Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 04 | Issue : 04 | Oct.-Dec. | 2015
Pages: 1038-1046

Physiological Studies on Valencia Orange Transplants Budded on Different Citrus Rootstocks I- Vegetative Growth Measurements

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ABSTRACT

This investigation was carried out during both 2013 and 2014 seasons to cover the influence of the two investigated factors i.e., rootstock citrus type (sour orange and Volkamer lemon) and mineral fertilization and their possible combinations. The influence was evaluated through the response of some vegetative growth of "Valencia" orange cultivar. The specific effect of rootstock type on some vegetative growth, data revealed that, Valencia orange budded on Volkamer lemon rootstock was better than the other investigated rootstock (sour orange) in this respect. Also, fertilizer with soil application of mixed minerals ores at 150 g/ plant + ¼ NPK application of control was superior in this respect where it was able to increase significantly vegetative growth as compared with the other different investigated fertilization especially NPK only (control) during both seasons of study. Concerning the interaction effect of the two investigated factors i.e., rootstock type and different mineral fertilization on vegetative growth of "Valencia" orange transplants, data show the highest vegetative growth were obtained with the combination between "Valencia" orange transplants budded on Volkamer lemon rootstock and fertilized with soil application of mixed minerals ores at 150 g/ plant + ¼ NPK application of control.

Key words: Citrus, rootstock, mineral fertilization, Physiological, Vegetative growth

Introduction

Citrus fruits have been cultivated for over 4000 years. Moreover, they are grown in nearly every country within 40 north – south latitude (Davies, 1985).The general area origin of citrus is believed to be south East Asia and spread during the middle ages, later to become established in all continents (Spiegel –Roy and Golds-Chmidt, 1996).

Citrus (*Citrus spp.*) one of the most important fruit crops grown in many tropical and subtropical countries. At the moment there is about 1.5 million hectares of citrus fruits cultivated for commercial scale in the world yielded nearly 40 million metric tons of oranges, lemons, limes, etc. In Egypt, citrus has great attention due to its importance for local consumption or as a main source for foreign currencies by exportation to the European country. The area of citrus cultivated in Egypt was increased rapidly with the reclamation of new desert lands reaches about 35.59 hectare (Anonymous, 2008).

In 2012/2013, total planted orange area is forecast at 163.000 hectares compared to 155,000 estimated for 2011/2012 and 150,000 hectares in 2010/2011. Production in 2012/2013 is forecast to increase to 3.88 million MT, up from the estimated 3.67 million MT in 2011/2012 compared to about 3.55 million MT in 2010/2011. The expected increase in total orange production is mainly due to the increase in the number of bearing trees. Statistics of Ministry of Agriculture (2014).

Oranges are a winter fruit well-suited to the Egyptian climate. Orange production accounts for half the total fruit production in Egypt. Cultivation is centered in two large geographic regions: The fertile Delta area and the newly reclaimed lands. Navel oranges are the predominant variety. Smaller amounts of local (Balady), Sweet, Valencia and other varieties are also produced. The harvest of navel oranges begins in October, but starts later for other cultivars in November, December up to March / April.

It is well known that more than 40% of production costs are devoted to nutrition practices. Besides, the need for fertilizers particularly nitrogen fertilizers is in a continuous demand to compensate the reduction of soil fertility that resulted from intensive cultivation over the years and the depletion of loamy colloids after building the High Dam.

Over the years, the heavy use of chemical fertilizers has resulted in serious problems in the soil. It is not only the salinity, but also and more importantly the pollution of the underground waters and the accumulation of the chemicals in plant tissue that is a major component of animal fodder human diet. As a result of misuse of chemical fertilizers, the natural biological balance in the soil is disturbed.

On the other hand, the chemical fertilizers have been extensively used before the First World War. By that time, the main source of minerals for plant nutrition was organic matter. The Chili salt used during the

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world war as an explosive material was used latter after the war as chemical fertilization, which opened the area of extensive use of chemical fertilizers in Agriculture (Castle *et al.,* 1993). The application of natural elements compound to *Citrus volkameriana* rootstock seedlings, reflects on improvement of seedling growth parameters as a stem length, stem diameter, number of leaves, leaf area. Also, stem leaf and root dry matter percentage and root distribution (Abdel Rahman *et al.,* 2009).

Thus, this study aimed to investigate application of some fertilizers on vegetative growth of Valencia orange transplants budded on Sour orange and Volkamer lemon rootstocks.

Materials and Methods

The present investigation was undertaken throughout the two successive seasons of 2013 and 2014 at Fruit Nursery of Horticulture Department, Faculty of Agriculture, Moshtohor, Benha University, Qalyubeia Governorate, Egypt. Uniform and healthy one-year- old transplants of Valencia orange cultivar budded on Sour orange and Volkamer lemon were the plant material used in this study. In both seasons of study and during the first week of February, these transplants were transplanted individually each in plastic pot of 35 cm. in diameter that previously had been filled with specific weight of growing medium consisting of clay and sand at equal proportion (by volume).

Before the experiment had been conducted in the first season, both mechanical and chemical analysis were done as shown in Table, 1 (a&b) according to the methods described by Jackson (1967).

Table (1-a): Physical properties of soil (%).

Partial distribution		
Total sand	Silt	Clay
60.00	10.00	30

Table (1-b): Chemical properties of soil.

Soluble cations meq/L				Soluble anions meq/L				Ca CO_3	PH	EC
Mg^{++}	Ca^{++}	K^{+}	Na^{+}	HCO_3^{-}	CO_3^{--}	$SO4^{--}$	Cl^{-}			
2.13	8.77	0.50	7.80	3.01	-	9.19	6.70	1.50	8.70	1.01

The mixed minerals ores used in this study were produced by Al-Ahram mining company. Chemical analysis for the mixed minerals ores shown in Table (2).

Item	Percentage (%) From	Percentage (%) To
SiO2	38.56	40.15
TiO_2	0.76	0.85
Al_2O_3	7.80	7.85
Fe_2O_3	3.58	4.52
MnO	0.61	0.74
MgO	2.47	3.92
CaO	13.45	16. 69
Na_2O	1.32	2.19
K_2O	3.97	4.51
P_2O_5	6.14	8.52
SO_3	5.38	6.28
L.O.I	7.01	9.14

This experiment involved ten treatments:

1-Mineral NPK fertilization program as control was annually added at the rate of 600 g ammonium sulphate, 200 g superphosphate and 200 g potassium sulphate per pot (plant).
2- Soil application of mixed minerals ores at 25 g/ plant + ½ NPK application of control.
3- Soil application of mixed minerals ores at 50 g/ plant + ½ NPK application of control.
4- Soil application of mixed minerals ores at 75 g/ plant + ½ NPK application of control.
5- Soil application of mixed minerals ores at 100 g/ plant + ½ NPK application of control.
6- Soil application of mixed minerals ores at 125 g/ plant + ½ NPK application of control.
7- Soil application of mixed minerals ores at 150 g/ plant + ¼ NPK application of control
8- Soil application of mixed minerals ores at 175 g/ plant + ¼ NPK application of control.
9- Soil application of mixed minerals ores at 200 g/ plant + ¼ NPK application of control.
10- Soil application of mixed minerals ores at 225 g/ plant + ¼ NPK application of control.

Whereas, the corresponding amount of each NPK fertilizer and mixed minerals ores were fractionized into three equal doses to be soil applied (mid-March, mid-May and mid-July) during every season.

Experimental layout:

The complete randomized block design with three replications was used for arranging the differential investigated treatments. Every replicate was represented by three transplants. The response of sweet orange transplants to differential treatments of the experiment was investigated through determining variances exhibited in the following measurements.

Vegetative growth measurements:

On last week of October during both seasons as the experiment was ended, the effects of different treatments on vegetative growth were evaluated by investigating the response of the following growth parameters:
- Stem height (cm.), Stem diameter (cm), Number of lateral shoots per transplants, Mean lateral shoot length (cm), Number of leaves, Leaf area, Total foliage area per transplant and Root length (cm).The method was described by Motskobili (1984).

Statistical analysis:

All data obtained during both seasons were subjected to analysis of variance and significant differences among means were determined according to Snedecor and Cochran, (1977). In addition, significant differences among means were differentiated according to the Duncan's, multiple ranges (Duncan, 1955).

Results and Discussion

This investigation was carried out to cover the influence of the two investigated factors namely: 1- root stock citrus type (Sour orange and Volkamer lemon), 2- Some mineral fertilization and their possible combinations on "Valencia" orange transplants were studied during both 2013 and 2014 seasons. Such influence was evaluated through the response of some vegetative growth of the treated "Valencia" orange cultivar.

Therefore, obtained results presented in Tables (3-10) in this study dealing with any of the abovementioned three aspects are separately during both seasons of study discussed as follows:

Vegetative growth:

In this regard in stem height; stem diameter; number of lateral shoots, mean of lateral shoot length, number of leaves; leaf area; leaf assimilation area and root length were the eight growth measurements of "Valencia" orange transplants investigated pertaining their response to the specific effect of investigated variables of each studied factor i.e., (Sour orange and Volkamer lemoncitrus rootstocks) and mineral soil applications as well as interactions effect of the combinations between the variables of both investigated factors.

Stem height (cm):

Specific effect:

As for theresponse to specific effect of rootstock species, data in Table (3) displays that, Valencia orange budded on Volkamer lemon surpassedstatistically Valencia orange budded on sour orange during two seasons of study in this respect. Meanwhile, the specific effect of fertilizer treatments, Table (3) displays that the stem was longer (higher) in transplants fertilized with NPK (300+100+100) + 25gm mixed minerals ores or NPK (300+100+100) + 75gm mixed minerals ores rather than in other treatments especially NPK (600+200+200) (control).

Interaction effect:

Regarding the interaction effect of various (citrus rootstock x fertilizer treatments) combinations Table (3) reveals that, Valencia orange budded on Volkamer lemon and fertilized with NPK (300+100+100) + 25gm mixed minerals ores had significantly the tallest stem. Meanwhile, the reverse was true with Valencia orange budded on sour orange and fertilized with NPK (600+200+200), In addition other combinations were in between during two seasons.

The obtained results are in confirm with Rathore and Chandra (2003); Hiwarale *et al.,* (2004); Abdel Rahman *et al.,* (2009) and Rattanpal and Sangwan (2011) on citrus species.

Table 3: Specific and interaction effects of fertilizer treatments, rootstock species and their combinations on transplant height of Valencia orange transplants during 2013 and 2014 seasons.

Treatments	Transplant height (cm)					
	Sour orange	Volkamaryana	Mean	Sour orange	Volkamaryana	Mean
	First season			Second season		
NPK (300 + 100 + 100) + 25 g mixed minerals ores	98.67cd	108.0a	103.4A	98.67de	109.5ab	104.1A
NPK (300 + 100 + 100) + 50 g mixed minerals ores	91.33gh	100.0cd	95.67B	86.67g	96.20ef	91.43D
NPK (300 + 100 + 100) + 75 g mixed minerals ores	96.67d-f	105.8ab	101.3A	99.33de	110.3a	104.8A
NPK (300 + 100 + 100) + 100 g mixed minerals ores	71.00k	77.75j	74.37F	65.67i	72.89h	69.28F
NPK (300 + 100 + 100) + 125 g mixed minerals ores	77.33j	84.68i	81.01E	85.00g	94.35ef	89.68D
NPK (150 + 50 + 50) + 150 g mixed minerals ores	88.67h	97.09de	92.88C	94.67ef	105.1bc	99.87BC
NPK (150 + 50 + 50) + 175 g mixed minerals ores	84.67i	92.71f-h	88.69D	85.67g	95.09ef	90.38D
NPK (150 + 50 + 50) + 200 g mixed minerals ores	93.67e-g	102.6bc	98.12B	97.00ef	107.7ab	102.3AB
NPK (150 + 50 + 50) + 225 g mixed minerals ores	92.00gh	100.7cd	96.37B	92.00f	102.1cd	97.06C
NPK (600 + 200 + 200)	72.00k	78.84j	75.42F	75.00h	83.25g	79.13E
Mean	86.60B	94.83A		87.97B	97.64A	

Values within the same column and raw for any of two investigated factors were individually differentiated by capital letters, while for the interaction small letters were used, mean followed by the same letter/s were not significantly different.

Stem diameter:

Specific effect:

As for the response to specific effect of rootstock species, data in Table (4) displays that, Valencia orange budded on Volkamer lemon surpassed statistically Valencia orange budded on sour orange during two seasons of study. Meanwhile, the specific effect of fertilizer treatments, Table (4) displays that, the stem was thickness in transplants fertilized with NPK (150+50+50) + 150gm mixed minerals ores or NPK (300+100+100) + 75gm mixed minerals ores rather than in other treatments especially NPK (600+200+200) (control).

Interaction effect:

Regarding the interaction effect of various (citrus rootstocks x fertilizer treatments) combinations Table (4) reveals that, Valencia orange budded on Volkamer lemon and fertilized with NPK (150+50+50) + 150gm mixed minerals ores had significantly the thickened stem. Meanwhile, the reverse was true with Valencia orange budded on sour orange and fertilized with NPK (600+200+200), In addition other combinations were in between during two seasons.

A similar result was also obtained by Zekri and Koo (1992); Abdel Rahman *et al.* (2009);Almeida *et al.* (2012) and Al-Karaki (2013).

Table 4: Specific and interaction effects of fertilizer treatments, rootstock species and their combinations on stem diameter of Valencia orange transplants during 2013 and 2014 seasons.

Treatments	Stem diameter (cm)					
	Sour orange	Volkamaryana	Mean	Sour orange	Volkamaryana	Mean
	First season			Second season		
NPK (300 + 100 + 100) + 25 g mixed minerals ores	6.33de	7.09cd	6.71C	6.33e-g	7.28b-f	6.81CD
NPK (300 + 100 + 100) + 50 g mixed minerals ores	5.67ef	6.35de	6.01CD	6.67d-g	7.67b-e	7.17BC
NPK (300 + 100 + 100) + 75 g mixed minerals ores	7.67bc	8.59ab	8.13B	7.33b-f	8.43a-c	7.88AB
NPK (300 + 100 + 100) + 100 g mixed minerals ores	5.67ef	6.35de	6.01CD	5.33gh	6.13e-h	5.73EF
NPK (300 + 100 + 100) + 125 g mixed minerals ores	5.67ef	6.35de	6.01CD	5.67gh	6.52d-g	6.09DE
NPK (150 + 50 + 50) + 150 g mixed minerals ores	8.67ab	9.71a	9.19A	7.67b-e	8.82ab	8.24A
NPK (150 + 50 + 50) + 175 g mixed minerals ores	5.33ef	5.97de	5.65DE	5.67gh	6.52d-g	6.09DE
NPK (150 + 50 + 50) + 200 g mixed minerals ores	7.67bc	8.59ab	8.13B	8.00a-d	9.20a	8.60A
NPK (150 + 50 + 50) + 225 g mixed minerals ores	5.67ef	6.35de	6.01CD	6.00f-h	6.90c-g	6.45C-E
NPK (600 + 200 + 200)	4.67f	5.23ef	4.95E	4.67h	5.37gh	5.02F
Mean	6.30B	7.06A		6.33B	7.28A	

Values within the same column and raw for any of two investigated factors were individually differentiated by capital letters, while for the interaction small letters were used, mean followed by the same letter/s were not significantly different.

Number of lateral shoots:

Specific effect:

As for the response to specific effect of rootstock species, data in Table (5) displays that, whereas Valencia orange budded on Volkamer lemon surpassed statistically Valencia orange budded on sour orange during two seasons of study in this respect. Meanwhile, the specific effect of fertilizer treatments, Table (5) displays that the transplants fertilized with NPK (150+50+50) + 200gm mixed minerals ores or NPK

(150+50+50) + 225gm mixed minerals ores gave highest number of lateral shoots compared with other treatments especially NPK (600+200+200) (control).

Interaction effect:

Regarding the interaction effect of various (citrus rootstock x fertilizer treatments) combinations Table (5) reveals that Valencia orange budded on Volkamer lemon and fertilized with NPK (150+50+50) + 200gm mixed minerals ores had significantly the highest number of lateral shoots. Meanwhile, the reverse was true with Valencia orange budded on sour orange and fertilized with NPK (600+200+200), In addition other combinations were in between during two seasons.

Table 5: Specific and interaction effects of fertilizer treatments, rootstock species and their combinations on No. of lateral shoots of Valencia orange transplants during 2013 and 2014 seasons.

Treatments	No. of lateral shoots/ transplant					
	Sour orange	Volkamaryana	Mean	Sour orange	Volkamaryana	Mean
	First season			Second season		
NPK (300 + 100 + 100) + 25 g mixed minerals ores	5.00g-i	12.67b	8.83BC	5.67e-h	14.00a	9.83B
NPK (300 + 100 + 100) + 50 g mixed minerals ores	7.33e-h	9.00c-e	8.17CD	8.00b-e	8.33b-d	8.17CD
NPK (300 + 100 + 100) + 75 g mixed minerals ores	5.67f- i	7.33e-h	6.50DE	7.33c-g	7.67c-f	7.50CD
NPK (300 + 100 + 100) + 100 g mixed minerals ores	5.67f-i	7.33e-h	6.50DE	5.33f-h	8.33b-d	6.83DE
NPK (300 + 100 + 100) + 125 g mixed minerals ores	5.33f-i	7.67e-g	6.50DE	5.00gh	6.33d-h	5.67EF
NPK (150 + 50 + 50) + 150 g mixed minerals ores	6.67e-h	11.33bc	9.00BC	7.67c-f	10.33b	9.00BC
NPK (150 + 50 + 50) + 175 g mixed minerals ores	5.67f-i	10.33b-d	8.00CD	4.67h	9.00bc	6.83DE
NPK (150 + 50 + 50) + 200 g mixed minerals ores	8.00e-f	17.67a	12.83A	7.67c-f	15.33a	11.50A
NPK (150 + 50 + 50) + 225 g mixed minerals ores	4.67hi	16.33a	10.50B	5.00gh	15.00a	10.00AB
NPK (600 + 200 + 200)	3.67i	6.33f-h	5.00E	4.33h	5.33f-h	4.83F
Mean	5.77B	10.60A		6.07B	9.97A	

Values within the same column and raw for any of two investigated factors were individually differentiated by capital letters, while for the interaction small letters were used, mean followed by the same letter/s were not significantly different.

Lateral shoot length (cm):

Specific effect:

As for the response to specific effect of rootstock species, data in Table (6) displays that, Valencia orange budded on Volkamer lemon surpassed statistically Valencia orange budded on sour orange during two seasons of study. Meanwhile, the specific effect of fertilizer treatments, Table (6) displays that, the lateral shoot was tallest in transplants fertilized with NPK (300+100+100) + 25gm mixed minerals ores or NPK (300+100+100) + 75gm mixed minerals ores rather than in other treatments especially NPK (600+200+200) (control).

Table 6: Specific and interaction effects of fertilizer treatments, rootstock species and their combinations on mean of lateral shoot length of Valencia orange transplants during 2013 and 2014 seasons.

Treatments	Mean of lateral shoot length (cm)					
	Sour orange	Volkamaryana	Mean	Sour orange	Volkamaryana	Mean
	First season			Second season		
NPK (300 + 100 + 100) + 25 g mixed minerals ores	22.00cd	35.53a	28.67A	21.33b-d	34.00a	27.67A
NPK (300 + 100 + 100) + 50 g mixed minerals ores	16.00gh	21.67cd	18.83CD	16.67ef	17.67de	17.17CD
NPK (300 + 100 + 100) + 75 g mixed minerals ores	22.00cd	27.67b	24.83B	25.33b	25.67b	25.50AB
NPK (300 + 100 + 100) + 100 g mixed minerals ores	17.33e-g	19.67d-g	18.50CD	16.67ef	16.67ef	16.67CD
NPK (300 + 100 + 100) + 125 g mixed minerals ores	13.00hi	21.33c-e	17.17DE	15.00ef	16.00ef	15.50DE
NPK (150 + 50 + 50) + 150 g mixed minerals ores	17.00fg	24.67bc	20.83C	15.33ef	23.67bc	19.50C
NPK (150 + 50 + 50) + 175 g mixed minerals ores	21.00c-f	28.33b	24.67B	22.67bc	25.00b	23.83B
NPK (150 + 50 + 50) + 200 g mixed minerals ores	13.00hi	26.00b	19.50CD	12.67fg	26.00b	19.33C
NPK (150 + 50 + 50) + 225 g mixed minerals ores	18.00d-g	21.67cd	19.83CD	17.33d-f	19.33c-e	18.33CD
NPK (600 + 200 + 200)	10.33i	20.00d-g	15.17F	9.33g	16.33ef	12.83E
Mean	16.97B	24.65A		17.23B	22.03A	

Values within the same column and raw for any of two investigated factors were individually differentiated by capital letters, while for the interaction small letters were used, mean followed by the same letter/s were not significantly different.

Interaction effect:

Regarding the interaction effect of various (citrus rootstocks x fertilizer treatments) combinations Table (6) reveals that, Valencia orange budded on Volkamer lemon and fertilized with NPK (300+100+100) + 25gm mixed minerals ores had significantly the tallest lateral shoot. Meanwhile, the reverse was true with Valencia orange budded on sour orange and fertilized with NPK (600+200+200). In addition other combinations were in between during two seasons.

A similar result was also obtained by Nasr (1982); Willis *et al.* (1991); Maust and Williamson (1992) and Maust & Williamson (1994).

Number of leaves / transplant:

Specific effect:

Table (7) shows that, the number of leaves per each individual transplants was influenced by rootstock type. Herein, Valencia orange budded on Volkamer lemon resulted in an increase in number of leaves /transplant as compared to that in Valencia orange budded on sour orange during both seasons of study. As for the specific effect of fertilizer treatments, it is quite evident that, transplants fertilized with NPK (150+50+50) + 150gm mixed minerals ores gave tallest lateral shoots rather than in other treatments especially NPK (600+200+200) (control).

Interaction effect:

Regarding the response of number of leaves per transplants to interaction effect of various combinations between citrus rootstock species and fertilizer treatments, it was so clear to notice that, the Valencia orange fertilized with NPK (150+50+50) +150gm mixed minerals ores gave the highest number of leaves transplant during two seasons of study. On the other hand, the reverse was found with the Valencia orange budded on sour orange and fertilized with NPK (600+200+200). In addition other combinations were in between during two seasons.

These results are in harmony with those obtained by Ebrahiem and Mohamed (2000); Abdel Rahman *et al.* (2009) and Almeida *et al.* (2012).

Table 7: Specific and interaction effects of fertilizer treatments, rootstock species and their combinations on number of leaves of Valencia orange transplants during 2013 and 2014 seasons

Treatments	Number of leaves / transplant					
	Sour orange	Volkamaryana	Mean	Sour orange	Volkamaryana	Mean
	First season			Second season		
NPK (300 + 100 + 100) + 25 g mixed minerals ores	62.33i	91.00c-e	76.67C	58.00i	94.00cd	76.00E
NPK (300 + 100 + 100) + 50 g mixed minerals ores	58.33i	97.33bc	77.83C	48.00j	100.30bc	74.17E
NPK (300 + 100 + 100) + 75 g mixed minerals ores	89.33d- f	95.67cd	92.50B	83.33ef	101.30bc	92.33C
NPK (300 + 100 + 100) + 100 g mixed minerals ores	78.67fg	83.33g	81.00C	77.67fg	87.33de	82.50D
NPK (300 + 100 + 100) + 125 g mixed minerals ores	68.67h	91.33c-e	80.00C	68.00h	95.00cd	81.50D
NPK (150 + 50 + 50) + 150 g mixed minerals ores	91.00c-e	145.0a	118.00A	86.00e	154.70a	102.30A
NPK (150 + 50 + 50) + 175 g mixed minerals ores	85.67ef	103.7b	94.67B	84.00ef	101.70bc	92.83C
NPK (150 + 50 + 50) + 200 g mixed minerals ores	96.00cd	96.67c	96.33B	96.00c	105.00b	100.50B
NPK (150 + 50 + 50) + 225 g mixed minerals ores	93.00cd	98.00bc	95.50B	95.00cd	98.00bc	96.50BC
NPK (600 + 200 + 200)	47.33j	70.33h	58.83D	37.33k	72.67gh	55.00F
Mean	77.03B	95.24A		73.33B	101.00A	

Values within the same column and raw for any of two investigated factors were individually differentiated by capital letters, while for the interaction small letters were used, mean followed by the same letter/s were not significantly different.

Average leaf area (cm^2):

Specific effect:

Data presented in Table (8) displayed that, Valencia orange budded on Volkamer lemon surpassed statistically Valencia orange budded on sour orange during two seasons of study. Meanwhile, the specific effect of fertilizer treatments, Table (8) displays that, the average leaf area was largest in transplants fertilized with NPK (300+100+100) + 100g mixed minerals ores rather than in other treatments especially NPK (600+200+200) (control).

Interaction effect:

Referring the interaction effect of citrus rootstock species and fertilizer treatments, it was quite evident that, the Valencia orange fertilized with NPK (300+100+100) +100gm mixed minerals ores gave the highest value of leaf area during two seasons of study. On the other hand, the reverse was found with the Valencia orange budded on sour orange and fertilized with NPK (600+200+200). In addition other combinations were in between during two seasons.

Table 8: Specific and interaction effects of fertilizer treatments, rootstock species and their combinations on leaf area of Valencia orange transplants during 2013 and 2014 seasons.

Treatments	Leaf area (cm2)					
	Sour orange	Volkamaryana	Mean	Sour orange	Volkamaryana	Mean
	First season			Second season		
NPK (300 + 100 + 100) + 25 g mixed minerals ores	15.00gh	23.67c	19.33DE	13.35g	18.41d-f	15.88D
NPK (300 + 100 + 100) + 50 g mixed minerals ores	15.67f-h	30.33b	23.00BC	15.80e-g	26.59b	21.19B
NPK (300 + 100 + 100) + 75 g mixed minerals ores	18.33d-g	23.33c	20.83CD	14.89fg	21.04cd	17.96CD
NPK (300 + 100 + 100) + 100 g mixed minerals ores	21.00cd	35.00a	28.00A	15.95e-g	31.63a	23.79A
NPK (300 + 100 + 100) + 125 g mixed minerals ores	17.00e-h	23.67c	20.33D	14.93fg	24.04bc	19.49BC
NPK (150 + 50 + 50) + 150 g mixed minerals ores	16.00f-h	22.67c	19.33DE	14.81fg	19.54de	17.18CD
NPK (150 + 50 + 50) + 175 g mixed minerals ores	20.67cd	27.67b	24.17B	16.89e-g	25.04b	20.96B
NPK (150 + 50 + 50) + 200 g mixed minerals ores	19.00d-f	20.00c-e	19.50D	16.82e-g	17.98d-f	17.40CD
NPK (150 + 50 + 50) + 225 g mixed minerals ores	16.00f-h	34.00a	25.00B	15.00fg	27.13b	21.06B
NPK (600 + 200 + 200)	14.00h	20.00c-e	17.00E	13.35g	18.31d-f	15.83D
Mean	17.27B	26.03A		15.18B	22.97A	

Values within the same column and raw for any of two investigated factors were individually differentiated by capital letters, while for the interaction small letters were used, mean followed by the same letter/s were not significantly different.

Total leaves assimilation area (cm^2):

Specific effect:

Data presented in Table (9) displayed that, Valencia orange budded on Volkamer lemon surpassed statistically Valencia orange budded on sour orange during two seasons of study. Meanwhile, the specific effect of fertilizer treatments, Table (9) displays that, the average leave assimilation area was largest in transplants fertilized with NPK (150+50+50) + 225gm mixed minerals ores rather than in other treatments especially NPK (600+200+200) (control).

Interaction effect:

Referring the interaction effect of citrus rootstock species and fertilizer treatments, it was quite evident that, the Valencia orange fertilized with NPK (150+50+50) +225gm mixed minerals ores gave the highest value of leaves assimilation area during two seasons of study. On the other hand, the reverse was found with the Valencia orange budded on sour orange and fertilized with NPK (600+200+200). In addition other combinations were in between during two seasons.

These results are in harmony with those obtained by Maust and Williamson (1992); Darwish *et al.,* (1992); Maust and Williamson (1994); Abdel Rahman *et al.* (2009) and El-Otmani *et al.* (2004).

Table 9: Specific and interaction effects of fertilizer treatments, rootstock species and their combinations on leaves assimilation area (cm^2) of Valencia orange transplants during 2013 and 2014 seasons.

Treatments	Leaves assimilation area (cm^2)					
	Sour orange	Volkamaryana	Mean	Sour orange	Volkamaryana	Mean
	First season			Second season		
NPK (300 + 100 + 100) + 25 g mixed minerals ores	934.9n	2153.97f	1544.46I	774.30o	1730.54h	1252.42H
NPK (300 + 100 + 100) + 50 g mixed minerals ores	914.03n	2952.02c	1933.03E	758.40o	2666.98c	1712.69E
NPK (300 + 100 + 100) + 75 g mixed minerals ores	1637.42j	1765.38h	1701.40G	1240.78m	2131.35f	1686.07F
NPK (300 + 100 + 100) + 100 g mixed minerals ores	1652.07i	2916.55d	2284.31D	1238.84m	2762.25b	2055.00B
NPK (300 + 100 + 100) + 125 g mixed minerals ores	1167.39hi	2161.78f	1664.59H	1015.24n	2283.80e	1649.52G
NPK (150 + 50 + 50) + 150 g mixed minerals ores	1456.00l	3287.15b	2371.58B	1273.66l	3022.84a	2148.25A
NPK (150 + 50 + 50) + 175 g mixed minerals ores	1770.80h	2869.38e	2320.09C	1418.76j	2546.57d	1982.67C
NPK (150 + 50 + 50) + 200 g mixed minerals ores	1824.00f	1933.40g	1878.70F	1614.72i	1887.90g	1751.31D
NPK (150 + 50 + 50) + 225 g mixed minerals ores	1488.00k	3332.00a	2410.00A	1425.00j	2658.74c	2041.87B
NPK (600 + 200 + 200)	662.62o	1406.60m	1034.61J	498.36p	1330.59k	914.48I
Mean	1350.73B	2477.82A		1125.81B	2302.16A	

Values within the same column and raw for any of two investigated factors were individually differentiated by capital letters, while for the interaction small letters were used, mean followed by the same letter/s were not significantly different.

Root length (cm):

Specific effect:

With regard to the specific effect of citrus rootstock species, Table (10) shows that root system of Volkamer lemon was relatively longer than that of sour orange. As for the specific effect of fertilizer treatments, it was quite evident that the response was more pronounced than that previously discussed with rootstock species.

Whereas, the root system in the transplants fertilized with NPK (300+100+100) + 100gm mixed minerals ores rather than in other treatments especially NPK (600+200+200) (control) during both seasons of study.

Interaction effect:

Referring the response of root length to the interaction effect of various combinations between citrus rootstock species and fertilizer treatments, Table (10) clears that the tallest root system was usually coupled with those Valencia orange transplants budded on Volkamer lemon and fertilized with NPK (300+100+100) +100gm mixed minerals ores. The reverse was true with Valencia orange transplants budded on sour orange and fertilized with NPK (600+200+200), whereas the shortest roots was statistically exhibited by such combination during both seasons of study.

The obtained results are in confirm with Rathore and Chandra (2003); Abdel Rahman *et al.* (2009) and Rattanpal and Sangwan (2011).

Table 10: Specific and interaction effects of fertilizer treatments, rootstock species and their combinations on root length of Valencia orange transplants during 2013 and 2014 seasons.

Treatments	Root length (cm)					
	Sour orange	Volkamar yana	Mean	Sour orange	Volkamaryana	Mean
	First season			Second season		
NPK (300 + 100 + 100) + 25 g mixed minerals ores	58.00g	78.33b	68.17CD	58.00de	65.80c	61.90B
NPK (300 + 100 + 100) + 50 g mixed minerals ores	58.33g	77.33b	67.83CD	50.67f-j	56.00d-f	53.33DE
NPK (300 + 100 + 100) + 75 g mixed minerals ores	60.00fg	80.67b	70.33BC	53.00e-h	68.33c	60.67B
NPK (300 + 100 + 100) + 100 g mixed minerals ores	70.67cd	87.00a	78.83A	47.33h-k	85.33a	66.33A
NPK (300 + 100 + 100) + 125 g mixed minerals ores	58.67g	68.33cd	63.50EF	45.67jk	50.00g-j	47.83F
NPK (150 + 50 + 50) + 150 g mixed minerals ores	66.67de	77.67b	72.17B	46.67i- k	75.00b	60.83B
NPK (150 + 50 + 50) + 175 g mixed minerals ores	58.67g	72.67c	65.67DE	54.00d-g	56.33d-f	55.17CD
NPK (150 + 50 + 50) + 200 g mixed minerals ores	63.33ef	68.67cd	66.00DE	48.33h-k	68.67c	58.50BC
NPK (150 + 50 + 50) + 225 g mixed minerals ores	61.33fg	63.33ef	62.33F	42.67k	59.00d	50.83EF
NPK (600 + 200 + 200)	43.00i	51.67h	47.33G	52.00f- i	46.33i-k	49.17F
Mean	59.87B	72.57A		49.83B	63.08A	

Values within the same column and raw for any of two investigated factors were individually differentiated by capital letters, while for the interaction small letters were used, mean followed by the same letter/s were not significantly different.

References

Abdel Rahman, M., A. EL-Metwally and Y. Ebrahim, 2009. Effect of natural elements compound applications on citrus trees and seedlings production. Egypt. J. of Appl. Sci., 24 (10 A).

Al-Karaki, G. N., 2013.The effect of arbuscular mycorrhizal fungi on the establishment of sour orange *(Citrus aurantium)* under different levels of phosphorus. Acta Horticulturae; 984:103-108.

Almeida, L. V. B., C. S. Martnho, R. A. Munizand A. C. CarvalhoJunio, 2012.Nutrient availability and growth of citrus rootstock fertilized with conventional and slow release fertilizers. Revista Brasileira de Fruticultura; 34(1):289-296. 15 ref.

Anonymous, 2008. Yearbook of statistics of Ministry of Agriculture. (Agricultural Economical and Statistical Department, Arab Republic of Egypt: Cairo) [In Arabic].

Castle, S.W., D.P. Tucker, H.A. Krezdornand C.O. Youtsey, 1993. Rootstocks for Frorida Citrus. Rootstock selection.Second ed., Univ. ab Florida, P. 14 – 21.

Darwish, O. H., F. F. Ahmed, M. A. El-Sayed and M. A. Mohamed, 1992.Foliar and soil applications of urea and their effects on growth, yield and quality of Balady orange trees. Minia J. Agric. Res. & Dev. 14 (1): 50-70.

Davies, F.S., 1985. Introduction to citrus culture. FRC 3212, Dept. Fruit Crops, Univ. of Flo., pp.102-103.

Duncan, B.D., 1955. Multiple test rang and multiple F tests. Biometries, II: 1-42.

Ebrahiem, T. A. and G. A. Mohamed, 2000. Response of Balady mandarin trees growing on sandy soil to application of filter mud and farmyard manure. Assuit Jour. of Agric. Sci. 31 (5): 55-69.

El-Otmani, M., F. Z., Taibi, B. Lmoufid, A. Ait-Oubahouand C. J. Lovatt, 2004. Improved use of foliar urea on Clementine mandarin to manipulate cropping in a sustainable production system. Acta Horticulturae, 632, 167-175.

Hiwarale, J. S., M. N. Patiland G. S. Laharia, 2004.Effect of organic and inorganic fertilizers on growth, yield and quality of acid lime.Annala of Plant Physiology. 18:1, 28-30.

Jackson, M. L., 1967. Soil Chemical Analysis. Prentice – Hall. Inc. Englewood Clif., N, I. Library Congress,U SA.

Maust, N. and M.Williamson, 1992. Nitrogen rate effect on growth containerized citrus nursery plants. Proceedings of the Florida State Horticultural Society; 104:191-195.

Maust, N. and M.Williamson, 1994. Nitrogen nutrition of containerized citrus nursery plants. Journal of the American Society for Horticultural Science; 119(2):195-201. 49 ref.

Motskobili, N. A., 1984. Assimilation area of Satsuma in relation to mineral nutrition and it's effect on productivity. Sub – tropicheskie Kultry, No. 5, 83-90 VNILL chayaisk, Makharadze, Georgian SSR. (C.F. Hort., Abst. 55:2979).

Nasr, A. F., 1982. Effect of some micro nutrients on growth, flowering and fruit quality of Washington Navel orange trees. Ph. D. Thesis, Fac. of Agric., Cairo Univ.

Rattanpal, H. S. and A. K. Sangwan, 2011. Influence of bio-control agent and bio-fertilizers on growth and productivity of Kinnow mandarin. Indian Journal of Ecology; 38(1):85-90.

Rathore, R. S. and A. Chandra, 2003. Effect of application of nitrogen in combination with zinc sulphate on vegetative growth characteristics of acid lime (*Citrusaurantifolia*Swingle) *cv.*Kagzi lime.Agricultural Science Digest. Agricultural Research Communication Centre, Karnal, India, 23: 3, 220-222.

Snedecor, G.W. and W.G. Cochran, 1988. Statistical methods. 6thEd. The Iowa state Univ. Press, Ames., Iowa, U.S.A. pp. 593.

Spiegel-Roy, P. and E.E. Golds-Chmidt, 1996. Biology of Citrus. Cambridge Univ. Press, Fruit published. PP. 229.

Willis, L. E., F. S. Davies and D. A. Graet, 1991.Fertilization, nitrogen leaching and growth of young 'Hamlin' orange trees on two rootstocks. Proceedings of the Florida State Horticultural Society., 103:30-37.

Zekri, M. and R. Koo, 1992.Use of controlled-release fertilizers for young citrus trees. Scientia Horticulturae; 49(3-4):233-241.