

EFFECT OF DIFFERENT ROOTSTOCKS ON VEGETATIVE GROWTH, FRUITING, FRUIT QUALITY AND FRUIT STORAGE ON TREES OF WASHINGTON NAVEL ORANGE

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ABSTRACT

This investigation was carried out for two seasons (2007 and 2008) on 11 years old trees of Washington navel orange trees grown in El-Bramon research farm at Dakahlia governorate and budded on four citrus rootstocks namely, Sour orange (SO), Volkamer lemon (VL), Troyer citrange (TC) and Rangpur lime (RL) to evaluate their growth, fruit set, yield, fruit quality and fruit storage on the trees. The following results were:

1- Trees of Washington navel orange trees grafted on Volkamer lemon rootstock appeared that the larger growth significantly (as tree height, canopy circumference, trunk circumference, spring shoots number and leaf area), followed by Rangpur lime, Troyer citrange, Sour orange rootstock, respectively.

2- Volkamer lemon stock gave significantly the highest values of final fruit set, yield, fruit weight, fruit size, total acidity, total soluble solids / total acidity ratio and ascorbic acid content, while Rangpur lime stock followed by Troyer citrange significantly increased for these traits comparing with Sour orange rootstock. In two seasons, initial fruit set, L/D ratio, T.S.S and fruit rind weight in the second season were not significantly affected with previous rootstocks in this study.

3- As for storage, the highest of loss percentage in fruit weight were found in fruits collected from budded trees on Sour orange stock and the lowest values were observed with Volkamer lemon rootstock in both seasons. Total acidity percentage significantly decreased when storage. Trees of Washington navel orange grafted on Volkamer lemon rootstock gave the highest of total acidity, but the lowest values were in collected fruits from budded trees on Sour orange rootstock. Meanwhile, no significant differences were detected on rind weight loss percentage and TSS % in the two study seasons between tested showed rootstocks.

Generally, the four rootstocks could be descending arranged according to their study character is tics of Washington navel orange fruits as follow: Volkamer lemon, Rangpur lime, Troyer citrange and Sour orange, respectively.

Also, Volkamer lemon rootstock could be recommended as a suitable rootstock for Washington navel orange trees under Delta region conditions for its superiority on Sour orange rootstock.

INTRODUCTION

Rootstocks have a vital influence on production of citrus orchards (El-Sayed 1999), although any citrus species can be used as rootstock, some are better suited to specific conditions than the others. The influence of rootstocks on behaviour of scions is very important and is superior the influence of environmental conditions on scions. Citrus rootstocks can influence vigour as well as cold, salinity, pest and lime resistance, flowering, fruiting and fruit quality.

Delta region is considered a suitable zone for a good yield and fruit quality of Navel orange in Egypt. Moreover, Sour orange represents the most common rootstock for citrus orchards in Egypt, it is susceptible to citrus tristeza virus which has stimulated a search for alternative rootstocks.

Vegetative growth of Washington navel orange trees (height, size and circumference of canopy, shoots number and leaf area of spring cycle) was bigger with Volkamer lemon stock than other studied rootstocks. Highest fruits set were shown in trees that budded on Volkamer lemon stock but, the high yield /tree was found on trees budded on Sour orange and Volkamer lemon. But, Volkamer lemon gains on Sour orange and other rootstocks of fruit quality according to citrus rootstocks as recently observed by Abd-El-Rahman (1994).

Growth and fruiting of Washington navel orange trees were greatly varied according to citrus rootstocks namely Troyer citrange, Volkamer lemon, Rangpur lime and Sour orange (Hassan 1984; Mansour *et al.*, 1993 and Abd-El-Rahman 1994).

According to Abd El Rahman (2002) trees of Washington navel orange grafted on Volkamer lemon rootstock showed the larger growth (as spring shoots, leaf area and tree canopy). The highest fruit weight, fruit volume, acidity and juice ascorbic content were shown in fruits collected from trees budded on Volkamer lemon stock, whereas, T.S.S/ Acid ratio was the highest in fruits collected from trees grafted on Sour orange stock. Juice weight percentage and total soluble solids were not significantly by Volkamer lemon and Sour orange rootstocks under study.

Dawood *et al.*, (2002) found that Volkamer lemon followed by Rangpur lime as better rootstocks than Sour orange. Their trees are characterized by: vigorous vegetative growth as indexed by tree height, volume index, trunk cross sectional area, total leaves number and leaf area. Generally, the rootstocks could be descendingly arranged according to their vegetative growth as follow: Volkamer lemon, Rangpur lime, Troyer citrange, Sour orange and finally Cleopatra mandarin, respectively.

Hagab and Shaarawy (2004) reported that Washington navel orange onto Volkamer lemon, Troyer citrange and Rangpur lime stocks had always the superior values of shoot length, leaf area, yield expressed in weight(kg) and number of fruits/tree, fruit weight, total soluble solids %, T.S.S./ acid and ascorbic acid content, contrary value of total acidity % in decreasing order. While, Sour orange stock produced the lowest values of all the previous investigated parameters except total acidity %.

Abd El-Wahab (2000) noticed that fruit storage of Washington navel orange at room temperature for 5 weeks increased the percentage of weight loss, total soluble solids and TSS / acid ratio, whereas an opposite trend was recorded for total acidity and vitamin C content. El-Helaly (2006) Valencia orange fruits were stored for up to 15 weeks at room temperature and noticed that the percentage of unmarketable fruits, weight loss, total soluble solids (TSS) and TSS / acid ratio were significantly increased. Meanwhile, the percentages of titratable acidity and values of ascorbic acid significantly decreased.

The purpose of this study was to the effect of different rootstocks (Sour orange, Volkamer lemon, Troyer citrange and Rangpur lime) on vegetative growth, fruiting, fruit quality and fruit storage of Washington navel orange trees under Dakahlia governorate conditions.

MATERIAL AND METHODS

The present study was carried out during two seasons of 2007 and 2008 on Washington navel orange trees (*C. sinensis*, Osbeck) grown in El-Bramon research farm at Dakahlia governorate and budded on four citrus rootstocks namely, Sour orange (SO), Volkamer lemon (VL), Troyer citrange (TC) and Rangpur lime (RL). The selected trees planted at 4 m a part in a clay soil, similar in vigor, size and subjected to the same cultural practices usually done in the orchard.

Twenty four healthy and uniform of Washington navel orange trees 10-year-old were selected. Three replicates were used for each rootstocks and every replicate was represented by two trees (4 rootstocks x 3 replicates x 2 tree = 24 trees).

Vegetative growth:-

Tree height (m), tree circumference (m) and trunk circumference (cm) were measured in mid-January and first of November of each season. Four secondary branches around each tree were assigned and labeled in February of both years. At spring cycle, shoots number and leaf area (cm²) were measured according to the equation of Chou (1966) = $\frac{2}{3}$ x length (cm) x width (cm). Moreover, initial fruit set % (after petals fall at late March) and final fruit set % (at the mid-August) were estimated as formula:-

$$\text{Initial fruit set \%} = \frac{\text{Number of setted fruits}}{\text{Total number of flowers}} \times 100.$$

$$\text{Final fruit set \%} = \frac{\text{Total number of fruits}}{\text{Total number of flowers}} \times 100.$$

Yield components:-

The yield (kg /tree and ton/ feddan) was calculated annually at harvest date (mid-November) (on the bases of having 168 trees/ feddan).

Fruit quality:-

In order to determine fruit quality characters, a random sample of 20 fruits was taken from each replicate at the 1st week of January to determine fruit weight (g) , fruit size(cm³) , shape index (length and diameter ratio) and rind weight (g). Total soluble solids (T.S.S) were determined by using Carl Zeiss hand refractometer, total acidity as gms of unhydrus citric acid. Moreover, T.S.S/acid ratio was also estimated. Vitamin C as mg ascorbic

acid were determined and estimated per mg /100 ml fruit juice according to A.O.A.C. (1965).

Storage:-

Losing in fruit weight and rind weight (g), T.S.S and total acidity were determined at storage period on Washington navel orange trees until the end of 1st week of February.

Statistical analysis:-

The experiment was arranged in a randomized complete block design. All data were subjected to statistical analysis according to Snedecor and Cochran (1967) and means were differentiated using the New L.S.D. test at 5 % level of probability.

RESULTS AND DISCUSSION

Vegetative growth:-

Table (1) show Washington navel orange tree height, tree circumference, trunk circumference, spring shoot number and leaf area. Significant differences were found between Sour orange and other rootstocks (Volkamer lemon, Rangpur lime and Troyer citrange) for its effect on these parameters during the two seasons of study. Where, Volkamer lemon rootstock gave the highest effect and Troyer citrange rootstock was the lowest value in this study as compared with Sour orange rootstock. No significant differences were observed between Sour orange and Troyer citrange rootstocks. Generally, the four rootstocks could be descending arranged due to their vegetative growth of Washington navel orange trees according to data from Table (1): Volkamer lemon, Rangpur lime, Troyer citrange and Sour orange.

(Table- 1): Effect of different rootstocks on vegetative growth of Washington navel orange trees during 2007 and 2008 seasons

Root-stock	2007					2008				
	Tr. he. (m)	Tr. cir. (m)	Tru. cir. (cm)	Shoots number	Leaf area (cm ²)	Tr. he. (m)	Tr. cir. (m)	Tru. cir. (cm)	Shoots number	Leaf area (cm ²)
SO	3.67	11.96	65.80	59.11	14.76	3.56	11.34	62.16	48.16	13.45
VL	4.62	14.81	84.27	73.18	19.58	4.94	16.00	81.94	69.02	19.49
TC	3.87	12.75	69.19	59.43	15.74	3.83	11.97	65.31	51.67	14.58
RL	4.25	13.97	78.13	69.17	18.95	4.29	14.06	75.46	66.98	17.63
LSD.05	0.31	1.21	8.21	8.34	3.15	0.30	1.23	7.43	7.10	3.01

SO= Sour orange VL= Volkamer lemon TC= Troyer citrange RL= Rangpur lime
 Tr. he.= Tree height Tr. cir.=Tree circumference Tru. cir.= Trunk circumference
 Shoots number/ secondary branch

From the above mentioned data, it could be concluded that the effect of different rootstocks (Sour orange, Volkamer lemon, Troyer citrange and Rangpur lime) on vegetative growth of Washington navel orange trees. The obtained data are in agreement with those obtained by Hassan (1984), Mansour *et al.*, (1993), Abd-El-Rahman (1994), Abd El Rahman (2002), Dawood *et al.*, (2002) and Hagab and Shaarawy (2004). They concluded that

vegetative growth of Washington navel orange trees (height, size and circumference of tree, shoots number of spring cycle and leaf area) were superior with Volkamer lemon comparing with other tested rootstocks.

Fruit set:

Data presented in Table (2) show that no significant differences were observed between different used rootstocks concerning initial fruit set. In this respect, Volkamer lemon rootstock gave best values than other used rootstocks in the two seasons. Differences in final fruit set percentage of Washington navel orange trees as affected by tested rootstocks were significant, and, the significant increase of final fruit set was taken from Volkamer lemon rootstock, meanwhile the significant decrease were observed from Sour orange rootstock in both 2007 and 2008 seasons. Generally, the four rootstocks could be descending arranged due to their fruit set percentage of Washington navel orange trees as follow according data from Table (2): Volkamer lemon, Rangpur lime, Troyer citrange and Sour orange.

Previous results agreed with those data such as Hassan (1984), Mansour *et al.*, (1993) and Abd-El-Rahman (1994). They found that highest fruits set were shown in fruits collected from trees budded on Volkamer lemon rootstock.

(Table-2):Effect of different rootstocks on initial, final fruit set % and yield (tree and feddan) of Washington navel orange trees during 2007 and 2008 seasons

Root-stock	2007				2008			
	Initial fruit set %	Final fruit set %	Yield / tree (kg)	Yield / feddan (ton)	Initial fruit set %	Final fruit set %	Yield / tree (kg)	Yield / feddan (ton)
SO	58.34	1.97	29.33	4.927	57.41	1.92	24.64	4.140
VL	68.32	2.34	45.98	7.725	67.58	2.27	39.74	6.676
TC	61.30	2.18	36.55	5.804	60.01	2.12	31.07	5.220
RL	64.39	2.27	38.19	6.416	63.14	2.20	36.73	6.171
LSD .05	N.S.	0.14	6.04	0.800	N.S.	0.13	5.84	0.784

SO= Sour orange VL= Volkamer lemon TC= Troyer citrange RL= Rangpur lime

Yield

It is quite clear from data presented in Table (2) that Washington navel orange trees on Volkamer lemon rootstock significantly produced of yield / tree (kg) and yield (ton) / feddan comparing with Troyer citrange, Rangpur lime and Sour orange in 2007 and 2008 seasons, whereas trees on Sour orange rootstock gave the lowest values in this respect. Generally, the four rootstocks could be descending arranged due to their yield of Washington navel orange trees according to data from Table (2): Volkamer lemon, Rangpur lime, Troyer citrange and Sour orange.

These results were obtained from Washington navel orange trees on Volkamer lemon in line with those of Hagab and Shaarawy (2004) who reported that Washington navel orange trees onto Volkamer lemon, Troyer citrange and Rangpur lime stocks gave maximum values of yield expressed in weight (kg) and number of fruits/tree.

Fruit quality:-

It is clearly from Table (3) fruit weight and size were non significantly affected by rootstock type in both seasons, except Sour orange was significantly affected on physical fruit quality (fruit weight and size) of Washington navel orange trees in two seasons of study. In this respect, fruit weight and size of trees on Volkamer lemon rootstock were the best when compared with Rangpur lime and Troyer citrange. The results of rind weight and L/D ratio were non significantly between four tested rootstocks in both seasons. Generally, the four rootstocks could be descending arranged due to their fruit physical characters of Washington navel orange fruits as follow according data from Table (3): Volkamer lemon, Rangpur lime, Troyer citrange and Sour orange.

This conclusion was in line with that obtained by Abd-El-Rahman (1994) who reported that Volkamer lemon gave a good effect on the quality attribute of Washington navel orange fruits as compare with on Sour orange fruit quality. Moreover, Abd El Rahman (2002) trees of Navel orange grafted on Volkamer lemon rootstock produced the highest fruit weight and volume. Also, Hagab and Shaarawy (2004) reported that Washington navel orange onto Volkamer lemon, Troyer citrange and Rangpur lime stocks had always the maximum values of fruit weight.

(Table-3):Effect of different rootstocks on fruit weight, fruit size, L/D ratio and rind weight of Washington navel orange fruits during 2007 and 2008 seasons

Root-stock	2007				2008			
	Fruit weight (g)	Fruit size (cm ³)	L/D ratio	Rind weight (g)	Fruit weight (g)	Fruit size (cm ³)	L/D ratio	Rind weight (g)
SO	197.20	230.10	1.01	124.05	191.67	227.08	1.00	120.64
VL	245.17	276.01	1.03	141.22	238.67	265.73	1.02	135.34
TC	222.98	249.99	1.02	132.27	220.13	244.01	1.01	126.18
RL	233.15	261.04	1.02	136.47	231.36	255.49	1.01	132.00
LSD.05	23.31	30.17	N.S.	N.S.	20.84	27.68	N.S.	N.S.

SO= Sour orange VL= Volkamer lemon TC= Troyer citrange RL= Rangpur lime

Data in Table (4) showed that total soluble solids % (TSS %) of Washington navel orange fruits was non significant with four rootstocks under study, but best values of TSS % were obtained from Washington navel orange fruits on Sour orange stock .With respect to total acidity and total soluble solids/ total acidity ratio, they were significantly affected by rootstocks under study. The trees on Volkamer lemon produced significant in total acidity % in both seasons of the study than Rangpur lime, Troyer citrange and Sour orange, while trees on Volkamer lemon gave significant on ascorbic acid content comparing with other tested rootstocks during the two seasons of study.

Such results are in harmony with that of Abd El Rahman (2002), who reported that the highest acidity and juice ascorbic content were shown in fruits collected from Navel orange trees budded on Volkamer lemon, whereas, TSS/ acid ratio was the highest in fruits collected from trees grafted on Sour orange stock. Total soluble solids were not significantly by Volkamer lemon and Sour orange rootstocks under study.

(Table-4):Effect of different rootstocks on TSS %, total acidity, TSS/acid ratio and Vitamin C of Washington navel orange fruits during 2007 and 2008 seasons

Root-stock	2007				2008			
	TSS %	Total acidity %	TSS / acid ratio	V. C mg/ 100 ml juice	TSS %	Total acidity %	TSS / acid ratio	V. C mg/ 100 ml juice
SO	12.42	0.74	16.78	53.88	12.39	0.78	15.88	51.45
VL	11.55	0.99	11.67	62.46	11.47	0.96	11.95	60.07
TC	11.43	0.88	12.99	55.01	11.39	0.88	12.94	54.40
RL	11.78	0.91	12.95	58.64	11.69	0.90	12.99	56.97
LSD05	N.S.	0.11	0.74	2.47	N.S.	0.10	0.67	2.25

SO= Sour orange VL= Volkamer lemon TC= Troyer citrange RL= Rangpur lime

Storage:

Data in Table (5) showed that the percent of loss weight of Washington navel orange fruits stored on the trees during 2007 and 2008 seasons. The obtained data indicated that there were significant differences in loss weight percentage of fruits in two seasons. In this respect, Washington navel orange trees budded on Volkamer lemon gave significantly decrease on loss weight during the two seasons of the study, while trees grafted on Sour orange gave significantly increase on loss weight of fruits that stored on trees for one month after harvest.

The data presented in Table (5) showed that, no significant differences were detected among loss of rind weight percentage and TSS % in the two study seasons, but total acidity percentage significantly decreased by storage especially with Sour orange rootstock in the two seasons of study when comparing with other study rootstocks. Trees of Navel orange grafted on Volkamer lemon rootstock showed the highest of different total acidity, but the lowest value of it were shown in fruits collected from trees budded on Sour orange rootstock. Generally, the four rootstocks could be descending arranged due to loss of fruit weight, rind weight, TSS and acidity during storage of Washington navel orange fruits as follow according data from Table (5): Volkamer lemon, Rangpur lime, Troyer citrange and Sour orange.

These findings were supported by those reported by Abd El-Wahab (2000) who found that fruit storage of Washington navel orange at room temperature for 5 weeks increased the percentage of weight loss, total soluble solids and TSS / acid ratio, whereas an opposite trend was recorded for total acidity and vitamin C content. El-Helaly (2006) Valencia orange fruits were stored for up to 15 weeks at the temperature and noticed that the percentage of unmarketable fruits, weight loss, total soluble solids (TSS) and TSS / acid ratio were significantly increased. Meanwhile, the percentages of titratable acidity and values of ascorbic acid significantly decreased.

(Table- 5): Effect of different rootstocks after fruit storage for 1 month on the trees of Washington navel orange fruits concerning loss weight {fruit weight and rind weight (g)}, T.S.S and total acidity during 2007 and 2008 seasons

Root-stock	2007				2008			
	Loss weight %		TSS %	Total acidity %	Loss weight %		TSS %	Total acidity %
	Fruit (g)	Rind (g)			Fruit (g)	Rind (g)		
SO	18.61	9.01	12.97	0.64	19.01	9.34	12.75	0.67
VL	12.10	7.23	12.43	0.80	13.44	7.45	12.37	0.82
TC	15.47	7.98	12.29	0.71	17.00	8.10	12.23	0.72
RL	14.36	7.55	12.57	0.76	14.87	7.97	12.49	0.80
LSD.05	3.57	N.S.	N.S.	0.07	4.01	N.S.	N.S.	0.08

SO= Sour orange VL= Volkamer lemon TC= Troyer citrange RL= Rangpur lime

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تأثير الأصول المختلفة على النمو الخضري ، الإثمار ، جودة الثمار وتخزين الثمار على الأشجار لصنف البرتقال أبوسره علي رزق فرحات هيكل معهد بحوث البساتين- مركز البحوث الزراعية – الجيزة- مصر

أجريت هذه الدراسة خلال عامي ٢٠٠٧ & ٢٠٠٨ على أشجار البرتقال أبوسره واشنجنطن عمرها ١١ عام منزرعه بالمزرعة البحثية بالبرامون بمحافظة الدقهلية ومطعمه على أربعة أصول وهم النارج – فولكاماريانا - التروير سترانج - ليمون الرانجبور لتقييم النمو الخضري ، عقد الثمار ، المحصول ، جودة الثمار وتخزين الثمار على الأشجار .
وكانت النتائج المتحصلة كما يلي :-

١- الأشجار المطعمه على أصل الفولكاماريانا أظهرت أكبر نمو معنوياً (ارتفاع الشجرة ، محيط الشجرة ، محيط الجذع ، عدد نموات الربيع الحديثة ومساحة الورقة) ، متبوعاً بالليمون الرانجبور متبوعاً بالتروير سترانج متبوعاً بالنارج بالترتيب.

٢- الأشجار المطعمه على أصل الفولكاماريانا أعطت أعلى قيم معنوية لعقد الثمار النهائي ، المحصول ، وزن الثمرة ، حجم الثمرة ، النسبة الكلية للحموضة الكلية ، النسبة بين المواد الصلبة الكلية الذائبة إلى الحموضة الكلية وفيتامين ج ، في حين الليمون الرانجبور متبوعاً بالتروير سترانج زادت تلك القياسات معنوياً عنها لأصل النارج. أثناء موسمي الدراسة ، عقد الثمار الإبتدائي ، النسبة لطول وقطر الثمرة ، النسبة المئوية المواد الصلبة الكلية الذائبة ووزن قشرة الثمرة تأثرهم غير معنوي لكل الأصول تحت الدراسة .

٣- أثناء التخزين ، كانت أعلى نسبة مئوية للفق في وزن الثمار التي أخذت من الأشجار المطعمه على أصل النارج ولوحظت أقل القيم للبرتقال أبوسره على أصل الفولكاماريانا في كلا الموسمين . النسبة المئوية للحموضة قلت معنوياً بالتخزين . أشجار البرتقال أبوسره المطعمه على أصل الفولكاماريانا أظهرت أعلى قيمة للحموضة الكلية ، ولكن أقل قيمة ظهرت للثمار المأخوذة من الأشجار المطعمه على أصل النارج . في حين لم تلاحظ إختلافات معنوية للنسبة للفق في وزن قشرة الثمرة والنسبة المئوية للمواد الصلبة الكلية في موسمي الدراسة للأصول المختبرة .
عموماً : الأصول الأربعة يمكن ترتيبها تبعاً للصفات المدروسة على الثمار للبرتقال أبوسره : أصل الفولكاماريانا ، ليمون الرانجبور ، التروير سترانج ثم أصل النارج .
التوصية : طبقاً لذلك يمكن التوصية لأصل الفولكاماريانا كأصل مناسب لأشجار البرتقال أبوسره تحت ظروف الدلتا لتفوقه على أصل النارج .

قام بتحكيم البحث

كلية الزراعة – جامعة المنصورة
مركز البحوث الزراعية

أ.د / محسن فهمي محمد
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