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IMPACT OF SOME NITROGEN FERTILIZATION TREATMENTS ON VALENCIA ORANGE TREES A. EFFECT ON FRUIT SET, YIELD AND FRUIT QUALITY

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ABSTRACT

This study was conducted during three successive seasons of 2013/2014, 2014/ 2015 and 2015/2016, on 6-year-old Valencia orange (*Citrus sinensis*, L. Osbeck) trees budded on sour orange rootstock and grown in sandy soil at 4 × 5 m under drip irrigation system. Forty-eight trees were subjected to 12 N fertilization treatments using ammonium nitrate (33.5%N) fertilizer. The N fertilizer was added through fertigation, soil application and trunk injection at different rates and periods. Trees fertigated at 1000 g N/ tree/year 3 times/ week gained the highest fruit set and fruit retention percentages in the three seasons. Trunk injected trees induced also higher percentages although they consumed very small amounts of N (0.2 – 0.3% of the recommended rate). Leafy inflorescences exhibited higher fruit set and fruit retention percentages than leafless ones. Fruit retention percentage on leafy inflorescences was 21.71, 3.14 and 2.97 folds its percentage on leafless ones in the three seasons, respectively. The highest yield and number of fruits/ tree as well as cropping efficiency were gained by trees fertigated at 1000 g N/tree/year 2 or 3 times/ week, followed by those soil applied at the same rate 3 times/ year and those trunk injected without significant differences between them in most cases. The produced fruits on trees of these treatments contained higher vitamn. C and lower total soluble solids (TSS)/ acid ratio. Trunk injected trees not only consumed very small amounts of fertilizers, but also produced comparable higher yield of fruits with higher firmness, juice volume, TSS/ acid ratio and vitamn. C content. They gave lower TSS and total acidity percentages in comparison with the other tested fertilization treatments in the three seasons.

Key words: Nitrogen fertilization, valencia orange, fertigation, soil application, trunk injection.

INTRODUCTION

Citrus is one of the most important fruit crops in the world and ranked first among fruit crops in Egypt. The cultivated area with citrus in Egypt has enormously increased through the last decades reaching about 530415 fad., out of them 440706 fad., are fruitful producing about 4402180 tons with average of 9.99 tons/fad. Sweet orange (*Citrus sinensis*, L. Osbeck) is one of the most important citrus species. Total areas of orange varieties occupy about 370087 fad., representing 69.77% of total citrus acreage, out of them 300949 fad., are fruitful, producing 3135931 tons with average of 10.42 tons/fad. The acreage of Valencia orange reached 145858 fad., representing 39.41% of orange acreage out of them 106862 fad., are fruitful, producing about 1030713 tons with average of 9.65 tons/ fad. (Statistics of Ministry of Agriculture, 2014).

Citrus trees require a range of plant nutrition's in various amounts to maintain high production of good quality fruits. Adequate nitrogen nutrition is essential for optimum vegetative growth and top fruit yield and quality. Nitrogen is very important in nutrition because it has an extreme importance in plants as a constituent of proteins, nucleic acids, vitamins, hormones, chlorophyll, and many other organic compounds, meaning that it is

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structurally involved in most catalytic molecules (Nijjar, 1985).

Nitrogen affects the absorption and distribution of all other elements, and it is particularly important to the tree during flowering and fruit set. (Obreza, 2001; Zekri and Obreza, 2002; Obreza *et al.*, 2008).

Heavy nitrogen requirements exist for citrus in the spring during flowering and fruit set when 75 -95% of all new shoots are produced. For maximum yields, it's absolutely necessary that sufficient nitrogen should be in the leaves at the right time (Nijjar, 1985). Studies in this respect, revealed that 900 - 1300 g N/ tree was optimum for Navel orange (Legaz *et al.*, 1981). Increasing nitrogen rate over the optimum dose encourages excessive vegetative growth and may cause ground water contamination when leached with excess irrigation water (Davies and Albrego, 1994; Schuman *et al.*, 2003; Alva *et al.*, 2006).

Conventional methods of plant nutrition depend upon fertilization through soil broadcasting, splitting, dressing and fertigation. Foliar fertilization can only serve as a supplement in a particular case such as high values of the soil solution, high $CaCO_3$ content and high salinity.

Fertigation is a technique for application of fertilizers in irrigation water. The advantages of fertigation include: 1) saving fertilizer application costs and labor; 2) fertilizer elements are already in solution and become available to plant roots more quickly than dry materials placed on soil surface; 3) the high flexibility in irrigation timing makes it easier to schedule fertilization; 4) minimizing soil compaction by avoiding heavy equipment traffic through the field to apply fertilizers; 5) careful regulation and monitoring of nutrient supply; 6) application of nutrients matched in amounts and timing to the plant nutrient requirements and 7) carefully managed fertigation results in lower nutrient leaching losses than broadcast application of water-soluble granular fertilizers (Burt *et al.*, 1998).

Trunk nutrition is a method of fertilizing trees through xylem tissue. This method was used along the time in small scale studies to solve the problem of uptake and/or translocation of a single element like iron or potassium. The previous studies on efficiency ratio of soil fertilization proved that a small portion of the added fertilizers is taken up by the plant roots, while the great portion 62-85% of nitrogen (Dixon, 2003), 80 - 95% of P and K (Halliday and Trenkel, 1992) is lost by leaching, volatilization, and fixation. So, injecting fertilizers directly through tree trunks may realize the efficacy of this method (Shaaban, 2012).

Moreover, trunk fertilization system is very simple, very cheap, and easy applicable, since it saves labor wedges paid for conventional fertilizer distribution along the tree growth season.

This investigation aimed to study the effect of various N application methods, *i.e.* fertigation, soil application, soil injection and trunk injection on fruit set, yield, and fruit quality of Valencia orange trees.

MATERIALS AND METHODS

This study was carried out during three successive seasons of 2013/2014, 2014/2015 and 2015/ 2016 on 6 – year-old Valencia orange (*Citrus sinensis* L. Osbeck) trees budded on sour orange rootstock. The trees were grown in a private citrus orchard located at Wady El-Mollak region, Abo-Hammad District, Sharkia Governorate, Egypt. The trees were planted at 5 x4 meters in sandy soil under drip irrigation system. The experimental trees were healthy and approximately similar in growth vigor and size and subjected to the normal agro–technical practices ordinary followed in the commercial citrus orchards in respect of irrigation, pruning, pest control and fertilization except nitrogen distribution at 1000 g N/tree/year and application methods.

All trees were supplied with each of calcium super phosphate and potassium sulfate at 200 kg/ fad./ year. Phosphoric acid (50%) was fertigated at 2 l/fad./week throughout growth season.

The experimental Procedures

Forty eight Valencia orange trees were chosen for this experiment. The selected trees

were subjected to the following 12 N fertilization treatments in the form of ammonium nitrate (33.5 % N):

1- Fertigation at 100 % of the recommended N dose (1000 g N/ tree/year) 3 times/week at flowering and fruit setting periods (early March till the end of May), and twice a week at the beginning of June until the end of September (T1).

2- Fertigation at 100% of the recommended N dose, 2 times/week at flowering and fruit setting periods (early March till the end of May), and once/ week at the beginning of June till the end of September (T2).

3- Fertigation at 75 % (750 g N/ tree/year) of the recommended N dose, 3 times a week at flowering and fruit setting periods (early March till the end of May), and twice a week from the early of June till the end of September (T3).

4- Fertigation at 75 % (750 g N/ tree/year) of the recommended N dose, 2 times a week at flowering and fruit setting periods, and 1 time/week from the first of June until the end of September (T4).

5- Soil application at 30% (300 g N/ tree) of the recommended N dose at early March + 70% (700 g N/ tree) fertigation once a week from April till the end of September (combined treatment) (T5).

6- Soil application at 100% of the recommended N dose (1000 g N/ tree) 3 times/ year at early of each of March, May and August (T6).

7- Soil application at 100% of the recommended N dose, 5 times/year at early March and mid of each of April, May, June and August (T7).

8- Soil application at 100% of the recommended N dose, 7 times/ year at the first of March, April, May, June, July, August and September (T8).

9- Soil injection with 100% (1000 g N/ tree) of the recommended N dose, 7 times/ year at the first of March, April, May, June, July, August and September (T9).

10- Trunk injection with N fertilizer solution (0.5 g / l) at early March till the end of September (T10).

11- Trunk injection with N fertilizer solution (0.62 g/ l) at early March till the end of September (T11).

12- Trunk injection with N fertilizer solution (0.75 g/ l) at early March till the end of September (T12).

The N fertilizer solution was injected throughout a pore (4 cm deep and 0.8 cm in diameter) in the trunk, 30 cm above soil surface, using an electrical poring machine model (-21J-13- China). A hard plastic tube (injection needle of 3.5 cm length and 0.5 – 1.5 cm in diameter) was tightened in the pore using hot paraffin wax which has the advantage of sterilizing the pore opening, stopping sap bleeding and preventing fertilizer solution from flowing out from the injection side. The injection needle was tightly connected with a small plastic tank containing fertilizer solution by a plastic tube. The plastic tank was located 1.5 m higher than the injection site and the fertilizer solution was continuously applied throughout the growth season.

With regard to soil injection treatment, 8 holes were holed using an auger 1m apart around tree trunk with 70 – 90 cm depth. About 430 g ammonium nitrate fertilizer were solved in 5 l water and equally distributed into the previously prepared holes 7 times / year.

The above mentioned treatments were adopted to the same trees during the three experimental seasons.

The responses of the tested Valencia orange trees to the applied N fertilization treatments were evaluated through the following parameters:

Fruit set and fruit retention percentages

Four similar branches at the different tree directions were labelled. The emerged flowers on leafy and leafless inflorescences on each branch were counted at the balloon stage by the end of March in each season. After fruit set by the end of April, the setted fruitlets on each inflorescence type were counted at the same branches. Then fruit set percentages were calculated for each inflorescence type. The remaining fruits on each branch and inflorescence type after June drop were counted before harvest in each season. Then fruit retention percentage was calculated.

Fruit yield

At the commercial harvesting date of Valencia orange cultivar (the end of February) the remained fruits on each tree were picked, counted and weighed in each season. Then the average yield per tree (kg/ tree) and the average number of fruits/ tree was registered.

Cropping efficiency

As Kg fruits/ m^3 canopy volume was calculated by dividing tree fruit yield (Kg/ tree) on the canopy volume (Roose *et al*., 1989; Whitney *et al*., 1995).

Fruit characteristics

After fruit harvest, 15 fruits were randomly collected from each replicate to determine the following fruit characteristics:

- Average fruit weight (g) and size (cm^3).
- Fruit firmness (g/cm^2)
- Ten fruits from each replicate were juiced in electrical blender. Then average juice volume/ fruit (cm^3) was estimated.
- Titratable acidity percentage in fruit juice was determined as citric acid by titration against 0.1 N sodium hydroxide solution in the presence of phenolphythalein index as indicator and the total acidity percentage was calculated (AOAC, 2006).
- Total soluble solids percentage (TSS%) was determined in fruit juice using a hand refractometer. Then TSS/ acid ratio was calculated.
- Vitamin C content as mg ascorbic acid / 100 ml juice was determined by titration against 2, 6-dichlorophenol endophenol dye (AOAC, 2006).

Statistical Analysis

This experiment was setted in a completely randomized block design with 12 treatments. Each treatment was applied to four orange trees (four replicates). The obtained data were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran (1980) using CO-STAT program. Differences between means were compared using Duncan's multiple range test at 0.05 level (Duncan, 1958).

RESULTS AND DISCUSSTION

Fruit Set (Initial Fruit Set) Percentage

Data in Table 1 show that the tested N fertilization treatments significantly affected fruit set percentage on leafy and leafless inflorescences of Valencia orange trees in the three seasons. However, trees fertigated at 1000 g N/tree 3 times/ week (control treatment) gained the highest fruit set percentage (34.01, 30.77 and 28.43%) in the three seasons, respectively, followed by trees fertilized *via* soil injection at 1000 g N tree 7 times/ year (32.39%) in the first season and those fertigated at 750 g N/tree 2 times/week (32.28 and 28.11%) in the first and third seasons and trunk injected trees at 0.5 g N/ l (29.07%) in the second season. Trunk injected at 0.75 g N/ l (27.68%) and those fertilized *via* soil application at 1000 g N/ tree 5 times/ year (25.98%) gained also higher fruit set percentages in the third season without significant differences between them. The lowest fruit set percentages were recorded for the other treatments, especially trees fertigated at 750 g N/ tree 3 times/ week (27.04%), those trunk injected at 0.62 g N/l (23.24%) and soil applied trees at 1000 g N/tree 3 times/year (19.44%) in the first, second and third seasons, respectively.

Concerning the effect of inflorescences type, the data show that leafy inflorescences exhibited higher fruit set percentages (32.05, 26.12 and 26.19%) than leafless ones (27.39, 24.72 and 23.02%) in the first, second and third seasons, respectively. Fruit set percentage on leafy inflorescences was 14.54, 5.36 and 12.10% higher than those on the leafless ones in the three seasons, respectively

The interaction between fertilization treatments and inflorescences type was significant in the three seasons and confirm the previously reported effect of each individual factor on fruit set percentage. Since, leafy inflorescences setted more fruits than leafless ones under most fertilization treatments. Fertigated trees at 1000 g N 3 times/week induced the highest fruit set percentage. Fruit set percentage on leafy inflorescences of Valencia orange trees ranged between 29.60- 36.01%,

Table 1. Effect of some nitrogen fertilization treatments on fruit set percentage on leafy and leafless inflorescences of Valencia orange trees (2013 / 2014, 2014 / 2015 and 2015 / 2016 seasons)

Inflorescence type / Fertilization treatment	First season (2013 / 2014)		Treatment mean	Second season (2014 / 2015)		Treatment mean	Third season (2015 / 2016)		Treatment mean
	Leafy (%)	Leafless (%)		Leafy (%)	Leafless (%)		Leafy (%)	Leafless (%)	
Fertigation at 1000 g N/ tree 3 times/ week	31.87 cd	36.17 a	34.01A	32.58a	28.98bc	30.77 A	32.93 a	23.93 efghi	28.43 A
Fertigation at 1000 g N/ tree 2 times/ week	27.57 f	27.97 f	27.76 E	29.29bc	27.66bcde	28.47 BC	22.88 efghi	21.30 hi	22.09 E
Fertigation at 750 g N/ tree 3 times/ week	31.40 cde	22.67 hi	27.04 E	25.77defg	20.81k	23.29 D	24.32 efghi	24.07 efghi	24.19 CDE
Fertigation at 750 g N/tree 2 times/ week	33.17 bc	31.40 cde	32.28 AB	25.62defgh	22.29ijk	23.95 D	29.95 ab	26.26 cdef	28.11 A
Soil application 300 g N at early March + 700g N/ tree fertigation	29.60 def	31.80 cd	30.7 BC	30.18ab	22.66hijk	26.41 C	23.33 efghi	21.69 hi	22.51E
Soil application at 1000 g N/ tree 3 times/ year	33.67 abc	24.33 gh	29 CDE	21.54jk	26.47cdef	24.00 D	22.83 efghi	16.05 j	19.44 F
Soil application at 1000 g N/ tree 5 times/ year	29.70 def	31.17 cde	30.43BCD	24.78efghi	27.99bcd	26.38 C	25.62 cdefg	26.34 bcde	25.98 ABC
Soil application at 1000 g N/ tree 7 times/ year	31.17 cde	26.80 fg	28.98CDE	22.83ghijk	24.35fghij	23.59 D	23.87 efghi	24.48 defgh	24.17 CDE
Soil injection at 1000 g N/ tree 7 times/ year	36.01 ab	28.77 ef	32.39 AB	23.36ghijk	22.40ijk	22.87 D	27.94 bcd	22.66 fghi	25.30 BCD
Trunk injection with N. (0.5 g/ l)	32.30 cd	22.87 hi	27.58 E	30.41ab	27.74bcde	29.07 AB	25.62 cdefg	22.44 ghi	24.03 CDE
Trunk injection with N. (0.62 g/ l)	35.70 ab	21.05 i	28.37 DE	24.32fghij	22.17ijk	23.24 D	25.77 cdefg	20.81 i	23.29DE
Trunk injection with N. (0.75 g/ l)	32.40 cd	23.77 hi	28.08 E	22.80ghijk	23.13ghijk	22.96 D	29.19 bc	26.16 cdef	27.68AB
Inflorescence type mean	32.05 A	27.39 B		26.12 A	24.72 B		26.19 A	23.02 B	

Means having the same letter (s) in each column are insignificantly different.

21.54 - 32.58% and 22.83 - 32.93%, whereas, the corresponding fruit set percentages on leafless inflorescences were 21.05 - 36.17%, 20.81 - 28.98% and 16.05- 26.26% in the first, second and third seasons, respectively.

In this respect, numerous investigators found that increasing number of nitrogen doses associated with early application prior or during flowering time markedly increased fruit set percentage (Govind and Prasad, 1983; Qin, 1999; Ebrahiem and Mohamed, 2000 ; Sharawy *et al.*, 2003; Tayeh *et al.*, 2003 ; Maji and Ghosh 2007; Abdi and Hedayat, 2010 and Martinez-Alcantara *et al.*, 2012).

Fruit Retention (Final Fruit Set) Percentage

It is clear from Table 2 that trees fertigated at 1000 g N/tree 3 times/ week gained the maximum fruit retention percentage (1.79, 2.76 and 1.78%, followed by those fertigated at 750 g N/ tree 2 times/ week, (1.10, 1.68 and 1.72%) and those trunk injected at 0.5 g N/ l (0.88, 1.66 and 1.70%) in the three seasons, respectively, without significant differences between them in each season. The minimum fruit retention percentages (0.41, 0.87 and 1.01%) were recorded for trunk injected trees at 0.62 g N/l in the first season and those fertilized *via* soil at 1000 g N/ tree 3 or 7 times/ year in the last two seasons, respectively. The other tested fertilization treatments were insignificantly different in fruit retention percentages in most cases.

Inflorescence type significantly increased fruit retention percentage in the three seasons. Leafy inflorescences retained higher fruit percentages (1.52, 2.20 and 2.08%) compared with leafless ones (0.07, 0.70 and 0.70%) in the three seasons, respectively. It is worthy to mention that fruit retention percentages on leafy inflorescences were 21.71, 3.14 and 2.97 folds its percentage on leafless ones in the three seasons, respectively. This means that most harvested fruits of Valencia orange trees were borne on the leafy inflorescences.

The interaction between the two tested factors was significant in the three seasons and supports the effect of each individual factor on fruit retention percentage. The highest fruit retention percentages (3.11, 4.41 and 2.56%) were recorded for leafy inflorescences of trees fertigated at 1000 g N/ tree 3 times/ week in the three seasons, respectively. Moreover, leafy inflorescences retained higher fruit set percentages than leafless ones under all tested fertilization treatments throughout the three seasons. Fruit retention percentage on leafy inflorescences ranged between 0.90 -3.11%, 1.42- 4.41% and 1.6- 2.56%, whereas those on leafless ones ranged between 0.00- 0.48%, 0.33- 1.12% and 0.34- 1.08% in the first, second and third seasons, respectively.

The obtained findings are in harmony with those of Maji and Ghosh (2007) on pummelo; Wassel *et al.* (2007) on balady mandarin and Martinez-Alcantara *et al.* (2012). They all reported that the greatest increase in fruit retention percentage was correlated with increasing number of nitrogen doses which produced the best tree conditions.

In this regard, Goldschmidt and Monselise (1978) stated that leafy inflorescences have better chances for fruit set than leafless ones, so, most of the fruit set on leafless inflorescences drop and the crop is eventually borne on leafy inflorescences. This could be attributed mainly to that leaves of leafy inflorescences may play a role in provision of photosynthates, mineral nutrients or hormones to facilitate persistence of the young fruits. Erner (1989) suggested that the better water transport capacity of leafy inflorescences shoots may be responsible for the higher rate of fruit set. He added that fewer than 1-2% of the total number of flowers produced on most commercially citrus cultivars (100,000 – 200,000 flowers) will produce harvestable fruits.

Yield/ Tree

As shown in Table 3 the tested fertilization treatments significantly affected fruit yield per tree in the three seasons. However, the highest yield/ Valencia orange tree was gained by trees fertigated at 1000 g N/ tree 2 times/ week (60.35, 66.70 and 66.66 Kg/ tree) in the first, second and third seasons, respectively followed by those trunk injected at 0.5 and 0.75 g N/ l (60.68, 63.50 and 61.50 Kg/ tree) in the three seasons, respectively without significant differences between them in the first two seasons. Valencia orange trees fertilized *via* soil

Table 2. Effect of some nitrogen fertilization treatments on fruit retention (final fruit set) percentage on leafy and leafless inflorescences of Valencia orange trees (2013 / 2014, 2014 / 2015 and 2015 / 2016 seasons)

Inflorescence type	First season (2013 / 2014)		Treatment mean	Second season (2014 / 2015)		Treatment mean	Third season (2015 / 2016)		Treatment mean
Fertilization treatment	Leafy (%)	Leafless (%)		Leafy (%)	Leafless (%)		Leafy (%)	Leafless (%)	
Fertigation at 1000 g N/ tree 3 times/ week	3.11a	0.48hi	1.79 A	4.41 a	1.12 ef	2.76 A	2.56 a	1.01 efg	1.78A
Fertigation at 1000 g N/ tree 2 times/ week	1.82c	0.16ij	0.99 B	2.15 c	0.54 i	1.34 EFG	1.68 d	0.59 efgh	1.13 CDE
Fertigation at 750 g N/ tree 3 times/ week	1.20ef	0.00j	0.60 DEF	2.27 c	0.50 i	1.38 DEF	2.31 abc	0.97efg	1.64AB
Fertigation at 750 g N/tree 2 times/ week	2.20b	0.00j	1.10 B	2.29 c	1.08 efg	1.68 BC	2.39 a	1.05 ef	1.72 AB
Soil application 300 g N at early March + 700g N/ tree fertigation	1.46de	0.00j	0.73 CD	1.46 de	0.71 fghi	1.08 GH	2.25 abc	0.63efgh	1.44 ABC
Soil application at 1000 g N/ tree 3 times/ year	1.41de	0.00j	0.70 CDE	1.42 de	0.33 i	0.87 H	1.79cd	0.35 h	1.07 DE
Soil application at 1000 g N/ tree 5 times/ year	1.38 e	0.00j	0.62 DEF	1.58 d	0.66 ghi	1.12 FGH	1.60 d	0.69 efgh	1.14 CDE
Soil application at 1000 g N/ tree 7times/ year	1.29ef	0.00j	0.64 CDEF	1.59 d	0.70 fghi	1.14EFGH	1.69 d	0.34 h	1.01 E
Soil injection at 1000 g N/ tree 7times/ year	0.90fg	0.02j	0.46 EF	3.11 b	0.63 hi	1.87 B	1.83 bcd	0.64 efgh	1.23 CDE
Trunk injection with N. (0.5 g/ l)	1.72cd	0.03j	0.88 BC	2.28 c	1.05 efgh	1.66 BCD	2.33 ab	1.08 e	1.70AB
Trunk injection with N. (0.62 g/ l)	0.99fg	0.17ij	0.41 F	2.17 c	0.70 fghi	1.43 CDE	2.26 abc	0.50 gh	1.38BCDE
Trunk injection with N. (0.75 g/ l)	1.22ef	0.00j	0.61 DEF	1.69 d	0.45 i	1.068 GH	2.27 abc	0.54 fgh	1.40 BCD
Inflorescence type mean	1.52 A	0.07 B		2.20 A	0.70 B		2.08 A	0.70 B	

Means having the same letter (s) in each column are insignificantly different.

Table 3. Effect of some nitrogen fertilization treatments on yield (kg/ tree) and yield components of Valencia orange trees (2013 / 2014, 2014 / 2015 and 2015 / 2016 seasons)

Fertilization treatment	First season (2013 / 2014)				Second season (2014 / 2015)				Third season (2015 / 2016)			
	Yield (kg/tree)	No. of fruits/ tree	Fruit weight (g)	Cropping efficiency (Kg/m^3)	Yield (kg/tree)	No. of fruits/ tree	Fruit weight (g)	Cropping efficiency (Kg/m^3)	Yield (kg/tree)	No. of fruits/ tree	Fruit weight (g)	Cropping efficiency (Kg/m^3)
Fertigation at 1000 g N/ tree 3 times/ week	48.24 cd	226.67 c	217.99ab	4.76 cd	50.73 e	240.00 ef	191.00 c	4.04 b	50.33 fg	253.7 g	189.0 c	3.5 bcd
Fertigation at 1000 g N/ tree 2 times/ week	60.35 a	311.00 a	186.59de	4.28 def	66.70 a	362.33 a	188.43cd	5.12 a	65.66a	361.3 a	188.2 c	4.02 a
Fertigation at 750 g N/ tree 3 times/ week	41.27 ef	186.33 d	187.00de	5.92 b	57.88 d	214.67 h	162.60 h	3.92 b	51.83 ef	233.3 j	160.3 h	3.42 d
Fertigation at 750 g N/tree 2 times/ week	38.25 fg	196.00 d	172.45 f	3.39 f	49.73 ef	229.67 g	184.63 d	3.97 b	49 fg	243.3 i	182.3 d	3.78 ab
Soil application 300 g N at early March + 700g N/ tree fertigation	44.35 de	224.67 c	183.82de	4.20 def	51.00 e	245.00 de	201.53 a	3.63 bc	48.66 gh	258.0 f	199.1 a	3.39 de
Soil application at 1000 g N/ tree 3 times/ year	53.73 b	299.00 a	174.05 f	4.25 def	62.00 bc	330.00 b	161.53 h	3.67 bc	61.66 b	322.0 c	157.5 i	3.17 ef
Soil application at 1000 g N/ tree 5 times/ year	54.43 b	311.67 a	161.42 g	4.75 cd	59.07 cd	323.33 b	171.67 f	3.84 bc	58.66 cd	343.3 b	165.1 g	3.53 cd
Soil application at 1000 g N/ tree 7times/ year	36.70 g	199.67 d	179.26 ef	7.32 a	44.63 g	232.67 fg	177.33 e	3.77 bc	44.33 i	245.7 h	179.1 e	3.74 bc
Soil injection at 1000 g N/ tree 7times/ year	41.83 ef	228.33 c	190.21 d	4.34 def	46.60 fg	248.33 de	177.03 e	4.20 b	46.00 hi	261.3 e	174.3 f	3.58 bcd
Trunk injection with N. (0.5 g/ l)	60.68 a	223.00 c	224.96 a	5.73 bc	56.50 d	246.00 de	185.57 d	5.07 a	54.33 e	260.3 e	182.5 d	3.58 bcd
Trunk injection with N. (0.62 g/ l)	50.40 bc	246.67 b	206.72 c	3.64 ef	63.17 ab	271.33 c	196.33 b	3.07 c	57.33 d	284.3 d	193.5 b	3.04 f
Trunk injection with N. (0.75 g/ l)	51.00 bc	251.67 b	209.81bc	4.57 de	63.50 ab	248.67 d	167.37 g	3.58 bc	61.5 bc	258.4 f	164.5g	2.76 g

Means having the same letter (s) in each column are insignificantly different.

application at 1000 g N/tree 7 times/ year (36.70, 44.63 and 44.33 kg/ tree) and soil injection at 1000 g N/ tree 7 times/ year (41.83, 46.60 and 46.00 kg/tree) produced the lowest yield/tree in the three studied seasons, respectively without significant differences between them in the last two seasons only. The other tested fertilization treatments produced intermediate yields. Trees fertilized *via* soil application at 1000 g N/ tree 3 times/year produced significantly higher yields (53.73, 62.00 and 61.66 Kg/tree) than those of N soil applied at 1000 g N/ tree 5 times/ year/ which produced lower yields throughout the last two seasons (59.07 and 58.66 Kg/tree), respectively without significant differences between them in the first two seasons. The yield of trees fertilized through soil application at 1000 g N/ tree 3 times/ year was 4.73 and 4.87% higher than that of those fertilized by soil application at 1000 g N/ tree 5 times/ year in the second and third seasons, respectively.

Generally, the average yield/ tree fertilized *via* soil application at 1000 g N/tree 3 and 5 times/year or those trunk injections with N at 0.62 and 0.75 g/ l was insignificantly different throughout the three seasons. Regarding fertigation treatments, the obtained data reveal that fertigation at 1000 g N/ tree 2 times/ week produced higher yields than those fertigated at 750 g N/ tree 3 (46.23, 15.34 and 26.68%) or 2 (57.78, 34.12 and 34.00%) times/ week in the three seasons, respectively without significant differences between the last two treatments in the first and third seasons. In the last two seasons, the trees fertigated at 750 g N/tree 3 times/ week produced higher yields than those under fertigation at 1000 g N/ tree 3 times/ week and those fertigated at 750 g N/ tree 2 times/ week without significant differences between them in the third season only. It is worthy to mention that trunk injection treatments gained comparable and higher yields/ tree throughout the three tested seasons although it consumped only 0.2- 0.3 from the recommend rate (1000 g N/ tree) in comparison with other fertilization treatments.

The obtained results are in harmony with those reported by El-Kassas (1983), Sabbah *et al*. (1997), Tayeh *et al.* (2003), Monga *et al.* (2004), Vedamani *et al.* (2006), Quinones *et al.* (2009), Ashkevari *et al.* (2012) and Patel *et al*. (2012). They all found that yield of citrus trees was increased with increasing fertilizer rate and number of applications. The obtained results are also in line with those reported by Shaaban (2009) on grapevines, Mohebi *et al*. (2010) and Abdi and Hedayat (2010) on Sayer and Kabkab date palm cvs.

On the contrary, Dubey and Yadav (2001 and 2003), working on Khasi mandarin trees found that fruit yield was decreased with application of 1000 g N. However, some workers reported that number and rates of nitrogen application did not affect the yield of orange trees (Mungomery *et al*., 1981 on Navel orange and Alva *et al*., 2001 on Valencia, Parason Browen , Hamlin and Sunburst trees).

Cropping Efficiency

Data in Table 3 clearly show that the highest cropping efficiency of Valencia orange tress was recorded for trees fertilized *via* soil application at 1000 g N/ tree 7 times/ year (7.32 Kg fruits/ m^3), followed by those fertigated at 750 g N/tree 3 times/week (5.92 Kg fruits/ m^3) and trunk injection with 0.5 g N/ l (5.73 Kg fruits/m^3) without significant differences between them in the first season. In the last two seasons, fertigation at 1000 g N/tree 2 times/week treatment gained the highest cropping efficiency (5.12 and 4.02 Kg fruits/ m^3) followed by those trunk injected with 0.5 g N/ l (5.07 Kg fruits/m^3) and those fertigated at 750 g N/tree 2 times/ week (3.78 Kg fruits/ m^3) in the second and third seasons, respectively without significant differences between them. The lowermost cropping efficiency was recorded for fertigation at 750 g N/ tree 2 times/ week (3.39 Kg fruits/ m^3), trunk injection with 0.62 g N/ l (3.07 Kg fruits/m^3) and trunk injection with 0.75 g N /l (2.76 Kg fruits/m^3) in the first, second and third seasons, respectively. The other tested fertilization systems recorded significantly different intermediate cropping efficiencies ranged between 3.64 – 4.76 Kg fruits/m^3 in the first season, 3.58-3.97 Kg fruits/m^3 in the second and 3.04 – 3.74 Kg fruits/ m^3 in the third season.

As a general, the highest yield per Valencia orange tree and cropping efficiency were recorded for trees fertigated at 1000 N/ tree 2 times / week, followed by those soil applied at the same rate 3 times / year and those trunk

injected without significant differences between them in most cases. Trunk injected trees not only received very small amounts of fertilizers, but also produced higher yields and gained higher cropping efficiency during the three tested seasons.

Number of Fruits/ Tree

It is quite evident from Table 3 that the number of the harvested fruits per tree was significantly affected by the tested fertilization treatments. The highest fruit No./ Valencia orange tree was gained by trees fertigated at 1000 g N/ tree 2 times/ week (311.67, 362.33 and 361.30 fruits/ tree) in the first, second and third seasons, respectively, followed by those fertilized through soil application at 1000 g N/ tree 3 or 5 times/ year throughout the three seasons, without significant differences between them in the first season only.

Trunk injected trees at 0.62 (246.67, 271.33 and 284.30 fruits/tree) and 0.75 g N/ l (251.67, 248.67 and 258.4 fruits/ tree) in the first, second and third seasons gained also higher number of fruits / tree, respectively, following the previous treatments which recorded the highest fruit No./ tree. Trees fertigated at 750 g N/ tree 3 or 2 times / week and those soil applied at 1000 g N/ tree 7 times/ year gave the least number of fruits/ tree in the three seasons without significant differences between them, especially in the first season. The other tested fertilization treatments produced intermediate fruit No./ tree.

Trunk injected trees at 0.62 g N/ l produced higher fruit No./ tree than those fertigated at 750 g N / tree 3 times/ week by 33.38, 26.39 and 21.86 % and lower than those fertigated at 1000 g N/ tree 2 times / week by 20.68 , 25.12 and 21.31% in the three seasons, respectively.

These findings are in agreement with those reported by Vedamani *et al.* (2006), who found that application of 1000 g N/ tree/ lime year was superior with respect to fruit number (697.5/ tree) and weight (28.44 g). Sharawy *et al.* (2003), Chao and Lovatt (2006), Wassel *et al.* (2007), Maji and Ghosh (2007), Ibrahim (2011) and Kumar *et al.* (2013) reported the same trend in different citrus species.

Fruit Weight and Size

Data in Table 3 show that weight and size of Valencia orange fruits were significantly affected by the studied fertilization treatments during the three seasons. However, in the first season, the highest fruit weight and size were recorded for trunk injected trees at 0.5 g N/ l (224.96 g and 219.00 cm^3/ fruit), followed by those fertigated at 1000 g N/ tree 3 times/ week (217.99 g and 203.17 cm^3/fruit) without significant differences between them, especially for fruit weight. Soil applied trees at 1000 g N/ tree 5 times/ year gave the lowest values (161.42 g and 158.00 cm^3/ fruit). In the last two seasons, trees fertilized *via* soil at 300 g N at early March + 700 g N/ tree fertigation (mixed treatment) produced the highest fruit weight and size (201.53 g and 203.33 cm^3/ fruit and 199.10 g &198.40 cm^3/fruit) and those fertigated at 1000 g N/ tree 3 times/ week (191.00 g and 197.20 cm^3/ fruit) in the second and third seasons respectively. The smallest fruit weight and size were gained by soil applied trees at 1000 g N/ tree 3 times/ year and those fertigated at 750 g N/ tree 3 times/ week (161.53 & 162.60 g and 155.00 & 154.00 cm^3/ fruit) in the second season and (157.50 & 160.30 g and 151.30 & 150.00 cm^3/ fruit) in the third one, respectively, without significant differences between them. Trunk injected trees at 0.62g N/ l induced markedly higher fruit weight and size in comparison with 0.5 or 0.75 g N and other tested fertilization treatments.

As general, trunk injected trees at various rates gained the highest fruit weight and size in the first season and ranked second in the other two seasons. This means that trunk injection may be a useful fertilization treatment without any adverse effect on fruit yield and fruit weight and size, despite the smallest fertilizer amounts used (only 0.2 -0.3% of the recommended dose).

These results are in line with those of Plessis and Koen (1988), Nakhlla *et al.* (1998); Gamal and Ragab (2003), Monga *et al.* (2002 and 2004), Ingle *et al.* (2006) and Wassel *et al.* (2007). They reported that fruit weight and size were increased with increasing N fertilizer doses.

Juice Volume/ Fruit

It is quite evident from Table 4 that, juice volume/ fruit was significantly affected by the studied fertilization treatments in the three seasons. However, trunk injection treatment either at 0.5 g N/ l (114.33 cm^3/ fruit) or 0.62 g N/ l (142.67 and 135.33 cm^3/ fruit) produced fruits with the largest juice volume / fruit in the first, second and third seasons, respectively. The lowermost juice volume / fruit was recorded for fertigated trees at 750 g N/ tree 2 times/ week (79.33 cm^3/ fruit) in the first season, and those fertilized *via* soil application at 1000 g N/ tree 3 times/ year (76.33 and 72.33 cm^3/ fruit) in the second and third seasons, respectively. The other treatments gained intermediate juice volumes/ fruit ranged between 87.00 – 106.67, 83.67 – 122.67 and 80.66 – 119.33 cm^3/ fruit in the first, second and third seasons, respectively.

All treatments of trunk injection recorded the largest juice volume/ fruit in comparison with the other tested fertilization treatments in the three seasons. Juice volume/ fruit of trunk injected trees was higher than that of fertigated ones at 750 g N / tree2 times / week by 44.12, 59.11 and 58.60% in the three seasons, respectively.

These findings confirm those of Nakhlla *et al.* (1998), Alva *et al.* (1998), Monga *et al.* (2004) and Vedamani *et al*. (2006) who revealed that application of 1000 g N/ tree/ year was superior respect to juice percentage (46.63%).

Fruit Firmness

It is clear from Table 4 that firmness force of Valencia orange fruits was significantly affected by the studied fertilization treatments in the three seasons. Anyhow, trees fertigated at 1000 g N/ tree 3 times/ week and those trunk injected at 0.75 g N/ l exhibited the highest fruit firmness values without significant differences between them in the three seasons, except the third one in which the trunk injection treatment was the highest. Trees fertilized *via* soil at 1000 g N/ tree 3 times/ year and those fertigated at 750 g N /tree 3 times/ week (1770.33 and 1761.00 g/ cm^2, respectively). Followed the previous treatments without significant differences between them in the first season only. The least fruit firmness values were recorded for trees fertilized through soil application at 300 g N at early March + 700 g N / tree fertigation (1638.67, 1701.00 and 1646.67 g) in the three seasons, respectively, followed by trunk injected trees at 0.62 g N/ l (1644.33, 1703.33 and 1666.67 g/cm^2) in the three seasons, respectively. The other tested fertilization treatments produced fruit with intermediate values of firmness.

As a general, trunk injected trees at 0.75 g N/l produced fruits with higher firmness in comparison with those injected at 0.5 or 0.62 g N/ l and most of the other tested fertilization treatments in the three seasons. Fruit firmness of Valencia orange fruits ranged between 1638.67-1798.00, 1696.67 – 1793.33 and 1643.33-1730.00 g/ cm^2 in the first, second and third seasons, respectively.

These findings are in harmony with these obtained by Nakhlla *et al.* (1998) on Navel orange, Li *et al.* (1999) on pommelo (cv. Shatianyou) and Dalal *et al.* (2009) on sweet orange.

Total soluble solids percentage (TSS%)

As shown in Table 5, the tested fertilization treatments significantly affected TSS percentage in fruit juice throughout the three seasons. However, trees fertilized *via* soil application at 1000 g N/ tree 7 times/ year produced fruits with the highest TSS percentage (14.83%), followed by those fertigated at 750 or 1000 g N/ tree 3 or 2 times/ week and those fertilized with 300 g N soil application at early March + 700 g N/ tree *via* fertigation, without significant differences between them in the first season. In the last two seasons, the highest TSS percentages were recorded for soil applied trees at 1000 g N/ tree 3 times/ year (15.27 and 14.56 %) and those fertigated at 750 g N/ tree 3 times/ week (15.03 and 14.33 %) without significant differences between them, beside soil applied trees at 1000 g N/ tree 5 or 3 times/ year in the second and third seasons, respectively. The other treatments induced significantly different intermediate TSS percentages. Throughout the three seasons, the lowest TSS percentage was found in fruit juice of trunk injected trees at 0.5 g N/ l (12.73, 12.73 and 12.03%, respectively), followed by those trunk injected at 0.75 g N/ l in the first season and those fertigated at 1000 g N/ tree 3 times/

Table 4. Effect of some nitrogen fertilization treatments on fruit size (cm^3), fruit firmness (g/cm^2) and juice volume (cm^3/ fruit) of Valencia orange fruits (2013/2014, 2014/2015, 2015/2016 seasons)

Fertilization treatment	First season (2013 / 2014)			Second season (2014 / 2015)			Third season (2015 / 2016)		
	Fruit size (cm^3)	Fruit firmness (g/cm^2)	Juice volume (cm^3)	Fruit size (cm^3)	Fruit firmness (g/cm^2)	Juice volume (cm^3)	Fruit size (cm^3)	Fruit firmness (g/cm^2)	Juice volume (cm^3)
Fertigation at 1000 g N/ tree 3 times/ week	203.17 b	1798.00 a	87.00 e	200.33 a	1793.33 a	115.00 c	197.2 a	1706.67 bc	112.33c
Fertigation at 1000 g N/ tree 2 times/ week	178.33 de	1739.33 bc	87.33 e	174.33 e	1716.67 cd	102.67 d	171.9 e	1680.00 def	97.00 f
Fertigation at 750 g N/ tree 3 times/ week	180.50 d	1743.33 bc	104.33 bc	154.00 g	1720.00 cd	90.33 f	150.0 g	1646.67 h	86.33g
Fertigation at 750 g N/tree 2 times/ week	169.33 f	1761.00 ab	79.33 f	179.67 d	1654.67 e	89.67 f	175.9 d	1643.33h	85.33 g
Soil application 300 g N at early March + 700g N/ tree fertigation	172.00ef	1638.67 d	89.67 e	201.33 a	1701.00 d	85.33 gh	198.4 a	1646.67 h	81.33h
Soil application at 1000 g N/ tree 3 times/ year	161.67 g	1770.33 ab	89.67 e	155. 00 g	1750.00 b	76.33 i	151.3 g	1710.00 b	72.33j
Soil application at 1000 g N/ tree 5 times/ year	158.00 g	1699.00 c	87.33 e	175.00 e	1696.67 d	83.67 h	171.3 e	1660.00 g	79.66 i
Soil application at 1000 g N/ tree 7times/ year	174.17 def	1730.33 bc	88.67 e	189.33 c	1735.67 bc	88.00 fg	185.9 c	1693.33 cd	80.66 hi
Soil injection at 1000 g N/ tree 7times/ year	175.67 def	1727.67 bc	100.67 cd	174.00 e	1741.00 bc	96.00 e	170.5 e	1676.67 efg	98.66e
Trunk injection with N. (0.5 g/ l)	219.00 a	1735.00 bc	114.33 a	163.33 f	1733.33 bc	111.33 c	159.8 f	1683.33 de	107.33d
Trunk injection with N. (0.62 g/ l)	187.00 c	1644.33 d	106.67 b	197.00 b	1703.33 d	142.67 a	193.6 b	1666.67 fg	135.33a
Trunk injection with N. (0.75 g/ l)	205.67 b	1762.67 ab	96.00 d	164.33 f	1786.67 a	122.67 b	160.6 f	1730.00 a	119.33b

Means having the same letter (s) in each column are insignificantly different.

Table 5. Effect of some nitrogen fertilization treatments on some chemical fruit characteristics of Valencia orange fruits (2013 / 2014, 2014 / 2015 and 2015 / 2016 seasons)

Fertilization treatment	First season (2013 / 2014)				Second season (2014 / 2015)				Third season (2015 / 2016)			
	TSS (%)	Total acidity (%)	TSS / acid ratio	Vit. C. (mg/100 ml)	TSS (%)	Total acidity (%)	TSS/acid ratio	Vit. C. (mg/100 ml)	TSS (%)	Total acidity (%)	TSS/ acid ratio	Vit. C. (mg/100 ml)
Fertigation at 1000 g N/ tree 3 times/ week	14.61 a	1.37 c	10.71bc	51.52 ab	13.40 f	2.16 ab	6.21c	38.08 g	12.70 f	1.30 d	9.77cd	49.92a
Fertigation at 1000 g N/ tree 2 times/ week	14.47 ab	1.69 a	8.58d	52.16 a	14.40 cd	1.49 def	9.83ab	43.84 ef	13.70 bcd	1.66a	8.26 e	48.64ab
Fertigation at 750 g N/ tree 3 times/ week	14.47 ab	1.62 ab	8.98 d	49.28 ab	15.03 ab	1.69 cd	9.06b	45.12 def	14.33a	1.45bc	9.92cd	47.04bc
Fertigation at 750 g N/tree 2 times/ week	14.67 a	1.56b	9.40 d	48.64 ab	14.77 bc	1.53 de	9.65ab	47.68 bcd	14.33 a	1.52b	9.40d	49.28 a
Soil application 300 g N at early March + 700g N/ tree fertigation	14.33 abc	1.32 cd	10.86b	50.56 ab	13.80 ef	2.28 a	6.05c	48.96 abc	13.83bc	1.36cd	10.14cd	47.04bc
Soil application at 1000 g N/ tree 3 times/ year	13.83 cde	1.19 ef	11.63ab	48.96 ab	15.27 a	2.13 ab	7.20 c	49.28 abc	14.56a	1.26d	11.57ab	48.64ab
Soil application at 1000 g N/ tree 5 times/ year	14.00 bcd	1.17 ef	11.94a	48.00 bc	14.93 ab	1.45 def	10.44ab	47.68 bcd	13.90 b	1.30 d	10.71bc	49.60a
Soil application at 1000 g N/ tree 7times/ year	14.83 a	1.21 de	12.34a	49.28 ab	14.23 de	1.36 ef	10.58ab	48.96 abc	13.53cd	1.12 e	12.09a	46.08 c
Soil injection at 1000 g N/ tree 7times/ year	13.33 ef	1.09 fg	12.28a	41.28 d	13.87 ef	1.50 def	9.27b	50.56 ab	13.16e	1.11 e	11.93a	40.93d
Trunk injection with N. (0.5 g/ l)	12.73 g	1.02 g	12.48a	44.16 cd	12.73 g	1.92 bc	6.64c	42.56 f	12.03g	1.02 e	11.79a	40.00 d
Trunk injection with N. (0.62 g/ l)	13.70 de	1.11 efg	12.41a	49.60 ab	14.13 de	1.43 def	9.91ab	51.84 a	13.43de	1.11e	12.11a	47.36 bc
Trunk injection with N. (0.75 g/ l)	13.03 fg	1.35 c	9.60 cd	48.96 ab	14.23 de	1.26 f	11.41a	46.40 cde	13.53cd	1.32d	10.23cd	48.64 ab

Means having the same letter (s) in each column are insignificantly different.

week in the last two seasons without significant differences between them. The percentage of TSS in the fruit juice of Valencia orange ranged between 12.73 – 14.83, 12.73 – 15.27 and 12.03 – 14.56% in the first, second and third seasons, respectively.

Total Acidity Percentage

Data in Table 5 show that total acidity percentage in the fruit juice was significantly affected by the studied fertilization treatments in the three seasons. However, the highest total acidity percentage was recorded for fruits produced on trees fertigated at 1000 g N/ tree 2 times/ week (1.69 and 1.66%) in the first and third seasons, respectively, and those fertigated at 750 g N/ tree 3 times/ week (1.62%) without significant differences between them in the first season only. The other treatments induced significantly different total acidity percentages. The lowermost total acidity percentages were recorded for soil and trunk injection treatments in both seasons, especially trunk injection at 0.5 and 0.62 g N/ l treatments.

In the second season, the trend was somewhat different. Since, the highest juice acidity percentage was recorded for trees received N at 300 g *via* soil at early March and 700 g N/ tree *via* fertigation (2.28%), those fertigated at 1000 g N/ tree 3 times/ week (2.16%) and trees received N at 1000 g / tree 3 times/ year (2.13%), without significant differences between them. Whereas, trees trunk injected at 0.75 g N/ l (2.26%) and most of other treatments exhibited the lowest acidity percentages. Total acidity percentages in the juice of Valencia orange fruits ranged between 1.02 – 1.69%, 1.26 – 2.28% and 1.02 – 1.66% in the three seasons, respectively.

TSS/ Acid Ratio

It is clear from Table 5 that, the tested fertilization treatments significantly affected TSS/ acid ratio in fruit juice in the three seasons. Anyhow, the effect of the studied fertilization treatments on TSS/acid ratio followed approximately an opposite trend to their effect on total acidity percentage in the three seasons. Thereby, trees fertilized *via* soil application at 1000 g N/ tree 3, 5 and 7 times/ year and those soil injected at 1000 g N/ tree 7 times/ year as well as trunk injected trees at 0.5 & 0.62 g N/ l exhibited the highest TSS/ acid ratio ranged between (11.63 - 12.48) in the first season and (11.57 – 12.11) in the third season without significant differences between them in each season. Trees fertigated at 1000 g N/ tree 2 times/ week gained the lowest TSS/ acid ratios (8.58 and 8.26) in the two seasons, respectively. Trees fertigated at 750 g N/ tree 3 and 2 times/ week (8.98 & 9.40) and those injected at 0.75 g N/ l (9.60) induced, also insignificantly different lower TSS /acid ratio in the first season.

In the second season, trees injected at 0.75 g N/ l exhibited the highest TSS/acid ratio in the fruit juice (11.41), followed in descendingly order by those fertilized *via* soil application at 1000 g N/ tree 7 (10.58) and 5 (10.44) times/ year, trunk injected trees at 0.62 g N/ l (9.91) and those fertigated at 1000 (9.83) and 750 (9.65) g N/ tree 2 times/week without significant differences between them.

Trees received 300 g N at early March through soil + 700 g N/ tree *via* fertigation gained the lowest TSS/ acid ratio (6.05) in the second season. The other treatments gave intermediate and insignificantly different ratios. It is worthy to notice that, trunk injected trees either at 0.5 and 0.62 g N/ l induced the highest TSS/ acid ratios through the three seasons of study ,except 0.5 g N/ l treatment in the second season through which 0.75 g N/ l treatment gained the highest TSS/ acid ratio**.**

Vitamin C Content

As shown in Table 5 ascorbic acid (Vit. C) content in Valencia orange fruit juice was significantly affected by the tested N fertilization treatments in the three seasons. However, fruits produced on fertigated trees at 1000 g N/ tree/ year 3 or 2 times/ week contained the highest vit. C content in the first and third seasons without significant differences between them. Trunk injected trees at 0.62 or 0.75 g N/ l produced fruits containing higher vit. C contents throughout the three seasons. Fruits produced on soil injected trees at 1000 g N/ tree 7 times/ year and those trunks injected at 0.5 g N/ l contained the lowest vit. C contents in the first and third seasons without significant differences between them. In the second season, trees fertigated at 1000 g N/ tree 3 (38.08 mg/

100ml juice) or 2 (43.84 mg/ 100 ml juice) times/ week and those trunk injected at 0.5 g N/ l (42.56 mg/ 100 ml juice) induced the lowest vit. C content. The other treatments exhibited higher vit. C contents without significant differences between them. However, vitamn. C content in Valencia orange fruits ranged between 41.28 – 52.16, 38.08 – 51.84 and 40.00 – 49.92 mg/100 ml juice in the first, second and third seasons, respectively.

These results came in line with those of Inoue and Isobe (1981) on satsuma mandarin, Nath and Mohan (1995) on Assam lemon, Monga *et al*. (2004), on Kinnow mandarin, Vedamani *et al*. (2006) on acid lime, Tian *et al.* (2007) on citrus, Shaaban (2009) on grapevines, Quinones *et al*. (2009) on clementine cv. Nules, Panigrahi and Srivastava (2011) on Nagpur mandarin, Kumar *et al*. (2013) on Khasi mandarin. They all found that fruit quality parameters were improved in trees fertilized with ammonium sulphate, since ascorbic acid content, TSS and citric acid in fruit juice were increased as N rates were increased, while TSS /acid ratio did not follow any definite trend.

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تأثير بعض معاملات التسميد النيتروجينى على أشجار البرتقال الفالنشيا

أ- التأثير على نسبة العقد والمحصول وجودة الثمار

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أجريت هذه الدراسة خلال ثلاثة مواسم متتالية ٢٠١٣/٢٠١٤ ، ٢٠١٤/٢٠١٥ ، ٢٠١٥ /٢٠١٦ على أشجار البرتقال الفالنشيا عمر ٦ سنوات مطعومة على أصل النارنج ومزروعة في تربة رملية على مسافة ٤ × ٥ م تحت نظام الرى بالتنقيط فى أحد حدائق الموالح الخاصة بمنطقة وأدى الملاك، مركز أبوحماد، محافظة الشرقية، مصر، حيث خضعت ٤٨ شجرة لإثنى عشر معاملة تسميد نيتروجينى باستخدام سماد نترات الآمونيوم (٣٣.٥% نتروجين)، وقد أضيف السماد النيتروجينى بطرق ومعدلات ومواعيد مختلفة خلال شبكة الرى (الرسمدة) أو عن طريق الإضافة الأرضية أو حقن الجذع بمحلول السماد، وقد أشارت النتائج المتحصل عليها أن الأشجار التى سمدت مع ماء الرى بمعدل ١٠٠٠ جم نيتروجين لكل شجرة ٣ مرات أسبوعيا أعطت أعلى نسبة لكل من عقد الثمار وبقائها على الأشجار حتى الجمع فى المواسم الثلاثة، كما أعطت الأشجار التى تم حقن جذعها نسبا عالية من العقد والثمار المتبقية بالرغم من إستهلاكها لكمية صغيرة جداً من السماد النيتروجينى (٠.٢ – ٠.٣% من المعدل الموصى به)، أظهرت النورات الورقية أعلى نسبة لعقد وبقاء الثمار عن مثيلتها غير الورقية فقد بلغت نسبة بقاء الثمار عليها ٢١.٧١ ، ٣.١٤ و ٢.٩٧ ضعف مثيلتها على النورات غير الورقية فى المواسم الثلاثة، على التوالي، كما أعطت الأشجار التي تم تسميدها خلال ماء الرى بمعدل ١٠٠٠جم نيتروجين لكل شجرة مرتين أو ثلات مرات أسبوعيا أعلى محصول وعدد ثمار لكل شجرة و كفاءة إثمار، تليها الأشجار التي سمدت عن طريق الإضافة الأرضية بنفس المعدل ثلاث مرات سنويا وتلك التي تم حقن جذعها بمحلول السماد وبدون فروق معنوية بينها فى معظم الحالات، إحتوت الثمار الناتجة من أشجار هذه المعاملات على أعلى محتوى من فيتامين ج وأقل نسبة للمواد الصلبة الذائبة/ الحموضة، الأشجار التى تم تسميدها بالحقن لم تستهلك كميات قليلة جداً من الأسمدة فقط، بل أعطت أعلى محصول للثمار وحققت ثمارها أعلى القيم لكل من صلابة الثمار وحجم العصير ونسبة المواد الصلبة الذائبة/الحموضة ومحتواها من حمض الأسكوربيك (فيتامين - ج) بالمقارنة بمعاملات التسميد الأخرى المختبرة في المواسم الثلاثة.

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