A COMPARATIVE STUDY ON VEGETATIVE GROWTH, ROOT GROWTH AND DISTRIBUTION OF FOUR PROMISING CITRUS ROOTSTOCKS GROWN ON CLAYEY SOIL AS COMPARED WITH THE SOUR ORANGE ONE

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ABSTRACT

This investigation was carried out on 4-year old five citrus rootstocks namely; Volkamer lemon (VL), Troyer citrange (TC), Rangpur lime (RL), Cleopatra mandarin (CM) and sour orange (SO) planted in Sep. 1995 at the Experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh, where the soil is a slight saline alkaline clayey soil.

The evaluation results indicated the superiority of VL followed by RL as better rootstocks than SO and other rootstocks. Their trees are characterized by: Vigorous vegetative growth as indexed by tree height, volume index, trunk cross sectional area, total leaf number and area per plant and entire plant component (fresh weight). Also, VL followed by RL had the greatest total root system (kg), the largest root horizontal spread and root vertical penetration. Moreover, they had the greatest fibrous roots with more superficial distribution.

CM had the smallest root system with a smaller main roots, more fibrous roots and larger root horizontal spread, while, TC and SO were intermediate in this respects.

Most roots of all rootstocks were located in the top 60 cm while most of fibrous roots were found at (0-30 cm) depth . Maximum root vertical penetration was as follows: VL, SO, RL, CM and finally TC. Meanwhile, maximum root horizontal spread was as follows: VL, CM, RL,TC and SO.

It could be concluded that VL followed by RL had the greatest root system density with more typical horizontal and vertical fibrous root distribution than sour orange and other rootstocks.

Generally, the five rootstocks could be descendingly arranged due to their vegetative growth , root density and distribution under this study conditions as follow: (VL & RL), (TC & SO) and finally (CM). Accordingly, both rootstocks (VL & RL) may be considered as suitable substitutes for sour orange in the slight saline alkaline clayey soil in Egypt.

Key Words: citrus rootstocks, vegetative growth, root growth, root density root distribution and root system.

INTRODUCTION

It is well known that, rootstocks exert a vital influence on the production of citrus trees (Monteverde, 1996; El-Sayed, 1999 and Dawood, 2001). Sour orange (the most commonly used rootstock for citrus orchards in Egypt) is considered a satisfactory rootstock, but its high susceptibility to Tristeza disease, and the spread of this disease in the Mediterranean region (Bitters *et al.*, 1973) and its detection in Israel (Moreno, 1988) have stimulated a search for alternative rootstock.

Choice of a rootstock becomes a matter of individual judgment when the merit of a rootstock depends on several characteristics and when none is superior in all respects. Therefore, the need for more information about some new rootstocks and their behavior under the environmental conditions of Egypt has become necessary to find a potential substitute for sour orange rootstock

Rootstocks root system is one of the most important factors which affect the adaptability of the rootstock in a given area. Many factors affect rootstocks root density and distribution such as, soil depth (Castle and Youtsey, 1977), soil texture (Avilan *et al.*, 1983), soil type, water conditions, soil macroprosity and high clay contents restricted root penetration (Avilan *et al.*, 1986), flooding (Protopapadakis *et al.*, 1998), water logging (Salem, 1991), salinity (Nieves *et al.*, 1991 and Garcia-Legaz *et al.*, 1993), and alkalinity (Sagee *et al.*, 1994 and Sudahono *et al.*, 1994).

Moreover, the differences among rootstocks in their response to different environmental stress are considerably varied in a given area (Monteverde *et al.*, 1990).

The purpose of this study was to evaluate and compare the vegetative growth, root system density and distribution Volkamer lemon (VL), Troyer citrange (TC), Rangpur lime (RL), Cleopatra mandarin (CM) with sour orange (SO) grown on a slight saline alkaline clayey soil at Sakha, Kafr El-Sheikh Governorate as a main rootstock for most citrus varieties in Egypt to find a potential substitute for it.

MATERIALS AND METHODS

1- Experimental plants and orchard soil: This experiment was carried out on 4-year-old seedlings of five citrus rootstocks grown at the Experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during 1996 till 1999 season. The tested rootstocks were: Volkamer lemon (*C. volkameriana*), Troyer citrange (*P. trifoliata* x *C. sinensis*), Rangpur lime (*C. aurntifolia* x *C. reticulata*), Cleopatra mandarin (*C. reticulata*)and Sour orange (*C. aurantium*).

The experimental seedlings were planted at the end of Sep. 1995 at 5 x 5 meters apart in a complete randomized block design with three seedlings plot replicated three times. All trees received the regular fertilization and the horticulture managements as recommended by the Ministry of Agriculture.

The planting soil is classified as clayey (54.9 % clay), the depth of water table was about 110-120 cm. Other physical and chemical properties were determined according to Chapman and Pratt (1978) and the data of soil analysis are presented in Table (1).

2- **Vegetative growth measurements:** plant height was estimated from the soil surface to the end of the growing point at the end of Nov. 1999. Volume index was calculated as indicated by Turrel (1946) after width measuring on Nov.1999. Trunk cross sectional area (TCSA cm^2) was also calculated by estimating trunk diameter (cm) at 10 cm above the soil surface. Leaf area was measured according to Singh and Snyder (1984) then, total leaf area per plant were calculated after total leaves per plant were numbered also, total leaves weight per plant were determined. Samples from total leaves were weighted and dried (at $70c^0$) to a constant weight for estimating total dry weight per plant. Total fresh vegetative growth and roots were estimated then total weight per plant was determined.

3- **Root system measurements:** Root system was studied on three excavated trees of each rootstock (the middle one of each plot) using the skeleton method (Kolesnikov, 1971 and Bohm, 1979) including depth, spread diameter, circumference of root system, in addition weight, length, density and distribution of skeletal, semi skeletal and fibrous roots and it was expressed as kgs.

4- **Statistical analysis:** The experiment was arranged in a randomized complete block design. All data were subjected to statistical analysis according to Steel and Torrie (1982).

RESULTS AND DISCUSSIONS

1- **Orchard soil:** With respect to some chemical and physical properties of the experimental soil (average of 0-120 cm depth) the obtained data (Table1) revealed that the planting soil is classified as clayey soil (54.9% clay) with a slight saline and alkaline, the mean of pH value (1-2.5 soil extract) was 8.46, EC was 3.61 (ds/m) and 2.36 % total carbonate. The depth of water table was about 110-120 cm. It had high Na/Ca and SAR, low of organic matter, aggregation index, infiltration rate, average nutrients (mg/kg soil) and bad structure coefficient and high saturated percent.

Table (1): Some chemical and physical properties of the experimental soil (average of 0-120 cm depth).

Chemical properties				Physical properties				
pH 1-2.5 soil ext.	EC ds/m	Na/Ca	SAR	W.S.A. (%)	A.I.	I.R.		Cr
8.46	3.61	2.42	7.54	8.38	0.19	229		1.34
Average nutrients mg/kg soil				O.M.	Total carb-onate (%)	Clay (%)	SP	Texture grade
N	P	K						
22	8.6	2.56		1.33	2.36	54.9	76.3	Clayey

A.I.= Aggregation index. I.R.=Infiltration rate (time in minutes).
Cr =Structure coefficient. SP = Saturated percent. W.S.A = Water stable aggregates.

2- Entire plant growth: With regard to rootstocks vegetative growth, data of Table (2) indicated the superiority of VL as compared with other rootstocks. It was characterized by the greatest tree height (3.33 m), TCSA (90.26 cm^2), tree volume (13.77 m^3), entire plant component as indexed by vegetative growth fresh weight (23.131 kg/tree), total roots (10.825 kg/tree), hole plant fresh weight (33.956 kg/tree). Also, total leaves per plant as indexed by leaves numbers (19143 leaf/tree), fresh weight (8.762 kg/tree) dry weight (3.173 kg/tree) and total leaves area (32.47 m^2/tree). RL came second, SO and TC were intermediate whereas CM recorded the least value in these respects with the exception of total leaves numbers for SO which had the least leaves numbers and TC was the highest rootstock (3.62m) followed by VL (3.33m). Accordingly, these rootstocks could be descendingly arranged as follows: VL > RL > TC > SO > CM.

Table (2): Entire plant growth of the five citrus rootstocks.

Root-stock	Max. Hei-ght (m)	TCSA (cm^2)	Tree Vol-ume (m^3)	Entire plant component FW (Kg)			Total leaves per plant			
				Veget-ative	Total roots	Hole plant	No	FW (Kg)	DW (Kg)	Area (m^2)
SO	2.31	32.98	3.25	8.739	3.948	12.686	4230	3.080	1.198	9.90
CM	2.05	28.27	2.58	7.978	3.544	11.521	6494	2.222	0.836	6.48
RL	2.62	50.70	7.58	11.934	5.727	17.663	9374	4.273	1.435	16.16
TC	3.62	53.07	2.87	8.393	4.535	12.928	9712	2.440	0.913	8.66
VL	3.33	90.26	13.77	23.131	10.825	33.956	19143	8.762	3.173	32.47
L.S.D at 5%	0.21	3.12	0.46	0.752	0.314	0.221	342.1	0.210	0.251	2.496

These result might be attributed to the largest root system of VL and RL rootstocks (Tables 3-6), which may uptake adequate amount of water and mineral nutrients via their roots and consequently caused the early and vigorous growth. Also, their tolerant or resistance to Phytophthora root rot (Carpenter and Furr, 1962), flooding (Protopapadakis *et al.*, 1998), water logging (Salem, 1991), salinity (Nieves *et al.*, 1991 and Garcia-Legaz *et al.*, 1993 El-Desouky and Atawia, 1998), alkalinity (Sagee *et al.*, 1994 and

Sudahono *et al.*, 1994), soil depth (Castle and Youtsey, 1977), soil texture (Avilan *et al.*, 1983) and soil type, water conditions, soil macroprosity and high clay contents (Avilan *et al.*, 1986). These conclusions find support in the results of Devy and Supriyanto, (1991); Azab and Hegazy, 1995 and Dawood, (1996) and are in accordance with those of Castle and Youtsey (1977) who reported that VL and RL rootstocks have a taproot, prominent vigorous lateral roots and larger number of feeder roots, SO and CM were intermediate.

3- Total root measurements: From table (3) it was obvious that, Volkamer lemon (VL) had the greatest root system density (10.825 kg/tree) distributed vertically by 68.79% and 28.69% in 0-30 cm and 30-60cm depth, respectively (97.48% in 0-60cm depth) and 2.52% deeper 60cm. It was followed in a decreasing order by RL and TC (5.727 and 4.535 kg/tree resp.) distributed vertically by 63.72, 68.73% and 27.24, 27.76% in 0-30 cm and 30-60cm depth, respectively (90.96, 96.49% in 0-60cm depth resp.) and 9.06, 3.51% deeper 60cm respectively. And then, SO and CM had 3.945 and 3.544 kg/tree respectively, distributed vertically by 60.39, 74.85 and 26.79, 21.02% in 0-30 cm and 30-60cm depth, respectively (87.18, 95.88% in 0-60cm depth resp.) and 9.06, 3.51% deeper 60 cm, respectively. Thus, it is clear that VL followed by RL had the greatest root system density and distribution while CM had the least root system density whereas TC and SO gave intermediate values in this respect.

Table (3): Total root measurements of 4-year old citrus rootstocks.

a- Horizontally (Kg).									
Root-stock	Distance far from the trunk of the tree							Total FW	M.R.S. (CM)
	0-30	30-60	60-90	90-120	120-150	150-180	Beyond 180		
SO	1.744	0.911	0.693	0.315	0.184	0.101	----	3.948	1.63
CM	1.251	0.893	0.670	0.507	0.164	0.052	0.006	3.544	1.86
RL	2.039	1.790	1.162	0.467	0.232	0.037	----	5.727	1.79
TC	1.621	1.425	1.012	0.353	0.090	0.034	----	4.535	1.64
VL	2.099	2.373	2.007	1.872	1.469	0.841	0.164	10.825	2.23
L.S.D at 5%	0.313	0.323	0.259	0.126	0.018	0.009	----	0.314	0.011

b- Vertically (Kg).									
Root-stock	Soil depth (cm)								M.R.P. (CM)
	0 – 30 cm		30 – 60 cm		Total of 0-60 cm		Deeper than 60 cm		
	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	
SO	2.384	60.39	1.058	26.79	3.442	87.18	0.505	12.79	86
CM	2.653	74.85	0.745	21.02	3.398	95.88	0.146	4.12	73
RL	3.649	63.72	1.560	27.24	5.209	90.96	0.519	9.06	78
TC	3.117	68.73	1.259	27.76	4.376	96.49	0.159	3.51	68
VL	7.446	68.79	3.106	28.69	10.552	97.48	0.273	2.52	88
L.S.D at 5%	0.208	----	0.354	----	0.562	----	0.079	----	2.6

These results are in line with those of Mokhtar (1984) and. Saad-Allah *et al.* (1985); Kosola and Eissentat (1994); Sharma and Dhillon (1997) and Vieira and Gomes (1999). On the other hand, the obtained results disagree with the conclusions of Allurwar and Parihor (1992).

As for maximum root spread (M.R.S.), it was found that VL had the largest root spread (2.23 m.), CM came second in this respect (1.86m) followed in a decreasing order by RL, TC and finally SO (1.79, 1.64 and 1.63 m., resp.). Meanwhile maximum root penetration was as follows VL, SO, RL, CM and finally TC (88, 86, 78, 73 and 68 cm. resp.).

These results are in line with those reported by El-Nokrashy *et al* (1981); Tuzcu *et al* (1999). Also, Bevington and Castle (1985) and Avilan *et al.* (1986) mentioned that soil type and soil water conditions affect root penetration and soil macroprosity values < 5% and high clay contents restricted root penetration.

Generally, this evaluation gave a good picture about the ability of root system to spread vertically and horizontally in the soil after 4-years of planting in open field, where the soil is a slight alkaline and saline soil. Accordingly, the better root system characteristics attained by VL and RL rootstocks may be helpful and enable the plant to get better control on water loss and delay the onset of water stress. Such conclusion agrees with the findings of Azab and Higazy (1995) and El-Sayed, (1999).

4- Skeletal roots: The data of table (4) revealed that VL had the highest values of skeletal roots meanwhile CM followed by TC had the least values whereas RL followed by SO were intermediate in this respect. However, RL followed by TC had the least skeletal roots percentages, meanwhile VL and SO gave the highest percentages and CM was intermediate in this respect.

As for horizontal skeletal roots distribution it was noted that, they were concentrated around the main trunk of the tree up to a distance of 60-90 cm far from the main trunk of the tree for RL and TC, 90-120 cm for CM, 120-150 cm for SO and 150-180 cm for VL.

With regard to vertical skeletal roots distribution it was noticed that, all skeletal roots were found in 0-60 cm depth for all studied rootstocks except SO which was found deeper than 60 cm depth by 4.86 %. These results may support the results of El-Nokrashy *et al.* (1981) and Saad Allah *et al.* (1985).

Table (4): Skeletal roots density and distribution of 4-years old citrus rootstocks.

a- Horizontally (Kg).									
Root-stock	Distance far from the trunk of the tree							Total	Persent
	0-30	30-60	60-90	90-120	120-150	150-180	Beyond 180		
SO	1.199	0.312	0.201	0.031	0.006	----	----	1.749	44.31
CM	0.868	0.288	0.200	0.060	----	----	----	1.416	39.95
RL	1.294	0.337	0.091	----	----	----	----	1.722	30.06
TC	0.994	0.421	0.152	----	----	----	----	1.567	34.55
VL	1.817	1.073	0.894	0.523	0.391	0.262	----	4.960	45.82
L.S.D. at 5%	0.102	0.014	0.023	----	-----	-----	----	0.318	----

b- Vertically (Kg).								
Root-stock	Soil depth (cm)							
	0 – 30 cm		30 – 60 cm		Total of 0-60 cm		Deeper than 60 cm	
	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
SO	1.227	70.11	0.438	25.03	1.665	95.14	0.085	4.86
CM	1.301	91.88	0.115	8.12	1.416	100.00	----	----
RL	1.499	87.05	0.223	12.95	1.722	100.00	----	----
TC	1.275	81.37	0.292	18.63	1.567	100.00	----	-----
VL	4.188	84.42	0.773	15.58	4.961	100.00	----	----
L.S.D. at 5%	0.171	----	0.093	----	0.232	----	----	----

5- Semi skeletal roots: Data of semi skeletal roots as shown in Table (5) indicated that VL and RL rootstocks produced the highest semi skeletal roots fresh weight. On the other hand, CM rootstock produced the least semi skeletal roots fresh weight. While, SO and TC were intermediate in this respect. However, RL followed by TC had the largest semi skeletal roots percentages, meanwhile, SO, VL and CM were nearly similar in this respect.

As for horizontal semi skeletal roots distribution it was noted that, it were spread up to a distance of 120-150cm far from the main trunk of the tree for RL and TC, 150-180cm for CM and SO, and beyond 180cm for VL.

With regard to vertical semi skeletal roots distribution it was noticed that, it was found by 97.78, 96.03, 95.11, 89.63 and 80.05% for VL, TC, CM, RL and SO respectively in 0-60cm depth. While, SO gave the largest semi skeletal roots (19.95%) followed by RL (10.37%) where, VL was the lowest semi skeletal roots (2.22%) followed by TC (3.97%) and CM (4.89%) in the layer deeper than 60cm depth.

These results may confirm the results of El-Nokrashy *et al.* (1981) and Saad Allah *et al.* (1985).

Table (5): Semi skeletal roots density and distribution of 4-years old citrus rootstocks.

a- Horizontally (Kg).									
Root-stock	Distance far from the trunk of the tree							Total	Percent
	0-30	30-60	60-90	90-120	120-150	150-180	Beyond 180		
SO	0.380	0.331	0.238	0.110	0.044	0.014	---	1.117	28.31
CM	0.232	0.333	0.225	0.168	0.057	0.008	---	1.023	28.90
RL	0.472	0.795	0.479	0.165	0.057	---	---	1.969	34.35
TC	0.370	0.473	0.445	0.212	0.039	---	---	1.539	33.87
VL	0.227	0.800	0.707	0.615	0.439	0.285	0.032	3.105	28.69
L.S.D. at 5%	0.113	0.127	0.172	0.053	0.014	---	---	0.458	---

b- Vertically (Kg).								
Root-stock	Soil depth (cm)							
	0 – 30 cm		30 – 60 cm		Total of 0-60 cm		Deeper than 60 cm	
	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
SO	0.563	50.36	0.332	29.70	0.895	80.05	0.223	19.95
CM	0.764	74.68	0.209	20.43	0.973	95.11	0.051	4.89
RL	1.139	57.91	0.624	31.72	1.763	89.63	0.204	10.37
TC	1.052	68.53	0.422	27.49	1.474	96.03	0.061	3.97
VL	1.735	55.84	1.303	41.94	3.038	97.78	0.069	2.22
L.S.D. at 5%	0.191	---	0.111	---	0.067	---	0050	---

6- Fibrous roots: As for total fibrous roots fresh weight density and distribution Table (6) revealed that VL had the greatest fibrous roots density (2.758 kg/tree) followed by RL (2.039 kg/tree) but, SO (1.080 kg/tree) had the least value while, TC (1.432 kg/tree) and CM (1.103 kg/tree) were intermediate in this respect. However, RL followed by TC had the largest fibrous roots percentages, meanwhile, SO, and CM were similar and VL was the least in this respect.

Concerning horizontal fibrous roots distribution it was found that, they were spread up to a distance of 150-180cm far from the main trunk of the tree for RL, TC and SO and beyond 180cm for VL and CM. The fibrous roots density were progressively less when it goes up or towards the main trunk. Table (6) also clear that the majority of fibrous roots horizontally density of VL were found at distance (90-150 cm) far from the main trunk of the tree while it were at (60-120 cm) for CM whereas it were at (30-90 cm) for RL, TC and SO. Vieira and Gomes (1999) reported that the effective distance of the roots defined by 80 % of root system is located at 1.86 cm from the trunk, also the largest roots concentrations occurring between the mid-point of the canopy radius and the outer edge of canopy (Avilan *et al.*, 1983)

As for vertical fibrous roots distribution it was noticed that, in all rootstocks most vertical fibrous roots were found at (0-60 cm), it was found by 93.23, 92.60, 91.39, 84.55 and 81.76% for TC, VL, CM, RL and SO, respectively. Meanwhile, SO (18.24%) followed by RL recorded the largest fibrous roots (19.95%) in the layer deeper than 60cm depth whereas, TC recorded the least value (6.77%), CM (8.60%) and VL were intermediate in this respect and it was also progressively decreased with increasing depth. Most of fibrous roots (> 80%) were recovered only from the upper 20-30cm of soil Sharma and Dhillon (1997). Root distribution was more superficial in VL and feeder roots were abundant in CM (Tribulato *et al.*, 1982). Tayde (1985) reported that RL had the highest fibrous roots than SO, TC and CM.

Table (6): Fibrous roots density and distribution of 4-years old citrus

a- Horizontally (Kg).									
Root-stock	Distance far from the trunk of the tree							Total	Percent
	0-30	30-60	60-90	90-120	120-150	150-180	Beyond 180		
SO	0.165	0.268	0.255	0.173	0.133	0.086	----	1.080	27.36
CM	0.152	0.272	0.245	0.279	0.106	0.043	0.006	1.103	27.36
RL	0.273	0.658	0.593	0.303	0.175	0.037	----	2.039	35.59
TC	0.257	0.532	0.415	0.141	0.053	0.034	----	1.432	31.58
VL	0.055	0.300	0.606	0.733	0.640	0.293	0.131	2.758	25.48
L.S.D. at 5%	0.024	0.149	0.135	0.088	0.061	0.023	----	0.346	----

b- Vertically (Kg).								
Root-stock	Soil depth (cm)							
	0 – 30 cm		30 – 60 cm		Total of 0-60 cm		Deeper than 60 cm	
	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
SO	0.594	55.09	0.288	26.67	0.882	81.76	0.197	18.24
CM	0.588	53.26	0.420	38.13	1.008	91.39	0.095	8.60
RL	1.011	49.58	0.713	34.97	1.724	84.55	0.315	15.45
TC	0.790	55.17	0.545	38.06	1.335	93.23	0.097	6.77
VL	1.524	55.26	1.030	37.35	2.554	92.60	0.204	7.40
L.S.D. at 5%	0.217	---	0.120	----	0.087	----	0.035	----

These results are in line with those reported by Castle and Youtsey (1977); Avilan *et al.*, (1983); Zhang *et al.* (1996); Sharma and Dhillon (1997) and Vieira and Gomes (1999).

CONCLUSION

It could be concluded that Volkamer lemon (VL) and Rangpur lime (RL) rootstocks had achieved the greatest vegetative growth and the largest root system with better vertical and horizontal distribution. Moreover, they had the greatest fibrous roots density and distribution, maximum root spread

and penetration compared with sour orange (SO) and other rootstocks. Thus, VL and RL may be considered as suitable substitutes for sour orange in the slight saline alkaline clayey soil in Egypt.

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الملخص العربى

دراسة مقارنة على النمو الخضرى والمجموع الجذرى لأربعة أصول موالح واعده نامية فى الأراضى الطينية مقارنة بأصل النارنج

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أجـرى هـذا البحـث فـى مواسم ١٩٩٦ حتى ١٩٩٩ على خمسة أصول موالح مختلفة عمرها أربع سنوات هى: الفولكا ماريانا ــ ليمون الرانجبور ــ التروير سيترنج ــ اليوسفى كيلوباترا ــ والنارنج ، و التى تم زراعتها فى مزرعة التجارب البحثية لمحطة البحوث الزراعية بسخا ــ محافظة كفرالشيخ فى سبتمبر عام ١٩٩٥ حيث التربة الطينية خفيفة الملوحة والقلوية. وذلك بهدف تقييم ومقارنة النمو الخضرى ، كثافة وتوزيع الجذور مع أصل النارنج الذى يعتبر أصلا رئيسيا فى مصر.

وقـد أوضـحت نـتائج التقيـيم أفضـليه استخدام الفولكاماريانا متبوعا بالليمون الرانجبور عن الأصول الأخرى حيث اتصفت أشجارهما بما يلى:

١- قـوة الـنمو الخضرى لأشجارهما ممثلا فى ارتفاع الشجرة ــ دليل الحجم ــ مسـاحة مقطع الجذع ــ عدد الأوراق والمساحة الورقية للشجرة لهذين الأصليين- وكذلك المكون الكلى للشجرة (وزن طازج وجاف).

٢- مجموعهـا الجذرى تميز بكثافة جذرية كبيرة وأكبر كميه من الجذور الليفيه مع أفضل توزيع افقى ورأسى لجذور الامتصاص وأكبر اختراق وانتشار أفقى فى التربة.

٣- تمـيز اصـل اليوسـفى كيلوباترا بأقل مجموع خضرى وجذرى واقل جذور رئيسيه واكثر غزارة للجذور الليفيه وذو انتشار أفقى كبير.

٤- أصلى التروير سيترنج والنارنج أعطيا قيم متوسطة بين المجموعتين.

٥- معظـم جـذور الأصـول المختلفة تقع فى الطبقة السطحية العليا (٠-٦٠سم) بينما معظم الجذور الليفيه تقع فى الطبقة السطحية العليا (٠-٣٠ سم).

٦- أقصـى انتشار رأسى لهذه الأصول تنازليا كالآتي: الفولكا ماريانا> النارنج> ليمون الرانجبور> اليوسفى كيلوباترا> التروير سيترنج.

٧- أقصـى انتشـار أفقى لهذه الأصول تنازليا كالاتي: الفولكا ماريانا> اليوسفى كيلوباترا> ليمون الرانجبور > التروير سيترنج> النارنج.

عمومـا ومـن نتائج التقييم المتحصل عليها فإن الأصول الخمسة موضع الاختبار يمكـن ترتيـبها تنازليا طبقا لدرجة نموها الخضرى وكثافة وانتشار جذورها تحت ظروف هـذا البحث كما يلى(الفولكاماريانا وليمون الرانجبور) ، (التروير سترنج ، النارنج) وأخيرا اليوسفى كيلوباترا.

وطبقا لذلك: فإنه يمكن اعتبار كلا الأصلين (الفولكاماريانا وليمون الرانجبور) كبدائل مناسبة لأصل النارنج فى الأرض الطينيه خفيفة الملوحه والقلويه فى مصر.