highest values of most vegetative and root growth parameters, also, gave the highest yield as Kg/tree or yield efficiency with higher values of fruit physical properties with poor chemical properties such as lower TSS value and higher acidty.

Moreover, Washington navel orange tree on Volkamer lemon rootstock had lower Na and Cl ions in their leaves which reflect its tolerance to these ions present in the soil. The higher values of chlorophyll, proline, total carbohydrate and C/N ratio and other good growth factors support its salt tolerance. Thus, Volkamer lemon as rootstock for Washington navel orange cultivar exhibited higher ability for growth and yield than on Sour orange under saline and alkaline condition of Kafr El-Sheikh soil. This conclusion needs more studies to assure the successful replacement of Volkamer lemon as a rootstock for Washington navel orange variety grown under different environmental conditions.

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ب- تقييم ليمون الفولكاماريانا كأصل لصنف البرتقال بسرة تحت ظروف كفر الشيخ.

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أجريت هذه الدراسة على أشجار برتقال بسرة عمرها ٨ سنوات مطعومة على أصل الفولكاماريانا والنارنج وذلك لتقييم النمو الخضري والجذري وجودة الثمار ومحتوى الأوراق والجذور من المعادن وقدرة الأصل على تحمل الملوحة علاوة على امتصاص ونقل بعض المعادن الثقيلة وأوضحت النتائج أن : –

١ – الأشجار المطعومة على أصل الفولكاماريانا كانت أكبر حجما وأعلى ارتفاعا. وكذا طول الفرع وعدد الأوراق على الفرع ومساحة الورقة ومساحة مقطع الساق عن الأشجار المطعومة على أصل النارنج.

٢ – أصل الفولكا ماريانا أعطى أعلى قيم لنمو الجذور مثل طول الجذور وكثافتها ووزنها الجاف وذلك على ثلاث أعماق مختلفة (٣٠ ، ٦٠ ، ١٥٠ سم) من سطح التربة وعلى مسافات مختلفة (٥٠ ، ١٠٠ ، ١٥٠ سم) من جذع أشجار البرتقال بسرة المطعومة على أي من الأصلين المختبرين عند المقارنة بأصل النارنج وكانت النتائج مؤكدة إحصائيا.

٣ – زادت نسبة العقد في الأزهار المتكونة على الأشجار المطعومة على أصل الفولكاماريانا بينما زادت نسبة تساقط الثمار في شهور مايو ، يونيو ، يوليو في الأشجار المطعومة على أصل النارنج.

٤ – أشجار البرتقال بسرة المطعومة على أصل الفولكا ماريانا أعطت أعلى محصول (كجم/شجرة) وكذلك أعطت أعلى كفاءة محصوليه بالنسبة للأشجار وذلك عند قياس المحصول (كجم/سم^2 من مساحة مقطع الجذع وكجم/م^3 من حجم الشجرة) وأحسن صفات جودة طبيعية للثمار متمثلة في طول وقطر ووزن وحجم الثمرة وسمك القشرة. أما صفات الثمرة الكيماوية فكانت قيمة المواد الصلبة الكلية الذائبة منخفضة و الحموضة مرتفعة في عصير الثمار على أصل الفولكا ماريانا مقارنة بنفس القيم على أصل النارنج. أما النارنج فكان منخفض في قيمة فيتامين ج عن أصل الفولكاماريانا.وقد سجل عصير الثمار على اصل الفولكاماريانا قيم أقل لنسبة المواد الصلبة الكلية إلى الحموضة في كلا الموسمين

٥ – أشجار البرتقال بسرة المطعوم على أصل الفولكاماريانا احتوت جذورها وأوراقها على أقل محتوى من الصوديوم والكلور وذلك عند المقارنة بالأشجار المطعومة على أصل النارنج بالإضافة على ذلك فإن مستوى البرولين ، والكربوهيدرات وكلوروفيل أ ، ب والمجموع الكلى للكلوروفيل سجل أعلى مستوى له في أوراق الأشجار المطعومة على أصل الفولكاماريانا عن تلك المطعومه على أصل النارنج.

٦ – أشجار برتقال بسرة المطعومة على أصل الفولكاماريانا أعطت أوراق محتواها من النيتروجين والبوتاسيوم والكالسيوم والماغنسيوم والمنجنيز والزنك والنحاس مرتفع عند المقارنة بالأشجار المطعومة على أصل النارنج أما أصل النارنج فقد تفوق فى محتوى أوراقة من الفوسفور والحديد.

٧ – احتوت جذور أصل الفولكاماريانا على أعلى مستوى من النيتروجين والفوسفور والبوتاسيوم والحديد والنحاس بينما وجد أن تركيز الكالسيوم والماغنسيوم والمنجنيز الزنك كان مرتفعا في جذور أصل النارنج بالمقارنة بأصل الفولكاماريانا وكانت النتائج مؤكدة إحصائيا على أي من الأصلي موضع الدراسة.

٨ – بالإضافة إلى ذلك الأشجار المطعومة على أصل النارنج احتوت على تركيزات أعلى من الرصاص والكادميوم والسيلينيوم والنيكل والكروم في الأوراق والجذور وقشرة الثمرة وعصير الثمرة عن مثيلاتها من الأعضاء النباتية على الأشجار المطعومة على أصل الفولكا ماريانا.

و الدراسة تؤكد أن الإحلال الناجح لأصل الفولكا ماريانا بدلا من النارنج كأصل لصنف البرتقال أبو سره يحتاج إلى دراسات أكثر تحت ظروف بيئية مختلفة.