Effect of Nitrogen Fertilization Added at Various Phenological Stages on Growth, Yield and Fruit Quality of Valencia Orange Trees.

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Abstract: This work was an attempt to declare the effect of both rootstocks kind and their response to different applied N-fertilizing regime on vegetative growth, yield and fruit quality of Valencia orange trees budded on either sour orange (SO) or Volkamer lemon (VL) rootstocks. The results indicated that adding 50% of total given N /tree/year at various phenological stages had simultaneously affected the vegetative growth, fruit set %, fruit yield/tree and the response of physical and biochemical fruit characteristics of Valencia orange trees to different N-treatments. Maximum fruit yield (Kg/trees) was obtained when adding 50 % of total given N /tree/ year at either pre-autumn or at fruit cell expansion phenological stages to Valencia orange budded on VL or SO. Adding 50 % of total given N/tree/year at various phenological stages significantly enhanced the fruit physical and chemical characteristics of Valencia orange.

[Hifny, H.A., Fahmy, M.A., Bagdady, G.A. Abdrabboh G.A. and Hamdy A.E. **Effect of Nitrogen Fertilization Added At Various Phenological Stages on Growth, Yield and Fruit Quality of Valencia Orange Trees.** *Nat Sci* 2013;11(12):220-229]. (ISSN: 1545-0740). http://www.sciencepub.net/nature. 32

Key words: Citrus rootstocks, Nitrogen, Phenological stages and Valencia orange.

1. Introduction

Valencia orange [***Citrus sinensis* L. (Osb.)**] is the most export cultivar among other citrus species in Egypt. Citrus in terms of fruit production and also fruit juice products are highly consumed and demanded worldwide **(FAO, 2012).** The total cultivated area of citrus in Egypt reached 395731 feddan(*) in the season 2011, which produce about 3.730685 tons /year. Citrus fruits are one of the major sources of human diet due to its high nutritive value, especially vitamin C. which is very much necessary for human health because of its unique functioning including increased immunity versus influenza and decreased accumulation of calcium oxalate in the kidneys **(Haleblian *et al.*, 2008).** It is well known that nutrients are essential for the proper metabolic functioning of trees and to ensure desirable commercial fruit production **(Obreza *et al.*, 1995)**. Several studies have been conducted to determine the optimal N rates and application frequencies for adult fruitful citrus trees. **Al-Jaleel *et al.* (2005)** reported that rootstocks can affect the success and profitability of virtually any commercial citrus industry. Rootstock kind has a significant effect on citrus tree growth and yield **(Castle, 1987; Wutscher, 1989)**. Currently, most young citrus trees are fertilized with N based on tree age or size without regard to rootstock characteristics **(Tucker *et al.*, 1995)**. However, **Syvertsen and Smith (1996)** claimed that larger trees on VL rootstock required higher N rates for optimum growth than smaller trees on SO rootstock. They suggested that N rate and application frequency should be adjusted based on rootstock and tree vigor. Therefore, the aim of this study is to declare the effects of two rootstocks Volkamer lemon (VL) or (SO) and their response to different applied N-fertilizing regime in regard to N-application frequencies on vegetative growth, yield and fruit quality of Valencia orange trees.

2. Materials and Method

This study was carried out during the two successive seasons of 2010/2011 and 2011/2012 on seven years old Valencia orange trees (VO) [***Citrus sinensis* L. (Osb.)**] grown in a sandy soil a private orchard at Wadi Almollak, Sharkia Governorate, Egypt. Valencia Orange trees were budded on two citrus rootstocks namely Sour orange (SO) (***Citrus aurantium* L.**) and Volkamer lemon (VL) (***Citrus volkameriana* Ten. and Pasq.**).

The present study entailed the adult fruitful trees of Valencia Orange budded on Sour orange and Volkamer lemon rootstocks to declare the effects of both rootstocks kind on vegetative growth and yield parameters as well as the response of the two rootstocks to different application frequencies of N-fertilizing regime.

The trees are planted at 3x5 meters apart and received adequate fertilizers through fertigation process, irrigated through drip irrigation system and subjected to the same cultural practices that were followed in the orchard. Forty five trees of Valencia orange are budded on Sour orange and the same number on Volkamer lemon are devoted for the present study. The trees were chosen nearly similar in growth vigor and healthy. All fertilizing treatments included control, involved three replicates with three

trees per a replicate on each rootstock. A complete randomized block design was followed.

The nutritional treatment:

Four nutritional treatments were designed to apply 50% of the total nitrogen to the tree once in the season and that was during occurrence one of the main four phenological stages of Valencia orange budded on the two rootstocks species such that each replicate might receive the same amount of N (400g/tree/year). The main phenological stages are pre spring flush stage, fruit cell division stage, fruit cell expansion stage and pre autumn flush stage. Each one of the four stages had received 50 % of total added N-fertilizer in one dose for one time in the season. The other 50 % of N-fertilizer was added in different dose (frequencies) during the season from Jan. 1st to Dec. 31st in so that the total received amount of N-fertilizer should be 400g of N/tree/year (Table 1).

2.1. The four treatments are as follows:

1. **T1:** 50 % of the N total amount (200 g N) was added in one dose in the season at **pre spring flush stage** in the period from Feb. 20th to Apr. 2nd (that was 43 d). The other 50% of N-fertilizer was received periodically added according to the orchard plan in the season.
2. **T2:** A dose of 200 g N was added in the season at **fruit cell division stage** during the period from Apr. 9th to May 21st (that was 42 d). The other 50% of N-fertilizer was received periodically added according to the orchard plan in the season.
3. **T3:** A dose of 200 g N was added once in the season at **the fruit cell expansion stage** in the period from May 28th to Aug. 20th (that was 84 d). The other 50% of N-fertilizer was received periodically added according to the orchard plan in the season.
4. **T3:** A dose of 200 g N was added once in the season at **pre autumn flush** during the period from Aug. 27th to Nov.26th (that was 91 d). The other 50% of N-fertilizer was received periodically added according to the orchard plan in the season.
5. **5**: Control treatment (400g/tree/year): 100% of the added N-fertilizer (400g/tree/year) in different frequencies was applied to the Valencia tree in the period from Jan. 1st to Dec. 31st in sub-doses according to the fertilizing program achieved in the orchard (Table 1).

2.2. Measurements:

The following measurements has been recorded:

2.2.1. Shoot length (cm):

20 shoots/tree replicated 3 times (3 trees per a replicate) were labeled devoted to measure the shoot length (cm) periodically every week.

2.2.2. Number of leaves/ shoot:

Twenty shoots per tree such that 5 shoots (among spring flush) per main branch (two years old), nearly uniform in diameter and length were labeled on 1st March. Number of leaves/ shoot were recorded at cessation of growth in ensuing December of each season.

2.2.3. Leaf area (cm^2):

A sample of twenty mature leaves replicated three times (3 trees/replicate) was abscised at cessation of growth in December, then leaf area (cm^2) was calculated according to the equation of **Ahmed and Morsy (1999)** as follows: **Leaf area = 0.49 (Length x Width) + 19.09 =... cm^2.**

2.3. Fruit set number and percentage:

Four branches (two years old) similar in growth, such that one branch in each original direction were chosen and twelve shoots per each main branch were tagged at balloon stage of the flowering. At blooming, all open flowers/ shoot were counted. After the end of fruit set, the number of fruit set was recorded and fruit set percentage was calculated according to the following equation:

$$\text{Initial fruit set \%} = \frac{\text{Total No. of set fruits /shoot}}{\text{Total No. of opened flowers/shoot}} \times 100$$

Retained fruits percentage: Number of retained fruits/tree was counted at harvest and calculated as follows:

$$\text{Retained fruits \%} = \frac{\text{No. of retained fruits at harvest/shoot}}{\text{No. of initial set fruits/shoot}} \times 100$$

2.4. Yield:

Harvesting was achieved on (22nd April 2011/2012 and 2011/2012 seasons) and yield (Kg/tree) was recorded. Fruit yield increment or reduction percentage is compared with the control was calculated by the following equation:

$$\text{Fruit yield increment or reduction (\%)} = \frac{\text{Fruit yield (kg)/treatment - Fruit yield (kg)/ control}}{\text{Fruit yield (kg)/ control}} \times 100$$

2.5. Fruit physical characteristics:

At harvest, samples of twenty fruits of each tree replicated three times were devoted to determine the following fruit characteristics: Fruit weight (g), fruit volume (cm^3) fruit peel weight (g) and peel thickness (cm) and fruit pulp weight (g).

2.6. Fruit biochemical characteristics:

Titratable acidity (%), TSS (%) and Ascorbic acid (vitamin C.) "mg/100 ml juice" were recorded. The biochemical components were determined and TSS/acid ratio was estimated.

Statistical Analysis: a complete randomized design was followed and analysis of variance (ANOVA) was performed using two ways ANOVA Co-stat software according to **Stern (1991)**.

3.Results and Discussion

3.1. Effect of adding 50 % of total given N/tree/year at different phenological stages on vegetative growth

3.1.1. Shoot length (cm):

Adding 50 % of total given N in one dose to Valencia orange trees budded on either SO or VL rootstocks significantly increased shoot growth expressed as (length in cm) in all phenological cycles as compared with control. These results are in harmony with those obtained by **Hussein *et al.* (2003) ,** who mentioned that soil application of N at 650 g/tree to Valencia and Washington navel orange budded on SO had increased the vegetative growth parameters *i.e.* (tree canopy, shoot length and shoot number). Results also showed that shoot growth curve expressed as shoot length of Valencia orange budded on VL was superior rather than those budded on SO rootstock. The present results are confirmed by the pervious work of **Davies and Albrigo (1994) ,** who reported that scions of citrus budded on lemon type rootstocks such as VL and Rough Lemon are usually more vigorous and productive than those budded on SO rootstock. The improving effects of adding 50% of total N-fertilizer during one of the four previously mentioned phenological stages on the vegetative growth might be attributed to the stimulation of growth that leads to an increasing of shoot length. N is an important nutrient for the plant, since it has the most important role in synthesis of chlorophyll, protoplasm, protein and nucleic acid. Beside, it increases the cell division and cell expansion, **(Said, 1998 and El- Naggar *et al.*, 2002)**. The best results regarding phenological stages in both VL and SO were gained when 50 % of total given N/tree/year was applied at pre- autumn growth flush cycle. The maximum shoot growth was obtained from autumn cycle in comparison to the other cycles.

Table (1): Amount of applied N(g/tree) at various phenological stages of Valencia orange budded on either Sour orange or Volkamer lemon citrus rootstocks in seasons 2010/2011 and 2011/2012.

Phenological stages	Control			Treatment I			Treatment II			Treatment III			Treatment IV		
	Nutrient g/tree	Nutrient g/tree /day	Nutrient g/tree (%)	Nutrient g/tree	Nutrient g/tree /day	Nutrient g/tree (%)	Nutrient g/tree	Nutrient g/tree /day	Nutrient g/tree (%)	Nutrient g/tree	Nutrient g/tree /day	Nutrient g/tree (%)	Nutrient g/tree	Nutrient g/tree /day	Nutrient g/tree (%)
Jan. 1st – Feb. 13th (44 d)	67	1.52	16.75	67	1.52	16.75	67	1.52	16.75	67	1.52	16.75	67	1.52	16.75
Pre spring flush. Feb. 20th - April 2nd (43)	95	2.21	23.75	**200***	4.55	50.0	95	2.21	23.75	95	2.21	23.75	95	2.21	23.75
Fruit cell division stage April 9th - May 21st (42)	86	2.05	21.5	86	2.05	21.5	**200***	4.76	50.00	86	2.05	21.50	86	2.05	21.50
Fruit cell expansion stage May 28th - August 20th (84 d)	104	2.05	26.0	104	2.05	26.0	104	1.17	26.00	**200***	2.25	50.00	104	1.17	26.00
Pre autumn flush August 27 - Nov. 26th (91 d)	44	0.48	11.0	44	0.48	11.0	44	0.48	11.00	44	0.48	11.00	**200***	2.20	50.00
Dec. 1st – Dec. 31st (31 d)	4	1.17	1.0	4	1.17	1.0	4	1.17	1.00	4	1.17	1.00	4	0.13	1.00
Sum of total N (g)/tree/year	400		100	**505**		126.25	514		128.5	496		142.50	556		118.50

(*) 50 % of total nutrient (g/tree)

The results are in agreement with those of **Menino *et al.* (2003),** who found that application of N at 720g N/ tree to "Lane Late" orange and Valencia orange trees led to the greatest tree canopy width in "Late Lane" orange and the greatest volume in Valencia trees.

3.1.2. Leaf area (cm^2):

Adding 50 % of total given N/tree/year at the various phenological stages significantly increased leaf area of Valencia orange budded on either VL or SO rootstocks as compared with those of control in both studied season (table 2). The results are in agreement with those of **Zaied *et al.* (2006),** who found that adding 100 kg N/Feddan/year to Washington Navel orange trees budded on SO led to an increase in its leaf area. Leaf area of Valencia orange budded on VL rootstock was superior rather than those budded on SO rootstock.

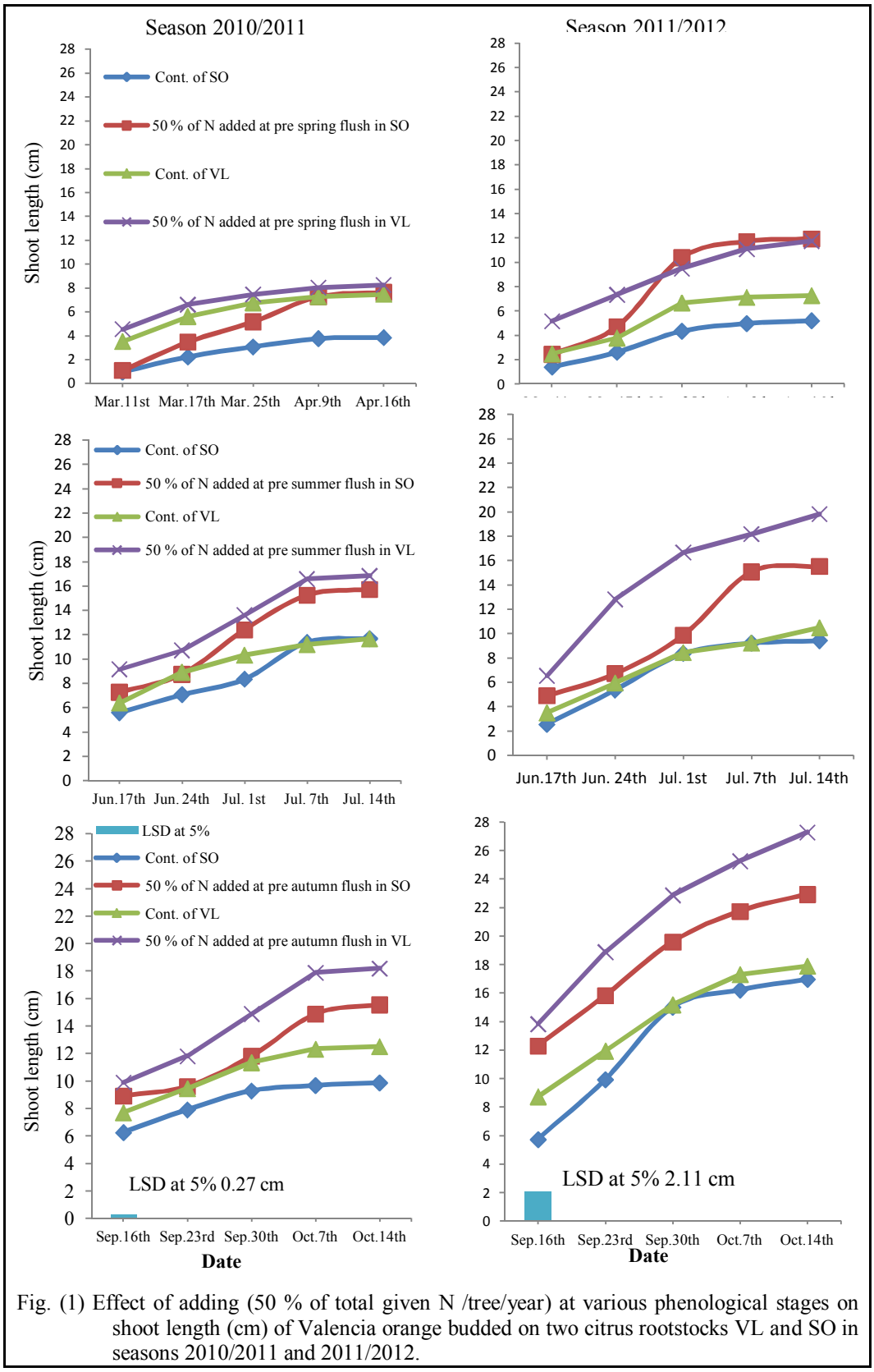


Fig. (1) Effect of adding (50 % of total given N /tree/year) at various phenological stages on shoot length (cm) of Valencia orange budded on two citrus rootstocks VL and SO in seasons 2010/2011 and 2011/2012.

These results are in harmony with those obtained by **Hegab *et al.* (2004),** who found that leaf area of Valencia orange trees budded on VL was superior rather than those budded on SO rootstock. Adding 50 % of total given N at the fruit cell expansion stage significantly increased leaf area more than did the application on other phenological stages (Table 1). The increase in leaf area (cm^2) may be due to the positive effect of nitrogen on many important plant structures, genetic and metabolic compounds in plant cells **(Don, 2001)**.

3.1.3. Leaves number:

All N treatments significantly increased the leaves number per shoot of Valencia orange budded on either SO or VL rootstocks in the two studied seasons compared with that of control (table 2). The results are in agreement with those of **Menino *et al.* (2003),** who found that application of N at 720g N/ tree to "Lane Late" orange and Valencia orange trees led to the greatest tree canopy width in "Late Lane" orange and the greatest volume in Valencia trees.

The increase in number of leaves per shoot may be due to the physiological role of nitrogen nutrient in stimulating the cell division and hence, the plant growth. In addition**,** nitrogen is an essential component of the proteins that build up the cell material and plant tissue **(Thompson *et al.* , 2002)**. The results also indicated that leaves number per shoot of Valencia orange budded on VL was superior rather than those budded on SO. The present result is confirmed by the pervious work of **Hegab *et al.* (2004),** who found that leaves number/shoot of Valencia orange budded on VL rootstock was superior rather than that budded on SO rootstock. Adding 50 % of given N at pre spring flush stage significantly increased the leaves number per shoot of Valencia orange more than did the application on other phenological stages (table 1). The results are in agreement with those of **Wassel *et al.* (2007),** who found that adding N at rates of 400, 600, 800 and 1000 g / tree /year on to Balady mandarin trees budded on SO rootstock increased shoot length and number of leaves per shoot in comparison with that of control.

Table 2. Effect of adding 50 % of total given N /tree/year at various phenological stages on vegetative growth of Valencia orange budded on citrus rootstocks in seasons 2010/2011 and 2011/2012.

Fertilization treatments and time of application	leaf area (cm^2)				No. of leaves/shoot			
	Season 2010/2011		Season 2011/2012		Season 2010/2011		Season 2011/2012	
	SO	VL	SO	VL	SO	VL	SO	VL
Cont.400 g N / tree during all phenological stages in growth season.	37.89e	48.99 d	43.25 f	46.6 f	6.15g	8.43f	7.29d	8.70d
200 g N /tree at pre spring flush. (Feb. 20th - April 2nd)	57.46 c	64.92 b	60.6cd	64.15 bc	12.80a	12.62 ab	15.24b	16.57b
200 g N /tree at fruit cell division stage (Apr. 9th - May 21st)	50. 47 cd	65.01 b	54.05 e	64.1 bc	10.45d	12.1 abc	15.67b	13.55c
200 g N /tree at fruit cell expansion stage (May 28th - Aug. 20th)	51.6 cd	72.89a	68.95 ab	72.6 a	11.95bc	9.80e	15.65b	18.20a
200 g N /tree at pre autumn flush (Aug. 27th - Nov. 26th)	47.41 d	54.4 cd	54.59 de	62.7 cd	11.5c	12.55 ab	12.00c	13.00c
Average (A)	49.05B	61.25A	56.62B	61.38A	10.57B	11.1A	13.17B	14.0A

Means followed by the same letter (s) in each column or row and the interactions are not significantly different at 5 % level.

3.2. Effect of adding 50 % of total given N on fruiting and yield:

3.2.1. Fruiting:

Adding 400 g/tree/year (control treatment) increased number of inflorescences/shoot, number of fruit set/shoot, fruit set percentage, No. of retained fruits per shoot on June,18th, number and percentage of retained fruits at harvest of Valencia orange budded on VL rootstock compared with that budded on SO. Adding 50 % of total given N/tree/year at pre spring flush phenological stage significantly increased number of inflorescences per shoot, number of fruit set/shoot, fruit set percentage, No. of retained fruits per shoot on June, 18th, number and percentage of retained fruits at harvest of Valencia orange trees budded on VL and SO rootstocks as compared with those of control in both seasons. These results are in line with findings of **Abo El-Komsan *et al.* (2003)** who reported that significant increase in fruit yield, number of leafy inflorescences, fruit set, fruit retention %, and reduced June drop was noticed when N applied at different rates to White Khalily orange trees as compared with those of control.

Also, no. of inflorescences /shoot, number of fruit set/shoot, fruit set percentage, no. of retained fruits per shoot on June, 18th, number and percentage of retained fruits at harvest of Valencia orange trees budded on VL

rootstock were superior to those budded on SO rootstock in control plants (Fig. 2). These results are in agreement with that of **Ibrahim (2005)** who cleared that fruit set % of Valencia orange trees budded on VL rootstock was higher than those budded on SO rootstock while fruit drop % showed an opposite trend. Fruit June drop percentage was decreased in response to either N application or citrus rootstocks in the two studied seasons (Fig. 2). Fruit June drop percentage of Valencia orange trees budded on SO rootstock was significantly higher than those budded on VL rootstock (Fig. 2). These results are in line with findings of **Schumann *et al.* (2003) ,** who reported that significant increase in fruit numbers and fruit yield/tree was noticed when 'Hamlin' orange trees were treated with different rates of N as compared with those of control.

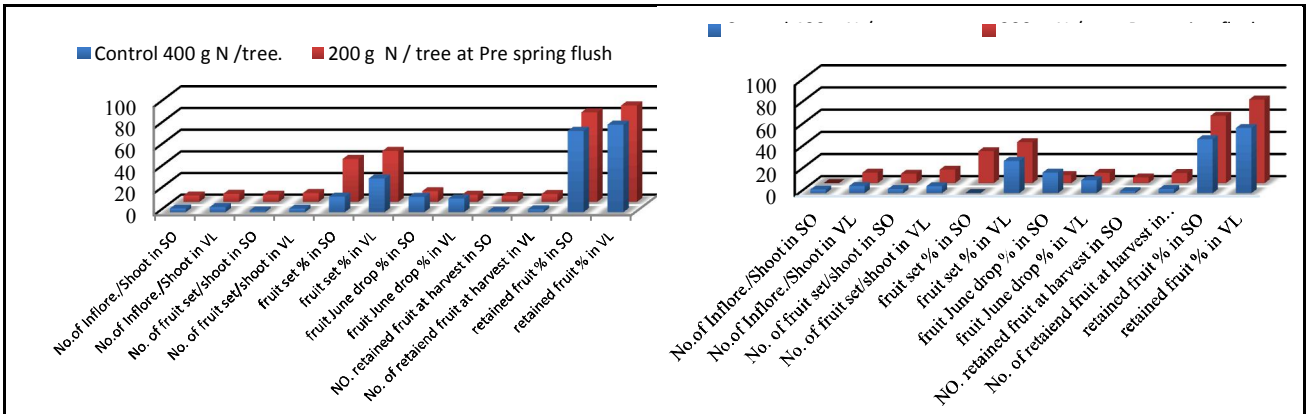


Fig. 2. Effect of adding 50 % of total given N /tree/year at pre spring flush phenological stage on fruit set %, fruit drop% and fruit retained % of Valencia orange cv. budded on the two rootstocks in seasons 2010/2011 and 2011/2012.

3.2.2. Fruit yield (kg/tree):

Fruit yield (kg/tree) of control plants slightly increased in Valencia orange trees budded on VL rootstock more than those on SO rootstock (fig. 3). The results indicated that rootstock kind had not a great effect on the fruit yield of the scion. The present results are in agreement with that previously obtained by **EI-Sayed *et al.* (2007)** who found that Washington navel orange budded on VL produced fruit yield (kg/tree) higher than those budded on SO rootstock. Adding 50 % of total given N fertilizer/tree/year at various phenological stages of Valencia orange trees budded on either VL or SO rootstocks significantly increased the fruit yield pre tree (kg/tree) when compared with that of control. However, VL rootstock caused more significant increase in fruit yield (kg/tree) than SO rootstock in all N-fertilizer treatments. The present results are in agreement with that previously obtained by **Alva *et al.* (2006),** who found that adding Nitrogen at different rates to Hamlin orange trees led to a significant increase in yield/tree.

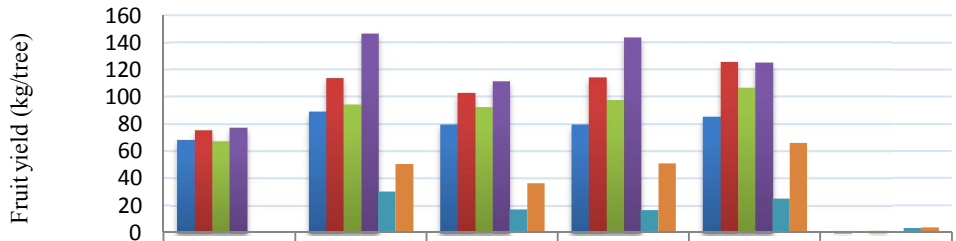
Adding 50 % of total given N/tree/year at both **pre autumn flush stage** for SO and **pre spring flush stage** under the effect of rootstock for VL caused the most increase in fruit yield (kg/tree) compared with other phonological stages and control. The marked effect of N-fertilizer treatments on increasing the fruit yield might be due to the cumulative stimulating effect of nitrogen treatments on the vegetative growth which form the base of flowering and fruiting **(Dawoud, 1994)**. Also, adding 50 % of total given N/tree/year at pre spring flush significantly increased the percentage of increase in yield (kg/tree) of Valencia orange budded on both VL and SO citrus rootstocks in comparison to other phenological stages and control (Fig. 3). On the other hand, adding 50% of the total N during the period of fruit cell expansion stage caused the least increase in the fruit yield (kg/tree). In fact nitrogen is the key component in mineral fertilizers applied to citrus groves, since it influences tree growth, fruit production as well as fruit quality than any other nutrient, **(Zekri and Obreza, 2003)**.

Valencia orange trees budded on VL rootstock was more responsive to the adding 50 % of total given N /tree/year at various phenological stages than those budded on SO rootstock regarding fruit yield (Fig. 3). Increasing fruit production of Valencia orange budded on VL rootstock may be due to its ability to generate more extensive root that would absorb more water and nutrients **(Reuther et al., 1967)**. Maximum increase in fruit production was found in the trees on VL rootstock in all phenological stages of Valencia orange in which 50% of total N was added.

3.3. Effect of adding 50 % of given total N on fruit physical characteristics at harvest:

Regarding the effect of rootstock kind on fruit weight and fruit volume of control treatment the results in table (3) showed that fruit weight of Valencia cv. budded on VL was greater than those budded on SO. Adding 50 % of the

total given N/tree/year to Valencia orange trees budded on either VL or SO rootstocks at various phenological stages had significantly increased fruit weight, fruit volume, fruit peel thickness, and fruit pulp weight in comparison to those of control (Tables 3 and 4). The present results are in agreement with that of **Sabban *et al.* (1997),** who found that fertilizing of Valencia orange trees budded on SO with N at 1000 g/ tree/year had increased fruit weight and volume compared with that of control. The increase in fruit weight and volume resulted from adding 50% of total N/tree/year in one dose through the period of each phenological stages could be attributed to the increase in number of leaves per shoot and leaf area caused by N-fertilizer and the subsequent stimulation of photosynthesis intensity the results in table (3), emphasized that Valencia orange budded on VL rootstock had possessed the greatest fruit weight, when the tree received 50% of total N-fertilizer during the period of pre spring flush or the period of fruit cell division stage.



	Cont. 400 g N / tree	Adding 50% of N at pre spring flush	Adding 50% of N at fruit cell division stage	Adding 50% of N at fruit cell expansion stage	Adding 50% of N at pre autumn flush	LSD at 5%
Season 2010/2011 (SO)	68.68	89.25	80.16	80	85.63	1.55
Season 2010/2011 (VL)	75.9	114.2	103.28	114.64	125.89	
Season 2011/2012 (SO)	67.62	94.6	92.6	97.82	106.98	1.93
Season 2011/2012 (VL)	77.48	146.64	111.5	143.57	125.34	
The increase % in yield / tree compared with control (SO)	0	29.94	16.71	16.49	24.67	3.17
The increase % in yield / tree compared with control (VL)	0	50.37	35.98	50.94	65.75	3.8

Fig. 3. Effect of adding 50 % of total given N /tree/year at various phenological stages on fruit yield (kg/tree) of Valencia orange budded either on SO or VL rootstocks in seasons 2010/2011 and 2011/2012.

Table.3. Effect of adding 50 % of given N /tree/year at various phenological stages on some physical characteristics of Valencia orange budded on citrus rootstocks in seasons 2010/2011 and 2011/2012.

Fertilization treatments and time of application	Fruit weight (g)				Fruit volume (cm^3)			
	Season 2010/2011		Season 2011/2012		Season 2010/2011		Season 2011/2012	
	SO	**VL**	**SO**	**VL**	**SO**	**VL**	**SO**	**VL**
Cont. 400 g N / tree during growth season.	217.1h	269.9ce	202.8j	237.9i	186.7i	277.4d	229.3g	231.7g
200 g N /tree at pre spring flush. (Feb. 20th - April 2nd)	239.1g	415.7a	249.2g	268.9e	261.7e	434.1b	250.8f	291.8c
200 g N /tree at fruit cell division stage (Apr. 9th - May 21st)	297.8d	380.8b	284.8c	286.6b	256.7f	390.1c	307.5b	333.3a
200g N /tree at fruit cell expansion stage (May 28th - Aug. 20th)	252.3f	413.6a	256.9f	271.9d	243.3h	484.4a	281.0d	271.7e
200 g N /tree at pre autumn flush (Aug. 27th - Nov. 26th)	257.4f	344.2c	243.6h	291.0a	247.7g	390.9c	253.8f	272.8e
Average (A)	252.7B	364.9A	247.5B	271.2A	239.2B	395.4A	264.5B	280.3A

Means followed by the same letter (s) in each column or row and the interactions are not significantly different at 5 % level.

Fruit peel thickness (cm) showed low response for adding 50% N /tree/year except in those applied at pre spring flush in VL in the first season and pre autumn stage in the second one, where the increase of peel thickness attained the maximum among all treatments and control (Table 4). VL usually supplies the scion with an extreme vigor, great tree size, and cause large fruit. VL rootstock vigority may be attributed to its ability to generate a more extensive root that would absorb more water and nutrients **(Reuther *et al.*, 1967)**. Adding 50 % of given N/tree/year

to Valencia orange budded on either VL or SO significantly increased the orange juice volume (cm^3) in comparison to those of control in both seasons. Also, Adding 50 % of total given N /tree/ year at either at fruit cell expansion or pre spring flush phenological stages to Valencia orange budded on VL or SO led to maximum Valencia orange fruit juice volume (cm^3) (Table 5). It could be observed that maximum values of growth parameter or fruit physical characteristics are not changes existed in a definite phenological stage of Valencia plant. The present results are in agreement with those of **Sabban *et al.* (1997) ,** who found that application of N 1000 g/ tree/year to Valencia orange trees budded on SO increased fruit juice volume of Valencia orange in comparison to control. Regarding the effect of kind of rootstock on fruit juice volume, no significant difference between the effect of two tested rootstocks on fruit Juice volume was found.

Table 4. Effect of adding 50 % of total given N /tree/year at various phenological stages on some physical characteristics of Valencia orange budded on citrus rootstocks in seasons 2010/2011 and 2011/2012.

Fertilization treatments and time of application	Fruit peel thickness (cm)				Fruit peel weight (g)			
	Season 2010/2011		Season 2011/2012		Season 2010/2011		Season 2011/2012	
	SO	VL	SO	VL	SO	VL	SO	VL
Cont. 400 g N / tree added during growth season.	0.37d	0.52bc	0.44 d	0.52cd	43.1h	70.1e	51.9g	61.3f
200 g N /tree at pre spring flush. (Feb. 20th - April 2nd)	0.57 bc	0.77a	0.39 ab	0.57 bc	68.4f	111.2b	74.8d	81.2c
200 g N /tree at fruit cell division stage (Apr. 9th - May 21st)	0.47cd	0.68 ab	0.57 bc	0.62 abc	63.0g	110.6b	74.0d	82.1c
200g N /tree at fruit cell expansion stage (May 28th - Aug. 20th)	0.57 bc	0.70ab	0.57 bc	0.64 abc	72.4d	118.8a	73.4d	88.9a
200 g N /tree at pre autumn flush (Aug. 27th - Nov. 26th)	0.53 bc	0.62 abc	0.59 bc	0.72 a	63.7g	98.5c	70.5e	85.7b
Average (A)	0.5B	0.66A	0.56B	0.61A	62.1B	101.8A	68.9B	79.9A

Means followed by the same letter (s) in each column or row and the interactions are not significantly different at 5 % level.

Table 5. Effect of adding 50 % of total given N /tree/year at various phenological stages on some physical characteristics of Valencia orange budded on citrus rootstocks in seasons 2010/2011 and 2011/2012.

Fertilization treatments and time of application	Fruit Pulp weight (g)				Juice volume of fruit (cm^3)			
	Season 2010/2011		Season 2011/2012		Season 2010/2011		Season 2011/2012	
	SO	VL	SO	VL	SO	VL	SO	VL
Cont. 400 g N / tree during growth season.	173.9c	199.9c	150.8g	176.5e	99.3h	99.9h	99.2e	93.3f
200 g N /tree at pre spring flush. (Feb. 20th - April 2nd)	170.7c	304.6a	174.4ef	187.7c	122.4c	112.7f	116.7a	114.2b
200 g N /tree at fruit cell division stage (Apr. 9th - May 21st)	234.8b	270.2ab	210.8a	204.4b	120.8d	116.1e	100.8e	112.5c
200g N /tree at fruit cell expansion stage (May 28th - Aug. 20th)	179.8c	294.8a	183.5d	182.9d	125.0b	130.2a	116.7a	108.3d
200 g N /tree at pre autumn flush (Aug. 27th - Nov. 26th)	193.7c	245.7b	173.1f	205.2b	121.1d	106.4g	99.2e	107.5d
Average (A)	190.6B	263.0A	178.5B	191.4A	117.7A	113.1B	107.2A	106.5B

Means followed by the same letter (s) in each column or row and the interactions are not significantly different at 5 % level.

3.4. Effect of adding 50 % of given N on fruit biochemical characteristics:

Comparing data of TSS%, and TSS/Acid ratio (Tables 6 and 7) in fruit juice of Valencia scions budded on VL or SO rootstock, it was clear that the control plants showed an increase in TSS% and TSS/Acid ratio when the rootstock was VL compared with other rootstock SO. Oppositely Valencia orange budded on so rootstock showed an increase in that total acidity comparing with VL-rootstock in control treatment. Adding 50 % of total given N /tree/year slightly increased TSS percentage of fruit in all studied phenological stages except the plant budded on VL rootstock in the first season 2010/2011 since the increase of TSS% was insignificant compared with other N treatments or control (Table 6). TSS/acid ratio and ascorbic acid values (V.C. mg/100ml of fruit juice) were increased when compared with those of control. The flavor and palatability of citrus fruit is a function of relative levels of TSS%, acids and the presence or absence of various aromatic or bitter juice constituents **(Davies and Albrigo, 1994)**

The Titratable total acidity percentage in fruit juice of Valencia orange trees budded on either VL or SO rootstocks at harvest was decreased as compared with that of control in both seasons. These results are in line with findings of **El-Saida (2006),** who found that application of N at (1200 g/tree) to Balady mandarin budded on SO increased vitamin C content. Similarly, **Schumann *et al.* (2003),** found that quadratic response of 'Hamlin' orange to N fertilizer can be seen in different parameters such as TSS % of orange juice which increased by increasing N-

fertilizer. Ascorbic acid (V.C.) and TSS percentage of Valencia orange trees budded on SO rootstock was superior to those budded on VL rootstock. The present results are in agreement with **EI-Sayed *et al.* (2007),** who found that Washington navel orange budded on VL produced fruits with highest juice acidity and ascorbic acid but presented lower TSS and TSS/acid ratio at harvest time in both seasons. The increasing in Ascorbic acid (V.C. mg/100ml of fruit juice) as well as Titratable acidity percentage in fruit juice at harvest time could be attributed to the increase in fruit weight and size and to the increase in shoot growth and leaf area caused by N-application **(Chen *et al.*, 1999).** Adding 50 % of total given N/tree/year at either fruit cell division stage or fruit cell expansion stages showed a stimulation in fruit biochemical characteristics in comparison to those received 50% of total added N-fertilizer during other phenological stages and control. Data also revealed that Ascorbic acid (vitamin C. content) and TSS percentage during the first season 2010/2011 of Valencia orange trees budded on SO rootstock was superior to those budded on VL rootstock. The best results regarding phenological stages in both VL and SO were gained when 50 % of total given N/tree/year was applied at either fruit cell division stage or fruit cell expansion stage as they caused the highest values of other fruit biochemical characteristics in comparison to control or other nutritional treatments.

Table 6. Effect of adding 50 % of total given N /tree/year at various phenological stages on some biochemical characteristics of Valencia orange budded on citrus rootstocks in seasons 2010/2011 and 2011/2012.

Fertilization treatments and time of application	TSS (%)				Titratable acidity (%)			
	Season 2010/2011		Season 2011/2012		Season 2010/2011		Season 2011/2012	
	SO	VL	SO	VL	SO	VL	SO	VL
Cont. 400 g N / tree during growth season.	9.0 ab	9.7a	8.3f	8.7e	1.0a	0.8 cd	1.1 a	1.0 b
200 g N /tree at pre spring flush. (Feb. 20th - April 2nd)	10.4a	7.7 b	9.3c	9.7b	0.9 ab	0.5 e	1.05 b	0.96 bc
200 g N /tree at fruit cell division stage (Apr. 9th - May 21st)	10.4a	7. 7 b	9.6b	9.7b	0.9 ab	0.7d	0.7 e	0.8 cd
200g N /tree at fruit cell expansion stage (May 28th - Aug. 20th)	10.5a	9.4a	9.7b	8.9d	0.8bc	0.7d	0.9 bc	0.89 d
200 g N /tree at pre autumn flush (Aug. 27th - Nov. 26th)	10.6a	8.0 b	10.0a	8.3a	0.9ab	0.6d	0.8 d	0.67 e
Average (A)	10.2A	8.5B	9.4A	9.1B	0.94A	0.389.4B	0.87B	0.92A

Means followed by the same letter (s) in each column or row and the interactions are not significantly different at 5 % level.

Table 7. Effect of adding 50 % of total given N /tree/year at various phenological stages on V.C. (mg/100 ml of fruit juice) and TSS/Acid ratio of fruit of Valencia orange budded on citrus rootstocks in seasons 2010/2011 and 2011/2012.

Fertilization treatments and time of application	V.C. mg/100 ml of fruit juice				TSS/Acid ratio			
	Season 2010/2011		Season 2011/2012		Season 2010/2011		Season 2011/2012	
	SO	VL	SO	VL	SO	VL	SO	VL
Cont. 400 g N / tree/year during growth season.	40.7e	37.4g	42.7c	38.5d	8.7b	13.0ab	7.2c	8.4bc
200 g N /tree at pre spring flush. (Feb. 20th - April 2nd)	45.6b	38.9f	54.6a	44.8bc	10.9ab	15.1a	8.9abc	10.1abc
200 g N /tree at fruit cell division stage (Apr. 9th - May 21st)	43.0d	37.7g	47.6b	45.4bc	10.9ab	11.2 ab	14.9a	12.0ab
200g N /tree at fruit cell expansion stage (May 28th - Aug. 20th)	46.9a	41.6e	47.3b	45.4bc	12.5 ab	13.7a	10.0abc	10.1abc
200 g N /tree at pre autumn flush (Aug. 27th - Nov. 26th)	44.3c	38.6f	43.3c	41.9c	11.4 ab	12.5ab	12.9ab	12.4ab
Average (A)	44.1A	38.9B	47.1A	43.2B	10.9B	13.1A	11.0A	10.6A

Means followed by the same letter (s) in each column or row and the interactions are not significantly different at 5 % level.

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11/22/2013