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EFFECT OF ROOTSTOCK AND INTERSTOCK ON GROWTH, YIELD AND FRUIT QUALITY OF SOME ORANGE VARIRTIES A. VEGETATIVE GROWTH, NUTRITIONAL STATUS AND YIELD

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ABSTRACT: *This experiment was designed as a long term study, started in 2008 till 2014 with the idea of using sour orange as interstock on volkamer lemon rootstock (SO/VL) for budding four orange varieties, namely, Olinda valencia ,spring navel, Parent navel, and Fukumoto navel oranges. The purpose was to avoid some disadvantages of volkamer lemon on physical and chemical fruit quality with the hope of maintaining tree growth and its productivity with good properties acceptable for local and foreign market. The obtained results showed that, Olinda valencia, Spring navel, Parent navel and Fukumoto navel oranges on volkamer lemon rootstock showed the best tree size with higher growth parameters, while the interstock gave intermediate values with most vegetative growth parameters. On the other hand the lowest values of tested growth parameters were obtained on the scions budded on sour orange. In this respect, Olinda valencia orange gave largest tree size and strong vegetative growth parameters compared to other varieties. The highest values of chlorophyll a, b and total chlorophyll were recorded on Spring navel orange budded on volkamer lemon rootstock. Leaf NPK analysis showed that maximum leaf nitrogen content was recorded on Olinda valencia and Parent navel oranges. Phosphor was maximum for Spring navel orange. As for potassium, it reaches maximum values in leaves of Parent and Fukumoto navel oranges. In addition, yield in terms of weight (kg) of fruits/tree - kg/cm3of canopy volume and kg/cm2 of trunk cross section area (TCSA). were high on volkamer lemon followed by sour orange rootstock, and intermediate on interstock. The interstock tended produce yield near to that on sour orange rootstock with better fruit properties as found in part (B) of this study .*

Key words: *Rootstock, Interstock, Budwood, Volkamer lemon, Fukumoto navel, Parent navel, Olinda valencia*

INTRODUCTION

Rootstocks selection is a major consideration in every citrus growing operation. It is fundamental to orchard success. Also, supporting the tree, the root system is responsible for absorption of water and nutrients, adapting the scion to particular soil conditions, and potentially providing tolerance to drought, salinity and some diseases (Louzada *et al.,* 1992 and Zayan *et al.,* 2004). More than twenty horticulture characters influenced by rootstock including for example tree vigour and size, nutritional status, yield and yield efficiency. In this respect, Zekri (2000) revealed that trunk cross sectional area (TCSA) and tree canopy volume of valencia orange grown on *C. volkameriana* were greater than those on Swingle citrumelo, Cleopatra mandarin and Milam lemon rootstocks. Dawood (2001 & 2002) found that, valencia and Washington navel oranges on *C. volkameriana* had the largest tree size and vegetative growth as well as yield efficiency as compared with those recorded on sour orange. Also, Castle *et al* (2010) evaluated valencia orange on 12 rootstocks for 15 years, they reported that, trees on Volkamer lemon was tallest, higher trunk cross sectional than other rootstocks.

Workers on Horticulture uses interstocks for many reasons such as avoiding scion/rootstock incompatibility, control of tree size and tolerance of some negative soil properties as well as to prevent injury from several trunk diseases with the use of resistant interstock trunks (Krezdorn 1978, Shokrollah *et al.,* 2011, Gimeno *et al*., 2012, Aboutalebi and Hassanzadeh 2014). Furthermore, interstocks may improve tree growth, yield and fruit quality. Castle 1992, Girardi and Filho 2006, Bakry *et al.,* 2007 and Yilmaz *et al.,* 2015, they studied the effect of interstocks on vegetative growth, leaf mineral content and amount of chlorophyll in leaf. Therefore, scions on volkamer lemon gave strong tree in size and growth as well as tolerance to environmental conditions.

The purpose of this long term study is to avoid or get rid of disadvantages of volkamer lemon on physical and chemical fruit properties , hopping to maintain tree growth and its productivity. Therefore, influences of volkamer lemon , sour orange rootstocks and interstock on growth , nutritional status and yield efficiency of four (scions) orange varieties namely, Olinda valencia, Spring navel, Parent navel and Fukumoto navel orange were studied in 2013 and 2014 seasons.

MATERIALS AND METHODS

This experiment is designed as a long term study started in 2008 with the idea of using double budding for volkamer lemon (VL) rootstock by using sour orange (SO) as interstock (SO/VL) for budding four orange varieties. In 2008 budwood from sour orange (SO) (*Citrus aurantium*) were budded on one year Volkamer lemon (VL) (*Citrus Volkameriana*) seedlings as interstock .Six months later, (VL), (SO) and (SO/VL) rootstocks were prepared at the same age and budded in 2009 with four orange varieties, namely Olinda valencia, Spring navel, Parent navel, and Fukumoto navel orange varieties. The experiments included twelve treatments were arranged in a randomized complete block design, each treatment replicated 3 times and 3 plots for a total of 9 tree per each rootstock.

Thus, 108 budded trees (12x9) were planted in 2010 in a private orchard at El-Bustan region, El- Beheira Governorate, Egypt planted at 5x5 meter apart. The soil is sandy and the mechanical and chemical analysis was done as shown in Table (1). All agricultural practices were done as usual in the orchard.

In 2013 and 2014 seasons, samples and field data were recorded as follows:

1- Olinda valencia orange on sour orange (SO).
2- Olinda valencia orange on volkamer lemon (VL).
3- Olinda valencia orange on interstock (SO/VL).
4- Spring navel orange on sour orange (SO).
5- Spring navel orange on volkamer lemon (VL).
6- Spring navel orange on interstock (SO/VL).
7- Parent navel orange on sour orange (SO).
8- Parent navel orange on volkamer lemon (VL).
9- Parent navel orange on interstock (SO/VL).
10- Fukumoto navel orange on sour orange (SO).
11- Fukumoto navel orange on volkamer lemon (VL).
12- Fukumoto navel orange on interstock (SO/VL).

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

Mechanical			Chemical		Cations (meq/l)				Anions (meq/l)		
Sand %	Silt %	Clay %	pH	Ec dS/m^{-1}	Na^+	Ca^{++}	Mg^{++}	CO_3^-	HCO_3^-	Cl^-	$SO4^{--}$
77.85	6.50	15.65	8.82	0.64	2.53	1.45	0.60	-	2.23	2.10	0.25

During 2013 and 2014 seasons the following data were recorded:

1. Vegetative growth:

1.1. Leaf parameters:

Leaves formed in spring shoot were counted in both seasons, twenty mature leaves were sampled in August from spring shoot to determining leaf area (cm^2) using a leaf area meter Model Li 3100 area- meter, then total leaf area (m^2) of spring shoot was calculated.

1.2. Shoot parameters:

Spring shoot formed by spring growth cycle was counted and measured as (cm) by ruler, then total growth (m) of spring shoots was calculated in both seasons.

1.3. Tree vigour:

Tree height (m) was measured from soil surface to the end of growth, trunk circumferences (cm) was measures by using stripe measurement. Canopy volume was calculated according to the following equation: $CV= 0.528 \times H \times D^2$. Whereas, H = tree height, D = tree diameter (Castle 1983).

2. Nutritional status:

2.1. Leaf chlorophyll content $\mu g/cm^2$:

Chlorophyll a and b were extracted from fresh leaves with N, N-dimethyl formamide and determined Spectrophotometrically at wave-length of 664 and 647 nm and then total chlorophyll was estimated according to the method described by Moran (1982).

2.2. Leaf NPK content:

Leaves sample was taken in September and washed with tap water followed by distilled water. Leaves were oven dried at 70°C to a constant weight. Dry weight was calculated then the dry leaves were ground and digested according to Chapman and Pratt (1961) and Jackson (1967). N, P and K. Total nitrogen % was determined by using the micro-kjeldahl method as described by Pregl (1945), Phosphorus % was determined coloremetrically as described by Murphy and Riley (1962) while, Potassium % was determined by using flame photometer as described by Brown and Lillelland (1974).

3. Yield:

At harvest time (December in both seasons), yield of each tree was determined as weight (kg) of fruits/tree . Yield efficiency was calculated as kg/$cm^3$of canopy volume and kg/cm^2 of trunk cross section area (TCSA).

Statistical analysis:

Statistical analysis was done as analysis of variance according to Snedecor and Cochran (1990), and the least significant differences (L.S.D. at 5% level) was used to compare the mean values.

RESULTS AND DISCUSSION

1. Vegetative growth:

1.1. Leaf parameters:

Data presented in Table (2) show the effect of rootstock and interstock on orange varieties and their interaction on leaf growth parameters in both seasons. As for the effect of rootstock and interstock, it is clear that most leaf growth parameters were significantly influenced by rootstocks and interstock. Trees on volkamer lemon (VL) rootstock have had the highest values of leaves number per spring shoot, leaf area per spring shoot and total leaves area of spring shoot followed in a descending order by interstock (SO/VL) and sour orange (SO) rootstock in both seasons respectively. The differences were significant among them in both seasons. These results are in agreement with Dawood (2002) and Zayan *et al*., (2004). In this respect, Mohamed (2011) and Hikal (2014) revealed that volkamer lemon rootstock reported the highest significant effect of leaves number per plant and leaf area of Balady lime and Washington navel orange compared to sour orange, Rangpur lime and Troyer citrange rootstocks.

Table (2). Effect of rootstock and interstock on leaf growth parameters of some orange varieties in 2013 and 2014 seasons.

Treatments	Rootstocks and interstock											
V \ R	Leaves number / spring shoot				Leaf area cm^2 from spring shoot				Total leaves area of spring shoots m^2			
	VL	SO	SO/VL	Mean	VL	SO	SO/VL	mean	VL	SO	SO/VL	Mean
2013												
Olinda valencia	8.33	5.67	6.33	6.78	35.02	26.50	31.10	30.87	2.92	1.51	1.98	2.14
Spring navel	7.67	5.33	5.67	6.22	24.50	20.33	22.17	22.33	1.88	1.08	1.26	1.41
Parent navel	7.33	5.33	7.33	6.66	28.80	24.80	26.89	26.83	2.11	1.33	1.97	1.80
Fukumoto navel	7.67	7.00	7.33	7.33	29.40	24.33	26.15	26.65	2.25	1.73	1.93	1.97
Mean	7.75	5.83	6.67		29.45	23.99	26.58		2.29	1.41	1.79	
L.S.D. at 5%	V =0.82 R= 0.50 VxR = 0.97				V = 4.51 R=1.18 VxR= 2.36				V = 0.88 R= 0.31 VxR= 0.62			
2014												
Olinda valencia	11.67	7.67	7.67	9.00	35.35	25.01	33.88	31.41	4.13	1.92	2.58	2.88
Spring navel	10.00	7.67	7.67	8.45	32.30	22.21	25.88	26.80	3.23	1.71	1.99	2.31
Parent navel	9.33	7.33	8.00	8.22	29.29	18.57	28.28	25.38	2.70	1.36	2.27	2.11
Fukumoto navel	10.00	8.33	8.33	8.89	33.71	22.87	26.06	27.55	3.40	1.92	2.19	2.50
Mean	10.25	7.75	7.92		32.66	22.17	28.53		3.37	1.73	2.26	
L.S.D. at 5%	V=1.42 R=0.50 VxR=1.00				V= 4.21 R =1.40 VxR= 4.09				V= 0.63 R= 0.27 VxR=0.54			

SO = Sour orange, VL = Volkamer lemon, V = Variety, R= Rootstock, SO/VL = Interstock

Regarding the effect of orange varieties, the results showed that, no significant differences were found for most leaf growth parameters among orange varieties in both seasons. Anyhow, Olinda valencia orange showed the higher values of leaf growth parameters than other orange varieties in the second season. Similar results were obtained by Martinez *et a*l. (1994) and Dawood (2002).

As for the effect of interaction between rootstock or interstock and scion cultivars, it is clear that, Olinda valencia orange on volkamer lemon rootstock gave highest values of leaf growth parameters followed by Fukumoto and Spring navel orange on the same rootstock, while the lowest values were obtained from Spring navel orange on sour orange rootstock followed by Parent navel orange on the same rootstock in both seasons. The interstock treatment(SO/VL) gave intermediate values with all orange varieties in both seasons. These results are in line with those reported by Abd Alla (1999) who reported that Washington navel orange, valencia orange and Balady mandarin on volkamer lemon and Rangpur lime exhibited the most vigorous growth compared to sour orange and other rootstocks.

1.2. Shoot parameters:

Data in Table (3) showed that the tested rootstocks were significantly affected on spring shoot growth parameters of the four orange varieties in both seasons. Olinda valencia, Spring navel, Parent navel and Fukumot navel orange had the highest spring shoot number, spring shoot length and total growth of spring shoots on volkamer lemon rootstock followed by those budded on the interstock with significant differences between them in both seasons. On the other hand, the lowest values of spring shoot growth parameters are belonged to scions budded on sour orange rootstock in both seasons while the interstock gave intermediate values of springe shoot growth parameters. The obtained results concerning the effect of citrus rootstocks on scion shoot growth parameters go in line with those mentioned by Dawood (2001 & 2002), Zayan *et al.,* (2004) and Hikal (2014).

With regard to the effect of four orange varieties, it was evident that all spring shoot growth parameters were not significant among all orange varieties in the first season only. Olinda valencia orange had the highest values of spring shoot number, spring shoot length and total growth of spring shoots followed by Spring navel orange without significant differences between them in both seasons. Parent navel orange and Fukumoto navel orange gave the lowest values of spring shoot parameters with significant differences between them and other varieties in the second season only. The results are in line with those obtained by Sayed and Abdel-Aziz (2010).

Also, a significant interaction effect between rootstock and interstock and scion varieties on spring shoot growth parameters was obtained. The highest values of spring shoot number, spring shoot length and total growth of spring shoots were occurred with Olinda valencia orange and Spring navel orange budded on volkamer lemon rootstock, while the lowest values was obtained from Fukumoto navel orange on sour orange rootstock. This result was more pronounced in the second season. Parent navel orange gave intermediate values in this respect. This results are in general agreement with those found by Bakry *et al.,* (2007).

Table (3). Effect of rootstock and interstock on spring shoot growth parameters of some orange varieties in 2013 and 2014 seasons.

Treatments	Rootstocks and interstock											
R / V	Spring shoot Number				Spring shoot length (cm)				Total growth of spring shoots (m)			
	VL	SO	SO/VL	Mean	VL	SO	SO/VL	mean	VL	SO	SO/VL	Mean
2013												
Olinda valencia	10.33	7.33	8.00	8.55	15.76	8.10	10.30	11.39	1.63	0.59	0.82	1.01
Spring navel	9.33	8.00	8.33	8.55	13.10	8.03	10.10	10.41	1.22	0.64	0.84	0.90
Parent navel	9.00	6.67	7.33	7.67	12.13	7.93	10.25	10.10	1.09	0.53	0.75	0.79
Fukumoto navel	6.33	6.00	6.33	6.22	9.77	8.17	8.10	8.68	0.61	0.49	0.51	0.51
Mean	8.75	7.00	7.50		12.54	8.06	9.69		1.10	0.56	0.73	
L.S.D. at 5%	V= 2.87 R=0.57 VxR= 1.14				V= 2.12 R=1.43 VxR=2.86				V= 0.23 R= 0.12 VxR= 0.24			
2014												
Olinda valencia	23.00	15.00	17.00	18.33	22.40	16.50	19.37	19.42	5.15	2.48	3.30	3.64
Spring navel	18.33	18.33	15.00	17.22	19.73	11.40	17.57	16.23	3.62	2.09	2.64	2.78
Parent navel	14.00	12.67	13.00	13.22	18.67	8.62	14.83	14.04	2.61	1.09	1.83	1.84
Fukumoto navel	13.00	12.67	20.67	15.45	16.67	9.77	13.83	13.42	2.16	1.24	2.86	2.09
Mean	17.08	14.67	16.42		19.37	11.57	16.40		3.39	1.73	2.66	
L.S.D. at 5%	V =1.71 R=1.72 VxR =0.43				V =2.32 R=1.76 VxR=2.35				V =0.55 R=0.20 VxR=0.40			

SO = Sour orange, VL = Volkamer lemon, V = Variety, R= Rootstock, SO/VL = Interstock

1.3. Tree vigour:

Data in Table (4) showed that, Volkamer lemon, sour orange and interstock were significantly effected on tree height, canopy volume and trunk circumferences of the four orange varieties in both seasons. Trees on volkamer lemon rootstock had the highest values of tree height, canopy volume and trunk circumferences followed by those on sour orange rootstock and interstock in both seasons respectively. The differences between sour orange and interstock were not significant in most cases. Similar results were obtained by Mansour *et al*., (1993).

In according to orange varieties, data in Table (4) showed that, Olinda valencia orange have had tallest and largest canopy volume and trunk circumferences followed by Fukumoto navel orange as compared with the other varieties in both seasons. Spring navel and Parent navel oranges gave the lowest values, and were found to be approximately at par during both seasons. These results are similar to those of Sayed and Adawy (2009).

The interaction between the two factors revealed that, Olinda valencia orange and Fukumot navel orange budded on volkamer lemon rootstock gave the highest values of tree height, canopy volume and trunk circumferences compared to other treatments in both seasons. On the other hand, Spring navel and Parent navel orange budded on sour orange or interstock had the lowest values in both seasons. The other treatments gave intermediate values for tree height, canopy volume and trunk circumferences in both seasons. Similar results about high, tree height, canopy volume and trunk circumferences of volkamer lemon were reported by Dawood, (2002) and Zayan *et al* (2004).

Table (4). Effect of rootstock and interstock on tree growth and vigour of some orange varieties in 2013 and 2014 seasons.

Treatments	Rootstocks and interstock											
R / V	Tree height (m)				Canopy volume (m^3)				Trunk circumferences (cm)			
	VL	SO	SO/VL	Mean	VL	SO	SO/VL	Mean	VL	SO	SO/VL	Mean
2013												
Olinda valencia	2.38	1.72	1.65	1.92	2.68	2.28	2.09	2.35	15.60	6.67	6.17	9.48
Spring navel	1.60	1.37	1.31	1.43	2.05	1.86	1.30	1.74	13.37	5.83	5.23	8.14
Parent navel	1.78	1.38	1.36	1.51	2.20	1.96	1.49	1.88	13.83	6.17	5.50	8.50
Fukumoto navel	2.14	1.68	1.56	1.79	2.27	2.01	1.60	1.91	15.00	6.53	5.70	9.08
Mean	1.98	1.54	1.47		2.30	2.05	1.62		14.45	6.30	5.65	
L.S.D. at 5%	V= 0.30 R= 0.18 VxR= 0.35				V= 0.46 R= 0.22 VxR= 0.43				V= 0.64 R= 0.52 VxR= 1.05			
2014												
Olinda valencia	3.09	2.00	1.92	2.34	3.36	2.76	2.56	2.79	22.67	12.67	12.27	15.87
Spring navel	2.06	1.67	1.64	1.79	2.48	2.33	1.95	2.25	15.17	9.17	8.67	11.00
Parent navel	2.09	1.73	1.67	1.83	2.87	2.56	1.99	2.47	15.67	10.83	10.13	12.21
Fukumoto navel	2.55	1.83	1.77	2.05	2.89	2.57	2.11	2.52	18.00	11.50	10.30	13.27
Mean	2.45	1.81	1.75		2.90	2.56	2.15		17.88	11.04	10.34	
L.S.D. at 5%	V= 0.54 R= 0.24 VxR= 0.48				V= 0.76 R= 0.35 VxR= 0.70				V =1.12 R=1.05 VxR=2.10			

SO = Sour orange, VL = Volkamer lemon, V = Variety, R= Rootstock, SO/VL = Interstock

Generally, it is obvious from Tables (2, 3 and 4) that, volkamer lemon rootstock showed the best tree size and growth parameters represented by leaves number per spring shoot, leaf area per spring shoot, total leaves area of spring shoot, spring shoot number, spring shoot length, total growth of spring shoots, tree height, canopy volume and trunk circumferences. Using sour orange as Interstock gave intermediate values with most vegetative growth parameters, on the other hand the lowest values of the tested growth parameters were obtained from scions budded on sour orange. These results are similar to those obtained by Perez-Zamora *et al*., (2002), Castle *et al*., (2010) and Shafieizargar *et al*., (2012). Moreover, Bakry *et al*., (2007) they observed that Washington navel orange and Balady mandarin budded on sour orange interstock on volkamer lemon gave intermediate values of most vegetative growth parameters compared to volkamer lemon and sour orange rootstocks. Such conclusions agree with those presented by Gimeno *et al*., (2012) who reported that Verna lemon trees grafted on valencia orange or Castellano orange interstock on sour orange rootstock had higher root, stem and total dry weight than that on sour orange rootstock.

As for comparison among orange varieties, Olinda valencia orange gave the largest tree size and strong vegetative growth parameters. Fukumoto, Parent and Spring navel oranges gave medium tree size and growth vigour.

2. Nutritional status:

2.1. Leaf chlorophyll content μg/cm^2:

Data in Table (5) clearly showed that, chlorophyll a, b and total content was significantly increased with scions budded on volkamer lemon rootstock in both seasons. Scions on sour orange rootstock recorded the lowest values of chlorophyll a, b and total content, while those on the interstock gave intermediate values in both seasons. the differences were significant between volkamer lemon and sour orange rootstock, while were not significant between volkamer Lemon rootstock and Interstock in both seasons. These results are in line with those reported by Abd Alla (1999) and Ennab (2003) on valencia orange, Washington navel orange and Balady mandarin on different rootstocks.

Table (5). Effect of rootstock and interstock on leaf chlorophyll content (μg/cm2) of some orange varieties in 2013 and 2014 seasons.

Treatments	Rootstocks and interstock											
R	Chlorophyll A				Chlorophyll B				Total Chlorophyll a + b			
V	VL	SO	SO/VL	Mean	VL	SO	SO/VL	mean	VL	SO	SO/VL	Mean
2013												
Olinda valencia	44.28	42.12	45.49	43.96	22.64	20.23	22.53	21.80	66.92	62.35	68.02	65.76
Spring navel	47.16	47.06	45.62	46.61	22.84	20.75	21.92	21.84	70.00	67.81	67.54	68.45
Parent navel	45.26	41.09	43.13	43.16	22.52	19.51	21.14	21.06	67.78	60.60	64.21	64.20
Fukumoto navel	44.47	40.92	43.99	43.13	20.88	19.25	19.69	19.94	65.35	60.17	63.68	63.07
Mean	45.29	42.79	44.56		22.22	19.93	21.32		67.51	62.73	65.86	
L.S.D. at 5%	V=2.92 R = 2.56 VxR = 5.13				V = 1.14 R= 1.27 VxR= 2.55				V = 2.11 R= 2.74 VxR= 5.48			
2014												
Olinda valencia	44.00	41.85	45.36	43.74	22.80	20.71	20.85	21.45	68.17	62.56	6621	65.65
Spring navel	48.24	46.07	42.23	45.51	24.17	20.80	23.94	22.97	72.41	66.87	66.17	68.48
Parent navel	42.15	39.66	43.30	41.70	24.28	18.49	21.49	21.42	66.43	60.37	64.79	63.86
Fukumoto navel	45.27	41.26	44.40	43.64	22.79	19.84	21.40	21.34	68.06	61.10	65.80	64.99
Mean	44.92	42..21	43.82		23.51	19.97	21.92		68.43	62.18	65.74	
L.S.D. at 5%	V = 1.30 R= 2.36 VxR= 4.72				V= 2.02 R= 0.54 VxR = 1.09				V = 1.38 R= 2.27 VxR= 4.54			

SO = Sour orange, VL = Volkamer lemon, V = Variety, R= Rootstock, SO/VL = Interstock

As for orange varieties, data in Table (5) showed that, chlorophyll a, b and its total values were higher in Spring navel orange and Olinda valencia orange than the other varieties in both seasons. The significant differences were obtained between Spring navel orange and other orange varieties. These results are similar to those of Dawood (2002) and Zayan *et al*., (2004).

Concerning the interaction between rootstock or interstock and scions, it is clear that the interaction effect on leaf chlorophyll a, b and total content was significant in both seasons. The highest values of chlorophyll a, b and total chlorophyll were found on Spring navel orange budded on volkamer lemon rootstock, while the lowest values were obtained from Parent navel and Fukumoto navel oranges trees budded on sour orange rootstock. All orange varieties budded on the interstock gave intermediate values of chlorophyll a, b and its total value in both seasons. Similar results were obtained by Ataweia *et al*.,(2011).

2.2. Leaf NPK content:

The results in Table (6) revealed that, volkamer lemon rootstock exhibited the highest values of leaf NPK content of scions followed by interstock and sour orange in both seasons, respectively. These results are similar with those reported by Smith *et al*., (2004) and Barakat *et al*., (2013). In this respect, Ahmed *et al*., (2007) reported that, leaf NPK content of Kinnow mandarin grafted on nine rootstocks was differed significantly, maximum value of NPK were recorded on rough lemon and volkamer lemon while, the minimum were recorded on Troyer citrange and Carrizo citrange rootstocks.

Table (6). Effect of rootstock and interstock on leaf NPK content of some orange varieties in 2013 and 2014 seasons.

Treatments	Rootstocks and interstock											
R / V	N %				P %				K %			
	VL	SO	SO/VL	Mean	VL	SO	SO/VL	mean	VL	SO	SO/VL	Mean
2013												
Olinda valencia	1.95	1.57	1.92	1.81	0.110	0.096	0.090	0.099	1.31	1.06	1.24	1.20
Spring navel	1.63	1.59	1.35	1.52	0.128	0.115	0.096	0.113	1.33	1.20	1.24	1.26
Parent navel	1.98	1.52	1.94	1.81	0.105	0.084	0.099	0.096	1.98	1.24	2.02	1.75
Fukumoto navel	1.63	1.34	1.57	1.51	0.093	0.086	0.088	0.089	1.59	1.27	1.57	1.48
Mean	1.79	1.51	1.70		0.109	0.095	0.093		1.55	1.19	1.52	
L.S.D. at 5%	V=0.094 R= 0.046 VxR=0.094				V= 0.006 R= 0.004 VxR=0.009				V =0.046 R=0.039 VxR= 0.077			
2014												
Olinda valencia	1.97	1.62	1.96	1.85	0.105	0.097	0.096	0.099	1.34	1.22	1.26	1.27
Spring navel	1.70	1.69	1.47	1.62	0.138	0.125	0.097	0.120	1.38	1.27	1.30	1.32
Parent navel	2.12	1.58	2.13	1.94	0.109	0.088	0.104	0.100	1.99	1.25	2.02	1.75
Fukumoto navel	1.71	1.46	1.67	1.61	0.097	0.089	0.091	0.092	1.80	1.39	1.93	1.71
Mean	1.88	1.59	1.81		0.112	0.099	0.097		1.63	1.28	1.63	
L.S.D. at 5%	V = 0.11 R= 0.09 VxR= 0.18				V= 0.006 R= 0.005 VxR=0.009				V=0.053 R=0.943 VxR=0.086			

SO = Sour orange, VL = Volkamer lemon, V = Variety, R= Rootstock, SO/VL = Interstock

As for the effect of orange varieties, it is clear from Table (6) that maximum leaf nitrogen content was recorded on Olinda valencia and Parent navel oranges, and minimum on Fukumoto navel orange in both seasons. Phosphor was maximum on Spring navel orange while minimum values were recorded in Fukumoto navel orange. Olinda valencia and Parent navel orange recorded intermediate values in both seasons. As regard to potassium, it was higher on Parent and Fukumot navel oranges while the minimum value was recorded for Olinda valencia orange in both seasons. Similar results were obtained by Toplu *et al*., (2008) and Aboutalebi *et al.,* (2012).

The interaction between the two factors revealed that, the highest leaf nitrogen value was found on Parent navel and Olinda valencia oranges budded on Volkamer lemon rootstock, and the lowest was found for Fukumoto navel orange budded on sour orange rootstock in both seasons. Leaf phosphor content recorded higher values in Spring navel orange on volkamer lemon and on sour orange rootstocks, and the lower values were noticed in Parent and Fukumot navel oranges budded on sour orange rootstock. This result was true in both seasons. Parent navel orange budded on interstock or volkamer lemon had the highest leaf potassium content, and the lowest values were obtained from Olinda valencia orange on sour orange rootstock. These results are in agreement with those of Labanauskas and Bitters (1974); Bakry *et al.,* (2007) and Jahromi *et al.,* (2012).

3. Yield:

Data in Table (7) showed that, yield as weight (kg/tree) of Olinda valencia, Spring navel, Parent navel and Fukumoto navel oranges was significantly higher on volkamer lemon rootstock than that on sour orange rootstock and interstock in both seasons. Moreover, orange scions on sour orange and interstock had similar yield without significant differences between them in both seasons. Similar results about high productivity of volkamer lemon were found by Zayan *et al.,* 2004 and Al-Obeed *et al.,* 2005. Such conclusions agree with those presented by Ramin and Alirezanezhad 2005 who reported that Ruby Red and Marsh grapefruit trees on volkamer lemon rootstock had more fruit number and weight (kg) per tree than those grown on Cleopatra mandarin and sour orange rootstock. In this respect Shafieizargar *et al.,* 2012 stated that Queen orange trees grafted on volkamer lemon rootstock had larger and heavier fruits than those on Cleopatra mandarin and S wingle citrumelo rootstocks. In this respect, Gardner,1968 reported that fruit yield of valencia and Hamlin oranges did not show a significant difference by interstock.

With regard, the effect of oranges, it is clear that, Olinda valencia orange had significantly higher yield than other varieties in both seasons. Spring navel, Parent navel and Fukumoto navel oranges had similar yield without significant differences among them in both seasons.

Olinda valencia on volkamer lemon rootstock gave the highest yield compared to other rootstocks in both seasons. This result was more pronounced in the second season. The lowest yield harvested from Fukumoto navel orange was on the interstock in both seasons. Generally, it is clear that, scions on volkamer lemon rootstock produce higher yield when compared with sour orange rootstock and interstock.

Data in Table (7) revealed that, yield efficiency as kg/ cm^2 of TCSA (trunk cross sectional area cm^2) and kg/m^3 canopy volume of tree was significantly affected by all treatments in both seasons. As for the effect of rootstocks and interstock, it is clear that yield efficiency as kg/cm^2 of TCSA was the highest for scions on Sour orange rootstock in both seasons. On the other hand, scions on volkamer lemon rootstock had the lowest values of yield efficiency as kg/cm^2 of TCSA during 2013 and 2014 seasons. Interstock produced trees gave intermediate values in this respect.

Significant differences were detected among rootstocks and interstock in both seasons. Also, yield efficiency as kg/m^3 canopy volume was highest for scions on volkamer lemon rootstock followed in descending order by those on sour orange rootstock and interstock in both seasons.

As for orange varieties, the results in Table (7) showed that, no significant differences were found for yield efficiency as kg/ cm^2 of TCSA (trunk cross sectional area cm^2) and kg/m^3 canopy volume of the tree among orange varieties in both seasons, excepted kg/m^3 of canopy volume was variable between Olinda valencia orange and Fukumot navel orange in the second season only.

Although, there is a significant interaction effect between the two factors, but there is no constant trend among treatments in both seasons. Generally, yield efficiency was higher on volkamer lemon followed by sour orange rootstocks, and intermediate on the interstock. In this concern Dawood (2001) and Zayan *et al*., (2004) conducted that, accumulative yields of valencia orange and Washington navel orange were higher from trees on volkamer lemon and Rangpur lime than those on Swingle citrumelo, Cleopatra mandarin and sour orange. Also, Georgiou, 2002 reported that volkamer lemon has been reported to significantly increase accumulative yield of Clementine mandarin compared with sour orange up to 45%. Moreover, higher yield efficiency was also reported for trees showed reduction in size by the used rootstocks (Castle *and* Phillips, 1980 and Roose *et al*., 1989).

Table (7). Effect of rootstock and interstock on yield efficiency of some orange varieties in 2013 and 2014 seasons.

Treatments	Rootstocks and interstock											
R / V	kg/tree				Kg /cm^2 TCSA				Kg /m^3 canopy volume			
	VL	SO	SO/VL	Mean	VL	SO	SO/VL	Mean	VL	SO	SO/VL	Mean
2013												
Olinda valencia	18.00	12.33	11.50	13.94	0.94	4.12	3.29	2.78	6.73	5.94	5.05	5.91
Spring navel	14.83	7.67	7.33	9.94	0.99	2.97	2.42	2.13	6.65	3.70	5.82	5.39
Parent navel	12.17	9.67	9.17	10.34	0.86	4.47	4.41	2.91	5.91	6.21	4.90	5.67
Fukumoto navel	11.67	8.67	7.00	9.11		3.64	2.11	2.13	5.15	5.54	3.81	4.83
Mean	14.17	9.59	8.75			3.80	2.81		6.11	5.35	4.90	
L.S.D. at 5%	V = 1.33 R= 1.19 VxR= 2.37				V =0.86 R=0.34 VxR= 0.69				V = 1.49 R= 0.76 VxR= 1.53			
2014												
Olinda valencia	20.33	16.67	16.00	17.67	0.51	1.39	1.30	1.07	6.15	6.08	6.21	6.15
Spring navel	13.00	11.17	10.50	11.56	0.51	1.24	1.04	0.93	5.45	4.90	4.16	4.84
Parent navel	12.50	9.17	8.50	10.06	0.64	1.10	0.85	0.86	4.72	5.15	3.69	4.52
Fukumoto nave	11.83	9.00	8.00	9.61		1.50	1.22	1.14	4.10	4.71	3.22	4.01
Mean	14.42	11.50	10.75			1.31	1.22		5.11	5.21	4.32	
L.S.D. at 5%	V = 1.48 R = 0.87 VxR = 1.75				V = 0.31 R= 0.21 VxR= 0.42				V = 1.65 R= 0.85 VxR= 1.69			

SO = Sour orange, VL = Volkamer lemon, V = Variety, R= Rootstock, SO/VL = Interstock

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تاثير الاصل و الاصل الوسطى على النمو و المحصول وصفات الجودة لثمار بعض اصناف البرتقال.

أ- التاثير على النمو الخضرى و الحالة الغذائية و المحصول.

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الملخص العربي

اجريت هذه التجربه كدراسه طويله ألأجل بدأت فى 2008 – 2014 باستخدام النارنج كأصل وسطى مع أصل الفولكاماريانا وذلك لتفادى عيوب أصل الفولكاماريانا على الخواص الطبيعه و الكيميائيه لثمار البرتقال مع أمل أحتفاظه بمميزاته فى قوه النمو و زياده المحصول وأجريت هذه التجربه بمزرعه خاصه بمنطقه البستان بمحافظه البحيره بهدف دراسه تأثير أصل النارنج كأصل وسطى بين أصل الفولكاماريانا و الصنف المطعم عليه من أربعه أصناف من البرتقال (البرتقال الصيفى أوليندا – البرتقال ابو سره اسبرينج – البرتقال ابوسره بيرينت – البرتقال ابو سره فوكوموتو) وذلك على النمو الخضرى والحاله الغذائيه للأشجار والمحصول والكفاءه المحصوليه . وقد اظهرت النتائج الاتى :

1- أعطت كل الأاصناف المطعومه على أصل الفولكاماريانا اعلى القيم لكل من حجم الشجره – و معظم قياسات النمو ، وأعطى ألأصل الوسطى قيم وسطيه لهذه القياسات وسجل أصل النارنج أقل القيم كما سجل البرتقال الصيفى أوليندا أعلى قيم لحجم الشجره وقياسات النمو الخضرى عند مقارنته باللأصناف الأخرى

2- زادت قيم كل من كلوروفيل أ ، ب ، الكلوروفيل الكلى فى الأصناف المطعومه على أصل الفولكاماريانا ولم يكن هناك فروق معنويه بينه و بين الأصناف على الأصل الوسطى وكانت أعلى القيم على صنف ابوسره اسبرنج المطعوم على أصل الفولكاماريانا.

3 – احتوت اوراق الأصناف المطعومه على أصل الفولكا ماريانا أعلى قيم من NPK يليه الأصناف التى على الأصل الوسطى ثم النارنج فى كلا الموسمين واعطت الاصناف اولندا الصيفى وابوسره بيرينت على اصل الفولكاماريانا أعلى القيم مقارنه بالاصناف الاخرى .

4- أعطت الاصناف على اصل الفولكاماريانا اعلى قيم للمحصول ممثل بالكيلو جرام لكل شجره بفروق معنويه بينه وبين الاصول الاخرى يليه أصل النارج ثم الاصل الوسطى بدون فروق معنويه بينهما فى كلا الموسمين كما سجل صنف البرتقال الصيفى اولندا أعلى القيم للمحصول مقارنه بالاصناف الأخرى بفرق معنويه فى معظم الحالات.

5- اظهرت النتائج ان الأصناف المطعومه على أصل النارنج أعطت أعلى كفاءه محصوليه ممثله بكيلوجرام/سم2من مساحه مقطع الجذع (Kg /cm2 of TCSA) بينما اعطت الأصناف على ا صل الفولكاماريانا اعلى قيم للكفاءه المحصوليه الممثله بالكيلو جرام لكل متر مكعب من حجم الشجره (Kg/m3 /canopy volume) يليه اصل النارنج ثم الأصل الوسطى فى كلا الموسمين بدون فروق معنويه بينهما ولم يكن هناك فروق معنويه بين الأصناف. تبين أن استخدام النارنج كأصل وسطى لم ينقص من محصول الأشجار المطعومه عليه نقصا معنويا وكان المحصول قريبا من الناتج عن أصل النارتج بمفرده.