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Evaluation of Some New Navel Orange Cultivars Budded on Sour Orange and Volkamer Lemon Rootstocks

M.A. Nasser, A.Z. Bondok, A.D. Shaltout and Noha Mansour
Department of Horticulture, Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

A FIELD EXPERIMENT was carried out in a private orchard at Wady El-Mollak, El-Sharqia Governorate, Egypt during two successive seasons (2012 and 2013) to evaluate flowering, fruit set, fruit drop, yield, fruit quality, mineral and total carbohydrates content of some newly introduced Navel orange cultivars (New Hall, Navelina, Navelate, Lane Late, Cara Cara, Spring, Fisher, Parent, Fukumoto and Leng). These cultivars were grafted on two commercial rootstocks "Sour orange" (*Citrus aurantium* L.) and "Volkamer lemon" (*Citrus Volkameriana* L.). The present experiment comprises ten scions and two rootstocks. The experiment was laid out in factorial experiment in a randomized complete block design.

Results showed that, the effect of cultivars namely, Navelate, Lane Late, New Hall and Navelina gave the highest values of fruit set and the lowest values of fruit drop. Whereas, New Hall gave the highest values of fruit weight and yield/tree followed by Navelina and Lane Late but New Hall gave large fruit size which not accepted in export and local market. Meanwhile, New Hall and Navelina cultivars gave the highest values of TSS, TSS/acid ratio and the lowest values of acidity. On the other hand, "Cara Cara" "Spring" and "Leng" gave significant lower values of N content than other Navel orange cultivar. Navelate and Lane Late gave the highest values of P, K and Ca. Regarding the effect of rootstocks, Volkamer Lemon rootstock gave the significant highest values of flowering, fruit set, fruit drop, yield parameters, peel thickness, macro and micronutrients content (N, P, K, Ca, Mg, Fe, Zn, and Mn) as compared with sour orange rootstock. On the other hand, Sour orange gave the significant highest values of juice volume, TSS, TSS/acid ratio. Volkamer Lemon gave lower values of total carbohydrates consequently gave lower values of C/N ratio than Sour orange rootstock. Regarding the combination between cultivars and rootstocks, Lane Late and New Hall cultivars on Volkamer Lemon gave the highest values of flowering, fruit set percentages and lower values of fruit drop as compared with other combinations. New Hall budded on both rootstocks gave the highest values of yield followed by Lane Late on Volkamer Lemon. The highest values of TSS, TSS/acid ratio were obtained when New Hall and Navelina budded on sour orange followed closely by the same cultivars on Volkamer Lemon rootstock and the trend was reversed for acidity. The highest values of N, P, Ca, Mg, Fe and Mn were obtained

when Lane Late budded on Volkamer Lemon rootstock. All Navel orange cultivars budded on Volkamer Lemon rootstock gave lower C/N ratio than budded on Sour orange rootstock. In spite of Volkamer Lemon rootstock gave higher values of yield/tree than sour orange but with low fruit quality especially for peel thickness, TSS and TSS/acid ratio. Finally it could be concluded that, New Hall gave the highest values of fruit weight and yield/tree followed by Navelina and Lane Late but New Hall especially on Volkamer Lemon gave large fruit size which not accepted in export and local market. So, it could be recommended by budded Navelina and Lane Late cultivars on Sour orange rootstock for suitable yield with high fruit quality.

Keywords: Fruit quality- Mineral content- Newly Navel orange cultivars- Sour orange- Volkamer Lemon- Yield.

Citrus harvested areas increased rapidly from year to year and reached about 439024 fedden in 2013 which produced an average of 9.5tons/fedden. Oranges are the most extensively produced citrus fruit which reached about 2,855,022 tons represented about 69.66% (Agricultural Statistics Institute, 2013). Extension of the cultivated area is due to fit environmental conditions, has a great attention due to its importance for local consumption, it highly economic value as a main source for exportation to the European countries and Gulf States Barakat *et al.* (2012). Egyptian exports are mainly from oranges (Navel and Valencia) which comprise the vast majority of citrus exports. The volume of Egyptian exports of orange reached about 1.102.538 ton representing 38.6 % of the total production (UPECH, 2013). Generally, Egypt has excellent opportunities for expanding its exports due to its favorable climate and strategic geographic location.

It is evident that virus and virus-like diseases are limiting yields in Egyptian citrus orchards, perhaps by as much as 10 or 20 % overall and much more severely in certain orchards. The use of disease-free bud wood for new plantings helps to prevent or minimize diseases damage that have insect vectors (FAO Corporate document Repository). Citrus trees are not native to the Mediterranean basin, they were introduced from their origins in Southeast Asia and the Malayan archipelago. It is well known that in all important citrus-producing areas of the world there is a constant interest in new and better varieties and stocks of the genus *Citrus*, and that a more or less continuous flow of plant introductions is occurring everywhere. Egyptian government agencies and private sectors import new, desirable varieties and use modern laboratory techniques to preclude diseases and pests, through the project of (Egyptian - German citrus improvement program) in Bahtim Res. station.

Navel orange is considered the most popular citrus fruits for Egyptians. Washington navel orange is often called parent navel orange, is the best known navel orange and is often used as standard for the industry (Ferguson *et al.*, 2014). Many other navel orange cultivars like (New Hall, Navelina, Navelate, Lane Late, Cara Cara, Spring, Fisher, Fukumoto and Leng) were imported and are now important to the citrus industry because they mature at slightly different

times (extending the season from fall through summer) were sport selection of Washington navel orange.

In the Mediterranean region, all citrus cultivars are mainly budded on sour orange (*Citrus aurantium* L.), due to its resistance to gummosis fungi, high adaptability to wide range of soil conditions and the ability to produce high fruit quality. However, Sour orange has shown to have some serious problems such as susceptibility to the citrus Tristeza virus and poor compatibility with some citrus cultivars (Castle, 2010).

According to the fact that, sour orange is susceptible to viral diseases such as "Tristeza" several rootstocks were introduced and tested for their compatibility, tolerance and adaptability to avoid the risk of future incidence in Egypt citrus orchards. Volkamer lemon is the second common rootstocks in Egypt especially in the newly reclaimed soils (Hudson *et al.,* 1990).

Volkamer lemon (*Citrus Volkameriana* L.) is a lemon hybrid and produces the most tree vigorous growth for the scions. Volkamer lemon appears to be one of the most promising rootstocks because its tolerance to Tristeza (Shafieizargar *et al.,* 2012).

Therefore, the present study was conducted with an objective to evaluate flowering, the fruit set, fruit drop, yield, fruit quality, mineral and total carbohydrates content of some newly introduced Navel orange cultivars grafted on two commercial rootstocks "Sour orange and Volkamer lemon" in Egypt

Materials and Methods

A field experiment was carried out in a private orchard at Wady El-Mollak, El-Sharqia Governorate, Egypt during two successive seasons (2012 and 2013) on some newly introduced Navel orange cultivars "New Hall, Navelina, Navelate, Lane Late, Cara Cara, Spring, Fisher, Parent, Fukumoto and Leng" budded on two citrus rootstocks Sour Orange (*Citrus aurantium* L) (SO) and Volkamer lemon (*Citrus Volkameriana* L.) (VL). Thus, the present experiment comprises ten scions and two rootstocks. So, the experiment was laid out in factorial experiment in a randomized complete block design with five replicates and each replicate was represented by one tree. The orange trees were selected on the basis of similarity in age "about seven years old", normal growth vigor, healthy, their flowering & fruiting behaviors. All trees received the same cultural practices and planted at 4 x 6 meter apart in sandy soil under drip irrigation system. Soil samples were taken from three locations of the experimental area at 0-30, 30-60 and 60-90 cm from the soil surface for physical and chemical analysis, which carried out according to Jackson (1958), Black *et al.* (1965) and Wilde *et al.* (1979) were shown in Table 1 and 2.

TABLE 1. Physical properties of the experimental soil

Organic matter	Particle size distribution				
	Sand (%)	Silt (%)	Clay (%)	Soil Texture	Field capacity (%)
0.02	90.66	8.633	0.703	Sand	20.2

TABLE 2. Chemical properties of the experimental soil

Depth	pH	$CaCO_3$	E.C dsm^{-1}	Saturation soluble extract							
				Soluble aions (meq/L.)				Soluble cations (meq/L.)			
				CO^-_3	HCO^-_3	SO^-_4	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
0-15	7.9	2.69	0.17	-	1.3	1.83	0.7	1.24	1.2	1.14	0.21
15-30	7.8	3.21	0.16	-	1.4	1.42	0.8	1.15	1.0	1.12	0.24
30-60	7.9	3.63	0.18	-	1.1	1.54	0.7	1.75	1.2	1.52	0.23

Depth	Available macronutrients (mg /100g)			Available micronutrients (ppm)			
	N	P	K	Fe	Mn	Zn	Cu
0-15	134	`1.5	8.35	7.47	1.14	0.68	2.11
15-30	133	`1.2	9.21	7.31	1.15	0.46	2.22
30-60	134	`2.0	8.25	7.02	1.13	0.55	2.13

The effect of the aforementioned treatments on fruit set, yield, fruit quality, mineral and total carbohydrates content in the two studied seasons were investigated as follows

The percentage of bud flowering, fruit set and fruit drop

Flowering bud% = (number of flowers bud /total number of buds) x 100

Number of flowers at full bloom was counted for both leafy and woody inflorescences to determine the fruit set. Fruits were counted after two weeks of full bloom and fruit setting was calculated by using the following formula:

Fruit set (%) = [Total number of fruitlets/ Total number of flowers] x 100

Fruit drop (%) = [(Total no. of fruitlets – No. of fruits in late Jun)/ Total no. of fruit lets] x 100

Yield

At maturity, the average number of fruits/ tree was counted on the mid of December of each season. Moreover, 10 fruits from each tree (replicate) were weighted, then the tree yield was theoretically calculated (kg).

Fruit quality

For each season, sample of five fruit / tree was randomly selected and used for the determination of the following physical and chemical properties:

Fruit shape, fruit firmness, peels thickness (mm) and juice volume (ml^3). The ascorbic acid content was determined by using 2, 6 dichlorophenolindophenol dye and 3% oxalic acid as substrate. Ascorbic acid was calculated as mg per 100 ml of juice. The titratable acidity was determined by titrating five ml of juice against sodium hydroxide (0.1 N) using phenolphthalein indicator. The acidity percentage was calculated as mg anhydrous citric acid per 100 ml of juice according to the A.O.A.C. (1995). The total soluble solids (TSS) were determined as % in juice by means of hand refractometer. The TSS/ Acid ratio was calculated.

Chemical analysis

Leaf mineral content was determined as follows: twenty leaves nearly of 5-7 months age were randomly collected from each replicate. The leaf samples were washed several times with tap water then rinsed with distilled water, dried at 70°C in an electric oven till a constant weight. Dry leaves were grounded and digested using sulphoric acid and oxygen peroxide according to (Jackson, 1973). Leaf mineral content of N, P, K, Ca, Mg, Fe, Zn and Mn were determined on dry weight. according to (Cottenie *et al.*, 1982).

Total carbohydrates content

Total carbohydrates content was estimated in stems at the first week of October in each season using the phenol sulfuric method according to Dubois *et al*. (1956) after the hydrolysis of carbohydrates, C/N ratio was calculated as follows: C/N ratio = Total carbohydrates of stem/ total nitrogen of stem.

Statistical analysis

The data of the experiment were subjected to proper statistical analysis of variance according to Snedecor and Cochran (1980). Duncan test was used to compare between means. Data were statistically analyzed using the analysis of variance adopting a SAS package.

Results and Discussion

The percentage of flowering, fruit set and fruit drop

Result in Table 3 show the effect of some newly Navel orange cultivars on two rootstocks on the percentage of flowering, fruit set and fruit drop during 2012 and 2013 seasons. In the two seasons, the percentage of flowering, fruit set and fruit drop were significantly affected by Navel orange cultivars, rootstocks and their interaction. Consequently, the highest significant values of flowering percentage were obtained by Lane Late cultivar followed closely by Parent,

Spring and Fisher especially in the second season. On the other hand, VL rootstock gave the highest significant values as compared with SO. Regarding the interaction, the highest significant values were obtained by Lane Late and Parent on VL rootstock followed closely by Fisher on VL and Lane Late on SO especially in the first season.

Concerning the percentage of fruit set, the lowest significant values were obtained by Cara Cara cultivar in the two studied seasons. While, the highest significant values were obtained by Navelate followed closely by Lane Late, New Hall, Navelina and Leng, respectively especially in the first season. On the other hand, VL rootstock gave the significant highest values as compared with SO. Regarding the interaction, the highest significant values were obtained when all cultivars budded on VL rootstock as compared with SO.

Concerning the percentage of fruit drop, the lowest significant values were obtained by Navelina, Lane Late, New Hall and Navelate cultivars. On the other hand, the lowest significant values were obtained by SO rootstock in the two seasons. Regarding the interaction, the lowest values were obtained when New Hall and Navelina budded on SO in the two growing season.

From the foregoing results, it could be concluded that, generally Navelate, Lane Late, New Hall and Navelina cultivars gave the highest values of fruit set and the lowest values of fruit drop. On the other hand, for all characters VL rootstock gave the highest significant values as compared with SO. Regarding the combination between Navel orange cultivars and two rootstocks in most cases, it is clear that Lane Late and New Hall cultivars on VL gave the highest values of flowering, fruit set percentages and lower values of fruit drop as compared with the other combinations

The obtained results are in agreement with those reported by Zayan *et al.* (2004) that the highest significant values for the percentage of bud flowering, fruit set and fruit drop were obtained by VL as compared with SO.

Yield

Data in Table 4 show the effect of some Navel orange cultivars on two rootstocks on fruit number, fruit weight and tree yield during 2012 and 2013 seasons.

Values of fruit number, fruit weight and yield were significant affected by Navel orange cultivars, rootstocks and their interaction in the two seasons.

Consequently, the significant highest values of fruit number were obtained by Navelate and Cara Cara especially in the second season. Regarding rootstocks, in the first season VL gave the significant highest values for fruit number but in the second season it was not significant between them. Regarding the interaction it was clear that Navelate and Cara Cara budded on both rootstocks gave the significant highest values in the two seasons.

TABLE 3. Effect of some Navel orange cultivars budded on two rootstocks on flowering, fruit set and fruit drop % during the 2012 and 2013 seasons.

Cultivars	Rootstocks								
	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Means
	Flowering%			Fruit set%			Fruit drop%		
	2012 season								
New Hall	25.41c-h	22.45h	23.93D\	45.20a	32.91e	39.05AB\	35.87a-d	32.6cd	34.24CD\
Navelina	26.28c-g	23.51f-h	24.80CD\	42.04a-c	35.12c-e	38.58AB\	35.05a-d	30.99d	33.02D\
Navelate	27.32b-e	24.32d-h	25.82B-D\	45.54a	35.56b-e	40.55A\	36.46a-d	33.07b-d	34.77B-D\
Lane Late	31.65a	28.32a-c	29.38A\	45.08a	34.25de	39.66AB\	34.15a-d	32.27cd	33.21CD\
Cara Cara	26.98b-f	22.88gh	24.93CD\	34.40de	29.54e	31.97C\	45.60a	42.58a-d	44.09A\
Spring	27.88b-d	23.98e-h	25.93B-D\	41.81a-c	32.09e	36.95AB\	42.92a-d	42.22a-d	42.57A\
Fisher	28.54a-c	24.54d-h	26.54BC\	42.41ab	31.08e	36.75AB\	45.15ab	40.86a-d	43.01A\
Parent	29.98ab	25.62c-h	27.80AB\	40.80a-d	30.27e	35.54BC\	44.01a-c	37.76a-d	40.89A-C\
Fukumoto	26.32c-g	23.98e-h	25.15CD\	40.32a-d	31.01e	35.66BC\	39.88a-d	39.57a-d	39.73A-D\
Leng	25.88c-h	23.11gh	24.50CD\	43.02a	32.08e	37.55AB\	45.04ab	39.42a-d	42.23AB\
Means	27.63A	24.27B		42.06A	32.39B		40.41A	37.13B	
	2013 season								
New Hall	35.46a-d	33.77b-d	34.61B\	51.17a	40.88c-e	46.03A\	38.07ab	36.29b	37.18C\
Navelina	34.40b-d	32.73cd	33.57B\	49.61a	40.18d-f	44.89AB\	38.61ab	36.17b	37.39C\
Navelate	35.44a-d	33.88b-d	34.66B\	50.30a	41.67b-f	45.99A\	39.80ab	36.87ab	38.34BC\
Lane Late	39.33a	36.44a-c	37.88A\	51.02a	40.52d-f	47.77AB\	39.02ab	37.10ab	38.06BC\
Cara Cara	34.66a-d	31.34d	33.00B\	44.22a-e	35.18f	39.70C\	47.59ab	35.89b	41.74A-C\
Spring	36.34a-c	33.43b-d	34.89AB\	50.10a	36.68ef	43.39A-C\	47.39ab	44.84ab	46.12A\
Fisher	36.22a-c	34.65a-d	35.44AB\	45.72a-d	36.21f	40.97BC\	45.81ab	44.93ab	45.37AB\
Parent	37.66ab	34.07b-d	35.87AB\	48.46a-c	34.65f	41.55A-C\	48.91a	44.61ab	46.76A\
Fukumoto	34.44b-d	33.77b-d	34.10B\	50.32a	36.59ef	43.46A-C\	47.72ab	43.60ab	45.66AB\
Leng	34.67a-d	32.10cd	33.39B\	48.78ab	34.86f	41.82A-C\	48.77a	44.94ab	46.86A\
Means	35.86A	33.62B		48.97A	37.74B		44.17A	40.52B	

In each season, means of each of rootstocks and cultivars or their interactions having the same letter (s) are not significantly different at 5% level.
*VL = Volkamer lemon , **SO = Sour orange

TABLE 4. Effect of some Navel orange cultivars and two rootstocks on fruit number, fruit weight and yield for tree during the 2012 and 2013 seasons .

Cultivars	Rootstocks								
	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Means
	Fruit NO./ tree			Fruit weight			Yield kg/tree		
	2012 season								
New Hall	149.21b-e	141.89de	145.52C\	380.00ab	387.33ab	383.67AB\	56.70a	54.96a	55.83A\
Navelina	146.87b-e	142.13de	144.49C\	345.33b-e	349.67b-d	347.50BC\	50.72bc	49.70b-d	50.21B\
Navelate	177.85a-c	180.44ab	179.10B\	278.33e-i	253.33g-i	265.83F\	49.50b-d	45.71e-g	47.61CD\
Lane Late	140.02e	136.53e	138.33CD\	364.67bc	346.67b-e	355.67BC\	51.06b	47.33d	49.20BC\
Cara Cara	201.11a	200.05a	200.61A\	231.67h-i	210.00i	220.83G\	46.59d-f	42.01hi	44.30F\
Spring	141.69e	143.83c-e	142.70C\	337.00b-f	300.00c-h	318.50C-E\	47.75c-e	43.15g-I	45.45EF\
Fisher	175.04a-d	138.12e	155.39C\	282.00d-h	321.67b-g	301.83D-F\	49.36b-d	44.43f-h	46.90DE\
Parent	143.59de	133.62ef	138.55C\	326.00b-f	332.67b-f	329.33CD\	46.81d-f	44.45f-h	45.63D-F\
Fukumoto	134.14ef	100.31f	115.24D\	353.67b-c	448.33a	401.00A\	47.44c-f	44.97e-h	46.21D-F\
Leng	140.15e	150.71b-e	145.13C\	299.67c-h	267.00f-i	283.34EF\	42.00hi	40.24i	41.12G\
Means	154.97A	146.76B		319.83A	321.67A		48.79A	45.70B	
	2013 season								
New Hall	176.50a-d	167.07c-e	171.71BC\	380.00a-c	392.00ab	386.00A\	67.07a	65.49ab	66.28A\
Navelina	172.27b-e	163.12c-f	167.62C\	345.33b-f	356.00b-d	350.67B\	59.49c	58.07cd	58.78B\
Navelate	192.40a-c	206.21ab	198.72A\	300.00e-g	253.33gh	276.67DE\	57.72cd	52.24e-h	54.98CD\
Lane Late	172.86b-e	179.78a-d	176.11BC\	351.27b-e	309.33d-f	330.30BC\	60.72bc	55.61c-f	58.17BC\
Cara Cara	175.93a-d	209.38a	190.20AB\	305.00d-g	226.67h	265.83E\	53.66d-g	47.46hi	50.56E\
Spring	165.37c-e	159.76c-f	162.66C\	337.00c-f	315.67d-f	326.33BC\	55.73c-f	50.43f-I	53.08DE\
Fisher	159.67c-f	155.16d-f	157.52C\	359.00a-d	329.67c-f	344.33B\	57.32c-e	51.15f-h	54.24D\
Parent	163.80c-f	156.69d-f	160.27C\	329.67c-f	326.00c-f	327.83BC\	54.00d-g	51.08f-h	52.54DE\
Fukumoto	140.88fe	130.29fe	135.47D\	393.67ab	412.00a	402.83A\	55.46c-f	53.68d-g	54.57D\
Leng	157.61d-f	155.06d-f	156.37CD\	310.33d-f	292.33fg	301.33CD\	48.91g-I	45.33i	47.12F\
Means	168.25A	167.73A		341.13A	321.30B		57.01A	53.05B	

In each season, means of each of rootstocks and cultivars or their interactions having the same letter (s) are not significantly different at 5% level.
*VL = Volkamer lemon , **SO = Sour orange

The significant highest values of fruit weight were obtained by New Hall and Fukumoto followed by Lane Late and Navelina especially in the first season. Regarding rootstocks, in the first season, it's effect was not significant for fruit weight but in the second season VL gave the significant highest values of fruit weight. Regarding the interaction it was clear that New Hall and Fukumoto budded on both rootstocks gave the significant highest values of fruit weight in the two seasons except Fukumoto budded on VL in the first season.

Concerning yield, results proved that the highest significant values were obtained by New Hall followed by Navelina and Lane Late cultivars. Regarding rootstocks, significant the highest values obtained by VL rootstock in the two seasons. The significant highest values of the interaction were obtained when New Hall budded on both rootstocks followed by Lane Late on VL.

From the above results, it could be concluded that New Hall gave the highest values of fruit weight and yield per tree followed by Navelina and Lane Late. In most cases, it is clear that yield parameters were increased when budded on VL as compared with SO rootstock. Regarding the interaction between cultivars and rootstocks, it is observed that, the highest values were obtained when New Hall budded on both rootstocks

The obtained data are in harmony with those reported by Ibrahim *et al.* (2004), Shafieizargar *et al.* (2012) and Barakat *et al.* (2013) on Navel and Valencia oranges cultivars. They reported that VL rootstock induced higher values of fruit weight and yield as compared with SO rootstock.

Fruit quality

Fruit physical properties

Result in Table 5 and Fig. 1 show the effect of some newly Navel orange cultivars budded on two rootstocks on fruit physical properties during 2012 and 2013 seasons.

In the two seasons, values of fruit shape, fruit firmness, peel thickness and juice volume were affected significantly by Navel orange cultivars, rootstocks and their interaction.

Consequently, the significant highest values of fruit shape were obtained by New Hall and Fukumoto cultivars especially in the second season while, fruit shape was not affected significantly by rootstocks in both seasons. With respect to combination between cultivars and rootstocks it is observed that, the effect varied slightly from season to another and the trend was clearer in the first season than the second whereas, the significant highest values were obtained by New Hall, Parent, Fukumoto and Leng on each rootstocks, other combinations gave more or significant less lower values expect Spring on SO. In the second season, the significant lowest value was obtained by Parent on VL.

TABLE 5. Effect of some newly Navel orange cultivars and two rootstocks on fruit shape, fruit firmness, peel thickness and juice volume during the 2012 and 2013 seasons .

Cultivars	Rootstocks											
	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Means
	Fruit shape			Fruit firmness			Peel thickness (mm)			Juice volume (ml³)		
	2012 season											
New Hall	1.13a-d	1.11a-d	1.12A-D\	12.75c-e	9.03f	10.89E\	7.05a	5.63ab	6.34A\	195.0e	276.3bc	235.7DE\
Navelina	1.07cd	1.04d	1.06C-E\	13.48c-e	13.41c-e	13.45CD\	4.21b-f	3.61c-f	3.91CD\	192.0e	198.7e	195.3G\
Navelate	1.04d	1.03d	1.04E\	14.71cd	17.30ab	16.01B\	4.11b-f	3.07e-f	3.59D\	256.3cd	268.3c	262.3BC\
Lane Late	1.03d	1.07cd	1.05DE\	13.54c-e	14.27cd	13.91CD\	4.35b-f	3.99b-f	4.17CD\	267.0c	273.3bc	270.2B\
Cara Cara	1.07cd	1.08b-d	1.08C-E\	18.73a	18.16a	18.44A\	4.43b-f	3.67c-f	4.05CD\	223.7ed	213.0e	218.3EF\
Spring	1.08cd	1.11a-d	1.10B-E\	12.76c-e	13.31c-e	13.03D\	5.30a-c	3.45d-f	4.38B-D\	270.7c	217.7c	271.2B\
Fisher	1.08cd	1.09b-d	1.08C-E\	13.51c-e	12.32de	12.92D\	5.37a-c	5.31a-c	5.34AB\	286.3a-c	263.7c	275.0B\
Parent	1.11a-d	1.23a	1.17AB\	9.01f	11.15ef	10.08E\	2.84f	4.10b-f	3.47D\	199.0e	285.3a-c	242.1CD\
Fukumoto	1.18a-c	1.21ab	1.20A\	13.39c-e	12.26de	12.82D\	5.16b-d	4.86b-e	5.01BC\	308.3ab	315.7a	312.0A\
Leng	1.13a-d	1.14a-d	1.13A-C\	15.18bc	14.60cd	14.89BC\	4.15b-f	3.80b-f	4.02CD\	208.7e	211.3e	210.0FG\
Means	1.09A	1.11A		13.71A	13.58B		4.70A	4.16B		240.7B	257.7A	
	2013 season											
New Hall	1.17a	1.15ab	1.16A\	12.75d-f	11.62f	12.19F\	6.02a	4.93b-d	5.48A\	284.7a-d	290.7a-d	287.7B\
Navelina	1.09ab	1.09ab	1.09B\	13.30c-f	13.66b-e	13.48DE\	4.21c-f	3.61fg	3.91CD\	209.3g	298.7a-c	254.0E\
Navelate	1.09ab	1.08ab	1.08B\	15.20bc	15.11bc	15.16B\	4.26c-f	3.07g	3.67D\	268.3c-e	264.0d-f	266.2C-E\
Lane Late	1.14a	1.06ab	1.10B\	13.87b-e	14.16b-d	14.01B-D\	4.10d-f	3.74fg	3.92CD\	276.0cd	295.7a-d	285.8BC\
Cara Cara	1.06ab	1.10ab	1.08B\	18.47a	17.75a	18.11A\	4.19c-f	3.61fg	3.90CD\	221.7g	226.3g	224.0F\
Spring	1.08ab	1.08ab	1.08B\	14.06b-d	13.23c-f	13.65C-E\	5.02bc	3.68fg	4.35BC\	274.7cd	278.3b-d	275.5B-D\
Fisher	1.08ab	1.05ab	1.07B\	13.42b-f	12.07ef	12.75EF\	5.48ab	5.44ab	5.46A\	268.0c-e	288.7a-d	278.3B-D\
Parent	1.05b	1.08ab	1.06B\	13.32c-f	12.01ef	12.67EF\	3.08g	4.29c-f	3.68D\	286.7a-d	236.7e-g	261.7DE\
Fukumoto	1.15ab	1.13ab	1.14AB\	13.84a-e	13.08d-f	13.46DE\	5.04bc	4.69b-e	4.89B\	317.7a	311.3ab	314.5A\
Leng	1.07ab	1.08ab	1.08B\	15.31b	14.45b-d	14.88BC\	4.03d-f	3.83e-g	3.93CD\	220.3g	232.0fg	226.2F\
Means	1.10A	1.09A		14.35A	13.72B		4.55A	4.09B		262.7B	272.2A	

In each season, means of each of rootstocks and cultivars or their interactions having the same letter (s) are not significantly different at 5% level.

*VL = Volkamer lemon , **SO = Sour orange

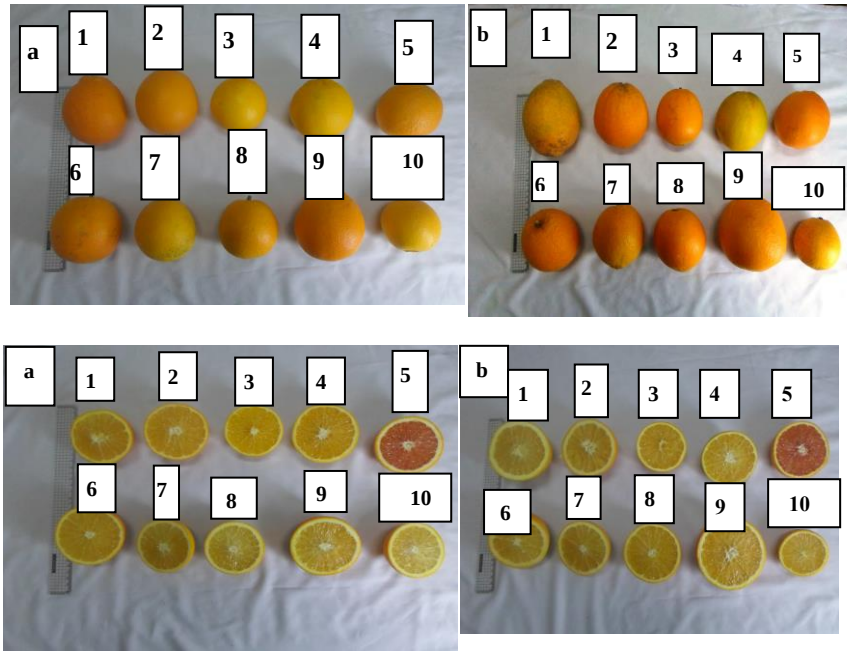

Fig. 1. Some newly Navel orange cultivars budded on sour orange and Volkamer Lemon rootstocks (a) Cultivars budded on sour orange (b) Cultivars budded on Volkamer lemon (1)New Hall (2) Navelina (3) Navelate (4) Lane Late (5) Cara Cara (6) Spring (7) Fisher (8) Parent (9) Fukumoto (10) Leng

Data concerning fruit firmness indicated that, the highest fruit firmness values were obtained by Cara Cara cultivar followed by Navelate in the two growing seasons. Regarding the effect of rootstock, it is observed that, VL gave the significant higher values than SO in the two growing seasons. Results revealed that Cara Cara gave the highest significant values in each rootstock and other combinations gave significantly lower values except Navelate on SO and Fukumoto on VL in the first and second seasons, respectively.

The significant highest values of peel thickness were obtained by New Hall cultivar followed closely by fisher cultivar during the two seasons. On the other hand, in the two seasons, VL gave significant higher values than SO rootstock. Generally, the significant highest values were obtained by New Hall on VL and Fisher on each rootstock in both seasons. Other combinations gave more or less significantly lower values except New Hall on SO and Spring on VL in the first season.

The significant highest values of juice volume were obtained by Fukumoto cultivar during two seasons. Regarding the effect of rootstocks it is noticed that, SO gave the significant highest values in the two seasons. The interaction was

significant in the two seasons whereas the effect varied from season to another. In the first season, the significant highest values were obtained by Fukumoto on each rootstock, Fisher on VL and Parent on SO. On the other hand, many other different combinations gave the significant highest values in the second season such as (New Hall and Fukumoto) on each rootstock, (Navelina, Lane Late and Fisher) on SO and Parent on VL.

From the foregoing results, it is noticed that New Hall cultivar especially on VL rootstock gave the highest values of fruit weight and yield per tree but with large fruit size and high values of peel thickness which not accepted in export and local market. (Personal communication with Elwadi Export for Agricultural Products)

In this respect, Zayan *et al.* (2004) on Valencia orange and Shafieizargar *et al.* (2012) on 'Queen' orange pointed out that, trees grafted on VL produced the largest fruits as compared with SO. Also, Ibrahim *et al.* (2004) reported that the significant highest values of peel thickness were obtained by Volkamer lemon whereas sour orange gave lowest values of peel thickness.

Fruit chemical properties

Data in Table 6 show the effect of different Navel orange cultivars, rootstocks and their interaction on vitamin C, TSS%, acidity and TSS/acid ratio during 2012 and 2013 seasons. Results showed that values of such parameters were significantly affected by Navel orange cultivars, rootstocks and their interaction through the two seasons.

Consequently, the significant highest values of vitamin C were obtained by New Hall cultivar during two seasons. Regarding the effect of rootstocks it is noticed that, SO gave the significant highest values in the two seasons. Regarding the interaction, the significant highest values were obtained by New Hall budded on each rootstocks and Spring budded on VL.

Concerning TSS, results proved that New Hall, Navelina and Leng cultivars gave the significant highest values. Regarding the rootstock, the significant highest values were obtained by VL rootstock in the two seasons. Regarding the interaction, the significant highest values of TSS were obtained when (New Hall, Navelina, Fisher, Fukumoto and Leng) were budded on each rootstock and Spring was budded on SO through two seasons.

Acidity was not affected significantly by Navel orange cultivars, rootstocks and their interaction in the two seasons except the effect of rootstocks in the second season whereas, rootstock gave the significant highest values of acidity. Navel orange cultivars had no effect on juice acidity. So, the results of both seasons clearly indicated that juice acidity was more or less similar for all combinations.

TABLE 6. Effect of some newly Navel orange cultivars budded on two rootstocks on vitamin C, TSS, acidity and TSS/acid ratio during the 2012 and 2013 seasons .

Cultivars	Rootstocks											
	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Mean	VL*	SO**	Means
	Vitamin C			TSS			Acidity			TSS/acid ratio		
	2012 season											
New Hall	46.15a	43.98ab	45.90A\	10.34ab	10.50a	10.42AB\	0.98a	0.96a	0.97A\	10.53ab	11.04a	10.79A\
Navelina	39.99d-f	38.65ef	42.93B\	10.00a-c	10.38ab	10.19AB\	0.96a	0.94a	0.95A\	10.40ab	11.03a	10.72A\
Navelate	41.18cd	41.52cd	40.10E\	9.38b-d	9.38b-d	9.38DC\	1.02a	1.00a	1.01A\	9.46a-d	9.76a-d	9.61AB\
Lane Late	42.65bc	40.74c-e	38.30F\	8.50d	9.00cd	8.75D\	1.16a	1.01a	1.09A\	8.57b-d	9.57a-d	8.57B\
Cara Cara	41.88b-d	40.77c-e	40.95C-E\	8.50d	9.34b-d	8.92CD\	1.11a	1.06a	1.09A\	7.06d	9.23a-d	8.14B\
Spring	45.65a	41.87b-d	41.25C-E\	9.55cd	9.78a-c	9.39CD\	1.18a	1.08a	1.13A\	7.29cd	8.95a-d	8.12B\
Fisher	40.21de	37.94f	42.21BC\	9.50a-d	10.00a-c	9.75BC\	1.03a	0.98a	1.01A\	9.48a-d	10.19ab	9.84AB\
Parent	40.71c-e	40.98cd	40.51DE\	9.55cd	9.57a-d	9.29CD\	1.00a	0.99a	1.10A\	9.57a-d	9.85a-c	9.46AB\
Fukumoto	41.77b-d	40.28dc	41.55B-D\	9.50a-d	10.00a-c	9.75BC\	1.13a	1.02a	1.08A\	8.38a-d	10.08ab	9.23AB\
Leng	41.22cd	40.44c-e	40.61DE\	10.38ab	10.50a	10.44A\	1.04a	0.98a	1.01A\	10.26ab	10.81ab	10.53A\
Means	41.11B	41.75A		9.41B	9.85A		1.06A	1.00A		9.00B	10.00A	
	2013 season											
New Hall	45.32a	42.98a-c	41.15A\	10.00ab	10.43a	10.22A\	0.99a	0.96a	0.98A\	10.29a-d	10.96ab	10.63A\
Navelina	40.87c-e	38.84de	42.59B\	10.00ab	10.43a	10.22A\	0.97a	0.95a	0.96A\	10.52a-c	11.20a	10.86A\
Navelate	41.98bc	42.22bc	40.98B\	9.00b-f	9.50a-d	9.29BC\	1.00a	0.97a	0.99A\	8.89a-f	9.58a-f	9.24A-D\
Lane Late	42.32a-c	41.07c-e	38.61C\	8.50d-f	8.76c-f	8.63CD\	1.06a	1.00a	1.03A\	7.37f	8.74a-f	8.05CD\
Cara Cara	41.98bc	41.55cd	41.53B\	8.37ef	8.50d-f	8.44D\	1.21a	1.02a	1.12A\	7.58ef	8.07c-f	7.83D\
Spring	44.98ab	42.20bc	41.71B\	9.00b-f	9.50a-d	9.25BC\	1.24a	1.10a	1.17A\	7.67d-f	8.86a-f	8.26CD\
Fisher	41.09c-e	38.39e	42.13B\	9.37a-e	9.78a-c	9.58AB\	1.01a	0.99a	1.00A\	9.17a-f	10.07a-e	9.62A-C\
Parent	41.07c-e	41.21c-e	40.74B\	8.00f	8.50d-f	8.25D\	1.00a	0.98a	0.99A\	8.06c-f	8.66a-f	8.36CD\
Fukumoto	41.94c	40.40c-e	41.43B\	9.36a-e	9.57a-d	9.47B\	1.14a	1.00a	1.07A\	8.33b-f	9.46af	8.90B-D\
Leng	40.88c-e	40.88c-e	41.22B\	10.00ab	10.38a	10.19A\	1.02a	0.98a	1.00A\	9.69a-f	10.69a-c	10.19AB\
Means	41.31B	41.91A		9.16B	9.54A		1.06A	0.99B		8.76B	9.63A	

In each season, means of each of rootstocks and cultivars or their interactions having the same letter (s) are not significantly different at 5% level.
*VL = Volkamer lemon , **SO = Sour orange

Regarding TSS/acid ratio, results showed that the significant highest values were obtained by many different cultivars such as (New Hall, Navelina, Navelate, Fisher and Leng in the two growing seasons. With respect to rootstocks it was observed that, SO rootstock gave the significant highest values of TSS/acid ratio in the two seasons. Regarding the interaction it was clear that the trend was slightly different from one season to another. In the first season, the significant lowest values were obtained from Lane Late, Cara Cara and Spring budded on VL. On the other hand, in the second season, the significant lowest values were obtained when budded Cara Cara on each rootstock and (Lane Late, Spring, Parent and Fukumoto) on VL rootstock. Other combinations gave more or less similar high values with the same statistical standpoint.

From the foregoing results, it is noticed that New Hall cultivar gave the highest values of vitamin C. Regarding other fruit chemical properties, New Hall and Navelina cultivars gave the highest values of TSS and TSS/acid ratio and the lowest values of acidity. On the other hand, SO gave the significant highest values of all fruit chemical properties except acidity whereas gave the lowest values. Regarding the interaction between cultivars and rootstocks, it is observed that, the highest values were obtained when New Hall and Navelina budded on SO followed closely by the same cultivars on VL rootstock and the trend was reversed for acidity.

Finally it could be concluded that, In spite of Volkamer lemon rootstock gave higher values of yield/tree than sour orange but with low fruit quality especially for peel thickness, TSS and TSS/acid ratio.

In this respect, Fruit from trees on SO tended to have higher ascorbic acid content than fruits from many other rootstocks. Fruits on SO rootstock are smooth, thin skinned, juicy, excellent in quality, and hold up well without appreciable deterioration after maturity (Harding *et al.* 1940). Hifny *et al.* (2012) pointed out that, Washington Navel orange fruits from trees budded on SO had higher vitamin C content and TSS % as compared with fruits from trees on VL.

Chemical analysis

Effect on leaf macronutrients content

Results in Table 7 show the effect of different Navel orange cultivars, rootstocks and their interaction on N, P, K, Ca and Mg content in leaves of Navel orange trees in 2012 and 2013seasons. In the two seasons, macronutrients (N, P, K, Ca and Mg) were significantly affected by Navel orange cultivars, rootstocks and their interaction.

TABLE 7. Effect of some newly Navel orange cultivars and two rootstocks on leaf macronutrient content (N, P, K, Ca and Mg) during the 2012 and 2013 seasons .

Cultivars	Rootstocks														
	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Means
	N%			P%			K%			Ca%			Mg%		
	2012 season														
New Hall	2.76a	2.56c-e	2.65A\	0.170a	0.145a-c	0.158A\	1.94cd	1.94cd	1.94B\	3.44cd	2.95f	3.20C\	0.467ab	0.415de	0.441AB\
Navelina	2.76ab	2.57cd	2.66A\	0.160a-c	0.113d-g	0.137B-D\	2.02b	1.91d	1.96AB\	3.36de	3.05f	3.20C\	0.447bc	0.402ef	0.424C\
Navelate	2.75ab	2.52c-f	2.63A\	0.163ab	0.137b-d	0.150AB\	2.08a	1.89de	1.98A\	3.64a-c	3.16ef	3.40B\	0.443bc	0.387fg	0.415C\
Lane Late	2.78a	2.63bc	2.70A\	0.168a	0.150a-c	0.159A\	2.03ab	1.93cd	1.98A\	3.83ab	3.62bc	3.72A\	0.475a	0.427cd	0.451A\
Cara Cara	2.52c-f	2.44d-f	2.47B\	0.117d-f	0.087g	0.101E\	1.78fg	1.60i	1.69E\	3.13ef	2.67g	2.90D\	0.382fg	0.300j	0.340E\
Spring	2.58c	2.43fg	2.50B\	0.148a-c	0.140b-d	0.144A-C\	1.89de	1.84ef	1.86C\	3.73ab	3.05f	3.39B\	0.383fg	0.355h	0.369D\
Fisher	2.76ab	2.51c-f	2.63A\	0.135c-e	0.105fg	0.120D\	1.79fg	1.68h	1.74D\	3.45cd	2.95f	3.20C\	0.472a	0.375gh	0.423C\
Parent	2.76ab	2.58c	2.66A\	0.138b-d	0.107fg	0.123D\	1.89de	1.76g	1.83C\	3.88a	3.36de	3.62A\	0.457ab	0.398e-g	0.428BC\
Fukumoto	2.77a	2.52c-f	2.64A\	0.153a-c	0.107fg	0.130CD\	1.98bc	1.89de	1.93B\	3.67a-c	3.16ef	3.42B\	0.473a	0.417de	0.445A\
Leng	2.43fg	2.30g	2.36C\	0.108e-g	0.153a-c	0.130CD\	1.53j	1.27k	1.40F\	3.04f	2.62g	2.83D\	0.327i	0.280j	0.303F\
Means	2.68A	2.51B		0.146A	0.124B		1.89A	1.77B		3.52A	3.06B		0.433A	0.376B	
	2013 season														
New Hall	2.76a	2.57d-f	2.67A\	0.163a-c	0.150a-e	0.157AB\	1.93ab	1.94ab	1.94AB\	3.51bc	2.98e-g	3.24C\	0.478a	0.445ab	0.462A\
Navelina	2.73ab	2.58c-f	2.65A\	0.167ab	0.113f-h	0.140CD\	2.02ab	1.92ab	1.97AB\	3.45b-d	3.06d-f	3.25C\	0.463a	0.437a-d	0.450AB\
Navelate	2.75a	2.52d-f	2.63A\	0.162a-d	0.138c-f	0.140A-C\	2.09a	1.89ab	1.99A\	3.76ab	3.37b-e	3.57AB\	0.445ab	0.393b-f	0.419B\
Lane Late	2.73ab	2.62a-e	2.68A\	0.175a	0.157a-d	0.166A\	2.05ab	1.94ab	2.00A\	3.92a	3.71ab	3.81A\	0.482a	0.438a-c	0.460A\
Cara Cara	2.54d-f	2.44fg	2.49B\	0.125e-g	0.097h	0.111F\	1.50cd	1.47cd	1.49C\	3.00e-g	2.63g	2.82D\	0.387c-f	0.317gh	0.352C\
Spring	2.56d-f	2.48e-g	2.52B\	0.148b-e	0.137d-f	0.143B-D\	1.87ab	1.83a-c	1.85AB\	3.74ab	3.06d-f	3.40BC\	0.388c-f	0.368e-g	0.378C\
Fisher	2.74ab	2.51d-f	2.63A\	0.137d-f	0.105gh	0.121E-F\	1.79a-c	1.71bc	1.75B\	3.46b-d	2.93fg	3.19C\	0.380a	0.385d-f	0.433AB\
Parent	2.72a-c	2.63a-d	2.68A\	0.137d-f	0.107gh	0.122EF\	1.88ab	1.76a-c	1.82AB\	3.76ab	3.43b-d	3.59AB\	0.472a	0.403b-e	0.438AB\
Fukumoto	2.77a	2.60b-e	2.68A\	0.152a-d	0.115f-h	0.133DE\	1.98ab	1.89ab	1.93AB\	3.73ab	3.11c-f	3.42BC\	0.482a	0.438a-c	0.460A\
Leng	2.52d-f	2.36g	2.44B\	0.115f-h	0.153a-d	0.134C-E\	1.49cd	1.30d	1.40C\	3.11d-f	2.73fg	2.92D\	0.342fg	0.285h	0.314D\
Means	2.68A	2.53B		0.148A	0.127B		1.86A	1.76B		3.54A	3.10B		0.442A	0.391B	

In each season, means of each of rootstocks and cultivars or their interactions having the same letter (s) are not significantly different at 5% level.

*VL = Volkamer lemon , **SO = Sour orange

Element	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Obreza *et al.* (1992)
Deficient	<2.2	<0.09	<0.7	<1.5	<0.20	
Low	2.2-2.4	0.09-0.11	0.7-1.1	1.5-2.9	0.20-0.29	
Optimum	2.5-2.7	0.12-0.16	1.2-1.7	3.0-4.9	0.30-0.49	
High	2.8-3.0	0.17-0.30	1.8-2.4	5.0-7.0	0.50-0.70	
Excess	>3.0	>0.30	>2.4	>7.0	>0.70	

Consequently, all Navel orange cultivars gave values in the optimum nitrogen levels except "Leng" especially in the first season. Meanwhile, "Cara Cara" and "Spring" gave significant lower values than other Navel orange cultivar in both seasons. With respect to rootstocks it was observed that, VL gave the significant highest values during the two seasons. Regarding the interaction, the least significant values were obtained by Leng on SO in the two seasons. On the other hand, the significant highest values were obtained when grafting different Navel orange cultivars on VL as compared with SO rootstock except "Cara Cara", "Spring" and "Leng" in both seasons.

Concerning phosphorus content, the significant highest phosphorus values were obtained by "New Hall", "Navelate" and "Lane Late" in the two growing seasons. On the other hand, VL gave the highest values of phosphorus content as compared with SO rootstock. Regarding the interaction, the significant highest values of phosphorus content were obtained when grafting (New Hall and Lane Late) on each rootstocks, (Navelina , Navelate and Fukumoto) on VL and (Leng) on SO in the two seasons. The least significant and suboptimal values where obtained when grafting other cultivars especially on SO rootstock.

In respect to potassium content, the significant highest values of potassium content were obtained by "Navelina", "Navelate" and "Lane Late" in the two seasons. With respect to rootstocks it was observed that, VL rootstock gave the significant highest values of potassium content. Regarding the interaction it was clear that the trend was slightly different from the season to another. In the first season, the significant highest values were obtained from "Navelate" and "Lane Late" on VL while the least significant value was obtained for Leng on SO. In the second season, all Navel orange cultivars gave the significant highest values on each rootstock as compared with "Cara Cara" and "Leng".

Concerning calcium content, the significant highest values were obtained from "Navelate", "Lane Late" and "Parent" cultivars especially in the second season. On the other hand, VL rootstock gave the significant highest values of calcium content. Regarding the interaction it could be observed that the significant highest values were obtained when grafting "Navelate", "Lane Late", "Spring", "Parent" and "Fukumoto" cultivars on VL as compared with SO.

Regarding Mg content, results proved that the New Hall, Lane Late and Fukumoto cultivars gave the highest values of Mg content especially in the first season. On the other hand, VL gave the highest values of Mg content during the two growing seasons. Regarding the interaction, it is quite evident that in the first season, the significant highest values of Mg content were obtained when grafting different Navel orange cultivars on VL as compared with SO. On the other hand in the second season, the significant highest values were obtained from New Hall, Navelina, Lane Late and Fukumoto on each rootstocks and Navelate, Fisher and Parent on VL rootstock.

General VL rootstock gave the significant highest values of macronutrients content (N, P, K, Ca and Mg) as compared with SO rootstock. These results are in harmony with these found by Khankahdani *et al.* (2006) El-Sayed (2013) and Barakat *et al*. (2013) who revealed that, VL generally exhibited significantly higher N, P, K and Mg content in Navel orange leaves compared to SO rootstock in both seasons. On the other hand, these results are in disagreement with those found by Hafez (2006) and Abdolhossein *et al*. (2012) who noticed that N, P and K in leaves recorded the highest values with the SO rootstock seedling.

Effect on leaf micronutrients content

Results in Table 8 show the effect of different Navel orange cultivars, rootstocks and their interaction on Fe, Zn and Mn content in leaves of Navel orange trees in 2012 and 2013 seasons. Results showed that values of micronutrients (Fe, Zn and Mn) were significantly affected by Navel orange cultivars, rootstocks and their interaction.

Regarding iron content the data showed that, the significant highest values were obtained by Lane Late cultivar in both the two seasons followed closely by New Hall, Navelina, Navelate, Spring, Fisher and Fukumoto only in the second season. On the other hand, VL rootstock gave the significant highest values during the two seasons. Regarding the interaction it could be observed that the highest values were obtained by some different combinations during the two seasons, but Lane Late on VL rootstock gave the highest values of iron content in 1st and 2nd seasons.

The highest values of zinc content were obtained by Navelate, Lane Late, Spring and Fisher in the two seasons while other cultivars were resulted in significant lower values except Leng in the second season. Meanwhile, VL rootstock gave the significant highest values during the two seasons. Regarding the interaction, it could be concluded that, all the combinations between different cultivars and VL rootstock gave higher values than the combinations on SO rootstock.

Regarding manganese content, the data showed that, Lane Late cultivar gave the significant highest values of Mn content in both seasons. Also, VL rootstock gave the significant highest values during the two seasons. Regarding the interaction it could be observed that the highest values were obtained by some different combinations during the two seasons whereas, New Hall, Navelina and Lane Late on VL rootstock gave the highest values of Mn content in 1st and 2nd seasons.

From the foregoing results, it could be concluded that, "Cara Cara" "Spring" and "Leng" gave significant lower values of N content than other Navel orange cultivar. Meanwhile, Navelate and Lane Late gave the highest values of P, K and Ca. On the other hand, Lane Late gave the highest values of Mg, Fe and Mn. VL rootstock gave the significant highest values of all macro and micronutrients content. Regarding the interaction between cultivars and rootstocks, generally the highest values of N, P, Ca, Mg, Fe and Mn were obtained when Lane Late budded on VL rootstock

TABLE 8. Effect of some newly Navel orange cultivars and two rootstocks on leaf micronutrient content (Mn, Fe and Zn) during the 2012 and 2013 seasons .

cultivars	Rootstocks								
	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Means
	Fe (ppm)			Zn (ppm)			Mn (ppm)		
	2012 season								
New Hall	125.67b-d	117.67e-g	121.67B\	78.83a-c	64.83h	71.83E\	84.48ab	80.98d-i	82.73B\
Navelina	128.33ab	119.83d-f	124.08B\	80.17a	67.00gh	73.58C-E\	84.32a-c	80.54e-i	82.43BC\
Navelate	126.50a-d	116.17e-h	121.33B\	82.33a	74.67b-e	78.50A\	83.32b-e	79.87g-i	81.60B-E\
Lane Late	133.00a	127.67a-c	130.33A\	81.67a	74.00de	77.83A-B\	87.10a	83.87b-d	85.49A\
Cara Cara	113.83f-i	102.33jk	108.08D\	78.83a-c	67.33gh	73.08DE\	80.98d-i	75.65j	78.32F\
Spring	120.17d-f	111.83g-i	116.00C\	79.83a	74.33c-e	77.08AB\	82.32b-g	78.76hi	80.54DE\
Fisher	122.67b-e	119.83d-f	121.25B\	81.83a	70.17e-g	76.00A-C\	82.98b-f	79.65g-i	81.32B-E\
Parent	118.33e-g	109.83hi	114.08C\	78.67a-c	68.17gh	73.42C-E\	83.99b-d	79.98f-i	81.99B-D\
Fukumoto	121.50c-e	102.50g-i	117.00C\	79.00ab	66.83gh	72.92D-E\	82.32b-g	79.32g-i	80.82C-E\
Leng	108.00ij	99.17k	103.58E\	77.83a-d	72.33ef	75.08B-D\	81.43c-h	78.32ij	79.87EF
Means	121.80A	113.68B		79.90A	69.97B		83.32A\	79.70B\	
	2013 season								
New Hall	126.33ab	118.33a-c	122.33AB\	79.33ab	66.83g	73.08C\	85.32a	80.43e-h	82.87B\
Navelina	127.00a-b	121.83a-c	124.42AB\	79.50ab	68.83e-g	74.17BC\	84.72ab	80.76d-g	82.74BC\
Navelate	125.00ab	117.00a-c	121.00AB\	81.00a	73.00d-f	77.00AB\	83.63a-c	79.43f-h	81.53B-E\
Lane Late	132.17a	125.67ab	128.92A\	81.00a	73.67c-e	77.33A\	85.89a	83.98a-c	84.94A\
Cara Cara	113.33a-c	87.83d	100.58D\	78.33a-c	68.50fg	73.42C\	82.32b-e	75.98i	79.15F\
Spring	122.83a-c	113.66a-c	118.25A-C\	96.17ab	75.67b-d	77.42A\	82.32b-e	79.65f-h	80.98DE\
Fisher	124.33ab	122.83a-c	123.58AB\	80.83a	69.83e-g	75.33A-C\	83.29a-d	78.98gh	81.14C-E\
Parent	118.33a-c	113.17a-c	115.75BC\	78.33a-c	67.83g	73.08C\	83.65a-c	80.20e-h	81.93B-D\
Fukumoto	123.17ab	112.67bc	117.92A-C\	78.50a-c	68.50fg	73.50C\	81.98d-g	78.98gh	80.48D-F\
Leng	109.67bc	103.67cd	106.67CD\	77.96a-c	72.83d-f	75.40A-C\	82.32b-e	77.98hi	80.15EF\
Means	122.22A	113.67B		79.40A	70.55B		83.54A\	79.64B\	

In each season, means of each of rootstocks and cultivars or their interactions having the same letter (s) are not significantly different at 5% level.

*VL = Volkamer lemon , **SO = Sour orange

Element	Fe (ppm)	Zn (ppm)	Mn (ppm)	Obreza *et al.* (1992)
Deficient	<35	<17	<17	
Low	35-59	18-24	18-24	
Optimum	60-120	25-100	25-100	
High	121-200	101-300	101-300	
Excess	>200	>300	>300	

The obtained data are in agreement with those reported by El-Sayed and Somaia (2008) reported that, Washington navel orange budded on VL and Rangpure lime rootstocks had significantly higher N, K, Mg, Fe and Zn and lower P. Sour orange and troyer citrange rootstocks recorded the highest values of P, moderate values of Mg, K, Fe, Ca and Mn. Jahromi *et al.* (2012) and Barakat *et al.* (2013) who reported that VL rootstock induced higher foliar leaf mineral content as compared with SO rootstock.

Effect on C/N ratio

Results in Table 9 show the effect of different Navel orange cultivars, rootstocks and their interaction on C/N ratio in stems of Navel orange trees in 2012 and 2013seasons. Results showed that values of total carbohydrates, total N and C/N ratio were significantly affected by Navel orange cultivars, rootstocks and their interaction.

The significant highest values of total carbohydrate were obtained by New Hall and Lane Late through two seasons. Regarding the rootstocks, SO gave the significant highest values of total carbohydrate during the two seasons. Concerning the interaction, New Hall, Navelate and Lane Late budded on SO gave the significant highest values of total carbohydrate during the two seasons.

While the significant highest values of total nitrogen were obtained by Lane Late during the two seasons whereas, some other cultivars gave the same highest values such: (Navelina) and (New Hall, Fisher, Parent and Leng) in the first and second seasons, respectively. Results showed that values of N were significantly affected by rootstocks in the first season only and VL. rootstock gave the significant highest value. Regarding the interaction it was clear that the trend was slightly different from one season to another. In the first season, the significant highest values of N were obtained when grafting New Hall, Navelina, Lane Late and Fisher on VL and other combinations gave more or less similar lower values. On the other hand in the second season, the significant highest values were obtained from New Hall, Lane Late, Fisher, Parent and Leng on each rootstocks and Navelina, Cara Cara on VL rootstock. Meanwhile, Navelate and Fukumoto cultivars gave the least significant values of N content on each rootstock.

The significant highest values of C/N ratio were obtained by New Hall, Navelate, Spring, and Fukumoto in two seasons. Meanwhile, SO rootstock gave the significant highest values of C/N ratio during the two seasons. Regarding the interaction, it could be concluded that, all the combinations between different cultivars on SO rootstock gave higher values than the combinations on VL rootstock.

From the foregoing results, it could be concluded that, VL gave lower values of total carbohydrates consequently gave lower values of C/N ratio than SO rootstock. In the same time, all Navel orange cultivars budded on VL rootstock gave lower C/N ratio than budded on SO rootstock.

TABLE 9. Effect of some newly Navel orange cultivars and two rootstocks on stem total carbohydrate, total nitrogen and C/N ratio during the 2012 and 2013 seasons

cultivars	Rootstocks								
	VL*	SO**	Means	VL*	SO**	Means	VL*	SO**	Means
	Total carbohydrates %			Total nitrogen %			C/N ratio		
	2012 season								
New Hall	10.62ef	12.36ab	11.49A\	0.96ab	0.70jk	0.83B\	11.02d	17.55a	14.28A\
Navelina	9.41hi	11.55a-d	10.48CD\	0.92a-d	0.77hi	0.85AB\	10.24de	14.96c	12.60C-E\
Navelate	9.59g-i	12.02ab	10.80BC\	0.92b-d	0.74ij	0.83BC\	10.48de	16.33a-c	13.41A-D\
Lane Late	10.18f-h	12.46a	11.32AB\	0.98a	0.78h-g	0.88A\	10.45de	1594a-c	13.19B-D\
Cara Cara	7.99k	10.36fg	9.17F\	0.81f-h	0.66kl	0.74E\	9.88de	15.59bc	12.73B-E\
Spring	8.66i-k	11.49b-e	10.07DE\	0.85ef	0.67kl	0.76DE\	10.20de	17.21ab	13.71AB\
Fisher	8.42jk	10.91d-f	9.66EF\	0.92a-c	0.73ij	0.83BC\	9.13e	14.93c	12.03E\
Parent	9.09ij	11.85a-c	10.47CD\	0.88c-e	0.71jk	0.79CD\	10.34de	16.81ab	13.57A-C\
Fukumoto	8.15k	11.01c-f	9.58EF\	0.83e-g	0.64l	0.74E\	9.80de	17.19ab	13.50A-D\
Leng	7.91k	10.91d-f	9.16F\	0.86d-f	0.66kl	0.76E\	9.16e	15.81bc	12.49DE\
Means	9.00B	11.44A		0.89A	0.71B		10.07B	16.23A	
	2013 season								
New Hall	11.07ef	12.40ab	11.74A\	0.96a	0.81a-e	0.89AB\	11.52c-f	15.36a	13.44AB\
Navelina	9.50hi	11.66c-e	10.58C\	0.87a-d	0.77b-e	0.82B-D\	10.91ef	15.16a	13.03AB\
Navelate	9.82gh	12.29a-c	11.05B\	0.75c-e	0.79b-e	0.77CD\	12.95a-e	15.60a	14.27A\
Lane Late	11.22de	12.90a	12.06A\	0.94ab	0.92a-c	0.93A\	12.01b-f	13.99a-c	13.00AB\
Cara Cara	8.20kl	10.50fg	9.35FG\	0.83a-e	0.76c-e	0.79B-D\	9.90f	13.91a-d	11.90BC\
Spring	8.87i-k	11.85b-d	10.36CD\	0.79b-e	0.83a-e	0.81B-D\	11.25d-f	14.33ab	12.79AB\
Fisher	8.78jk	11.07ef	9.93DE\	0.90a-d	0.79a-e	0.84A-C\	9.83f	13.99a-c	11.91BC\
Parent	9.28h-j	11.91bc	10.63BC\	0.87a-d	0.85a-d	0.86A-C\	10.64ef	14.17a-c	12.40BC\
Fukumoto	7.96l	10.46fg	9.21G\	0.68e	0.75de	0.72D\	11.74b-f	14.08a-c	12.91AB\
Leng	8.41kl	11.17d-f	9.79EF\	0.85a-d	0.92a-d	0.88AB\	9.89f	12.24b-f	11.06C\
Means	9.31B	11.63A		0.84A	0.82A		11.06B	14.28A	

In each season, means of each of rootstocks and cultivars or their interactions having the same letter (s) are not significantly different at 5% level.
*VL = Volkamer lemon , **SO = Sour orange

Generally, combinations between different cultivars on VL rootstock gave lower values of C/N ratio than SO rootstock but in the same time gave highest values of fruit set and yield may be due to the increase of scions vigor budded on VL rootstock resulted from increase the nutrients absorption efficiency from soil which reflected in the canopy growth, leaf mineral content and yield. So, it was expected that, after few years Navel orange cultivars budded on VL rootstock may be suffer from alternate bearing.

Regarding data for effect of rootstocks on C/N ratio, similar results were found by Zayan *et al*. (2004) who found that C/N ratio of Valancia orange trees budded on VL and Rangpur lime recorded the significant lowest values of C/N ratio. Whereas trees budded on Troyer citrange recorded highest value of C/N ratio. While trees budded on SO rootstock recorded intermediate values of C/N ratio.

Conclusion

From the aforementioned results, it could be concluded that, VL rootstock was more effective in improving yield and leaf mineral content of all cultivars but with low fruit quality than SO rootstock. Regarding cultivars, New Hall gave the highest values of fruit weight and yield/tree followed by Navelina and Lane Late but New Hall especially on VL gave large fruit size which not accepted in export and local market. So, it could be recommended by budded Navelina and Lane Late cultivars on SO rootstock for suitable yield with high fruit quality.

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تقييم بعض أصناف البرتقال بسرة الجديدة المطعومة على أصلى النارنج والفولكاماريانا

محمد عبد الحميد ناصر، علاء الدين زكى بندق ، عاصم دسوقى شلتوت و نهى منصور
قسم البساتين – كلية الزراعة – جامعة عين شمس–القاهرة – مصر .

أجريت تجربة حقلية خلال موسمى 2012 ، 2013 بمزرعة خاصة بوادى الملاك - محافظة الشرقية - جمهورية مصرالعربية وذلك لتقييم التزهير وعقد الثمار والمحصول وجودة الثمار والمحتوى المعدنى للأوراق ونسبة الكربوهيدرات للنيتروجين لبعض أصناف البرتقال بسرة (نيوهول – نافالينا – نافليت – لانى ليت – كارا كارا – سبرنج – فيشر – بيرنت – فوكوموتو – لنج) والتى طعمت على أصلى النارنج والفولكاماريانا .

وتتلخص اهم النتائج المتحصل عليها فى التالى:
تقييم الأصناف :
أعطت الأصناف "نيوهول – نافالينا – نافليت – لانى ليت" أعلى قيم لعقد الثمار وأقل قيم للتساقط بالمقارنه بالأصناف الأخرى. بينما اعطى صنف النيوهول اعلى قيم لوزن الثمار ومحصول الأشجار ولكن كانت الثمار ذات حجم غير مناسب للتصدير والتسويق المحلى . وأعطى كل من صنفى نيوهول ونافالينا اعلى قيم للمواد الصلبة الذائبة الكلية ونسبة المواد الصلبة الذائبة الكلية للحموضة وأقل قيم للحموضه. كما وجد أن الأصناف " كارا كارا – سبرنج – لنج" قد أعطت أقل قيم

لمحتوى الأوراق من النيتروجين بالمقارنه بالأصناف الأخرى . وقد اعطى صنفى نافليت و لانى ليت اعلى قيم لعنصر الفوسفور والبوتاسيوم والكالسيوم. واعطت الأصناف "نيوهول –نافليت – سبرنج – فوكوموتو" أعلى قيم لنسبة الكربوهيدرات للنيتروجين.

تقييم الأصول:

اعطى أصل الفولكاماريانا اعلى قيم للتزهير والعقد وتساقط الثمار والمحصول ووزن الثمار وسمك قشرة الثمرة كما اعطى اعلى قيم لمحتوى الأوراق من العناصر بالمقارنة بأصل النارنج. بينما اعطى النارنج قيم اعلى فى نسبة العصير و نسبة المواد الصلبة الذائبة الكلية و نسبة المواد الصلبة الذائبة الكلية للحموضة. وقد اعطى اصلى الفولكاماريانا أقل قيم للكربوهيدرات الكلية و نسبة الكربوهيدرات للنيتروجين بالمقارنة مع أصل النارنج.

على الرغم من أن اصل الفولكاماريانا اعطى محصولاً اعلى من اصل النارنج لأصناف البرتقال بسرة محل الدراسة ألا انه اعطى صفات جوده ثمرية أقل ، حيث أعطى اعلى قيم لسمك القشرة واقل قيم لكل من السكريات الذائبة الكلية و نسبة السكريات الذائبة الكلية للحموضه.

التأثير المتبادل بين الأصل والطعم:

اعطى صنف لانى ليت ونيوهول المطعوم على أصل الفولكاماريانا أعلى قيم للتزهير وعقد الثمار وأقل قيم للتساقط. وأظهرت النتائج أعلى قيم للمحصول لصنف النيوهول المطعوم على الأصلين ثم يليه صنف اللانى ليت المطعوم على اصل الفولكاماريانا. وتحققت أعلى قيم للمواد الصلبة الذائبة الكلية و المواد الصلبة الذائبة الكلية للحموضة عندما طعم النافلينا على النارنج. وظهرت أعلى قيم للنيتروجين والفوسفور و الكالسيوم والماغنسيوم والحديد والمنجنيز عندما طعم صنف اللانى ليت على اصل الفولكاماريانا.

اعطت كل الأصناف المطعومه على الفولكاماريانا أقل قيم لنسبة الكربوهيدرات للنيتروجين بالمقارنة بتلك المطعومة على أصل النارنج.

مما سبق يمكن التوصية بأنه يفضل زراعة صنفى النافالينا واللانى ليت المطعومه على أصل النارنج تحت ظروف محافظة الشرقية بجمهورية مصر العربية للحصول على محصول مناسب وجودة ثمار عالية.