EVALUATION STUDY ON WASHINGTON NAVEL ORANGE CULTIVAR BUDDED ON FIVE ROOTSTOCKS.

1. Vegetative growth, root distribution and ability to salt tolerance

By

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ABSTRACT

This work was conducted during 2000 and 2001 seasons on 6 years old of Washington navel orange trees budded on five rootstocks, grown on Sakha Horticulture Research Station, Kafr El-Sheikh governorate, Egypt to study the effect of rootstocks on vegetative growth, root distribution and ability to tolerate salinity. The obtained results indicated that tree size and growth vigour of Washington navel orange were significantly affected by the used rootstock i.e., Volkamer lemon and Rangpur lime produced the highest tree height, trunk diameter, canopy volume, trunk cross sectional area and stock and scion girths. Meanwhile, Cleopatra mandarin rootstock gave the lowest values of all growth parameters. On the other hand, trees on sour orange and Troyer citrange rootstocks recorded intermediate values with most growth parameters.

Volkamer lemon and Rangpur lime rootstocks had the highest values of dry weight, number and length of fibrous roots at 50, 100 and 150 cm from the tree trunk (at 30, 60 and 90 cm depth from soil surface) when compared with the other tested rootstocks. Leaf chlorophyll content a ,b and its total value and leaf proline concentration of Washington navel orange trees were high on Volkamer lemon and Rangpur lime rootstocks, while total carbohydrate percentage recorded lower values than other tested rootstocks.

INTRODUCTION

Selection of suitable rootstock is an important decision for growers, because rootstock has a significant effect on scion growth

and root distribution, as well as its tolerance to certain soil conditions such as high salinity, alkaline and water logging.

The effect of rootstocks on growth parameters have been studied by many workers such as Monteverde *et al* (1990), Martinez *et al* (1994), Valbuen (1996), El-Sayed (1999) and Dawood (2001). They concluded that both of Volkamer lemon and Rangpur lime rootstocks exhibited the most vigourous growth characterized by longer tree height, larger tree volume, thicker trunk, higher number of new shoots in spring and summer, larger leaf area and per plant of different citrus varieties.

Also, Hassan (1984) ,Saad-Allah *el al* (1985a), Allurwar and Parihar (1992) and El-Sayed (1999) reported that Volkamer lemon and Rangpur lime as rootstocks had the highest values of fibrous root length, root density and root dry weight at different distance from tree trunk at different depths from soil surface and resulting in a better rooting density and distribution than sour orange rootstock. In addition, laboren *et al* (1991), Escalona *el al* (1994), Azab (1995) and El-Sayed (1999) studied the effect of rootstocks on leaf chlorophyll, carbohydrate and proline contents of different citrus varieties, they reported that leaves of the tested scions on Volkamer lemon rootstock had higher level of proline, chlorophyll a, b and its total value and carbohydrate (%) than those recorded on sour orange rootstock.

So, the purpose of this study is to evaluate and compare Washington navel orange grown on five rootstocks namely: Volkamer lemon, Rangpur lime, Troyer citrange, Cleopatra mandarin, and sour orange. The evaluation included the vegetative growth, root distribution and some physiological changes in leaves related to the used rootstock.

MATERIALS AND METHODS

The present study was carried out on 6 years old Washington navel orange trees budded on five different citrus rootstocks in the experimental farm of Sakha Horticulture, Research Station, Kafr El-Sheikh governorate, Egypt during 2000 and 2001 seasons. The tested rootstocks were: sour orange (*Citrus aurantium*), Volkamer lemon (*Citrus Volkameriana*), Troyer citrange (*Poncirus trifoliata x Citrus sinensis*), Rangpur lime

(*Citrus aurntifolia x Citrus reticulata*) and Cleopatra mandarin (*Citrus reshni*). The trees were planted at 5 x 5 meters in a complete randomized block design with three trees plot replicated three times for a total of nine trees per rootstock budded with Washington navel orange. Mechanical and chemical analysis of experimental orchard soil was done as shown in Table (1).

Table (1). Mechanical and chemical analysis of experimental orchard soil.

Mechanical				Chemical			Available ppm			DTPA extractable ppm.				
Sand %	Silt %	Clay %	T.	pH	EC	O.m %	N	P	K	Fe	Zn	Pb	Ni	Cd
9.7	32.2	58.2	Clay	8.0	3.4	1.9	18.5	7.8	273.5	20.1	9.97	0.48	0.74	0.19

In both seasons, all trees received the following fertillization programe: 300 gm ammonium sulphate / tree in March + 450 gm ammonium sulphate / tree in June + 200 gm ammonium nitrite / tree and 200 gm potassium sulphate / tree in August. In this study, four branches of 2 inches in diameter in the four directions of each tree were selected and tagged for sampling, measuring and all determinants were used to evaluate and compare vegetative growth behaviour of Washington navel orange in the following terms:

1- Vegetative growth measurements:

- Tree height (m): tree height of each replicate was measured from the soil surface to the end of growth in both seasons.
- Trunk diameter (cm): diameter of each tree trunk per replicate was measured at
- 10 cm above soil surface using vernier calipar.
- Canopy volume (m^3): the canopy volume was calculated using the equation: 0.5238 x tree height x diameter square., according to Turrel (1946).
- Trunk cross sectional area (TCSA cm^2).
- Trunk girth (cm): data were recorded on stock and scion girths at 5 cm below and above the bud union respectively during the two seasons.
- Area per leaf (cm^2): three leaves (base, medium, terminal) were collected from spring and summer flushes and leaf area

was measured using leaf area meter mode Li. 3100, then average leaf area was calculated according to Singh and Snyder (1984). Also leaf area per shoot was calculated.

- Leaf number per shoot: leaves number per shoot was counted for spring and summer flushes. Also shoot length of both spring and summer flushes was measured.

2- Root system measurements:

In September of both seasons, fibrous 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 and Bornes (1971) using an auger 10 cm in diameter and 30 cm length. The auger was driven into the soil to a depth of 30, 60 and 90 cm each from the soil surface. The soil samples were washed through 1-cm mesh to separate root from soil. Fibrous (? 2 mm) root length as cm / auger, root density as number of fibrous roots / auger and fibrous root dry weight as gm / auger were determined according to Newman (1966) and Hassan *et al* (1984).

3-Chemical determination of some organic substances in leaves:

- **Leaf proline content:** leaf proline content was determined in 0.5 gm fresh weight of fully mature leaves samples from spring flush collected from each replicate and proline concentration was calculated as u mole/gm fresh weight according to Bates *et al* (1973).
- **Leaf chlorophyll content:** fresh leaf sample was taken from each replicate to determine chlorophyll a,b and its total according to Moran and Porath (1980).
- **Carbohydrate substances:** ten leaves were sampled from each replicate, then washed and dried at 65C° to a constant weight to determine carbohydrate substances as follwes: 0.5 g of each dry sample was weighed to extraction of reducing and non-reducing sugars was done by 80% ethyl alcohol. The reducing and non-reducing sugars were determined according to Ruck (1963). The starch was determined in 0.1g of the residue according to Anon (1965) and the factor 0.9 was used to calculate the strach

(Ranganna, 1979). Total carbohydrates and C/N ratio were calculated (Dubois *et al,* 1956).

All obtained data were statistically analyzed using a randomized complete block design according to Snedecor and Cochran (1967), and the least significant difference (L.S.D. at 5% level) was used to compare the main values.

RESULTS AND DISCUSSION

1- Effect of rootstocks on vegetative growth behaviour:

Data in Table (2) showed that tree size and growth vigour of Washington navel orange trees were significantly affected by the tested rootstocks. Volkamer lemon rootstock produced highest tree height and trunk diameter followed by Rangpur lime with significant differences between them in both seasons. Meanwhile, Cleopatra mandarin rootstock gave the least values in this respect when compared with all tested rootstocks. Moreover, Sour orange and Troyer citrange rootstocks gave intermediate values of tree height and trunk diameter when compared with other rootstocks and the differences were significant between all tested rootstocks in both seasons. These results are in agreement with Hassan (1984), and Martinez *et al* (1994) who reported that Volkamer lemon was generally the best rootstock for Olinda and Valencia 121 varieties for their better growth than other tested rootstocks.

Concerning the effect of rootstocks on canopy volume (m^3) and trunk cross sectional area (TCSA cm^2) of Washington navel orange scion, it is clear, in both seasons, that trees on Volkamer lemon rootstock gave the largest tree canopy volume (m^3), and trunk cross sectional area (TCSA cm^2) followed by Rangpur lime rootstock, whereas trees on Cleopatra mandarin rootstock gave the least canopy volume and TCSA values. Sour orange and Troyer citrange rootstocks recorded intermediate values in this respect. The differences were significant in the two seasons among all tested rootstocks in both growth parameters (Table 2). These results are in line with those reptorted by Monteverde *et al* (1990) who found that Valencia scion on Volkamer lemon had the greatest tree canopy volume. In that respect, Dawood (2001) on Valencia, Dawood (2002) and El-Sayed (1999) on Washington navel orange suggested that, Volkamer lemon as rootstock for Valencia and

Washington navel orange trees produced the largest canopy volume and trunk cross sectional area as compared with those on sour orange rootstock.

Also, data presented in Table (2) revealed that Washington navel orange trees budded on Volkamer lemon produced more stock and scion girths, followed by tree on Rangpur lime rootstock with significant differences between them in both seasons. Trees on sour orange and Troyer citrange rootstocks were moderate in that respect, meanwhile Cleopatra mandarin rootstock gave the least values of stock and scion girths in both seasons. The differences were significant between all tested rootstocks in both seasons. The obtained herein results concrening stock and scion diameter are in line with those reported by Mehrotra *et al* (1999). In addition, El-Sayed (1999) suggested the superiority of Volkemer lemon and Rangpur lime as rootstocks for Washington navel, Valencia orange and Balady mandarin.

Data presented in Table (3) showed that most leaf growth parameters were significantly influenced by the tested rootstock. As for average leaf area in spring and summer flushes, it is clear that trees on Volkamer lemon rootstock produced the highest leaf area, followed by Rangpur lime rootstock with significant differences between them during the two growth flushes in both seasons. However, the values of leaf area of spring and summer flushes were intermediate on sour orange and Troyer citrange rootstocks without significant differences between them in both seasons. The least values in this respect belonged to Cleopatra mandarin in both seasons (Table 3).

Regarding the average leaves area per shoot, it was highest in trees on Volkamer lemon and Rangpur lime in both seasons with significant differences between them. While the least values were found in trees on Cleopatra mandarin. On the other hand, trees on sour orange and Troyer citrange gave intermediate values (Table 3). Concerning, the average number of leaves per shoot, it was highest in Washington navel orange trees budded on Volkamer lemon and Rangpur lime with significant differences between them. The least value was found in those grown on Cleopatra mandarin with significant differences among them. This result is true in the two seasons, except for spring flushes in the second

season, the differences among the obtained values were not significant (Table 3). In this respect, sour orange and Troyer citrange gave intermediate values during spring and summer flushes in both seasons.

Table (2): Tree vigour parameters of Washington navel orange as affected by five rootstocks during 2000 and 2001 seasons.

Rootstock	Tree Height m	Trunk Diameter cm	Canopy Volume m^3	TCSA* cm^2	Girth cm	
					stock	Scion
		2000				
Sour orange	1.57	4.33	4.91	14.73	12.73	11.88
Volkamer lemon	2.02	5.57	10.45	24.73	16.64	15.46
Troyer citrange	1.76	4.85	6.90	18.48	13.58	11.00
Rangpur lime	1.95	5.38	9.41	22.74	15.30	13.77
Cleopatra manderain	1.26	3.47	2.53	9.46	11.35	10.34
L.S.D 5%	0.07	0.12	0.14	0.14	0.74	1.25
1%	0.10	0.16	0.20	0.20	1.01	1.70
		2001				
Sour orange	1.86	5.13	8.16	20.68	14.82	14.08
Volkamer lemon	2.41	6.64	17.71	34.64	19.43	18.45
Troyer citrange	1.97	5.43	9.68	23.16	14.80	12.29
Rangpur lime	2.26	6.23	14.62	30.50	17.50	15.93
Cleopatra mandrain	1.44	3.97	3.78	12.38	12.84	11.82
L.S.D 5%	0.04	0.05	0.18	0.21	0.12	0.58
1%	0.06	0.06	0.24	0.29	0.17	0.80

* TCSA (Trunk cross sectional area cm^2)

Data in Table (3) showed that the average shoot length of Washington navel orange was longest on Volkamer lemon rootstock followed by Rangpur lime with significant differences between them. However, trees on Troyer citrange and sour orange exhibited nearly similar shoot length in the second season only. On the other hand, Cleopatra mandarin as rootstock produced the least values of Washington navel orange shoot length. This result was true in spring and summer flushes (Table 3).These results agree with those reported by Saad–Allah *et al* (1985a), Azab and Hegazy (1995) and El-Sayed (1999). They found that the number of new shoots in spring and summer flushes, shoot length and total shoot length were largest in Washington navel orange tree budded on Volkamer lemon rootstocks when compared with other tested ones.

Table (3): Leaf growth parameters of Washington navel orange trees as affected by five citrus rootstocks during 2000 and 2001 seasons.

Rootstock	Av. Leaf Area cm^2		Av leaves area per shoot cm^2		AV. Shoot length (cm)		Av. No leaves per shoot	
	* Spr.	Sum.	Spr.	Sum.	Spr.	Sum.	Spr	Sum
			2000					
Sour orange	15.86	14.70	150.7	113.2	13.50	12.33	9.5	7.7
Volkamer lemon	18.67	16.62	224.0	161.2	17.72	16.09	12	9.7
Troyer citrange	15.58	14.42	104.4	93.7	13.18	11.00	6.7	6.5
Rangpur lime	16.42	14.80	156.0	121.4	15.14	13.34	9.5	8.2
Cleopatra mandarin	14.94	14.25	92.6	78.4	11.84	10.69	6.2	5.5
L . S . D 5 %	0.31	0.40	2.60	3.38	0.08	0.16	1.13	1.40
1 %	0.43	0.56	3.55	4.61	0.11	0.22	1.61	1.97
			2001					
Sour orange	15.11	13.47	111.8	97.0	13.8	12.2	7.4	7.2
Volkamer lemon	15.96	15.38	153.2	144.6	19.4	17.8	9.6	9.4
Troyer citrange	14.65	13.32	96.7	79.9	13.6	11.6	6.6	6.0
Rangpur lime	15.60	13.57	127.9	105.8	15.6	16.2	8.2	7.8
Cleopatra mandarin	14.35	13.19	89.0	71.2	12.4	9.2	6.2	5.4
L . S . D 5 %	0.36	0.96	4.27	3.08	1.89	1.74	N.S	1.29
1 %	0.49	1.32	5.83	4.20	2.60	2.40	N.S	1.79

* Spr. (Spring) Sum. (Summer) N.S not significant

From the result presented in Tables (2 and 3) it is obvious that all growth parameters of Washington navel orange measured were significantly affected by the tested rootstock. Volkamer lemon and Rangpur lime as rootstocks showed the best growth parameters represented by tree height, trunk diameter, canopy volume, girths (stock and scion), leaf area, leaves area per shoot, leaves number per shoot and shoot length. sour orange and Troyer citrange as rootstocks for Washington navel orange gave intermediate values with most growth parameters, on the other hand, the lowest values of the measured growth parameters were obtained on Cleopatra mandarin comparing with the other tested rootstocks.

These results are similar to those obtained by Monteverde *et al.* (1990), Martinez *et al.* (1994) and El- Sayed (1999) on some orange cultivars. The results presented in Tables (2 and 3) revealed that Volkamer lemon and Rangpur lime rootstocks produced higher values of all vegetative growth parameters measured for Washington navel orange trees than those recorded on the other

tested rootstocks. This result may be due to that, the two superior rootstocks attaind higher growth vigour to the scion, these results agreed with those reported by El–Sayed (1999) who refered the superiority of Volkamer lemon and Rangpur lime rootstocks to their vigourous growth, which in turn influenced the most vegetative growth parameters of Washington navel orange. Valencia orange and Balady mandarin as scions. It is concluded that, Volkamer lemon and Rangpur lime exhibited more tolerant to salinity and drought conditions than other tested rootstocks as obtained by El– Hammady *et al* (1995) who stated that Volkamer lemon and Rangpur lime are more tolerant to salinity than sour orange and Cleopatra mandarin. Also, Azab and Hegazy (1995) reported that Rangpur lime, Volkamer lemon and Maycrophylla had better growth and controlled plant water relations under arid evironment of Qater when compared with the other rootstocks such as Cleopatra mandarin.

In light of the obtained results in Tables (4,5 and 6), it was cleared that Volkamer lemon and Rangpur lime had large root system with high distribution and density in soil, which in turn played an important role in the absorption of water and mineral nutrients from soil solution. The ability of both rootstocks in this respect may explain the vigourous growth of most vegetative growth parameters discussed herein.However, contrary to Volkamer lemon and Rangpur lime as vigourous rootstocks, Cleopatra mandarin rootstock produced lower values of all vegetative growth parameters recorded for Washington navel orange as scion when compared with those on all other tested rootstocks.It could be attributed to that Cleopatra mandarin rootstock had a degree of dwarfing effect on scion growth. These results agree with those reported by Dawood (1996) who found that Cleopatra mandarin gave the least plant height, canopy volume and trunk diameter. In this line, Dawood *et al* (2002) also reported that Cleopatra mandarin recorded the lowest values of tree height, TCSA and tree volume when compared with Volkamer lemon, Rangpur lime, Troyer citrange and sour orange. Concerning Troyer citrange and sour orange rootstocks, they had intermediate values with most vegetative growth parameters measured for Washington navel orange scion grown on each of them when compared with

those recorded on the other tested rootstocks. These results agreed with those reported by El–Sayed (1999) and Dawood *et al* (2002 a) under Kafr El-Sheikh conditions.

2-Root growth parameters:

a-Fibrous root length / auger :

Data in Table (4) showed the fibrous root length of sour orange, Volkamer lemon, Troyer citrange, Rangpur lime and Cleopatra mandarin which budded by Washington navel orange at 50 cm distance from tree trunk and at 30 cm depth. It was clear that Volkamer lemon had the longest fibrous root length followed by Rangpur lime with significant differences between them in both seasons. However, Troyer citrange and sour orange gave intermediate values in this respect with significant differences between them in the second season only. On the other hand, Cleopatra mandarin had significantly recorded the shortest root length in comparison with all tested rootstocks.At 60 cm depth, Volkamer lemon produced significantly longer root length than that on other tested rootstocks. While, Rangpur lime and sour orange gave intermediate values without significant differences between them. On the other hand, Troyer citrange and Cleopatra mandarin had the shortest root length in this respect.Moreover, at 90-cm depth, Volkamer lemon produced the longest root length followed by Rangpur lime with significant differences between them. sour orange gave intermediate values of root length. On the other hand, Cleopatra mandarin recorded the shortest root length. These results were true in both seasons (Table 4).Similar results were obtained at 100 and 150 cm from tree trunk and at 30,60 and 90cm depths. In most cases root length was significantly longest in Volkamer lemon as compared with all tested rootstocks, then Rangpur lime came second. sour orange and Troyer citrange gave intermediate values of root length. Contrary, Cleopatra mandarin recorded the shortest values of root length when compared with all tested rootstocks. This result was true in both seasons (Table 4).

Generally, the results indicated that root length was decreased down wards from the surface and the value of root length in deeper layer (90cm) was the least. These results are in harmony with those obtained by Nasr and Hassan (1984)and Allurwar and

Parihar (1992). They reported that the best root system (feeder root length and fresh weight) was found on Rough lemon and Volkamer lemon rootstocks as compared with Cleopatra mandarin rootstock . Such conclusion find support in the results of Saad-Allah *et al* (1985b), reported that Rangpur lime had the longest of both skeletal and fibrous roots.

Table (4): Fibrous root length as cm/auger* of five citrus rootstocks as affected by Washington navel orange tree during 2000 and 2001 seasons.

Rootstock	50 cm from tree trunk			100 cm from tree trunk			150 cm from tree trunk		
	-30cm depth	- 60cm depth.	-90 cm depth	-30cm depth	-60cm depth.	-90 cm depth	-30cm depth	-60 cm depth.	-90 cm depth
				2000					
Sour orange	5.3	5.4	2.2	3.8	5.2	1.1	5.5	4.7	1.5
Volkamer lemon	6.7	7.2	3.4	10.4	7.9	2.2	9.4	7.7	2.3
Troyer citrange	5.3	3.9	1.3	3.8	4.2	1.1	4.9	4.1	1.5
Rangpur lime	5.5	5.5	2.6	7.1	5.5	1.2	5.6	5.6	1.6
Cleopatra mandarin	4.3	2.9	1.3	3.3	3.8	1.0	4.2	3.6	1.4
L . S . D 5 %	0.36	0.28	0.22	0.59	0.47	0.05	0.37	1.15	0.39
1 %	0.53	0.40	0.32	0.86	0.69	0.07	0.54	1.68	0.57
				2001					
Sour orange	7.1	8.3	2.4	5.2	8.6	1.6	7.5	6.9	3.2
Volkamer lemon	8.5	10.2	5.3	14.8	10.2	3.4	10.7	10.6	4.0
Troyer citrange	6.5	5.9	2.3	5.0	7.3	1.6	7.5	5.9	3.2
Rangpur lime	7.1	8.8	3.6	9.6	8.7	1.8	8.2	8.6	3.7
Cleopatra mandarin	5.0	5.6	2.2	4.3	6.9	1.4	6.7	5.5	2.8
L . S . D 5 %	0.42	0.44	0.22	0.44	0.42	0.24	0.29	0.27	0.49
1 %	0.61	0.64	0.32	0.65	0.61	0.35	0.43	0.39	0.71

*auger = 2356 cm^3

b-Fibrous root density as number of roots / auger:

Data in Table (5) showed that at 50, 100 and 150cm destance from tree trunk at 30,60 and 90 cm depths, the number of roots was higest on Volkamer lemon which varied among all tested rootstocks then came Rangpur lime, sour orange and Troyer citrange. Finally Cleopatra mandarin had the lowest values of number of roots. The differences were significant among all tested rootstocks. This result was true in both seasons. Similar results were obtained by Allurwer and Perihar (1992), El-Syed (1999) and El-Wakel (1999). They reported that Volkamer lemon had significantly higher number of roots per tree than that recorded on sour orange or Troyer citrange.

Table (5): Fibrous root density as number of fibrous roots /auger* of five citrus rootstocks as affected by Washington navel orange trees during 2000and 2001 seasons.

Rootstock	50 cm from tree trunk			100 cm from tree trunk			150 cm from tree trunk		
	-30cm depth	- 60cm depth.	-90 cm depth	-30cm depth	- 60cm depth.	-90 cm depth	-30cm depth	-60cm depth	-90 cm depth
				2000					
Sour orange	4.92	4.66	1.97	3.11	4.87	1.95	4.50	3.97	1.37
Volkamer lemon	11.85	12.71	5.91	18.30	13.75	3.88	16.55	13.52	3.98
Troyer citrange	3.77	3.03	1.69	2.25	3.17	1.75	3.84	3.16	1.12
Rangpur lime	5.51	6.04	2.39	7.46	5.69	2.29	5.82	5.99	1.70
Cleopatra mandarin	2.75	2.16	1.21	2.07	2.43	1.48	2.69	2.33	1.11
L . S . D 5 %	0.75	1.07	1.22	0.36	0.40	0.40	0.37	0.54	0.55
1 %	1.10	1.56	1.78	0.52	0.59	0.59	0.54	0.79	0.80
				2001					
Sour orange	6.71	7.11	2.04	6.74	6.69	1.49	5.19	5.02	4.08
Volkamer lemon	16.26	17.43	7.72	25.10	15.22	4.76	22.36	17.59	5.46
Troyer citrange	5.26	4.80	1.79	4.13	4.87	1.48	6.08	4.71	2.97
Rangpur lime	7.62	7.78	3.60	10.77	7.63	1.93	7.70	8.28	4.57
Cleopatra mandarin	3.57	4.05	1.40	3.53	4.32	1.55	5.62	4.47	1.96
L . S . D 5 %	0.30	0.62	0.60	0.52	0.45	0.28	0.46	0.40	0.40
1 %	0.44	0.90	0.88	0.75	0.65	0.41	0.67	0.58	0.58

*auger = 2356 cm^3

c- Fibrous root dry weight / auger:

Data in Table (6) showed that Volkamer lemon had the highest value of root dry weight followed by Rangpur lime with significant differences between them. Sour orange and Troyer citrange gave intermediate values without significant differences between them in most cases. On the other hand, Cleopatra mandarin gave the lowest root dry weight when compared with the other tested rootstocks. This result came true in both seasons (Table 6). In addition, the obtained results agreed with those reported by Dawood *et al* (2002a) and El-Syed (1999). They found that Volkamer lemon had the greater total root system (kg) than that on other tested rootstocks such as Cleopatra mandarin rootstock.

Generally, it is clear that, data in Tables (4,5 and 6) show that, Volkamer lemon and Rangpur lime had more ability to produce more roots longer with higher root dry weight when compared with the other tested rootstocks.It was obvious that the fibrous roots at 30 cm depth at all distance from tree trunk (50, 100 and 150 cm) were higher in number than those at deeper layers of soil surface. These results are in line with those obtained by Hassan

(1984), Saad- Allah *et al.* (1985a, b), Allurwar and Parihar (1992) and El-Sayed (1999). These results may attributed to the relatively high root growth rates of Volkamer lemon and Rangpur lime, also due to its ability to tolerate soil type, slight alkaline and saline soil conditions.

Table (6): Fibrous root dry weight as gm /auger* of five citrus rootstocks as affected by Washington navel orange trees during 2000 and 2001 seasons.

Rootstock	50 cm from tree trunk			100 cm from tree trunk			150 cm from tree trunk		
	-30cm depth	-60cm depth	-90cm depth	-30cm depth	-60cm depth.	-90cm depth	-30cm depth	-60cm depth.	-90cm depth
				2000					
Sour orange	0.930	0.880	0.230	0.670	0.920	0.180	0.850	0.750	0.260
Volkamer lemon	1.078	1.156	0.538	1.664	1.250	0.353	1.505	1.230	0.362
Troyer citrange	0.872	0.700	0.224	0.598	0.732	0.173	0.849	0.730	0.260
Rangpur lime	1.022	1.120	0.444	1.382	1.053	0.240	1.079	1.110	0.316
Cleopatra mandarin	0.766	0.600	0.220	0.576	0.677	0.134	0.747	0.650	0.250
L . S . D 5 %	0.095	0.176	0.058	0.088	0.095	0.015	0.074	0.253	0.013
1 %	0.131	0.243	0.080	0.121	0.132	0.021	0.102	0.349	0.017
				2001					
Sour orange	1.280	1.205	0.325	0.921	1.266	0.248	1.167	1.022	0.356
Volkamer lemon	1.482	1.591	0.738	2.290	1.547	0.486	2.070	1.678	0.497
Troyer citrange	1.200	0.947	0.305	0.822	1.007	0.238	1.156	0.991	0.350
Rangpur lime	1.406	1.545	0.611	1.901	1.448	0.330	1.483	1.523	0.435
Cleopatra mandarin	1.052	0.823	0.303	0.792	0.931	0.185	1.026	0.887	0.346
L . S . D 5 %	0.049	0.025	0.033	0.017	0.013	0.026	0.020	0.043	0.032
1 %	0.072	0.037	0.048	0.025	0.015	0.038	0.029	0.063	0.046

*auger= 2356 cm^3

The results in Tables (4, 5 and 6) indicated that Volkamer lemon and Rangpur lime had larger fibrous root system with more distribution in the same soil volume in horizontal and vertical level than all tested rootstocks. This ability helps to absorp more amount of water and mineral nutrients. This result could explain the vigorous of vegetative growth of Washington navel orange tree budded on Volkamer lemon and Rangpur lime rootstocks. These results find support with our obtained data in Table (2 and 3) and assure the relationship between root ability and vigorous vegetative growth of Washington navel orange grown on Volkamer lemon and

Rangpur lime as rootstocks. Also, Syvertsen (1981) stated that Carrizo citrange and rough lemon seedlings had the highest root conductivity, whereas Cleopatra mandarin and sour orange had less ability.

3- Physiological changes of some organic substances as affected by the tested rootstocks:

a- Leaf chlorophyll content:

Data in Table (7) showed that leaf chlorophyll content (a, b and its total value) of Washington navel orange trees was slightly affected by rootstocks.

Table (7): Leaf chlorophyll (ug / cm ^{2}), carbohydrate % , C/N ratio and proline (ug/g fresh weight) content of Washington navel orange trees as affected by five citrus rootstocks during 2000 and 2001 seasons .

Rootstock	Chlorophyll ug / cm ^{2}			Carbohydrate %				C/N ratio	Proline ug/g fresh weight
	A	B	Total	reducing sugar %	Non – reducing sugar %	Starch %	Total %		
2000									
Sour orange	37.67	14.72	52.40	1.58	1.74	7.25	10.57	4.16	0.456
Volkamer lemon	37.37	14.82	52.20	1.41	1.69	7.29	10.39	3.68	0.667
Troyer citrange	37.32	14.30	51.62	1.60	1.77	7.21	10.58	4.31	0.425
Rangpur lime	37.20	14.25	51.70	1.44	1.72	7.32	10.48	3.87	0.535
Cleopatra mandarin	36.82	14.85	51.67	1.67	1.82	7.40	10.89	4.51	0.418
L.S.D 5 %	N.S	0.17	0.46	N.S	0.07	N.S	0.15	0.07	0.010
1 %	N.S	0.24	0.64	N.S	0.09	N.S	0.22	0.10	0.014
2001									
Sour orange	41.77	21.19	62.96	1.62	1.75	7.32	10.69	4.56	0.511
Volkamer lemon	42.29	21.73	64.02	1.44	1.71	7.30	10.45	3.78	0.721
Troyer citrange	42.14	22.11	64.25	1.63	1.79	7.28	10.70	4.76	0.481
Rangpur lime	41.27	20.40	61.67	1.48	1.74	7.37	10.59	4.04	0.590
Cleopatra mandarin	38.77	18.66	57.43	1.71	1.85	7.46	11.02	4.98	0.469
L.S.D 5 %	N.S	2.06	3.28	0.04	0.06	N.S	N.S	0.34	0.015
1 %	N.S	2.84	4.52	0.06	0.08	N.S	N.S	0.47	0.020

Chlorophyll a, b and its total value were higher in the second season than that on the first season. Moreover, trees budded on Cleopatra mandarin had lower content of chlorophyll a, b and its total in their leaves when compared with other tested rootstocks, while chlorophyll a, b and its total value of Washington navel

budded on other tested rootstocks were nearly similar without significant differences in most cases. However, Volkamer lemon and Rangpur lime as rootstocks recorded higher values of chlorophyll a, b, and its total value in leaves of Washington navel orange as scion than those recorded on Cleopatra mandarin rootstock. This increasing in chlorophyll may be due to increasing the absorption of mineral nutrients, especially N and Mg which in turn increased their levels in leaves. This explanation agreed with those of El-Sayed (1999). She reported that Volkamer lemon and Rangpur lime as rootstocks absorped more of N, K, Ca, Mg, Fe and Mn tending to increase their levels in leaves of Washington navel, Valencia orange and Balady mandarin as scions varieties than those determined for Cleopatra mandarin as rootstock. Similar results were obtained by Schembecker and Lodders (1991) and El-Sayed (1999). They reported that Washington navel orange budded on Cleopatra mandarin had lower values of chlorophyll a, b and its total value.

b- Leaf carbohydrate:

Leaf reducing and non-reducing sugars %, starch % and total carbohydrate contents in Washington navel orange grown on different rootstocks showed two different trends, the first on Cleopatra mandarin, Troyer citrange and sour orange which recorded significantly higher values of all carbohydrate fractions in Washington navel orange leaves, the second, on Rangpur lime and Volkamer lemon which had lower values in that respect. Such reduction in all carbohydrate frations could be attributed to active vegetative growth in the trees budded on Volkamer lemon and Rangpur lime rootstocks. On the contrary, Cleopatra mandarin rootstock has a degree of dwarfing effect on Washington navel orange as scion, so the reduction in vegetative growth vigour led to carbohydrate accumulation in the tested scion grown on this rootstock.

This explanation finds support in the results of Azab(1995) on seven citrus rootstocks, who reported that Volkamer lemon and Rangpur lime contained lower level of total carbohydrate % than in Cleopatra mandarin. In addition, El-Sayed (1999) mentioned that Rangpur lime and Volkamer lemon as rootstocks for Washington

navel orange had lower values of carbohydrate than those on Cleopatra mandarin.

c- Leaf C / N ratio:

It is clear that trees budded on Rangpur lime and Volkamer lemon had the least C/N ratio in their leaves. Moreover, Washington navel orange trees on Troyer citrange and sour orange had intermediate values in their leaves. On the other hand, leaves from those budded on Cleopatra mandarin had the highest C / N ratio with significant differences when compared with all rootstocks. Similar results were found by Azab (1995) and El-Sayed (1999).

d- Leaf proline content:

Leaf proline content was higher in Washington navel orange trees on Volkamer lemon and Rangpur lime than those on the other rootstocks with significant differences among them. It was clear that trees on sour orange had intermediate values. On the other side, trees on Troyer citrange and Cleopatra mandarin had the least values of proline content without significant differences among them (Table 7). These findings are in accordance with those obtaind by Laboren *et al* (1991), Escalona *et al* (1994) and El-Sayed (1999).

In light of the obtained results, it could be concluded that Washington navel orange trees grown on Volkamer lemon and Rangpur lime rootstocks had higher amount of chlorophyll a, b and its total value and also higher levels of proline content when compared with the other tested rootstocks. This result may explain the ability of Volkamer lemon and Rangpur lime rootstocks to tolerate salinity, alkaline and drought stresses as suggested by Azab (1995) and El-Sayed (1999). Accordingly, under stress conditions (salinity and drought) amount of chlorophyll a, b and its total value were reduced and also, led to accumulate higher level of proline in leaves. Ennab (1997) and Zayan *et al* (2002) found higher accumulation of proline in leaves of papaya plant and grapevine under salt and drought stresses. This conclusion finds support in the results of Levitt, (1980) and Zayan *et al* (2002).

Finally, it could be concluded that Volkamer lemon and Rangpur lime rootstocks could tolerate salinity and alkaline stress under Kafr El– Sheikh conditions than all tested rootstocks due to their ability to absorp more K+ ions than Na+ when soil solution contains high concentration of Na+ ions in the alkaline soil.

REFERENCES

Allurwar, M.W.and S. K. Parihar (1992). Comparative study of root systems of common rootstocks of orange J. Soils and Crops. 2 (1): 100-101.

Anon, (1965) Determination of moisture content, total soluble solids, starch and ash. Official method of analysis of the association of official agricultural chemists. Washington, D. C.

Azab, S.A. (1995). Studies on seven citrus rootstocks under the arid environment of Qatar 2- leaf and root chemical constituents. Zagazig J. Agric. Res. 22 (5): 1315 – 1328.

Azab, S.A. amd A. K. Hegazy (1995). Studies on seven citrus rootstocks under the arid environment of Qatar. 1- Growth performance and plant water relations. Zagazig J. Agric- Res. 22(5): 1301-1314.

Bates, L. S.; R. P. Walkden and I. O. Teare (1973). Rapid determination of free proline for water stress studies. Plant and Soil. 39:205-207.

Dawood, S. A. (1996). Evaluation of vegetative growth and nutrient composition of nine citrus rootstocks under north Delta environmental conditions. 1st Egypt – Hung. Hort. Conf. 1:171-181.

Dawood, S. A. (2001). Growth, yield, fruit quality and leaf mineral content of Valencia orange trees on sour orange and Volkamer lemon grown on slightly alkaline clay soil. J. Agric. Res. Tanta Univ., 27 (4): 726 – 736.

Dawood, S. A. (2002). Evaluation of Washington navel orange on sour orange and Volkamer lemon grown on slightly alkaline clay soil conditions. J. Agric. Res. Tanta Univ., 28 (1): 157-167.

Dawood, S. A.; M. M. Abdel- Metaal and A. A. El- Hossiny (2002). A comparative study on vegetative growth, root

growth and distribution of four promising citrus rootstocks grown on clay soil as compared with the sour orange one.J. Agric. Res. Tanta Univ., 28(1): 119- 131.

Dubois, M.; K. A. Gilles; J. K. Hamiliton; P. A. Rebers and F. Smith (1956). Colorimetric method for determination of sugars and related substances. Analytical chemistry. 28 (3): 350- 356.

El-Hammady, A. M.; M. Abou- Rawash; A, Abou- Aziz; N. Abdel-Hamid and E. Abdel- Moneim (1995). Impact of irrigation with salinized water on growth and mineral content of some citrus rootstock seedlings. Annals Agric. Sci., Ain Shams Univ., Cairo, 40 (1): 327 – 341.

Ellis, F. B. and B. T. Bornes (1971). A mechanical method for obtaining soil cores. Plant and soil 35:209.

El- Sayed, Somaia A. (1999). Physiological studies on some orange varieties budded on different rootstocks. Ph. D. Thesis. Fac. Agric., Tanta Univ.

El-Wakel, H. (1999). In vitro rooting study of some promising citrus rootstocks. Annals Agric. Sci., Ain Shams Uinv. Cairo. 40 (2): 705-716.

Ennab, H. A. (1997). Tolerance of papaya plants to different levels of salinity. M. Sc. Thesis, Fac. Agric., Tanta University.

Escalona, M.; N. Nieves; J. F. Acosta; J. L. Gonzalez; C. G. Borroto; M. Blanco and A. Gonzalez (1994). Physiological and biochemical aspects of water stress in Marsh grapefruit (citrus paradisi) Centro – Agricola. 21(2): 31-37.

Hassan, M . M . (1984). Effect. of citrus rootstocks on root distribution, tree growth and leaf mineral composition of Washington navel orange trees. Egypt . J . Hort .11 (2) : 201 - 207.

Hassan, M. M.; A. A. Abdel- Kawi and A. Rifay (1984). Effect of nitrogen fertilization on growth , yield and root distribution of grapevines . Egypt. J. Hort. 11(2) 209-213.

Laboren, E. G.; M. Wagner and F. Reyes (1991). Proline concentration as an indicator of water deficit in three citrus rootstocks. Fruits. Paris. 46(3): 259-264.

Levitt, J. (1980). Responses of plants to environmental stress. Volume II. Water, Radiation, Salt and other stress. Academic Press – New York.

Martinez, C.; H. Lima and J. Rivas (1994). Growth and productivity of 5 types of Valencia orange on different rootstocks during the developmental phase. (Hort. Abst. 64: 710).

Mehrotra, N.K.; Vij; H. Kumar; P. S. Aulakh and P. singh (1999). Performance of Marsh seedless cultivar of gropefruit (Citrus paradisi Macf) on different rootstocks. Indian J. Hort. 56 (2): 141- 143.

Monteverde, E. E.; F. J. Reyes; G. Laboren and J. R. Ruiz (1990). Citrus rootstocks in Venezuela: Behavior of Valencia orange on ten rootstocks. Proc. Int. Soc. Citriculture, 1: 47-55..

Moran, R and D. Porath (1980). Chlorophyll determination in intact tissues using N, N dimethylformamide. Plant physiol. 65:478-479.

Nasr, M. E. and M. M. Hassan (1984). Root distrobution and leaf mineral content of balady orange (Citrus sinensis Linn Osbeck) trees on three rootstocks. Egypt. J. Agric.Res., 62 (3): 305- 312.

Newman, E. I. (1966). A method of estimating the total length of roots in sample. J. Appl. Ecol. 3: 139.

Ranganna, S. (1979). Manual of analysis of fruit and vegetable products. 2nd ed. Tata McCraw- Hill, Publishing Company Limited, NewDelhi, pp 9-15.

Ruck, J. A. (1963). Chemical methods for analysis of fruit and vegetable products, Canada Dept. of Agriculture, Publication No. 1154. PP 9.

Saad-Allah, M. H.; M.A. Galal and M. A. El-Nokrashy (1985 a). Performance of white Khalily orange trees on three different rootstocks in sandy soil. Bull. Fac. Agric., Univ. Cairo 36(2): 1077-1092.

Saad-Allah, M. H.; M. A. Galal and M. E. Nasr (1985 b). Performance of vegetative growth and root system of some citrus rootstock seedlings in sandy soil. Bull. Fac . Agric. Univ. Cairo 36 (2): 1093-1103.

Schembecker, F. K. and P. Lodders (1991). Influence of N supply on fruit / leaf ratio, chlorophyll content of leaves and net photosynthetic rate of cox orange rootstocks clone combination. Fruchteverwertung. 39(5): 196-201(Hort. Abst. 61: 1724).

Singh, T. N. and G. H. Snyder (1984). Leaf area index and dry biomass. Taro- Agron- J. 76: 750- 753.

Snedecor, G. W. and W. G. Cochran (1967). Statistical Methods. Iowa state Univ. Press, Iowa, USA.

Syvertsen, J. P. (1981). Hydraulic conductivity of four commercial citrus rootstocks. J. Amer. Soc. Hort. Sci. 106 (3): 378 – 381.

Turrell, F. M. (1946). Tables of surfaces and volumes of spheres and of prolate and oblate spheroids, and spheroidal coefficients. Univ., Calif. Press. Berkeley.

Valbuen, H. (1996). Evaluation of volkamer lemon (C. volkameriana Pasq.) and cleopatra mandarin (C. reshi Hort.) as rootstocks for Persian lime (C. latifolia tam.) in the middle region of the guasare river valley, Sierv de Perija, Zulia State, Venezuela. Revista de la Facultad de Agronomia, Universidad del Zulia 13(2): 139-151 (Hort. Abstracts 1997, 67(7): 6374).

Zayan, M. A.; A. F. El- Sammak; S. M. Zeerban and A. R. El-Shereif (2002). Physiological responses of some grapevine varieties to drought conditions. 2nd Inter. Conf. Hort. Sci. Fac. of Agric. Kafr El- Sheikh. Tanta University.(3/2): 782 – 796.

دراسة تقييم لصنف البرتقال أبو سرة المطعوم على خمسة أصول

١- النمو الخضري و الانتشار الجذري و القدرة على تحمل الملوحة

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الملخص العربي

أجريت هذه الدراسة خلال عامي ٢٠٠٠ و ٢٠٠١ على أشجار برتقال بسره عمرها ٦ سنوات والمطعومة على خمسة أصول مختلفة هي الفولكاماريانا و الترويز سترانج وليمون الرانجبور واليوسفي كليوباترا والنارنج والتي تم زراعتها في مزرعة التجارب البحثية بسخا كفر الشيخ مصر. وذلك لدراسة النمو الخضري و الانتشار الجذري و القدرة على تحمل الملوحة و قد بينت النتائج أن :-

١- تأثر حجم وقوة النمو في شجرة البرتقال أبو سرة معنويا بالأصل المستخدم، فاصلى الفولكاماريانا وليمون الرانجبور أعطوا أعلى قيم من طول وقطر وحجم الرأس ومساحة مقطع الساق ومحيط كلا من الأصل والطعم. بينما أقل قيم وجدت على الأشجار المطعومة على أصل اليوسفي كليوباترا ، في حين أن الأشجار المطعومة على أصلي النارنج و الترويز سترانج أعطت قيم متوسطة في هذا المجال .

٢- أعطى أصلي الفولكاماريانا وليمون الرانجبور أعلى قيم للوزن الجاف وعدد الجذور وطول الجذور المغذية على مسافة ٥٠ ، ١٠٠ ، ١٥٠ سم من جذع الشجرة (وعلى أعماق ٣٠، ٦٠، ٩٠ سم من سطح التربة) وذلك عند المقارنة بباقي الأصول .

٣- أظهر تحليل أوراق البرتقال أبو سرة المطعوم على أصلي الفولكاماريانا وليمون الرانجبور مستوى عالي من البرولين بينما أعطى مستوى أقل من الكربوهيدرات .