J. Agric. Sci. Mansoura Univ., 28 (2): 1359 - 1372, 2003

THE EFFECT OF SOME CITRUS ROOTSTOCKS ON VEGETATIVE GROWTH, LEAF MINERAL CONTENTS, FLOWERING, FRUIT SET, YIELD AND FRUIT QUALITY OF WASHNTING NAVEL ORANGE TREES

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ABSTRACT

This study was carried out during two successive seasons (1999 and 2000), at El-Kanater El-Khareia, Research Station, Kalubia Governorate to evaluate the effect of three citrus rootstocks, namely sour orange, rough lemon and balady lime, on vegetative growth, flowering, fruit set, leaf mineral contents, yield and fruit quality of Washington navel orange trees, grown on clay loamy soil.

Sour orange gave the highest values of tree circumference, shoot length, fruit T.S.S., T.S.S./Acid ratio, Vitamin C and leaf N and Mn contents, while Rough lemon increased tree height, leaf area, fruits number and fruits weight per tree, fruit size, rind thickness, juice weight percentage and leaf Fe and Zn contents. Meanwhile, Balady lime increased fruit weight, juice weight percentage, acidity and leaf P and K contents. No marked differences were detected as regard to the effect of rootstocks on blooming date, flowering, number of leafy and leafless inflorescences and fruit set.

INTRODUCTION

Rootstocks exert a vital influence on the production of citrus trees, although any citrus species can be used as a rootstock ,some are better suited to specific conditions than the others.

The effect of rootstocks on citrus fruit quality have received much attention in the last years . A comparison between rootstocks such as sour orange(C. aurantium, L.), rough lemon (C. Jambhiri Lush)and balady lime (C. aurantifolia) were tested in relation to their effect on growth, yield and fruit quality of Washington navel orange (C.sinensis L.Osbeck) . Sour orange is being used as a rootstock for citrus trees grown on various types of soils. Balady lime is more suitable for sandy soil. . Phillps (1969), Levy and Mendel (1982), Abou Rawash *et al.* (1995) and Creste and Lima (1995), Tree size and growth vigor were significantly influenced by rootstocks, El-Barkauky *et al.* (1984), Beridze (1987) and Castle and Trucker (1989). Rough lemon rootstock produced the largest tree highest followed by sour orange, whereas , balady lime gave the lowest values and sour orange had the largest circumference. The lowest concentration of fruit constituents were found in fruits of trees budded on rough lemon rootstock,(Georgiou, 2000) .

There are no marked effect of rootstocks on the shape of fruits as indicated by the dimension ratio results, Aiyappa *et al.* (1968), Lbabanouskas *et al.* , (1963) they also concluded that rough lemon rootstocks causes a considerable decrease in total soluble solids comparing with sour orange. On the other hand , fruits on sour orange rootstock have higher sugar, acids ,and Vitamin C than those on rough lemon .El-Barkauky *et al.* (1984) and Abou Rawash and El-Hammady (1995).

Thus , the objective of this study was to determine the effect of three citrus rootstocks i.e. sour orange. rough lemon and balady lime on growth, flowering , fruit set fruiting , yield , fruit quality and leaf minerals content of Washington navel orange trees grown on clay loamy soil .

MATERIALS AND METHODS

This investigation was carried out during seasons of 1999 and continued till season 2000 on trees grown on clay loamy soil at El-Kanater El-Khyria ,Research Station , Kalubia Governorate. Washington navel orange trees of 40 -years old budded on three different rootstocks i.e., Sour orange , balady lime , and Rough lemon , planted at 5X5 m. apart were used to determine .

1) Vegetative growth.

Tree height (m), tree circumference (m),scion and stock diameter 10cm above and bellow union zone, scion/rootstock ratio. union area diameter , shoot length(cm) ,leaf area (cm2) were studied according to the equation of Chou(1966). leaf number/shoot, tree canopy volume was calculated according to (Turell 1946)

2) Flowering

Flower beginning , full bloom and end, flowering period , number of flowers per leafy and leafless inflorescences , the number of flowers per secondary branch were studied .

3) Fruit set percentages:

The number of fruit set on selected four branches on each tree was counted at the end of March. The percentages of initial fruit set were also calculated separately for the leafy and leafless inflorescences. The final number of retained fruiting were counted at mid-Nov. and the percentages of retained fruits were calculated.

4)Leaf minerals content .

For mineral analysis, 20 mature leaves of 6 months old from non-fruiting spring shoots were collected in September of both seasons, then oven dried at 70°C and ground for chemical determination as follows.

0.2 gm of each ground sample was digested using the procedure suggested by Jackson (1958). The digested solution was used for the determination of N, P, K, Fe, Zn and Mn nutrients.

Total nitrogen was estimated according to microkjeldahl method as described by Pregl (1945). Total phosphorus was determined using the method recommended by Chapman and Pratt (1961).

Moreover, K, Fe, Zn and Mn nutrient were determined directly in the diluted digested solution using the Atomic absorption spectrophotometer (Perkin elmer 3300). Anyhow, N, P and K elements were calculated as percentages in dry matter, whilst Fe, Zn and Mn were estimated on the basis of ppm.

5) Yield:

Yield was determined at the harvesting time (early December) as kg/tree and number of fruits/tree were counted then the hypothetic yield was calculated(on the bases of having 168 trees/Fadden) by tons per Fadden

6) Fruit quality :

After fruits reached maturity stage according to Nasr (1982) (250days from full bloom), ten fruits were sampled from each tree of each replicate to make a composite sample of(90) fruits representing a rootstock during 1999 and 2000 seasons, and the following properties were conducted .

A – Physical fruit properties.

Fruit weight (gm) and volume (cm3)were studied . while fruit length (cm.), fruit diameter (cm) and rind inickness were measured using a venire caliper, and fruit shape(length/diameter ratio) were calculated, rind color was concerned and recorded, rind weight(gm)and juice weight(gm.) were determined .

B – chemical fruit properties .

B-1- Titration total acidity (%as citric acid) according to (A.O.A.C.1970)_

B-2 - Total soluble solids (T.S.S.%) using hand refractometer.

B-3 - T.S.S/acid ratio was calculated

B-4 - Ascorbic acid (vitamin C) was determined according to (A.O.A.C.1970).

The experiment was conducted as complete randomized block design . Each treatment had three replicates with nine trees / replicate . All data were subjected to analysis of variance and means were separated using now L.S.D. values 5% (Snedecor & Cocheran 1967) .

RESULTS AND DISCUSSION

1.Vegetative growth:

Data presented in Table(1)show that tree growth was significantly influenced by different rootstocks used. With respect to tree circumference it is obvious that in both seasons sour orange rootstock increased significantly tree circumference value than both rough lemon and balady lime rootstocks . Meanwhile, rough lemon rootstock produced the largest tree height followed by sour orange .On the contrary, balady lime decreased significantly tree height

No significant differences were observed between rootstocks concerning trunk diameter 10 cm above or below union zone or scion /stock ratio and union zone. In this respect, sour orange rootstock gave values over than of rough lemon and balady lime respectively.

Moreover, sour range rootstock increased significantly shoot length of Washington navel orange trees comparing with those of rough lemon and balady lime.

Table (1): Influence of three citrus rootstocks on vegetative growth of Washington navel orange trees (1999 and 2000 seasons).

Studied characters	1999			2000			L.S.D. 5%	AV.		
	SO	RL	BL	SO	RL	BL		SO	RL	BL
Circumference of tree(m)	15.1	13.0	12.7	15.8	13.2	12.8	1.2	15.5	13.1	12.8
Tree height(m)	4.1	4.3	3.8	4.2	4.4	3.9	0.5	4.2	4.4	3.8
Scion diameter 10cm above union area (cm.)	36.6	35.0	30.3	37.9	36.6	33.4	N.S.	37.3	35.7	31.8
Stock diameter 10cm below union area (cm.)	46.7	41.4	38.2	51.0	44.6	39.8	N.S.	48.4	43.0	38.9
Scion /rootstock ratio	0.8	0.9	0.8	0.8	0.8	0.8	N.S.	0.8	0.8	0.8
Union area diameter (cm.)	38.2	37.3	30.3	39.8	38.2	33.4	N.S.	38.9	37.9	31.8
Shoot length	16.0	11.2	9.6	16.2	11.8	10.1	1.2	16.1	11.5	9.8
Leaf area (cm2) spring sycle	15.6	19.5	14.8	15.8	20.1	15.3	4.3	15.7	19.8	15.1

SO=sour orange RL= rough lemon

BL= balady lime av.=avarage

Farthermore, trees budded on rough lemon had the largest leaf area followed by those of sour orange and balady lime. The differences however ,reached significant level at balady lime only.

These results are in agreement with Georgiou (2000) Abu Rawash *et al.* (1995) Castle and Trucker (1989) Oppenheimer (1969). They concluded that rough lemon produced the largest tree height and leaf area followed by trees on sour orange rootstock

2. Flowering:

Flowering was presented in Table (2) and Fig (1) it is clear that flowering was commenced in early March in both seasons. Full bloom was occurred in the third week of March ,petal fall continued until late March while ended at the beginning of April. No differences were regarded between rootstocks. These results confirm the findings of Levy and Mendel (1982).They found that no differences were obtained concerning the effect of rootstocks on flowering date.

Besides, number of leafy and leafless inflorescences, total number of flowers/secondary branch, number of flowers per leafy and leafless inflorescences, initial fruit set %, fruiting % are presented in Table(3) and Fig.(1) it cleared that there were no significant differences between the three rootstocks. Leafy inflorescences had always higher initial fruit set % than leafless inflorescences .The same finding was obtained by Levy and Mendel (1982).

3. Leaf mineral content:

Data presented in Table (4) showed that sour orange rootstock increased leaf N content as compared with the other rootstocks used. Meanwhile , rough lemon decreased leaf N content, however the differences were not significant. The trees budded on balady lime gave the highest values of leaf P and K contents in the two seasons of study but the significance lacked between the three studied rootstocks. Trees on rough lemon rootstock produced high level of Fe as compared with the other rootstocks. The differences were significant between rough lemon and balady lime in the first season only. Concerning leaf Zn content, rough lemon rootstock increased its value insignificantly than the others used. Finally, sour orange rootstock increased leaf Mn content, the differences was significant when compared with balady lime in the first season only.

Such results are in harmony with that of Nasr and Hassan, (1984) and Saad-Allah *et al.*(1985) They found that sour orange rootstock increased N and Mn, while rough lemon increased Zn content in white Kelley orange trees. Taylor and Dimsey (1993) proved that leaf K concentration of Navel and Valencia orange was low on rough lemon rootstock but induced high Fe and Zn concentrations. Meligy and Gobran (1995) reported that sour orange increased leaf N content, while Rough lemon increased leaf Fe and Zn contents of Valencia orange

Table (2) Influence of three citrus rootstocks on flowering dates of Washington navel orange trees (1999 and 2000 seasons).

	1 st season 1999					2 nd season 2000				
	Beg	full bloom	retal fall max	end	period days	Beg	full bloom	retal fall max	end	period days
Sour orange	6\3	19\ 3	24\3	3\4	28	8\3	20\3	26\3	5\4	27
rough lemon	10\3	23\3	28\3	10\4	30	8\3	19\3	25\3	3\4	25
balady lime	8\3	20\3	24\3	6\4	28	9\3	19\3	26\3	6\4	27
New L.S.D. 5%	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

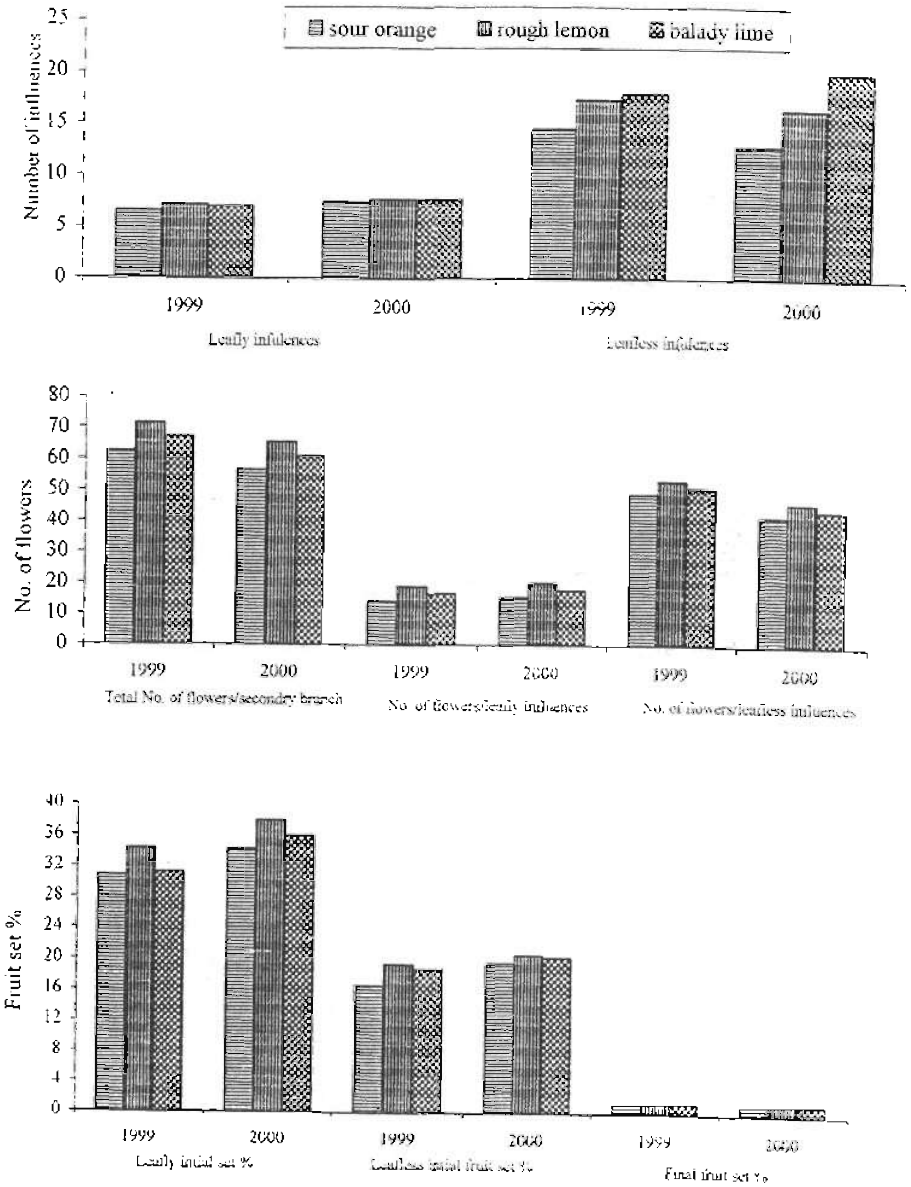

Fig (1) Influnece of some rootstocks on Flowering and fruit set percentage of Washington navel orange trees seasons (1999 and 2000)

Table (3): Influence of three citrus rootstocks on flowering and fruit set percentage of Washington navel orange trees 1999 and 2000 seasons).

Rootstocks	No.Leafy infulences	No.Leafless infulences	Total no. of flower/secondry branch	No. of flower/leafly infulences	No. of flowers/leafless infulences	Leafly intial fruit set %	Leafless intial fruit set %	Final fruit set %/leafly and leafless		Final fruit set %
(Season 1999)										
Sour orange	6.5	14.4	62.4	13.9	48.5	30.7	16.4	1.03	0.34	1.37
Rough lemon	7.1	17.2	71.2	18.7	52.5	34.2	19.2	1.05	0.35	1.40
Balady lime	6.9	17.8	66.9	16.3	50.6	31.1	18.6	1.04	0.35	1.39
New L.S.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N. S.	N. S.	N. S.
(Season 2000)										
Rough lemon	7.6	16.3	65.3	19.8	45.5	37.8	20.4	1.06	0.32	1.38
Balady lime	7.6	19.9	60.9	17.5	43.4	35.8	20.1	1.05	0.32	1.37
New L.S.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N. S.	N. S.	N. S.

Table (4): Influence of three citrus rootstocks on leaf minerals content of Washington navel orange trees/999 and 2000 seasons)

Rootstocks	Season 1999						Season 2000					
	%			ppm			%			ppm		
	N	P	K	Fe	Zn	Mn	N	P	K	Fe	Zn	Mn
Sour orange	2.55	0.18	1.22	168.00	40.00	50.00	2.60	0.17	1.12	160.00	43.00	45.00
Rough lemon	2.42	0.17	1.25	175.00	45.00	42.00	2.45	0.16	1.20	161.00	45 00	44.00
Balady lime	2.45	0.19	1.30	160.00	40.00	47.00	2.50	0.18	1.22	152.00	39.00	40 00
L . S. D. at 5 %	N. S.	N. S.	N. S.	14.00	N. S.	6.00	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.

4. Effect of rootstocks on yield:

Results concerning fruits number, fruits weight per tree, yield per tree either as weight (kg) or hypothetic yield per Fadden are presented in table (5). The obtained data showed that yield of trees budded on rough lemon produced higher yield but the greatest fruits weight resulted from trees budded on balady lime rootstock. These results agree with Georgiou(2000). andAbu Rawash *et al.*(1995),.They concluded that the yield of trees budded on rough lemon was higher than on sour orange rootstock.

5. Fruit quality:

5-1 Fruit physical properties

Fruit color:

It was known that the changes in fruit color which affected primarily by climatic conditions during fruits development. This effect was most obvious during the two seasons. The most striking differences were observed with lower temperature in 2000 than 1999 during months Nov to Dec . The effect of rootstocks on the changes in fruits color .Fig (2) showed that. the changes were mainly from dark green at the third week of October to light green at the first week of December to orange at the first week of January in the fruits of trees budded on sour orange. Meanwhile the fruits from trees budded on balady lime change from light green at the third week of October to yellow orange at the first week of December to light orange at the first week of Jan . Fruits of trees budded on rough lemon changes from yellow to orange to deep orange at the same time .

These results agree with results of Abu Rawash *et al.* (1995). Beridze (1987) El-Barkouky *et al* (1984), and Levy and Mendel (1982).As they found the same results

Results presented in Table (6) indicated that, rootstocks had a significant effect on most fruit physical measurements used. Both weight, size, length and diameter were greater in fruits of trees budded on balady lime rootstock than fruits from trees on the other used rootstocks. Fruits of trees on sour orange were significantly smallest in weight ,size ,length and diameter. The picture was more clear in the second season. As for rind thickness ,fruits of trees budded on balady lime rootstock have a thinner rind with low weight comparing with those of rough lemon and sour orange respectively . With respect to juice weight % data showed a similar trend with the previous physical properties . These results go in line with results of Castle(1989), El-Barkouky *et al* .(1984) and Bitters and Batchear (1951), They found that the changes in physical fruit properties have been attributed to rootstocks. Levy and Mendel (1982)and Saad – Allah et al . (1985). concluded that the thickness of the rind of fruit of trees budded on balady lime was smaller than those on sour orange but juice was heavier .

6-2- Fruit chemical properties .

As shown in Table (6) the lowest concentrations of juice total soluble solids and acidity were found in fruits of trees budded on rough lemon rootstocks compared with the others . No differences in acidity between sour orange and rough lemon were observed , while sour orange took the highest

Changes of fruit peel color during development of Washington Navel orange tree as affected by three different rootstocks. season 2000

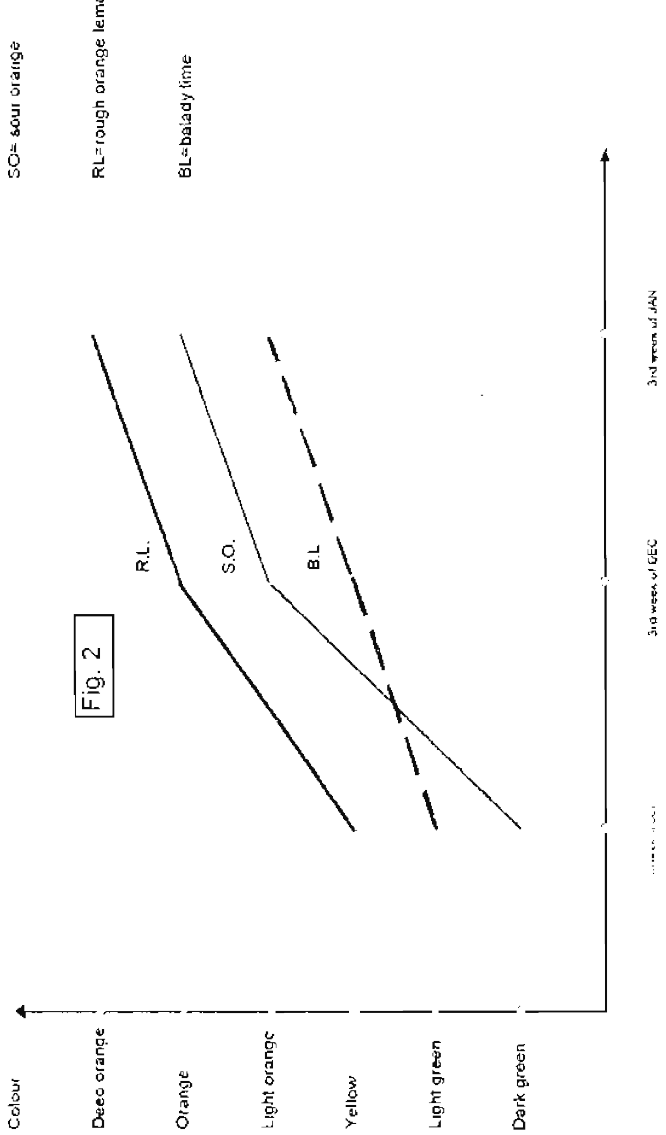

Fig. 2

Table (5): Influence of three citrus rootstocks on yield of Washington navel orange trees (1999 and 2000 seasons)

Rootstocks	(Season 1999)				(Season 2000)			
	Fruit No./tree	Fruit weight (gm).	Kg./ tree	Hypothetic yield tons/fed.	Fruit No. /tree	Fruit weight (gm).	Kg./ tree	Hypothetic yield tons/fed.
Sour orange	273.19	250.00	68.29	11.47	269.21	249.99	67.30	11.31
Rough lemon	290.26	262.00	76.05	12.77	285.10	261.97	74.69	12.55
Balady lime	260.32	288.00	74.97	12.59	252.30	287.00	72.66	12.21
L . S. D. at 5 %	22.10	21.10	N. S.	N. S.	23.14	18.40	N. S.	N. S.

Table (6): Influence of three citrus rootstocks on fruit physical and chemical properties of Washington navel orange trees (1999 and 2000 seasons)

(Seson 1999)

Rootstocks	Physical properties								Chemical properties			
	Fruit weight (gm.)	Fruit size (cm3)	Length (cm)	Diameter (cm)	Shape L/D ratio	Rind thickness (mm.)	Rind weight (gm.)	Juice weight %	TSS	Acidity %	TSS/ acidity	Ascorbic acid (mg.)/100 ml juice
Sour orange	250.00	259.00	7.20	7.02	1.03	5.10	32.14	34.00	11.20	0.84	13.33	48.30
Rough lemon	282.00	297.00	7.89	7.90	1.01	4.50	28.35	35.80	10.50	0.83	12.65	45.60
Balady lime	288.00	298.00	7.98	7.78	1.03	4.20	26.46	35.80	10.70	0.96	11.14	43.80
L . S. D. at 5 %	21.12	19.11	0.92	0.95	-	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	2.30
(Season 2000)												
Sour orange	255.00	264.00	7.40	7.20	1.03	5.40	34.02	34.90	11.40	0.81	14.07	47.70
Rough lemon	284.00	298.00	8.10	7.92	1.02	4.80	30.24	36.60	10.50	0.81	12.96	45.40

total soluble solids values , but the highest vitamin "C" content was noticed in case of sour orange rootstock followed by rough lemon and then balady lime. No significant differences were obtained between rootstocks in T.S.S., acidity and T.S.S/acid ratio.In this respect, Levy and Mendel (1982). El-Barkouky et al (1984), and Saad-Allah et al.(1985), found that no differences in acidity between sour orange and rough lemon but fruits of trees on rough lemon contained the higher vitamin "C".

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تأثير بعض أصول الموالح على النمو ومحتوى الأوراق من العناصر والتزهير والعقد والمحصول وصفات جوده الثمار لأشجار البرتقال بسرة

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معهد بحوث البساتين- مركز البحوث الزراعية – الجيزة

أجريت هذه التجربة في محطة بحوث البساتين بالقناطر الخيرية، محافظة القليوبية خلال عامي ١٩٩٩-٢٠٠٠ على البرتقال بسره المطعم على ٣ أصول هي (النارنج – الليمون البلدي- الليمون المخرفش) وكان عمر الأشجار ٤٠ سنه وتم اختيار ٢٧ شجره من كل اصل لإجراء الدراسة عليها .الأشجار مزروعة على مسافات ٥ × ٥ متر و أجريت هذه الدراسة لمعرفة تأثير الأصول الثلاثة على النمو الخضري والتزهير والعقد والمحصول والصفات الطبيعية والكيمائية للثمار ومحتوى الأوراق من عناصر النيتروجين والفسفور والبوتاسيوم والحديد والزنك والمنجنيز وأهم النتائج المتحصل عليها من هذه الدراسة هي.

١- سبب أصل النارنج زيادة محيط الأشجار وطول الفرع ونسبة المواد الصلبة الذائبة ونسبة المواد الصلبة الذائبة إلى الحموضة وفيتامين ج وكذلك محتوى الأوراق من عنصري النيتروجين والمنجنيز.

٢- أما أصل الليمون المخرفش فسبب زيادة ارتفاع الشجرة ومساحة الورقة ومحصول الشجرة من الثمار عددا ووزنا كذلك حجم الثمرة وسمك القشرة وحجم العصير ومحتوى الأوراق من عنصري الحديد والزنك.

٣- سبب أصل الليمون المالح زيادة وزن الثمرة ووزن العصير والحموضة ومحتوى الأوراق من عنصري الفسفور والبوتاسيوم.

٤- وجدير بالذكر أنه لم يكن للأصول المستعملة في هذه الدراسة تأثير على موعد التزهير أو عدد النورات الزهرية والو رقية أو النسب المئوية للعقد على هزة النورات .