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Nutritional Status and Yield Efficiency of Navel and Valencia Orange Trees as Affected by Used Rootstocks

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Abstract: This study was carried out during 2007-2008 and 2008 – 2009 seasons on Navel and Valencia orange cultivars budded on Sour orange and Volkamer lemon rootstocks. Results indicated that, leaves of Valencia orange on Volkamer lemon rootstock recorded the highest N and Mg content, Naval orange on Volkamer lemon recorded the highest P content and Naval orange on Sour orange showed the highest K and Ca content. Navel orange significantly improved P and K content in roots of Volkamer lemon rootstock compared to Valencia orange on Sour orange rootstock. Valencia orange increased N, Ca and Mg content in roots Sour orange rootstock. Valencia orange significantly increased N and Ca content in Sour orange bark and P, K in Volkamer lemon bark. Navel orange enhanced Mg in Sour orange bark. Volkamer lemon rootstock was more effective in increasing N and K content in bark of both cultivars than Sour orange rootstock which significantly increased Ca and Mg in Valencia orange bark and P in Navel orange bark. Tree yield efficiency as weight was the highest for Valencia orange on Sour orange in the first season and Volkamer lemon in the second one. Meanwhile, tree yield efficiency as number of fruits was the highest for Navel orange on Volkamer lemon in the first season and Valencia orange on the same rootstock in the second one. Generally, Volkamer lemon rootstock was more effective in improving yield efficiency of both cultivars than Sour orange rootstock.

Key words: Navel orange · Valencia orange · Sour orange · Volkamer lemon · Nutrient content · Yield efficiency

INTRODUCTION

Commercial citrus varieties are propagated asexually by budding on compatible rootstocks. There is no controversy over the importance of citrus rootstock for better citrus production. Rootstocks provide growers with useful tool to manipulate the vigor and performance of orchard trees. Effects on tree size, precocity, fruit production and maturity are achieved through complex interrelationship between the roots and canopy of the plant. Rootstocks directly affect the ability of plants to up take the water and nutrients from the soil. They are also able to significantly alter the pattern of canopy development and functions such as photosynthesis [1].

Sour orange (*C. aurantum* L.) rootstock is reported to be susceptible to quick decline, resistance to gummosis, better tolerant to salts as compared with other some rootstocks, suited for heavy moist soil, gives good yields and quality fruits, but, the size of the fruit is smaller, thin and smooth skin, high TSS and acidity, fruit can be hold on the tree to the fruitless maturity of the variety without loss in the quality. So, sour orange, considered, the dominant rootstock in the Mediterranean region, here 88% of citrus fruits are produced [2]. All citrus cultivars are mainly budded on sour orange, which is highly susceptible to tristeza [3-5].

Moreover, Citrus volkamer lemon is a Rangpur type, but exhibits the same horticultural characteristics as Rough Lemon. So trees on Rough Lemon stocks are largely replaced by trees on volkamer lemon stock. volkamer lemon seems to be the most vigorous rootstock of all, so requires much more pruning schedules than other stocks [6]. Mineral nutrients are greatly influenced by rootstocks. Different scions exhibit variable quantities of nutrients from different rootstocks. Scion bark of Kinnow contained less nitrogen when compared to rootstock bark where as Potassium was higher in scion and lower in rootstocks bark [7]. Similarly Highest values

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of nitrogen were associated with the Satsuma on Carrizo citrange and lowest on sour orange [8]. However Araujo *et al*. [9] observed no effect of rootstocks on nitrogen and phosphorus contents in the Ponkan mandarin grafted on different rootstocks. Phosphorus contents were low on sour orange compared another rootstocks.

Georgiou [10] showed that, Volkamer lemon are the most promising for replacing the sour orange rootstocks. Waqar *et al.* [11] found that, Volkamer lemon was the best in relation to nutrient uptake and yield compared with another rootstocks.

Taiz and Zeiger [12] mentioned that, total nitrogen caused direct role in photosynthesis, carbohydrates and protein synthesis has very importance to plant growth and development control. Phosphorous has a key role as it affects fruit quality and the right balance of nitrogen to phosphorous is important for fruit setting and good quality of fruit. Potassium is the main element in fruit and it has profound effect on fruit quality than any other element. Potassium regulates the opening and closing of stomata and directly related to water use efficacy in plants.

Calcium promotes early root formation and growth, improves general plant vigor, stiffness of stalks and improves fruit integrity. Calcium influences the uptake of other nutrients such as phosphorous, manganese, iron, zinc and boron [13].

The objective of this study was to assess the impact of Sour Orange and Volkamer lemon rootstocks on Navel and Valencia orange nutrient status and yield efficiency under sandy soil.

MATERIALS AND METHODS

This study was carried out during 2007-2008 and 2008 - 2009 seasons on 16 -year- old Navel and Valencia orange (*Citrus Sinensis L Osbek*) trees budded on Sour Orange (*Citrus Aurantum*) and Volkamariana (Volkamer lemon) rootstocks.

The study was conducted in private Orchard at Al-Nubaria region EL- Beheira Governorate Egypt. Trees were planted at 5x5 meter in sandy soil under drip irrigation system and received similar horticulture practices. Laboratory work was carried out in Citrus Department Pomology Lab, Institute of Horticultural Research. Physical and chemical analyses of the soil are presented in Table (1).

Trees were selected in randomized Complete Block Design (RCBD) with five replications to investigate the specific effect of two studied factors, rootstock species (Sour orange and Volkamer lemon),citrus cultivars (Washington navel and Valencia orange) as well as the interaction effect of the combinations.

Fertilization was annually 15m3 manure / feddan with 1kg Super phosphate / tree (once in December) and the nutrient requirements were applied as fertigation system distributed through along season (macro-elements as a units/feddan: (N-120kg, P-35kg, K-80kg, Ca-18kg and Mg-14kg) and micro-elements (Fe, Zn and Mn) were applied as a foliar 2 times / year).

Determination of Mineral Contents in Leaves, Roots and Skin Bark: In mid September during first and second seasons, full expended leaves, were taken from spring flushed tagged shoots (about thirty leaves) per each replicate (tree), Root system measurements, late September for both season, root samples were taken from four directions at a distance about 1 m from the trunk of the tree throw four spots at depth 0-30 cm by using cylinder auger (24.0cm in height and 29.0mm in diameter). Soil samples were washed and the roots were separated to two types (less than 0.2 mm and more than 0.2 mm) and piece of skin bark was cut using a sharp knife for chemical analysis.

The wet digestion of 0.25 g plant materials (leaves, roots and bark) was carried out with sulphouric and perchloric acid s as reported by Piper [14].

Total Nitrogen (N): Was determined by modified microkjeldahl procedure according to Chapman and pratt [15].

Phosphorus (P): Was determined by using "specal" spectrophotometer at 882 U.V. according to the method described by Murphy and Piely [16].

Potassium (K): Was determined using flame photometer according to Brown and Lilliland [17].

Calcium (Ca) and Magnesium (Mg): Were determined using atomic absorption spectrophotometer "perkin elmer-3300" according to Chapman and pratt [15] a known weight of dried sample (2 gm) was weighed in porcelain crucible and placed in temperature-controlled muffle furnace at 550°C for several hours until a constant weight was obtained [18].The percentage of ash was calculated on a dry weight basis.

Yield Efficiency: At harvest time for both orange cvs. (Navel Orange at January and Valencia at March) in both seasons all fruits per each replicate were

Table 1: Physical and chemical analysis of the soil in the experimental site

		Soil depth				Soil depth	
Analysis		0-30 cm	30-60 cm	Analysis		0-30 cm	30-60 cm
Soil cations meq/l	Ca+2	0.70	1.90	Macro elements ppm	N	15.00	25.00
	Mg+2	0.10	0.50		P	33.00*	9.00*
	Na+	0.76	1.20		K	96.00	160.00
	K+	0.53	0.47		-	-	-
Soil anions meq/l	-CO3	-	-	Micro elements ppm	Fe	3.82	6.00
	-HCO3	1.20	1.20		Cu	0.14	0.18
	-Cl	0.50	0.50		Zn	0.24	0.40
	-SO4	0.39	2.37		Mn	0.30	2.72
pH (1:2.5)		8.50	8.60	$Caco_3$ %		1.70	3.60
Ec ds/m (1:2.5)		0.20	0.46	-		-	-

*fertilizer program depending on phosphoric acid as a source of P fertigation which added monthly.

picked, number and weight (kg) were determined. Yield efficiency was calculated as a fruit number or weight (kg) related to canopy of the tree (number / M^3 or Kg/M^3).

Statistical Analysis: Obtained data were subjected to analysis of variance using CoStat- Statistics Software version 6.1, while the percentage values were square roots transformed as described by Sokal and Rohlf [19] then it were subjected to analysis of variance.

RESULTS AND DISCUSSION

Nutrient Content in Leaves of Navel and Valencia Oranges Trees: Results presented in Table 2 reveal the variation of nutrients content in leaves of Naval and Valencia orange cultivars, as affected by rootstock used. Volkamer lemon generally exhibited significantly higher N, P, K and Mg content compared to sour orange in both seasons, except for the difference between N content in the first experimental season, which showed statistical insignificance. Contrarily, sour orange recorded higher Ca content compared to Volkamer lemon in both investigated seasons. On the other hand and regardless of rootstock, Valencia orange showed higher N, P and Mg content compared to Naval orange. Statistical significance was recorded only between P content in the first experimental season and between N content in the latter one. On the other hand, Naval orange leaves showed significantly higher K and Ca content compared to leaves of Valencia orange in both seasons.

Finally, it is worth mentioning that Valencia orange grafted on Volkamer lemon recorded the highest N and Mg content, Naval orange on Volkamer lemon recorded the highest P content and Naval orange on Sour orange showed the highest K and Ca content. Our result are in consonance with the results of Path *et al.* [20] whom indicate that rootstock affect minerals percentage of scion leaves in Tahiti lime. Also, Taylor and Dimsey [21] reported that rootstock type attentive to scion cultivar has different effects on mineral elements concentration of scion leaf. Georgiou [10] showed that, P and K in Nova mandarin leaves were induced by Volkamer lemon rootstock. Jahromi *et al.* [22] found that total N concentration in leaf of Washington navel orange on Sour orange had not significant difference and total N concentration in leaf of Valencia orange was in optimum range.

Nutrients Content in Roots of Sour Orange and Volkamer Lemon Rootstocks

Roots Less Than (0.20 mm): Data presented in Table 3 show that, budding Valencia orange on Sour orange and Volkamer lemon had significantly increased N content in roots of both rootstocks when compared with Navel orange cultivar. Moreover, Sour orange roots showed higher N content than Volkamer lemon. As for the P content, it was found that roots of Volkamer lemon budded with Navel orange recorded the highest content compared to other combinations. Meanwhile, the lowest values of P content were detected in roots of Sour orange rootstocks budded with Navel or Valencia orange cultivars. Moreover, it is worth mentioning that rootstocks significantly affected root P content, while scions had a minor effect on this element.

Significant increases in K content were recorded in roots of Volkamer lemon when budded with Navel orange. On the other hand the lowest values of K content were detected in roots of Sour orange budded with Valencia orange scions. It was also noticed that Navel orange scions and Volkamer lemon rootstock significantly improved K content in roots compared to Valencia orange scions and Sour orange, respectively. It was also found

Table 2: Effect of Sour orange and Volkamer lemon rootstocks on nutrient content in leaves of Navel and Valencia oranges cultivars during 2007-2008 and 2008-2009 seasons

		2007-2008 season			2008-2009 season		
Aspect	Rootstocks	Navel O.	Valencia O.	Mean	Navel O.	Valencia O.	Mean
N	Sour orange	2.35b	2.52ab	2.44A	2.83c	3.00b	2.92B
	Volkamer lemon	2.52ab	2.67a	2.60A	3.05b	3.23a	3.14A
	Mean	2.44A	2.60A		2.94B	3.12A	
P	Sour orange	0.11c	0.15b	0.13B	0.15d	0.20b	0.18B
	Volkamer lemon	0.17a	0.15b	0.16A	0.23a	0.19c	0.21A
	Mean	0.14B	0.15A		0.19A	0.20A	
K	Sour orange	1.46a	1.04b	1.25B	1.55a	1.08c	1.32B
	Volkamer lemon	1.46a	1.33a	1.39A	1.52ab	1.43b	1.48A
	Mean	1.46A	1.18B		1.54A	1.26B	
Ca	Sour orange	5.48a	4.67b	5.07A	6.56a	5.22b	5.89A
	Volkamer lemon	4.40b	3.73c	4.07B	4.93c	4.25d	4.59B
	Mean	4.94A	4.20B		5.74A	4.74B	
Mg	Sour orange	0.34b	0.18c	0.26B	0.40b	0.22d	0.31B
	Volkamer lemon	0.23c	0.39a	0.31A	0.26c	0.46a	0.36A
	Mean	0.28A	0.29A		0.33A	0.34A	

Values followed by the same letter (s) are not significant at 0.05% L.S.D.

Table 3: Effect of Navel and Valencia oranges cultivars on nutrient content in roots (less than 0.2mm) of Sour orange and Volkamer lemon rootstocks during 2007-2008 and 2008-2009 seasons

		2007-2008 season			2008-2009 season		
Aspect	Rootstocks	Navel O.	Valencia O.	Mean	Navel O.	Valencia O.	Mean
N	Sour orange	1.40b	1.68a	1.54A	1.66b	1.80a	1.73A
	Volkamer lemon	1.23c	1.68a	1.45B	1.46c	1.80a	1.63B
	Mean	1.32B	1.68A		1.56B	1.80A	
P	Sour orange	0.11c	0.11c	0.11B	0.15c	0.18bc	0.17B
	Volkamer lemon	0.19a	0.17b	0.18A	0.24a	0.20b	0.22A
	Mean	0.15A	0.14A		0.20A	0.19A	
K	Sour orange	1.28c	1.14d	1.21B	1.32c	1.16d	1.24B
	Volkamer lemon	1.88a	1.64b	1.76A	2.01a	1.79b	1.90A
	Mean	1.58A	1.39B		1.67A	1.48B	
Ca	Sour orange	1.79c	5.20a	3.50A	1.95c	5.92a	3.93A
	Volkamer lemon	4.60b	0.92d	2.76B	5.02b	1.05d	3.04B
	Mean	3.20A	3.06B		3.49A	3.48A	
Mg	Sour orange	0.12c	0.23a	0.18A	0.17c	0.28a	0.23A
	Volkamer lemon	0.16b	0.14bc	0.15B	0.20b	0.17c	0.19B
	Mean	0.14B	0.18A		0.19B	0.23A	

Values followed by the same letter (s) are not significant at 0.05% L.S.D.

that using Valencia orange as scions significantly increased Ca in roots of Sour orange while Ca content decreased in roots of the same rootstock when budded with Navel orange. Ca in Sour orange roots was significantly higher than Volkamer lemon roots. Navel orange scions enhanced Ca in roots of Volkmer lemon and Sour orange rootstocks but Valencia orange scions decreased Ca content in roots of both rootstocks.

Sour orange roots recorded the highest values of Mg content when budded with Valencia orange scions and the lowest values with Navel orange scions. Valencia orange scions significantly increased Mg content in roots of both Sour orange and Volkamer lemon. Sour orange roots contained higher Mg than Volkamer lemon roots.

Roots More Than (0.20 mm): Data in Table 4 clear that, the highest significant N content was recorded in Sour orange roots budded with Valencia orange. On the other side, the lowest values were detected in Volkamer lemon roots budded with Valencia orange in the first season and

Table 4: Effect of Navel and Valencia oranges cultivars on nutrient content in roots (more than 0.2mm) of Sour orange and Volkamer lemon rootstocks during 2007-2008 and 2008-2009 seasons

		2007-2008 season			2008-2009 season		
Aspect	Rootstocks	Navel O.	Valencia O.	Mean	Navel O.	Valencia O.	Mean
N	Sour orange	1.12b	1.46a	1.29A	1.24b	1.75a	1.49A
	Volkamer lemon	1.22b	1.12b	1.17B	1.17c	1.18c	1.17B
	Mean	1.17B	1.29A		1.2B	1.47A	
P	Sour orange	0.12b	0.07c	0.1B	0.17b	0.1c	0.13B
	Volkamer lemon	0.18a	0.08c	0.13A	0.23a	0.11c	0.17A
	Mean	0.15A	0.08B		0.2A	0.11B	
K	Sour orange	1.06c	0.74d	0.9B	1.08c	0.79d	0.93B
	Volkamer lemon	1.2a	1.14b	1.17A	1.28a	1.17b	1.23A
	Mean	1.13A	0.94B		1.18A	0.98B	
Ca	Sour orange	1.32c	4.2a	2.76A	1.75d	4.85a	3.3A
	Volkamer lemon	4a	1.64b	2.82A	4.24b	2.12c	3.18B
	Mean	2.66B	2.92A		3.00B	3.48A	
Mg	Sour orange	0.36ab	0.26c	0.31A	0.41b	0.39b	0.4A
	Volkamer lemon	0.32b	0.37a	0.35B	0.31c	0.45a	0.38A
	Mean	0.34A	0.32B		0.36B	0.42A	

Values followed by the same letter (s) are not significant at 0.05% L.S.D.

Table 5: Effect of Navel and Valencia oranges cultivars on nutrient content in bark of rootstocks during 2007-2008 and 2008-2009 seasons

		2007-2008 season			2008-2009 season		
Aspect	Rootstocks	Navel O.	Valencia O.	Mean	Navel O.	Valencia O.	Mean
N	Sour orange	1.68d	2.67a	2.18A	1.82d	3.06a	2.44A
	Volkamer lemon	1.85c	2.13b	1.99B	2.03c	2.20b	2.11B
	Mean	1.77B	2.40A		1.92A	2.63B	
P	Sour orange	0.05c	0.03d	0.04B	0.09Bc	0.07c	0.08B
	Volkamer lemon	0.08b	0.12a	0.10A	0.10B	0.16a	0.13A
	Mean	0.07A	0.08A		0.09B	0.11A	
K	Sour orange	0.62c	0.62c	0.62B	0.68c	0.70c	0.69B
	Volkamer lemon	0.76b	0.88a	0.82A	0.80b	1.00a	0.90A
	Mean	0.69B	0.75A		0.74B	0.85A	
Ca	Sour orange	1.84b	3.60a	2.72A	2.14b	4.09a	3.12A
	Volkamer lemon	1.62c	1.64c	1.63B	1.91d	2.01c	1.96B
	Mean	1.73B	2.62A		2.02B	3.05A	
Mg	Sour orange	0.21a	0.16b	0.19A	0.26a	0.20b	0.23A
	Volkamer lemon	0.14b	0.09c	0.12B	0.17b	0.12c	0.14B
	Mean	0.18A	0.13B		0.22A	0.16B	

Values followed by the same letter (s) are not significant at 0.05% L.S.D.

Navel orange in the second one. Valencia orange was more effective in enhancing N content in roots of both rootstocks than Navel orange. Regardless cultivars, Sour orange roots had higher N content as compared with Volkamer lemon and the differences were significant.

Concerning P content, Volkamer lemon roots recorded the highest values when budded with Navel orange. Meanwhile, the lowest values were recorded in roots of Sour orange when budded with Valencia orange cultivar. Valencia orange as a scion significantly decreased P content in Volkamer lemon and Sour orange roots. Volkamer lemon roots had higher P content than Sour orange rootstock.

K content was the highest in Volkamer lemon roots and the lowest in Sour orange roots. Navel orange increased K content in roots of both used rootstocks while the opposite was found with Valencia orange when budded on both rootstocks.

As for Ca content it was significantly the highest in Sour orange roots when budded with Valencia orange while, it was significantly the least when the same rootstock was budded with Navel orange. The opposite trend was found with Volkamer lemon rootstock. Valencia orange significantly enhanced Ca content in roots of both used rootstocks in comparison to Navel orange. Ca content was significantly higher in Sour orange roots compared with Volkamer lemon.

In addition Mg, the highest values was observed in Volkamer lemon roots budded with Valencia orange. Meanwhile, the lowest values was detected in Sour orange roots budded with Valencia orange in the first season and Volkamer lemon budded with Navel orange in the second one. In general, Ca was higher in Sour orange roots than Volkamer lemon roots and the differences were significant in the first season only. These results coincide with those obtained by Seyam [23] who found that Sour orange seedling had roots with higher level of N and P as compared with Volkamer lemon.

Nutrient Content in Trunk Bark of Rootstocks and Scions

Rootstocks Bark: Budding Valencia orange cultivar on any of the considered rootstocks significantly increased N content in rootstocks bark compared with Navel orange cultivar which significantly decreased N content in Sour orange bark (Table 5).

With respect to P content, it was evident that, P in Volkamer lemon bark budded with Valencia orange cultivar was significantly higher in than that of Sour orange. Budding Navel orange cultivar on the two used rootstocks significantly decreased P content in their bark.

K content was significantly the highest in Volkamer lemon bark budded with Valencia orange cultivar. Insignificant differences were attributed to budding both Navel and Valencia orange on Sour orange in both seasons. K content of Sour orange bark was significantly the least in both seasons.

Ca was the highest in Sour orange bark budded with Valencia orange and the lowest in Volkamer lemon budded with Navel orange.

In addition Mg content the highest significant value was detected in Sour orange bark budded with Navel orange while the lowest values were found in Volkamer lemon budded with Valencia orange. Navel orange was more effective in increasing Mg than Valencia orange also Sour orange bark contained significantly higher Mg than Volkamer lemon rootstock.

Scions Bark: Data in Table 6 ravel that, N content significantly increased in Valencia and Navel orange barks when budded on Volkamer lemon compared with those budded on sour orange. The highest values were observed with Valencia orange on Volkamer lemon while the lowest values were found with Navel orange on Sour orange rootstock in both seasons. Regardless rootstocks, Valencia orange bark contained higher N than Navel orange.

Concerning P content, the highest significant value was found in Navel orange bark on Sour orange rootstock. Insignificant differences were attributed to budding Navel and Valencia orange on both Sour orange and Volkamer lemon rootstocks in both seasons. P content was significantly the least Valencia orange bark.

In addition K content the highest value was found in Navel orange on Volkamer and the lowest in Valencia orange grown on Sour orange. K content was significantly higher in bark of Navel orange than Valencia orange in both seasons. Also, Volkamer lemon rootstock was more effective than Sour orange in increasing K content of both cultivars.

Ca was the highest in Valencia orange on Sour orange and the lowest in Navel orange on the same rootstock. Similar trend was found for Valencia and Navel orange on Volkamer lemon rootstock. Regardless cultivars, Sour orange recorded higher significant values than Volkamer lemon rootstock. Also, Valencia orange trees contained higher Ca in their bark than Navel orange.

Sour orange rootstock induced significantly the highest Mg in bark of both Navel and Valencia orange. A marked reduction in Mg content was noted in Navel and Valencia orange budded on Volkamer lemon rootstock. Meanwhile, significantly the least Mg content was due to budding Navel orange on Volkamer lemon rootstock. Regardless rootstocks there were no significant differences among both Navel and Valencia oranges. Different scions exhibit variable quantities of nutrients from different rootstocks, whereas, scion bark of Kinnow mandarin contained less nitrogen when compared to rootstock bark where as Potassium was higher in scion and lower in rootstocks bark.

Yield Efficiency of Navel and Valencia Orange Trees

Yield Efficiency (No. /M^3): Yield efficiency as number of fruits per M^3 of tree canopy was the highest for Valencia orange on Sour orange rootstock in the first season and Volkamer lemon rootstock in the second one. However, no

Table 6: Effect of rootstocks on nutrient content in bark of Navel and Valencia oranges cultivars during 2007-2008 and 2008-2009 seasons

		2007-2008 season			2008-2009 season		
Aspect	Rootstocks	Navel O.	Valencia O.	Mean	Navel O.	Valencia O.	Mean
N	Sour orange	1.85c	2.13b	1.99B	2.15C	2.57b	2.36B
	Volkamer lemon	2.13b	2.30a	2.22A	2.54B	2.92a	2.73A
	Mean	1.99B	2.22A		2.34B	2.74A	
P	Sour orange	0.12a	0.06c	0.09A	0.16a	0.09b	0.13A
	Volkamer lemon	0.10b	0.06c	0.08A	0.15a	0.10b	0.13A
	Mean	0.11A	0.06B		0.16A	0.10B	
K	Sour orange	0.74c	0.72c	0.73B	0.82c	0.78d	0.80B
	Volkamer lemon	0.82a	0.78b	0.80A	0.96a	0.88b	0.92A
	Mean	0.78A	0.75B		0.89A	0.83B	
Ca	Sour orange	1.40d	2.40a	1.90A	1.81c	2.83a	2.32A
	Volkamer lemon	1.56c	1.62b	1.59B	1.93c	2.13b	2.03B
	Mean	1.48B	2.01A		1.87B	2.48A	
Mg	Sour orange	0.20a	0.22a	0.21A	0.25a	0.25a	0.25A
	Volkamer lemon	0.11b	0.12b	0.12B	0.13b	0.15b	0.14B
	Mean	0.16A	0.17A		0.19A	0.20A	

Values followed by the same letter (s) are not significant at 0.05% L.S.D.

Table 7: Effect of rootstocks on yield efficiency of Navel and Valencia oranges trees during 2007-2008 and 2008-2009 seasons

		2007-2008 season			2008-2009 season		
Aspect	Rootstocks	Navel O.	Valencia O.	Mean	Navel O.	Valencia O.	Mean
As weight	Sour orange	5.63c	7.33b	6.48B	7.06b	7.09b	7.07B
	Volkamer lemon	10.72a	7.76b	9.24A	10.43a	11.79a	11.11A
	Mean	8.17A	7.54A		8.75A	9.44A	
As number	Sour orange	19.76b	35.45a	27.61B	30.16c	42.95a	36.56B
	Volkamer lemon	32.46a	33.39a	32.93A	35.07b	44.98a	40.03A
	Mean	26.11B	34.42A		32.62B	43.96A	

Values followed by the same letter (s) are not significant at 0.05% L.S.D

significant differences were detected among rootstocks. Navel orange on Sour orange had the lowest yield efficiency in both seasons. Valencia orange recorded higher significant values than Navel orange in both seasons (Table 7).

Concerning yield efficiency as kg per M^3 of tree canopy data in Table 7 show that, the highest values were recorded with Navel orange on Volkamer lemon in the first season and Valencia orange on the same rootstock in the second one. Meanwhile, the lowest values were recorded with Navel orange on Sour orange in both seasons. Regardless rootstocks, Navel orange recorded higher value than Valencia orange in the first season and the opposite was found in the second one however no significant differences were detected among them. Generally, yield efficiency as number or weight was highest on Volkamer lemon and lowest on Sour orange rootstock. In this concern Elham [24] found that, Valencia orange trees on Troyer Citrange rootstock produced higher yield than the trees on Sour orange rootstock. Moreover, higher yield efficiency was also reported for trees reduced in size by rootstocks [25, 26].

Georgiou [10] evaluated yield and yield efficiency of Nova mandarin trees on eleven rootstocks he found that, Palestine rootstock performed well followed by Rough lemon, Sour orange and Volkamer lemon among all rootstocks. Also, Ali *et al.* [27] observed the performance of Allen Eureka lemon trees on seven rootstocks. They found that, trees on Citrus macrophylla and Volkamer lemon were the most productive, while trees on Rough lemon and Sour orange had the lowest yield.

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