EVALUATION STUDY ON WASHINGTON NAVEL ORANGE CULTIVAR BUDDED ON FIVE ROOTSTOCKS.

2. Flowering, yield and fruit quality.

By

Zayan M.A.; S.M.Zeerban; H. M. Ayaad; S.A. Dawood* and H.A. Ennab*

Hort. Dept., Fac. Agric., Kafr El-Sheikh, Tanta Univ.

*Hort. Dept., Sakha Agric. Res. St., Kafr El-Sheik

ABSTRACT

The influence of five rootstocks on flowering, yield and fruit quality of Washington navel orange trees was evaluated for trees grown on clay soil in Sakha Agriculture Research Station, Kafr El-Sheikh, Egypt. The percentage of flowering, fruit set exhibited moderate values for trees budded on Volkamer lemon and Rangpur lime, but the least percentage of fruit drop was found on the same rootstocks. Volkamer lemon and Rangpur lime as rootstocks for Washington navel orange cultivar produced higher yield with good physical fruit characters in terms of length, diameter, volume, weight, juice volume. On the other hand, The same rootstocks produced fruits with lower of some chemical characters such as T.S.S and acidity as well as coarse peels.

INTRODUCTION

The citrus rootstocks had a significant effects on tree vigour, flowering and fruiting as well as fruit quality. Citrus rootstocks can influence flowering, fruit set, fruit size and fruit quality of scion variety due to physiological and chemical properties of the rootstock used. Studies show clearly the effect of rootstocks on flowering, fruit set and fruit drop. Dawood (2002) and El-Sayed (1999) stated that the percentage of fruit set in Washington navel orange trees on Volkamer lemon were higher than those on sour orange rootstock. Contrary fruit drop in May, June and July was higher on sour orange rootstock than that recorded on Volkamer lemon rootstock. Valbuen (1996), Protopapadakis *et al.* (1998) and Dawood (2001) reported that yield as fruit number or weight/tree of different citrus varieties was greater on Volkamer lemon than that on sour orange or Cleopatra mandarin rootstocks. Moreover. Monteverde (1989), Protopapadakis *et al.* (1998) and El-Sayed

(1999) suggested that fruit quality in terms of fruit length, diameters, weight, volume and juice of fruits produced from trees on Volkamer lemon were higher than those produced from those on sour orange or Cleopatra mandarin rootstocks. Also, trees on Volkamer lemon produced fruits with the lowest total soluble solids and total acidity values. So, this study aimed to evaluate and compare five citrus rootstocks on flowering, yield and fruit quality of Washington navel orange under Kafr El-Sheikh conditions.

MATERIALS AND METHODS

The present study was carried out on 6 years old trees of Washington navel orange budded on five different citrus rootstocks in the experimental farm of Sakha Horticulture Research Station. Kafr El-Sheikh governorate, Egypt during 2000 and 2001 seasons. The tested rootstocks were: sour orange (*Citrus aurantium*), Volkamer lemon (*Citrus volkameriana*), Troyer citrange (*Ponsirus trifoliata x Citrus sinensis*), Rangpur lime (*Citrus aurntifolia x Citrus reticulata*) and Cleopatra mandarin (*Citrus reshni*). The trees were planted at 5 x 5 meters in a complete randomized block design with three trees plot replicated three times for a total of nine tree/rootstock budded with Washington navel orange. Mechanical and chemical analysis of experimental field soil was done as shown in Table (1).

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

Mechanical				Chemical			Available ppm			DTPA extractable ppm				
Sand %	Silt %	Clay %	T.	pH	EC	OM %	N	P	K	Fe	Zn	Pb	Ni	Cd
9.7	32.2	58.2	Clay	8.0	3.4	1.9	18.5	7. 8	273.5	20.1	9.97	0.48	0.74	0.19

In both seasons, all trees received the following fertilization programe: 300 gm ammonium sulphate/tree in March + 450 gm ammonium sulphate/tree in June + 200 gm ammonium nitrite/tree and 200 gm potassium sulphate/tree in Augest. In this study, four branches of 2 inches in diameter from each replicate were selected and tagged in the four directions counting and fruit sampling.

1- Flowering, fruit set and fruit drop:

a- **The percentage of flowers:** the number of flowers on tagged branches on each tree was counted every 3 days intervals and continued until the end of blooming, then the percentage of flowers was calculated.

b- **The percentage of Fruit set:** The number of setting fruits was counted twice at weekly intervals until fruit setting complete. then fruit set was calculated as percentage of the initial number of flowers.

c- **The percentage of fruit drop:** the number of dropped fruits was counted twice at weekly intervals until mid of September when no fruit drop was noticed, then the percentage of dropped fruit was estimated depending on the total number of the remained fruits/tree.

2- Yield and yield efficiency:

a- **Yield:** at harvest time (December in both seasons), the yield of each tree was determined as number and weight (kg/tree) of fruits/tree.

b- **Yield efficiency:** yield efficiency was calculated as fruit number/cm^2 of TCSA (Trunk cross sectional area) and fruit number/m^3 of canopy volume. Also, fruit weight (kg/m^3)of canopy volume and fruit weight (kg/cm^2) of TCSA were calculated.

3- Fruit quality:

To determine fruit quality, 10 fruits were taken at random from each tree at harvest time of both seasons and prepared for determination of physical and chemical fruit characteristics.

a- Physical characters: Fruit weight (gm), fruit length (L-cm) and daimeter (D-cm) were measured and their fruit shapes (L/D ratio) were calculated. Fruit volume (cm^3), number of segments, rind thickness (mm), number of seeds/fruit and juice volume (cm^3)/fruit were determined.

b- Chemical characters:

- Total soluble solids (TSS) were determined by handly refractometer.

- Total acidity was determined as citric acid according to A.O.A.C. (1967) using 0.1 N sodium hydroxide.
- Ascorbic acid (VC) as mg/100 ml juice was determined by 2,6 dichlorophenol indophyenol according to Jacobs (1951).
- TSS/acid ratio was calculated.
- All obtained data were statistically analyzed using a randomized complete block design according to Snedecor and Cochran (1967), and the least significant difference (L.S.D. at 5% level) was used to compare the main values.

RESULTS AND DISCUSSION

1- Effect of rootstocks on flowering , fruit set and fruit drop:

a- The precentage of flowers :

In March of both seasons, most flowers was produced especially in 21, 24 and 27 of March. In the frist season, results indicated that the trees budded on sour orange gave the highest percentage of flowers followed by Troyer citrange and Rangpur lime. Beside, Volkamer lemon had intermediate values in this respect (Fig. 1 and 2). Meanwhile, the lowest percentage of flowers was counted in the trees budded on Cleopatra mandarin.Significant differences were not considered in most cases.

Generally, the blooming period was started in the second week of March continued until the first week of April. The percentage of flowers was less in the beginning, then increased gradually until arrived the maximum in March, 24 then decreased gradually in April 8. This result was true in both seasons. Concerning the effect of rootstocks on the percentage of flowers, there was no effect or any clear trend due to different rootstocks in both seasons (Figures 1 and 2). Similar results were reported by Saad-Allah *et al.* (1985), Barbera and Carimi (1988) and Inoue (1989).

b- The percentage of fruit set:

It is clear that the trees budded on Troyer citrange produced the highest percentage of fruit set, followed by Rangpur lime and Volkamer lemon without significant differences among them. Trees on sour orange and Cleopatra mandarin gave intermediate values as compared with other three rootstocks as shown in (Figures 3 and

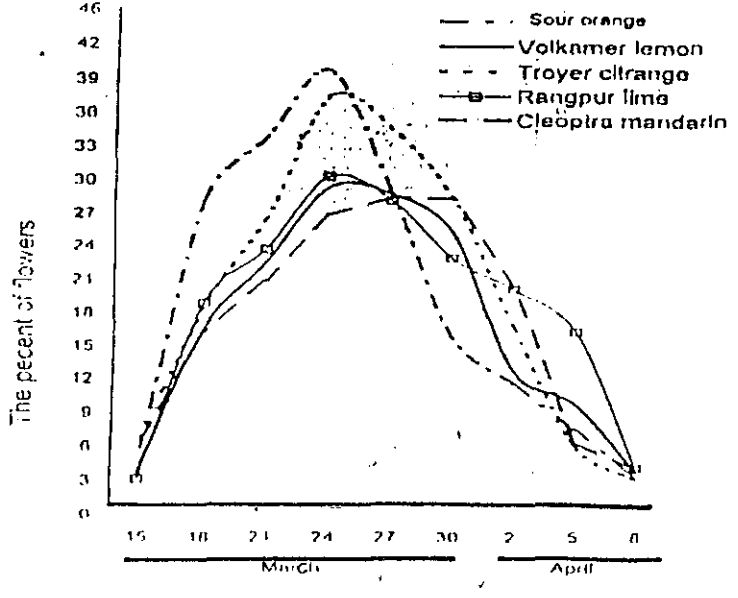

Fig. (1): The percentage of flowers production and blooming period in Washington navel orange tree as affected by five citrus rootstocks in 2000 season

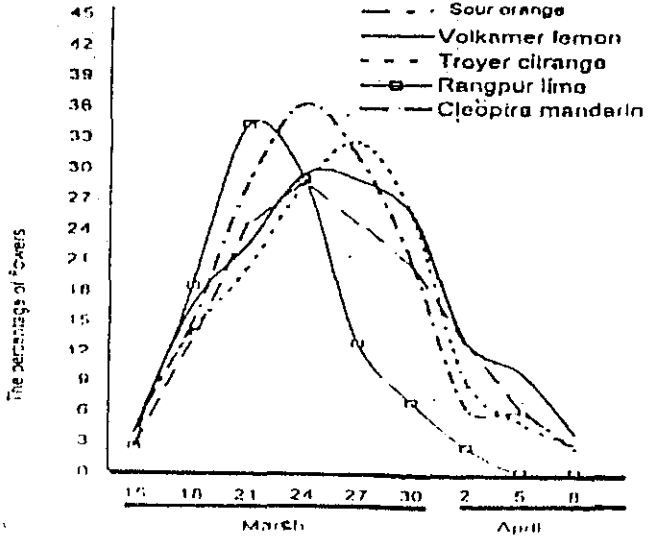

Fig. (2) The percentage of flowers production and blooming period in Washington navel orange tree as affected by five rootstocks in 2001 season.

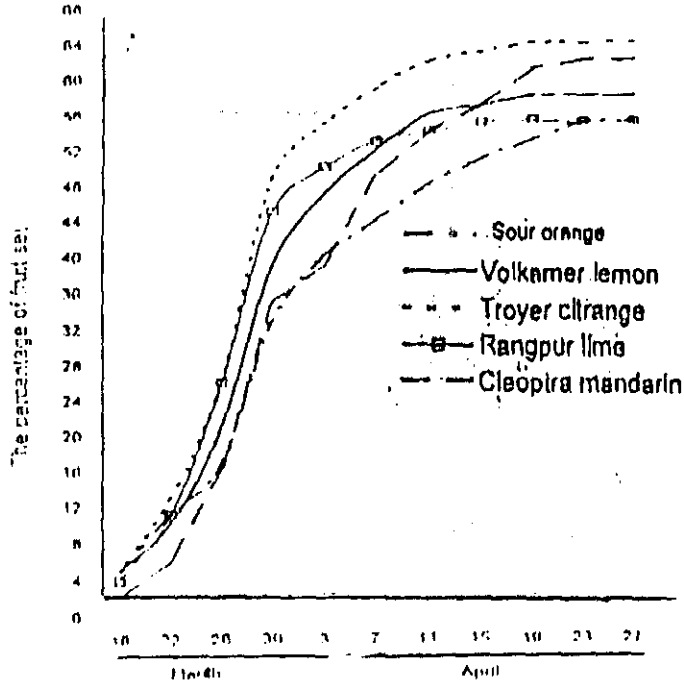

Fig. (3): The percentage of fruit set in Washington navel orange tree as affected by five citrus rootstocks in 2000 season

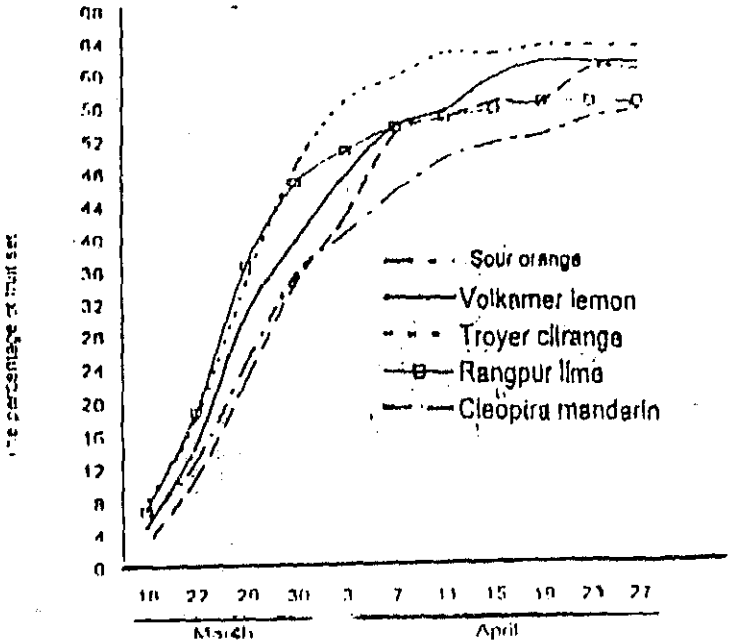

Fig. (4) The percentage of fruit set in Washington navel orange tree as affected by five rootstocks in 2001 season.

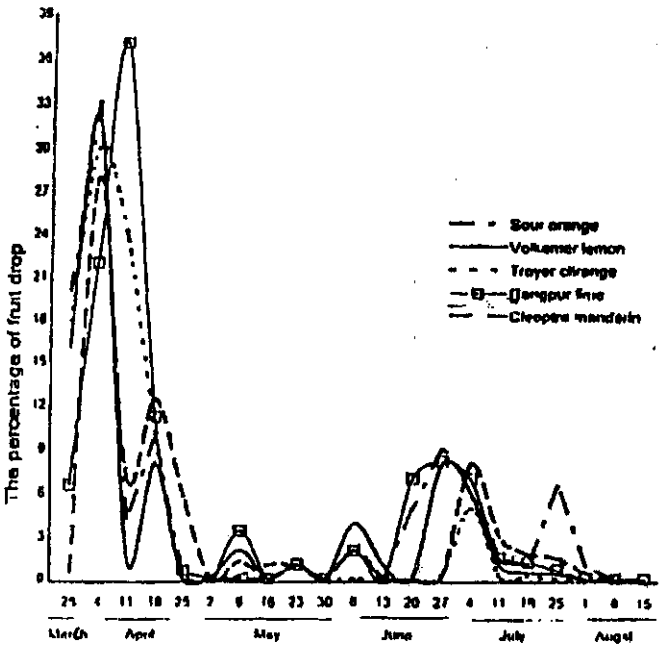

Fig. (5): The percentage of fruit drop waves in Washington navel orange tree as affected by five citrus rootstocks in 2000 season

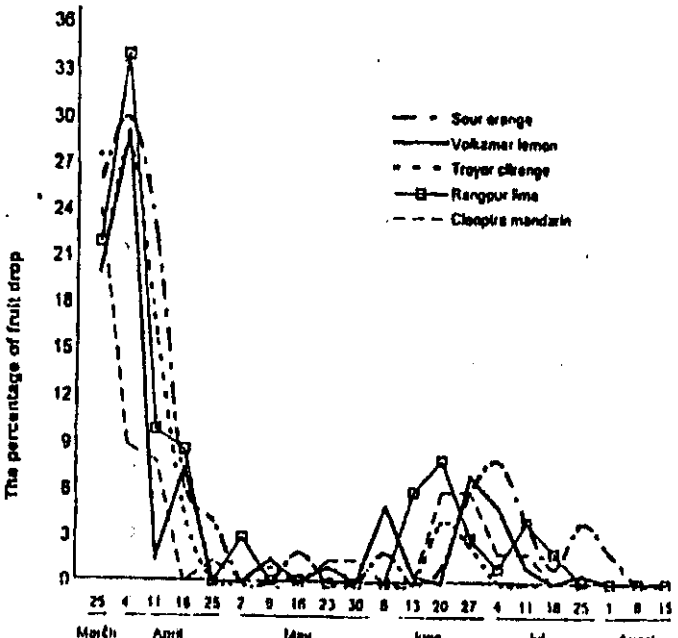

Fig. (2) The percentage fruit drop waves in Washington navel orange tree as affected by five rootstocks in 2001 season.

4).Generally, fruit set percentage in Washington navel orange budded on different rootstocks counted less fruits in March, 18 then increased at later dates of March and April. This result means that the flowers produced in the first period had low set ability but those produced in the second and third periods exhibited more fruit setting. This result was true in both seasons (Figures 3 and 4) . It seems that the effect of rootstock on fruit set of Washington navel orange was nearly similar among all tested rootstocks and the differences in most cases were not significant. This result agreed with those reported by Mohsen *et al.* (1989) , Inoue (1989) and El-Sayed (1999).

c- The percentage of fruit drop:

Concerning fruit drop of Washington navel orange, it is clear from (Figures 5 and 6) that there were four fruit drop waves, the first wave was happened in March and April, the droping percentage was counted as small fruits and fruitlets . In this period trees budded on sour orange, Troyer citrange and Volkamer lemon recorded the highest percentage of dropped fruits, while trees on Rangpur lime and Cleopatra mandarin counted the least percentage of fruit drop depending on the total number of flowers counted on the tagged branches. The second wave of dropping was noticed in May and it counted low percentage of dropped fruits. This result means that no clear differences were obtained due to all tested rootstocks. The third dropping wave was noticed in June, the trees budded on sour orange, Volkamer lemon and Rangpur lime dropped more percentage of fruits, while those on Troyer citrange and Cleopatra mandarin gave less percentage. This result was true in both seasons (Figures 5 and 6).The fourth dropping wave was recorded in July and August and it counted high percentage in the first season and low in the second season. Generally, fruit drop in Washington navel trees was seemed to be less on Volkamer lemon and Rangpur lime, especially in June and July when compared with the other tested rootstocks. Similar results were reported by Barbera and Carimi (1988) , Abbas (1997) and El-Sayed (1999).

2- Effect of rootstocks on yield and yield efficiency:

a- Yield as number and weight (kg)/tree:

It is clear that from Table (2) that yield as number of fruits/tree and weight (kg/tree) of Washington navel orange was highest on Volkamer lemon, followed by Rangpur lime. Moreover, those budded on Troyer citrange and sour orange gave intermediate values in this respect, but the lowest number of fruits/tree and weight (kg/tree) was recorded for those budded on Cleopatra mandarin. The differences were significant among all tested rootstocks . This result was true in both seasons.

Table (2): Yield and yield efficiency of Washington navel orange trees as affected by five citrus rootstocks during 2000 and 2001 seasons.

Rooot stock	Yield		Yield efficiency			
	No. of fruits/tree	Kg/tree	No. of fruits/cm^2 of TCSA	No. of fruit/m^3	kg/cm^2 of TCSA	Kg/m^3
2000						
Sour orange	73	8.79	4.95	14.86	.0.59	1.79
Volkamer lemon	140	19.54	5.74	13.39	0.80	1.86
Troyer citrange	99	11.66	5.35	14.34	0.63	1.68
Rangpur lime	128	17.03	5.62	13.60	0.74	1.80
Cleoptra mandarin	39	4.25	4.12	15.41	0.44	1.67
L .S. D 5%	4.68	0.08	0.07	0.40	0.09	0.08
1%	6.39	0.11	0.09	0.55	0.12	0.12
2001						
Sour orange	136	14.93	6.57	16.66	0.72	1.82
Volkamer lemon	257	35.07	7.41	14.51	1.01	1.98
Troyer citrange	155	16.75	6.68	16.01	0.72	1.73
Rangpur lime	219	28.07	7.18	14.97	0.92	1.91
Cleoptra mandarin	63	6.46	5.08	16.66	0.52	1.70
L .S. D 5%	5.94	1.05	0.20	0.48	0.04	0.04
1%	8.10	1.44	0.27	0.66	0.06	0.06

Generally, yield of Washington navel orange trees was higher on Volkamer lemon and Rangpur lime than those on the other tested rootstocks. Moreover, Troyer citrange and sour orange had intermediate values of yield as number of fruit and weight/tree. On the other hand , trees on Cleopatra mandarin had low yield when compared with other rootstocks (Table 2).

These results, generally agreed with those findings of Valbuen (1996)who reported that *C. latifolia* trees on Volkamer

lemon rootstocks had more fruit number and average weight/tree than those grown on Cleopatra mandarin rootstock. In this respect, Protopapadakis *et al.* (1998) stated that Washington navel orange trees grafted on Volkamer lemon rootstock had larger and heavier fruits than those on sour orange rootstock.

b- Yield efficiency:

Data in Table (2) revealed that, yield efficiency as number of fruits/cm^2, kg/cm^2 of TCSA and kg/m^3 of canopy volume seemed to be higher with Volkamer lemon and Rangpur lime as rootstocks for Washington navel orange trees. Moreover, Troyer citrange and sour orange gave intermediate values. The lowest values belonged to those on Cleopatra mandarin rootstock. These results find support in those reported by Dawood (2001), Dawood (2002). Also, El-Sayed (1999) reported that yield and yield efficiency values were higher in trees on Volkamer lemon than those on sour orange rootstock under Kafr El-Sheikh conditions.

On the other hand, yield efficiency as number of fruits/m^3 of canopy volume recorded the highest value in the tree on Cleopatra mandarin followed by sour orange rootstock. While the least value was recorded for trees on Volkamer lemon and Rangpur lime rootstocks. Trees on Troyer citrange gave moderate values in this respect. This result could be attributed to that Cleopatra mandarin had dwarfing effect on Washington navel orange as scion, While those of Volkamer lemon and Rangpur lime behaved as vigorous for scion. Such conclusions agreed with the findings of Kurian *et al.* (1996) who found that fruit yield of mango cv. Alphonso scion expressed as the number or weight of fruits/unit space occupied by the canopy, was considerably higher on dwarfing rootstocks when compared with vigorous one.

3- Effect of rootstocks on fruit quality :

a- Physical characters:

The effect of rootstocks on fruit quality as physical characters was studied in both seasons (Table 3). The results showed that fruit length, fruit diameter, volume and fruit weight were highest in fruits from trees budded on Volkamer lemon, followed by tree on Rangpur lime, then came sour orange and Troyer citrange. Contrarly, Cleopatra mandarin rootstock produced

the least value of Washington navel orange fruit length, fruit diameter, volume and fruit weight, but the differences were not significant among all tested rootstocks in the frist season. The same results were obtained in the second season and the differences were not significant only between sour orange and Troyer citrange as rootstocks for Washington navel orange.

Beside, the results in Table (3) indicated that rind thickness was thicker in fruits on Volkamer lemon and Troyer citrange with significant differences between them in both seasons. sour orange and Cleopatra mandarin produced fruits with moderate rind thickness without significant differences between them in both seasons. But rind thickness of fruits from trees budded on Rangpur lime was thinner than that measured for tested rootstocks. These results were true in both seasons. These results were generally agreed with those obtained by El- Sayed (1999). Also, the obtained results were in line with those reported by Dawood (2002) who found that Washington navel orange budded on Volkamer lemon had larger fruit diameter, heavier fruit weight with thicker peel thickness and tended to increase fruit juice than that on sour orange rootstock.

Such conclusions agreed with those of Monteverde (1989) who suggested that after evaluation of Valencia orange on ten rootstocks for fruit quality, Volkamer lemon seemed to be suitable rootstock for this cultivar. On the other hand, El-Azab *et al.* (1978), on Washington navel and Valbuen (1996), on persian lime, stated that Cleopatra mandarin rootstock produced the smallest fruits comparing with sour orange, Troyer citrange and Volkamer lemon rootstocks.

b- Chemical characters

Data in Table (4) showed that T.S.S and acidity values were higher in fruits from trees on Rangpur lime, followed by sour orange and Cleopatra mandarin with significant differences among them in both seasons. Fruits on Volkamer lemon had significantly lower T.S.S and acidity values when compared with all tested rootstocks. This reduction in T.S.S, acidity and T.S.S/acid ratio may affect flavour value to Egyptian consumers but may be not for foreign markets, this conclusion needs more information about export markets. However, thicker peel remains as quality problem

of Washington navel orange fruits porduced on Volkamer lemon as rootstock.

Table (3): Physical characters of fruit quality of Washington navel orange trees as affected by five citrus rootstocks during 2000 and 2001 seasons.

Rootstock	Fruit length cm	Fruit diameter cm	Fruit shape	Fruit volume cm^3	Fruit weight (g)	Rind thickness (cm)	Juice volume cm3/ Fruit
2000							
Sour orange	6.20	5.96	1.04	126	119	0.42	45.66
Volkamer lemon	6.70	6.60	1.01	151	139	0.55	63.33
Troyer citrange	6.00	5.86	1.02	123	117	0.52	44.33
Rangpur lime	6.30	6.06	1.03	143	132	0.41	57.66
Cleopatra mandarin	5.90	5.40	1.09	124	108	0.51	39.66
L . S . D 5.	N.S	0.27	0.05	N.S	2.84	0.03	4.03
1.	N.S	0.40	N.S	N.S	4.12	0.04	5.87
2001							
Sour orange	5.71	5.85	1.02	116	109	0.47	42.06
Volkamer lemon	6.55	6.45	1.01	147	136	0.57	61.98
Troyer citrange	5.51	5.38	1.02	112	107	0.48	40.71
Rangpur lime	6.11	5.78	1.05	138	128	0.40	55.95
Cleopatra mandarin	4.95	4.95	1.00	113	101	0.47	36.36
L . S . D 5.	0.312	0.78	NS	3.75	2.96	0.02	4.54
1.	0.430	NS	NS	5.17	4.08	0.04	6.26

Concerning, T.S.S./acid ratio, it was higher in fruits from trees budded on Volkamer lemon and Rangpur lime with significant differences among them only in the first season. However, T.S.S./acid ratio in fruits from trees budded on Troyer citrange and sour orange gave moderate values without significant differences among them in the two seasons. In this respect, the lowest values was obtained when Cleopatra mandarin was used as rootstock for Washington navel orange variety.As for vitamin C content, fruits from trees budded on sour orange and Cleopatra mandarin recorded higher values without significant differences between them. Trees on Troyer citrange and Rangpur lime contained intermediate concentration of vitamin C. On the other hand, fruits from trees budded on Volkamer lemon had the least values of vitamin C. This result was true in both seasons (Table 4). The obtained herein results agreed with those found by El-Barkouky *et al.* (1984), Saad –Allah *et al.* (1985), Abd-Allah *et al.* (1998), Meligy *et al.* (1999) and Dawood (2001).

Table (4): Chemical characters of fruit quality of Washington navel orange trees as affected by five citrus rootstocks during 2000 and 2001 seasons.

Rootstock	2000season				2001season			
	T.S.S.	Acidity.	T.S.S/acid ratio	Vitamin C Mg/100 ml guice	T.S.S.	Acidity.	T.S.S/acid ratio	Vitamin C Mg/100 ml guice
sour orange	11.74	1.22	9.63	41.75	11.64	1.23	9.47	38.46
Volkamer lemon	9.57	0.92	10.41	36.12	9.59	0.95	10.10	35. 35
Troyer citrange	10.16	1.06	9.59	41.36	10.84	1.17	9.27	37. 98
Rangpur lime	12.56	1.24	10.13	40.49	12.36	1.21	10.22	39. 29
Cleopatra mandarin	11.57	1.25	9.26	41.74	10.81	1.20	9.01	38. 28
L . S . D 5.	0.03	0.03	0.21	0.21	0.05	0.04	0.25	1. 34
. 1.	0.05	0.04	0.29	0.31	0.08	0.06	0.34	1. 85

Generally, data in Tables (2, 3 and 4) revealed that Volkamer lemon and Rangpur lime as rootstocks for Washington navel orange cultivar produced higher yield with good physical fruit characters in terms of length, diameter, volume, weight, juice volume. On the other hand, the same rootstocks produced fruits of chemical fruit characters such as lower T.S.S and acidity values. beside fruits in total soluble solids and acids, with coarse peels. Similar results were reported by Davies and Albrigo (1994) and Protopapadakis *et al.* (1998). They found that Washington navel orange on Volkamer lemon produced fruits with the lowest total soluble solids and total acids.

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دراسة تقييم لصنف البرتقال أبوسرة المطعوم على خمسة أصول
٢ – التزهير و المحصول و جودة الثمار

محمد زيان ، سمير زعربان ، حمدية عياد ، سامى داود* ، حسن عناب*
قسم البساتين ، كلية الزراعة بكفرالشيخ ــ جامعة طنطا
*قسم البساتين ، مركز البحوث الزراعية ، سخا

الملخص العربي

أجريت هذه الدراسة خلال عامي ٢٠٠٠ و٢٠٠١ على أشـــجار برتقال بسره عمرها ٦ سنوات والمطعومة على خمسة أصول مختلفة هـــي الفولكاماريانا و التروير سترانج وليمون الرانجبور واليوســـفي كليوبـــاترا والنارنج والتي تم زراعتها في مزرعة التجارب البحثية بسخا كفر الشـــيخ مصر. و ذلك بهدف دراسة تأثير الأصول على التزهير و المحصـــول و جودة الثمار و قد بينت النتائج أن :-

١- الفولكاماريانا وليمون الرانجبور أعطى تزهير متوسط بينما أقل نسبة تساقط للثمار وجدت على نفس الأصلين .

٢- محصول أشجار البرتقال أبو سرة)عددا و وزنا كجم لكل شجرة(عالي على أصلي الفولكأماريانا وليمون الرانجبور. بينماالأشجار على أصل اليوسفي كليوباترا أعطت أقل محصول، أما أصلي النارنج والترويز سترانج أعطت محصول متوسط في كلا الموسمين.

٣- الأشجار المطعومة على أصلى الفولكاماريانا وليمون الرانجبور أعطت ثمار ذات صفات طبيعية جيدة مثل كبر حجم ووزن الثمار وكذلك طول وقطر الثمرة وحجم العصير عند المقارنة بالأصول الأخرى. إضافة إلى ذلك فإن الأشجار المطعومة على النارنج والترويز سترانج أعطت ثمار متوسطة في الصفات الطبيعية بينما الأشجار المطعومة على اليوسفي كليوباترا أعطت أقل قياسات في هذا المجال .

٤- الثمار المأخوذة من الأشجار المطعومة على أصلي الفولكاماريانا والترويز سترانج كانت أكثر سمكا عن قشرة الثمار المأخوذة من الأشجار المطعومة على أصل ليمون الرانجبورفي حين ان قشرة الثمار المأخوذة من الأشجار المطعومة على أصلي النارنج واليوسفي كليوباترا كانت متوسطة بين الأصلين و ذلك في كلا الموسمين.

٥- أشجار البرتقال أبو سرة المطعومة على أصلي الفولكاماريانا وليمون الرانجبور أنتجت ثمار ذات صفات كيماوية أقل مثل المواد الصلبة الكلية والحموضة وفيتامين ج بينما نسبة المواد الصلبة إلى الحموضة كانت عالية و كانت هذه النتائج مؤكدة إحصائيا في كلا الموسمين .