Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 06 | Issue : 04 | Oct.-Dec. | 2017
Pages:1447-1458

Response of "Washington" Navel Orange Trees to Nitrogen and Zinc Treatments

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Received: 19 Sept. 2017 / Accepted: 29 Nov. 2017 / Publication date: 30 Dec. 2017

ABSTRACT

This investigation was carried out during three successive seasons (2013/2014 – 2014/2015 and 2015 / 2016) on Washington navel orange (*Citrus sinensis* L) trees budded on sour orange rootstock (*C. aurantium*) and grown in sand– Loamy soil under flooding irrigation system from Nile water source in a private orchard at El- Qalubia Governorate, Egypt. Trying to study the effect of some nitrogen rates (500, 600 and 700) g/tree/yr as a soil application and foliar spraying with two phases of Zinc ($ZnSo_4$ or Zn-EDTA) on some vegetative growth parameters, C/N ratio, leaf mineral elements content, tree yield efficiency and some of fruit quality. Results indicated that, both nitrogen low and moderate applications rates had a significantly increased C/N ratio, leaf: (Fe, Zn and Mn) contents, average of fruit: (weight & size), fruit shape index, (juice TSS & TAC) percentage, TSS/TAC ratio and vitamin C content. In addition, both of Zn-EDTA or $ZnSo_4$ applications had insignificant effect on: numbers of leaves/ shoot, leaf area, leaf N content, average fruit size, fruit shape index, fruit peel thickness, juice TSS percentage, TAC percentage and TSS/TAC ratio. On the other hand, moderate or high nitrogen rates with Zn So_4 significantly improved shoot: (length & diameter), leaf area, leaf K percentage and Zinc content. Also, moderate or high nitrogen rates with Zn-EDTA had a significant increase of numbers of leaves / shoot, leaf Fe content, tree yield efficiency, fruit peel thickness, juice acidity percentage and TSS/ TAC ratio.

Key words: Nitrogen, $ZnSo_4$, Zn-EDTA, Citrus cvs, TSS/TAC ratio and C/N ratio.

Introduction

Washington navel orange (*Citrus sinensis* L.) is one of the most important citrus fruits grown in Egypt. Fertilization is essential for plant growth and development and must be constantly obtained from the soil (Arnon and Stout, 1939). Under Nile-Delta Egypt conditions, citrus producers need adequate amounts especially at critical crop growth stages, especially, fruit initiation and development (Obreza and Morgan, 2008; Alva *et al.,* 2005).

Nitrogen is the pre-requisite and most important nutrient for citrus cultivation (Embleton and Jones 1978; Dasberg *et al.,* 1984; Alva and Tucker 1999; Boman and Obreza 2002; Alva *et al.,* 2003). Also, it is essential to enhance plants biological processes (normal cell division, being part of several molecules such as amino acids, nucleic acids, chlorophylls, (Amtmann and Blatt, 2008) growth, respiration and enables plants to use the energy of sunlight to form sugars from carbon dioxide and water) (Abbas and Fares, 2008). Excess nitrogen application enhances vegetative tree growth (Alva *et al.,* 2003; Schumann *et al.,* 2003) and may cause ground water contamination if leached with excess irrigation and/or rainfall (Alva and Paramasivam, 1998; He *et al.,* 2000; Alva *et al.,* 2006). Also, the fruit is large and puffy, maturity is delayed, and re-greening increases.

After High Dam builing, Nile – Delta region is suffering from a lacke of some essential elements. Zinc deficiency is considered a widespread nutritional disorder in many plants. Moreover, not only that, but zinc availability is inversely related to soil pH and its deficiency in a variety of plant species is frequently noted on calcareous soils with pH >8.0. Even in its earliest stages, zinc deficiency reduces tree vigor, yield and result small fruit with poor quality (Swietlik, 2002; Parker, 1937b; Smith and Storey 1979; Embleton *et al.,* 1988).There was no difference in the effectiveness of Zn compounds for foliar sprays applied to apples (Neilsen and Neilsen, 1994). Generally, use an annual foliar spray (zinc - EDTA) alone or in a combination spray with other minor elements on the spring flush leaves (when they are about two-thirds their full size) .Whereas, severely deficient trees

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need two or more sprays during the season. Micro- nutrition elements as EDTA source are more expensive. The major objectives of this paper were to evaluate the effect of nitrogen (different rates) application and zinc spraying (various sources), according to tree phonological stages requirements , on tree nutritional status, biomass tree growth, fruit yield and quality, of 35 years old Washington navel orange trees grafted on 'Sour orange', under Nile – Delta region conditions.

Materials and Methods

This investigation was carried out during three successive seasons (2013/2014 – 2014/2015 and 2015/2016) on Washington navel orange trees budded on sour orange rootstock, grown in a private orchard at the Delta region El Qlubia Governorate, Egypt. Thirty – six trees of 35 –year- old, planted at 5 × 5 m apart in sand - loamy soil (Table 1) under flooding irrigation system (Nile water) were carefully selected as being healthy, disease free and uniform as possible in their vigorous and size to study the effect of different nitrogen soil applications levels (N_1" 500 g / tree", N_2" 600 g/ tree" and N_3 " 700 g/tree") every level was divided to three doses/yr as follow : 40% at the 1st week of March ; 30% at the 1st week of May and 30% at the 1st week of July as (Calcium nitrate 15 % N at the 1st dose; Ammonium nitrate 33% N at the 2nd and 3rd doses; Ammonium sulfate 20%) . Two different Zinc phases (Zin-EDTA"300g/600L." and $ZinSo_4$ "3kg/600 L.") were sprayed twice: at the 1st week of May (at70% leaf expanded) and repeated at the 1st week of July**.** All devoted trees received regularly the same horticultural adopted in citrus orchards according to Agric. Ministry of Egypt recommendations. The complete randomized block design with three replications (each replicate was represented by a single tree) was used for arranging the following eighteen trees.
Treatments as follow:
T1- Nitrogen (N_1) 500g/tree/yr + Zn-EDTA 300 g / 600 L.
T2- Nitrogen (N_2) 600g/tree/yr + Zn-EDTA 300 g / 600 L (The control)
T3- Nitrogen (N_3)700g/tree/ yr + Zn-EDTA 300 g / 600 L.
T4- Nitrogen (N_1) 500 g/tree/yr + Zinc sulfate 3kg / 600 L.
T5- Nitrogen (N_2) 600 g/tree/yr + Zinc sulfate 3kg / 600 L.
T6- Nitrogen (N_3)700 g/tree/ yr + Zinc sulfate 3kg / 600 L.

- These treatments were applied up to three consecutive years on the same trees.

Table 1: Mechanical and Chemical analysis of the orchard soil under experimental trees.

	Particle size dist.		Soluble ions (meq./L)						Available nutrient (ppm)		
Depth (cm.)	0-30	30-60	Cations			Anions			Depth (cm.)	0-30	30-60
Coarsed sand	37.20	37.00	Depth (cm.)	0-30	30-60	Depth (cm.)	0-30	30-60	P	11.30	2.50
Fine sand	38.40	35.70	Ca++	13.00	11.50	CO_3	-	-	K	317.5	220.00
Silt	14.60	15.60	Mg++	10.00	6.50	HCO_3	10.00	7.00	Mn	6.00	3.80
clay	9.80	11.70	Na+	8.90	6.30	Cl	4.00	4.00	Fe	8.00	6.00
Textural class	Sandy Loam	Sandy Loam	K+	5.10	5.10	SO_4	22.00	18.40	Zn	2.20	0.80
EC mmhos/cm at 250c	3.65	2.86							Cu	1.00	0.40

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Measurements and analysis

Four branches one year old were chosen for each tree. Four shoots from the current spring growth cycle were labeled to follow up the effects of the differential investigated treatments were evaluated through the response of the following measurements:

1- Vegetative growth:

Spring vegetative flushes: shoot length & diameter (cm.); number of leaves / shoot and leaf area (cm^2).

2- Physiological parameters:

C / N ratio was determined at the mid of September: sample of mature non-fruiting spring shoots were taken, defoliated and weighed. Then, oven dried at 70 centigrade. Total carbohydrates (g/100g. DW): powders samples were acid hydrolyzed and the resulting data signing sugar designated as available carbohydrates was determined by the di-nitro-salicylic acid (DNS) method of Fisher and Stein, (1961) . Total nitrogen was determined in mature leaves.
Then C/ N ratio was calculated = Total carbohydrates in shoots / Total nitrogen in leaves.

3- Leaf minerals content:

Mature leaves from non-fruiting spring flushes were collected in September for the three seasons determine leaf mineral content in

a) Total nitrogen by semi-micro Kjeldahl method as described by Pregel (1945).
b) Phosphorus using " Specol" spectrophotometer at 882U.V. according to the method described by Murphy and Riely (1962).
c) Potassium was determined using Flame photometer according to Brown and Lilleland (1946).
d) Iron, Zinc and Manganese were determined using Atomic Absorption Spectrophotometer "Perkin Elmer -3300" alter Chapman and Part (1961).

4- Tree yield efficiency as kg/m^3 canopy:

Fruit yield was recorded annually. Yield in relation to tree volume was used as a measure of tree efficiency (Tree efficiency) = kg of fruits /m3 canopy of tree, (Castle and Philips, 1980).

5- Fruit quality:

A sample of 10 fruits per each replicate was selected in the 1st week of January to determine the fruit quality as follows:

a) Fruit physical characteristics: average of fruit weight (g), fruit size (ml.), fruit shape Index and peel thickness (cm).
b) Fruit chemical characteristics: Juice (TSS %, T.AC %, TSS/T.AC ratio and Vit.C (mg/ 100 g. juice) (A.O.A.C., 1990).

6- Statistical analysis:

The experiment was set in a split plot design with three replicates and six treatments. Where, Nitrogen levels treatments were randomly arranged in the main plots, zinc phases were distributed in the sub plots. The necessary samples were obtained from three trees representing three replicates for each treatment. The obtained data each season were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran (1980) using M-STAT program. Means values represented the various investigated treatments were compared by the Duncan's multiple range test (Duncan, 1958) at 0.05 level of significance.

Results and Discussion

1- Vegetative growth parameters:

a. Shoot length (cm) :

Nitrogen at 700g / tree /yr had statistically increased spring vegetative shoot length Table (2) when compared to the other nitrogen rates (500 & 600 g/tree/yr) during the three successive seasons . However, there were no significant effects for nitrogen rates (500 &600 g/tree/yr) in both the 1st and the 2nd seasons. Let, nitrogen (500 g/tree/ yr) significantly reduced shoot length in the 3rd season. Spraying $ZnSo_4$ significantly increased shoot length in the 1st and 2nd seasons as compared to Zn-

EDTA applications. While, in the 3rd season, data displayed no significant effect for both zinc sources on shoot length (Table 2). As for the interaction, data presented cleared that both nitrogen and zinc applications had a significant and fluctuated effect on shoot length during the three studied seasons. Whereas, nitrogen 700 g/ tree /yr plus $ZnSo_4$ treatment resulted in the highest values and nitrogen 500 g/tree/yr Plus Zn-EDTA was the lowest in the 1st season. While nitrogen 700 g/tree/yr Plus Zn-EDTA or $ZnSo_4$ gave insignificant effect highest shoot length and nitrogen 500 g/tree/yr Plus Z-EDTA was the lowest in the 2nd season. On the other hand, nitrogen 700 g/tree/yr. plus Zn-EDTA was the highest and nitrogen 600 g/tree/yr Plus Zn-EDTA was the lowest in the 3rd season.

Table 2: Effect of Nitrogen and Zinc treatments on vegetative growth parameters of Washington navel orange tree during three seasons of study.

Treatments	First season			Second season			Third season		
	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means
Shoot length (cm)									
N_1	6.033 c	10.00 a	8.02 B	8.100 b	12.33 a	10.22 B	8.53 d	12.47 b	10.50 C
N_2	7.033 b	10.27 a	8.65 B	9.033 b	12.87 a	10.95 B	10.03 c	13.20 ab	11.62 B
N_3	10.50 a	10.53 a	10.52 A	13.13 a	12.47 a	12.80 A	13.83 a	12.50 b	13.17 A
Means	7.856 B	10.27 A		10.09 B	12.56 A		10.80 A	12.72 A	
Shoot diameter (cm)									
N_1	0.55 d	0.83 ab	0.69 B	0.59 d	0.89 a	0.74 B	0.61 d	0.90 a	0.76 B
N_2	0.65 c	0.85 a	0.75AB	0.70 c	0.90 a	0.80AB	0.72 c	0.93 a	0.83 A
N_3	0.75 b	0.81 ab	0.78 A	0.79 b	0.88 a	0.84 A	0.81 b	0.89 a	0.85 A
Means	0.65 B	0.83 A		0.70 B	0.89 A		0.71 B	0.91 A	
Number of leaves / shoot									
N_1	13.56abc	9.667 c	11.61 B	14.41 ab	13.00 b	13.70A	15.07 b	13.44 b	14.26B
N_2	12.78 bc	14.00 ab	13.39AB	13.82 b	12.58 b	13.20A	14.22 b	13.41 b	13.81B
N_3	17.67 a	16.33 ab	17.00 A	18.43 a	15.18 ab	16.81A	19.38 a	15.52 b	17.45A
Means	14.67 A	13.33 A		15.55 A	13.59 A		16.22 A	14.12 A	
Leaf area (cm^2)									
N_1	25.47 bc	29.93 a	27.70A	27.96 bc	32.52 a	30.24A	28.45 b	32.91 a	30.68AB
N_2	24.40 c	28.17 ab	26.29A	26.66 c	30.60 ab	28.63A	27.05 b	31.09 a	29.07 B
N_3	28.41 ab	28.76 ab	28.58A	30.94 ab	31.22 ab	31.08A	31.45 a	31.69 a	31.57 A
Means	26.09 A	28.95 A		28.52 A	31.45 A		28.98 B	31.90 A	

Mean followed by the same letter are not significantly different at 5% level.

b. Shoot diameter (cm):

Data in Table (2) revealed that increasing of nitrogen rate increased shoot diameter , where as , nitrogen 700 g /tree/yr significantly gave the highest values when compared to the other two rates (500 & 600) g/tree./yr during the three seasons. Moreover, $ZnSo_4$ had significantly increased of shoot diameter during the three seasons in compared to Zn – EDTA. Referring to data in Table (2) it can be noted that a significant effect of different nitrogen rates plus the two Zinc sources on shoot diameter , whereas, nitrogen 600 g /tree /yr Plus zinc sulfate applications gave the highest values , while , nitrogen 500 g/tree/yr With Zn-EDTA was the lowest during the three seasons.

c. Number of leaves / shoot :

Data tabulated in Table (2) indicated that by increasing N rate from500 to 700 g/tree/yr it resulted in an increase in number of leaves / shoot. Whereas, N700 g /tree / yr significantly gave a high number of leaves / shoot in compared to N 500 g /tree / yr in the 1st season and N 500 or 600 g /tree / yr in the 3rd season and with no significant effect in the 2nd season. With regard to the effect of zinc sources, data presented cleared that no significant differences in number of leaves / shoot during the three seasons. As for the interaction between N rates and the two Zinc phases data presented in Table (2) showed a significant effect on number of leaves / shoot during the three studied seasons. Moreover , N700 g /tree / yr plus Zn-EDTA spraying gave the highest values, while, N500 g/tree/ yr with zinc sulfate in the 1st season and N 600 g /tree / yr plus zinc sulfate in the 2nd and 3rd seasons were the lowest.

d.Leaf area (cm^2):

Concerning the effect of treatments on leaf area data in Table (2) indicated that all nitrogen rates in this study had no significant responded on Washington navel orange leaf area during the 1st and the 2nd seasons, while, a high dose of nitrogen (700g/tree / yr) significantly increased it in the 3rd season in compared to both (500 and 600) g/tree / yr. Also, data resulted that spraying of zinc sulfate improved the leaf area with in significant effect for Zn-EDTA during the three seasons. In addition, data in Table (2**)** revealed that all nitrogen rates plus spraying zinc sulfate statistically attained the highest leaf area values as compared to them with Zn – EDTA which was the lowest in the three studied seasons.

The obtained results regarding the effect of nitrogen and Zinc treatments on some vegetative growth parameters in this study agree partially with the earlier findings of Yaseen *et al.* (2004); Alva *et al.* (2006); Zaman and Schumann, (2006) . They indicated that citrus trees have three growth cycles, therefore fertilizer application program should be properly designed according to growth cycle, otherwise it is not possible to improve the plant health and fruit production. Moreover, increasing nitrogen application rates and $ZnSo_4$ spraying must be positively reflected on some vegetative growth. Zinc sulfate solution tend tar to acidity which caused a reduction in the pH of spraying solution, this may be increase Zn^{++} uptake in compared to Zn-EDTA solution (Thomas *et al.,* 2011). Generally, Zinc deficient 'McIntosh' apple seedlings doubled the amount of shoot growth when were sprayed with $ZnSo_4$ or a Zn Chelate (Neilsen and Hogue, 1983). Both forms of Zn were equally effective. Due to increased growth and the associated dilution effect, Zn tissue concentrations remained the same in the treated and control plants. On the other hand, the obtained results may be attributed to such fact that the number of leaves per mature shoot is an inheritable characteristic for each species or cultivar characterized by its relative constancy. Based on a limited number of published reports, it appears that foliar sprays are effective in stimulating vegetative growth on fruit trees suffering from severe Zn deficiencies.

2- Physiological parameters:

C / N ratio:

In this respect, data in Table (3) revealed that N_1 (500 g/tree/yr) application significantly increased navel orange tree C / N ratio during the three seasons, also, N_2 (600 g/tree/yr) in the 1st season when compared to other nitrogen rates. In additions, spraying the two Zinc phases gave the opposite trend, whereas, Zinc sulfate had a significant increasing in C/N R during the 1st and the 2nd season. While, both two Zinc sources had no significant effect in the 3rd season. As for the interaction between the nitrogen application rates and spraying Zinc, data presented in Table (3) cleared significant effect during the three seasons. Whereas, N1 (500 g/tree /yr) plus $ZnSo_4$ gave the highest C/N R values and N1 (500 g/tree/yr) plus Zn-EDTA was the lowest.

Table 3: Effect of Nitrogen and Zinc treatments on C/N ratio of Washington navel orange tree during three seasons of study.

Season	1st			2nd			3rd		
Treat.	Zn-EDTA	$ZnSo_4$	**Means**	Zn-EDTA	$ZnSo_4$	**Means**	Zn-EDTA	$ZnSo_4$	**Means**
N_1	9.623 e	28.26 a	18.94A	11.70 d	27.37 a	19.54A	10.56 e	24.89 a	17.73A
N_2	16.41 d	21.17 b	18.79A	14.79 c	17.97 b	16.38B	13.62 d	16.78 bc	15.20B
N_3	15.23 d	18.13 c	16.68 B	15.40 c	18.17 b	16.78B	15.27 c	17.52 b	16.39AB
Means	13.75 B	22.52 A		13.96 B	21.17 A		13.15 A	19.73 A	

Mean followed by the same letter are not significantly different at 5% level.

It can be concluded that C/N ratio positively increased with a reduction of nitrogen rates applications which reduces the protein in the cells. Hence, Zinc spraying enhanced vegetative growth which increased photosynthesis output. The obtained results regarding the effect of nitrogen applications and Zinc spraying on shoot Carbohydrates/ nitrogen contents goes partially with the earlier findings of (Abbas and Fares, 2008) who illustrated that nitrogen is on essential element to enhance plants biological processes (normal cell division, growth and respiration) and enables plants to use the energy of sunlight to form sugars from carbon dioxide and water.

3- Leaf minerals content:

- **Macro – elements :**

a. Leaf nitrogen content percentage:

Leaf nitrogen significantly responded positively to the effects of nitrogen applications rates. Increasing of nitrogen rate from 500 to 700 g/tree /yr was translated into an increase leaf nitrogen conc. Data in Table (4) indicated that both nitrogen (600 g/tree/yr) or (700 kg/ tree /yr) significantly increased leaf nitrogen content when compared to nitrogen (500 g/tree/yr) during the three studied seasons . As for the two Zinc phases effect, data resulted that Zn-EDTA spraying enhanced of leaf nitrogen, whereas, it gave a high values content with in significant differ to $ZnSo_4$ during the 1st and the 2nd seasons. While, in the 3rd seasons this response became clearly significant .In addition , data in Table (4) showed that nitrogen application rate (500g/tree/yr) plus Zn-EDTA significantly increased leaf nitrogen contents during the 1st and the 3rd seasons , while , nitrogen (600g/tree/yr) with $ZnSo_4$ was significantly the highest in the 2nd season. On the other hand, nitrogen (500g/tree/yr) plus $ZnSo_4$ was the lowest during the three seasons.

Table 4: Effect of Nitrogen and Zinc treatments on leaf macro elements content percentage of Washington navel orange tree during three seasons of study.

Treatments	First season			Second season			Third season		
	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means
Leaf nitrogen content									
N_1	2.38 a	1.49 c	1.94 A	2.26 a	1.63 c	1.95 B	2.44 a	1.71 e	2.08 B
N_2	1.81 bc	1.94 abc	1.88 A	2.00 b	2.27 a	2.14 A	2.14 d	2.37 ab	2.26 A
N_3	2.12 ab	1.99 abc	2.06 A	2.19 a	2.18 a	2.19 A	2.24 c	2.29 bc	2.27 A
Means	2.10 A	1.81 A		2.15 A	2.03 A		2.27 A	2.13 B	
Leaf phosphorus content									
N_1	0.1567 a	0.1467 a	0.1517A	0.1533 a	0.1433 a	0.1483A	0.1633 a	0.1433 a	0.1533A
N_2	0.1500 a	0.1567 a	0.1533A	0.1533 a	0.1533 a	0.1533A	0.1500 a	0.1633 a	0.1567A
N_3	0.1967 a	0.1533 a	0.1750A	0.1633 a	0.1633 a	0.1633A	0.1533 a	0.1633 a	0.1583A
Means	0.1678 A	0.1522 A		0.1567 A	0.1533 A		0.1556 A	0.1567 A	
Leaf potassium content									
N_1	0.98 b	0.77 d	0.87 B	1.14 b	0.91 d	1.02 B	1.20 a	0.98 b	1.09 A
N_2	0.86 c	1.03 b	0.94 A	0.96 cd	1.18 b	1.07 AB	0.99 b	1.26 a	1.12 A
N_3	0.68 e	1.13 a	0.90 AB	1.00 c	1.24 a	1.12 A	1.03 b	1.29 a	1.16 A
Means	0.84 B	0.97 A		1.03 A	1.11 A		1.07 A	1.17 A	

Mean followed by the same letter are not significantly different at 5% level.

b. Leaf phosphorus content percentage:

As for the effect of some nitrogen rates and Zinc treatments on leaf P% content, data tabulated in Table (4) cleared that all nitrogen (500,600 and 700) g/tree/yr applications rates and $ZnSo_4$ spraying or their interaction had significant effect on Washington navel orange leaf P% content as compared to the control (600kg/tree/yr) during the three studied seasons.

***c.** Leaf potassium content percentage:*

Referring to Table (4) data resulted that both nitrogen rate N_2 (600g/tree/yr) or N_3 (700g/tree/ yr) had significant increasing leaf K% when compared to N_1 (500g/tree/yr) during the 1st and the 2nd season. All of nitrogen rates in this study had insignificant effect in the 3rd season. Moreover, spraying $ZnSo_4$ significantly improved leaf K% in compared to Zn-EDTA during the three seasons. As for the interaction between nitrogen rates and Zinc phases data in Table (4) indicated that a significant effect during the three studied seasons, whereas, nitrogen 700g/tree/yr plus $ZnSo_4$ gave the highest values and nitrogen 700g /tree/yr with Zn-EDTA in the 1st season and nitrogen 500g/tree/yr plus $ZnSo_4$ in the 2nd and the 3rd seasons was the lowest.

- **Micro-elements :**

a. Leaf iron content (ppm):

Data in Table (5) indicated that nitrogen N_2 (600g/tree/yr had significant increasing effect on leaf iron content as compared to N_1 500g/tree/yr and N_3 700g/tree/yr during the three seasons .Whereas, the high rate $N_3$700 g/tree/yr significantly reduced it in the 1st and the 2nd season . With respect of the two phases of foliar Zinc spraying, data revealed that Zn- EDTA applications significantly increased leaf iron content in compared to $ZnSo_4$ during the three seasons. Moreover, nitrogen rates applications plus the two Zinc phases spraying had significant effect on navel orange leaves iron content in the three seasons. However, nitrogen rate N_1 and N_2 gave the highest values in the 1st season, but N_2 was the highest during the 2nd and the 3rd seasons. On the other hand, a high rate of nitrogen N_3 plus $ZnSo_4$ gave the lowest iron values during the three studied seasons.

Table 5: Effect of Nitrogen and Zinc treatments on leaf micro elements content (ppm) of Washington navel orange tree during three seasons of study.

Treatments	First season			Second season			Third season		
	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means
Leaf iron content									
N_1	90.67 a	73.92 d	82.29 B	94.63 b	77.67 d	86.15B	97.83 b	76.41 d	87.12B
N_2	94.62 a	85.47 b	90.05 A	102.4 a	89.71 c	96.04A	108.6 a	92.31 c	100.5A
N_3	79.74 c	67.43 e	73.58 C	86.37 c	74.92 d	80.65C	89.26 c	78.59 d	83.93B
Means	88.34 A	75.61 B		94.46 A	80.77 B		98.57 A	82.44 B	
Leaf zinc content									
N_1	46.31 f	67.06 b	56.69 B	58.18 e	84.24 b	71.21B	61.03 e	84.92 b	72.97B
N_2	47.22 e	92.01 a	69.61 A	61.10 de	93.50 a	77.30A	65.02 d	92.12 a	78.57A
N_3	49.48 d	54.21 c	51.85 C	63.01 d	75.48 c	69.24B	62.75 de	78.35 c	70.55B
Means	47.67 B	71.09 A		60.76 B	84.41 A		62.94 B	85.13 A	
Leaf manganese content									
N_1	54.49 a	54.73 a	54.61 A	59.84 b	64.95 a	62.40A	61.35 b	63.92 a	62.63A
N_2	44.64 b	39.83 c	42.24 B	47.31 d	54.27 c	50.79C	49.90 d	57.52 c	53.71B
N_3	43.52 bc	47.12 b	45.32 B	47.66 d	60.37 b	54.02B	48.39 d	60.96 b	54.68B
Means	47.55 A	47.23 A		51.60 B	59.87 A		53.21 B	60.80 A	

Mean followed by the same letter are not significantly different at 5% level.

b. Leaf zinc content (ppm):

In this concern, data tabulated in Table (5) disclosed that nitrogen rate N_2 (600g/tree/yr) significantly increased leaf Zinc content when compared to other nitrogen rates N_1 and N_2 during the three seasons. In addition, $ZnSo_4$ spraying had a significant increase in leaf Zn contents in compared to Zn- EDTA application at the three studied seasons. As for the interaction, data presented in Table (5) indicated that different nitrogen application rates plus Zinc foliar spraying had a significant effect on leaf Zn contents during the investigation seasons. Whereas, nitrogen rate N_2 (600g/tree/yr) with $ZnSo_4$ resulted in the highest values during the three seasons. While, nitrogen N_3 (700 g/tree / yr) plus Zn-EDTA was the lowest.

c. Leaf manganese content (ppm)

In this regard , data presented in Table (5) cleared that nitrogen N_1(500g/tree/yr) had a significant increased in leaf Mn content in compared to other nitrogen rates N_2 or N_3 during the three studied seasons . However, both Zn – EDTA or Zn So_4 spraying had insignificant effect on leaf Mn content in the 1st season. But, Zn So_4 significantly increased Mn content in the 2nd and the 3rd seasons when compared to Zn-EDTA. Also, data in Table (5) resulted that nitrogen N_1 (500g/tree/yr) plus Znso4 significantly led to the highest Mn values and nitrogen N_2 (600g/tree/yr) with Zn-EDTA was the lowest during the three seasons.

As expected, increasing nitrogen rate from (500 to 700) g/tree/yr) will be reflected by on increase leaf nitrogen contents. However, this increase in the nitrogen may have a negative impact on the product or fruit quality characteristics. Thus, the obtained results attributed between nitrogen rate 80kg/Fed./yr plus Zn-EDTA and 100 kg/Fed./yr plus $ZnSo_4$ applications significantly increased leaf:

N and K percentage with no significant effect on P% contents. As for micro- elements contents: nitrogen rate 600g/tree/yr plus $ZnSo_4$ had significant increase in leaf: Fe and Zn, while, nitrogen N1 (500g/tree/yr) plus $ZnSo_4$ significantly increase leaf Mn content. The obtained results goes in the line with the finding of Alva *et al.,* (2005) for 'Hamlin' citrus trees and He *et al.,* (2003) for grapefruit, under Florida conditions. They mentioned that increasing N rate to 160 kg/ha/yr was translated by leaf N response of 0.008 g/kg for each supplementary kg N supply. Increasing nitrogen rates from 160 to 192 and from 192 to 232 kg/ha/yr have induced a limited N leaf response at 0.004 and 0.005 g/kg, respectively, for each nutrient unit added. This observation would suggest that 232 Kg/ha N application may represent an upper limit of required nitrogen rate.

4- Tree yield efficiency (kg/m3 canopy) :

Referring to Data in Table (6) it can be noted that tree yield efficiency (kg/m3 canopy) significantly increased with increasing nitrogen application rate. Whereas N_3 (700g/tree/yr) gave the highest values as compared to other nitrogen rates during the three seasons. On the other hand, both Zn – EDTA or $ZnSo_4$ spraying had insignificant effect on yield efficiency in the 1st season, while, Zn-EDTA significantly increased tree production in the 2nd and 3rd seasons in compared to $ZnSo_4$ application. Moreover, nitrogen N_3 (700g/tree/yr) plus Zn- EDTA significantly was the highest tree yield efficiency but nitrogen N_1 (500g/tree/yr) with $ZnSo_4$ was the lowest in the three studied seasons Table (6).

Table 6: Effect of Nitrogen and Zinc treatments on yield efficiency (Kg/m^3) of Washington navel orange tree during three seasons of study.

Season	1st			2nd			3rd		
Treat.	Zn-EDTA	$ZnSo_4$	**Means**	Zn-EDTA	$ZnSo_4$	**Means**	Zn-EDTA	$ZnSo_4$	**Means**
N_1	1.533 e	1.370 f	1.452 C	1.627 d	1.417 e	1.522C	1.677 d	1.437 e	1.557C
N_2	1.703 d	2.700 b	2.202 B	1.943 c	2.813 b	2.378B	1.950 c	2.843 b	2.397B
N_3	3.467 a	1.853 c	2.660 A	3.317 a	1.890 c	2.603A	3.393 a	1.913 c	2.653A
Means	2.234 A	1.974 A		2.296 A	2.040 B		2.340 A	2.64 B	

Mean followed by the same letter are not significantly different at 5% level.

5- Fruit quality:

a. Fruit physical characteristics:

1- Fruit weight (g):

Data in Table (7) indicated that increasing of nitrogen rates from 500 to 700 g/tree/yr significantly reduced average fruit weight during the three seasons. In spite of, both Zinc phases spraying had insignificant effect on fruit weight at the 1st season, but $ZnSo_4$ significantly increased it during the 2nd and 3rd seasons. As for the interaction between nitrogen rates applications and Zinc spraying, data presented in Table (7) showed a significant effect on average of fruit weight during the three seasons. Whereas, nitrogen N_1 (500g/tree/yr) plus $ZnSo_4$ scored the highest fruit weight and nitrogen N_3 (700g/tree/yr) with Zn-EDTA was the lowest.

2- Fruit size (ml.):

In this respect data in Table (7) cleared that increasing of nitrogen rates applications gave the same trend of their effect on fruit weight. Whereas, both nitrogen rates (600 or 700) g/tree/yr had a significant reduction in the fruit size in compared to nitrogen N_1 500 g/tree/yr during the three studied seasons. In addition, both Zinc phases had insignificant effect on fruit size for all investigated study. As for the interaction between nitrogen rates applications and Zinc spraying data presented in Table (7) showed the same trend of fruit weight at the three seasons.

3- Fruit shape index:

It can be noted that Washington navel orange fruit shape trended to the "Ellipsoid" shape under this study. Moreover, data in Table (7) cleared that increasing nitrogen applications rates significantly reduced the "Ellipsoid" shape when compared to the lower (500g/tree/yr) or the moderate rate (600 g/tree/yr) during the three studied seasons . As for the effect of Zinc spraying data in Table (7) showed no significant of both Zinc phases spraying on Washington navel orange fruit shape index under this study. Moreover nitrogen N_2 (600g/tree/yr) applications plus $ZnSo_4$ spraying significantly increased the fruit height or reduced fruit width which reflected on fruit shape and nitrogen 700g/tree/yr with Zn-EDTA reduced it during the three seasons .

Table 7: Effect of Nitrogen and Zinc treatments on fruit physical characteristics of Washington navel orange tree during three seasons of study.

Treatments	First season			Second season			Third season		
	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means
Fruit weight (g)									
N_1	267.7 b	298.3 a	283.0 A	275.0 b	309.7 a	292.3A	281.3 b	316.0 a	298.7A
N_2	255.7 b	265.0 b	260.3AB	263.3 bc	278.7 b	271.0B	269.3 bc	285.7 b	277.5B
N_3	236.3 b	255.0 b	245.7 B	247.3 c	266.0 b	256.7B	254.7 c	272.3 bc	263.5B
Means	253.2 A	272.8 A		261.9 B	284.8 A		268.4 B	291.3 A	
Fruit size (ml.)									
N_1	270.5 ab	297.5 a	284.0 A	280.5 b	315.8 a	298.1 A	289.7 b	322.4 a	306.0 A
N_2	234.0 bc	249.9 bc	241.9AB	244.2 cd	262.1 bc	253.1 B	255.8 cd	278.2 bc	267.0 B
N_3	210.5 c	228.9 bc	219.7 B	226.0 d	247.2 cd	236.6 B	235.1 d	261.5 bcd	248.3 B
Means	238.3 A	258.8 A		250.2 A	275.0 A		260.2 A	287.4 A	
Fruit shape index									
N_1	1.110 b	1.080 bc	1.095 B	1.170 ab	1.130 b	1.150A	1.180 a	1.160 a	1.170A
N_2	1.180 a	1.190 a	1.185 A	1.160 ab	1.210 a	1.185A	1.170 a	1.220 a	1.195A
N_3	1.027 c	1.050 bc	1.038 B	1.040 c	1.060 c	1.050B	1.027 b	1.070 b	1.048B
Means	1.106 A	1.107 A		1.123 A	1.133 A		1.126 A	1.150 A	
Fruit peel thickness (cm.)									
N_1	0.46 c	0.73 b	0.59 A	0.36 d	0.65 b	0.51 C	0.35 d	0.62 ab	0.48 C
N_2	0.79 ab	0.56 bc	0.68 A	0.72 a	0.48 c	0.60 B	0.68 a	0.42 c	0.55 B
N_3	0.69 bc	0.99 a	0.84 A	0.60 b	0.76 a	0.68 A	0.59 b	0.67 a	0.63 A
Means	0.65 B	0.76 A		0.56 A	0.63 A		0.54 A	0.57 A	

Mean followed by the same letter are not significantly different at 5% level.

4- Fruit peel thickness (cm.):

Fruit peel thickness significantly responded to the effects of nitrogen applications rates, Table (7) revealed that increasing of nitrogen rates from (500 to 700) g/tree/yr had insignificant increase of peel thickness in the 1^{st} season. While, nitrogen N_3 (700g/tree/yr) significantly gave the highest values during both the 2^{nd} and the 3^{rd} season when compared to other nitrogen rates. Also, data presented indicated that $ZnSo_4$ spraying significantly increased fruit peel thickness when compared to Zn-EDTA in the three seasons. Table (7) cleared that the interaction effect of nitrogen rates applications with Zn – EDTA or $ZnSo_4$ spraying; data had a significant effect on peel thickness (cm.) during the three seasons. Nitrogen N_3 (700g/tree/yr) plus $ZnSo_4$ treatment had the highest value in the 1^{st} season. While, nitrogen N_2 (600g/tree/yr) with $ZnSo_4$ gave the highest values in 2^{nd} or the 3^{rd} season. In addition, nitrogen N_1 (500 g/tree /yr) plus Zn-EDTA was the lowest.

b) Fruit chemical characteristics:

1. Fruit juice TSS percentage :

Data in Table (8) revealed that either nitrogen different rates applications or both Zinc phases had insignificant effect on fruit juice TSS percentage during the 1^{st} season. Whereas, nitrogen N_1 (500g/tree/yr) significantly increase TSS percentage in compared to other nitrogen rates during the 2^{nd}

and the 3rd season. While, Zn-EDTA spraying had a significant increase of TSS percentage when compared to $ZnSo_4$ in the 2nd season. As for the interaction between different nitrogen rates with the two Zinc phases had a significant effect in the three studied seasons (Table 8). Nitrogen N_1 (500g/tree/yr) plus Zn-EDTA scored the highest values and N_2 (600 g/tree/yr) with $ZnSo_4$ had the lowest value.

Table 8: Effect of Nitrogen and Zinc treatments on fruit chemical characteristics of Washington navel orange tree during three seasons of study.

Treatments	First season			Second season			Third season		
	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means	Zn-EDTA	$ZnSo_4$	Means
Fruit juice TSS percentage									
N_1	10.50 a	9.83 ab	10.17A	11.33 a	10.50 c	10.92 A	11.67 a	10.83 ab	11.25 A
N_2	10.33 a	8.75 b	9.54 A	10.67 b	9.08 d	9.88 C	10.83 ab	9.33 c	10.08 B
N_3	10.33 a	10.00 ab	10.17A	10.67 b	10.50 c	10.58 B	11.00 ab	10.67 b	10.83AB
Means	10.39 A	9.52 A		10.89 A	10.03 B		11.17 A	10.28 A	
Fruit juice TAC percentage									
N_1	0.78ab	0.77 ab	0.77A	0.82ab	0.77 bc	080A	0.80 a	0.79 a	0.80A
N_2	0.82 a	0.75 b	0.78A	0.84 a	0.74 c	0.79A	0.81 a	0.77 a	0.79A
N_3	0.77ab	0.79 ab	0.77A	0.77bc	0.79abc	0.78A	0.74 a	0.79 a	077 A
Means	0.79 A	0.76 A		0.81 A	0.77 A		078 A	0.78 A	
Fruit juice TSS/TAC R									
N_1	13.46 a	12.77 a	13.21 A	13.82 a	13.64 a	13.65A	14.59 ab	13.71 b	14.06A
N_2	12.60 b	11.67 ab	12.23 A	12.70 a	12.27 a	12.51A	13.37 b	12.12 b	12.76A
N_3	13.42 a	12.65 ab	13.21 A	13.86 a	13.29a	13.56A	14.86 a	13.51 b	14.06A
Means	13.15 A	12.52 A		13.44 A	13.03 A		14.32 A	13.18 A	
Fruit juice vitamin C content (mg/100 ml juice)									
N_1	45.63 a	38.27 d	41.95AB	45.70 a	38.70 b	42.20A	45.83 a	38.80 d	42.32A
N_2	45.20 a	40.47 c	42.83 A	45.47 a	41.03 b	43.25A	45.60 a	41.40 bc	43.50A
N_3	42.47 b	38.10 d	40.28 B	43.00 ab	38.60 b	40.80A	43.50 ab	39.77 cd	41.63A
Means	44.43 A	38.94 B		44.72 A	39.44 B		44.98 A	39.99 B	

Mean followed by the same letter are not significantly different at 5% level.

2. Fruit juice T.AC percentage:

In this regard, data presented in Table (8) cleared that, nitrogen rates (500, 600 and 700) g/tree/yr application and both Zinc phases spraying had insignificant effect on fruit juice T.AC % during the three studies seasons. On the other hand , the interaction between nitrogen applications and zinc spraying had a significant effect on juice T.AC % during the investigated three seasons .Whereas, nitrogen N_2 (600 g/tree/yr) plus Zn-EDTA gave the highest values and the same rate of nitrogen (N_2) with $ZnSo_4$ was the lowest .

3.Fruit juice TSS/Acid ratio :

In this respect, data tabulated in Table (8) cleared that all nitrogen rates N_1, N_2 and N_3 had insignificant effect on juice TSS / Acid ratio during the three seasons. While, Zn-EDTA spraying significantly increased the TSS/Acid R in compared to $ZnSo_4$ for all studied three seasons. As for the interaction effect data in Table (20) indicated that it had significant effect during the three seasons. Whereas, nitrogen rate N_3 (700g/tree/yr) with Zn-EDTA gave the highest values .While, nitrogen rate N_2 (600g/tree/yr) plus Zn-EDTA was the lowest.

4. Fruit juice Vit. C content (mg/100 ml juice):

In spite of nitrogen rate N_2 (600g/tree/yr) application significantly increased juice Vit. C contents in the 1st season as compared to N_3 rate, Table (8)**,** yet, all nitrogen rates had insignificant effect on Vit. C. contents in the 2nd and 3rd season. Also, Zn-EDTA spraying significantly increases Vit. C. when compared to $ZnSo_4$ spraying in the three seasons. Data presented in Table (8**)** showed significant effect for the three rates of nitrogen plus the two zinc phases during the three seasons. Whereas, nitrogen rate N_1 plus Zn-EDTA gave the highest values and nitrogen rate N_3 with $ZnSo_4$ was the lowest.

Under this study, it can be concluded that tree yield efficiency has a linear relation with increasing nitrogen application rates from 500 to 700 g/tree/yr plus spraying Zn-EDTA. Moreover, nitrogen application rate 700 g/tree/yr plus spraying Zn-EDTA had a significant the smallest fruit weight and size in compared to both nitrogen 500 or 600 g/tree/yr application rates with $ZnSo_4$ spraying. Generally, Washington navel orange cultivar had a "Ellipsoid" fruit shape, while, nitrogen 600 g/tree/yr application rate plus $ZnSo_4$ significantly increased a "Ellipsoid" fruit shape degree. Both nitrogen 600 or 700 g/tree./yr plus $ZnSo_4$ increased the average of fruit peel thickness when compared to nitrogen rate 500 g/tree/yr plus Zn-EDTA spraying. As for the fruit chemical characteristics , increasing nitrogen rates had increasing fruit juice acidity % and reducing the TSS% and Vit .C contents .The obtained results are in the line with the findings of Schumann *et al.,* (2003) on Hamlin orange; However, high nitrogen use efficiency levels, which appeared the most adequate according to the fruit yield and quality, are substantially higher than 4.4 kg N/T as reported by Koo *et al.,* (1984) for Florida orange trees, Alva *et al.,* (2005) and He *et al.,* (2003) for grapefruit who indicated that nitrogen rates must be in limited range applications . Zn foliar sprayed one and two months before an thesis increased fruit set and not fruit size (Swietlik, 1996). Yield also tended to increase following foliar sprays applied just after the bloom and again 3 months later but the response was not statistically significant. Both Zinc sources had a fluctuated effect on all measurements parameters under study. This results are harmony with those found by (Smith and Storey, 1979; Embleton *et al.,* 1988) , who mentioned that in citrus, $Zn (NO_3)_2$ alone and in combination with urea and ammonium nitrate raised leaf Zn level more than $Zn\ So_4$. Whereas, (Neilsen and Neilsen, 1994) indicated that there was no difference in the effectiveness of Zn compounds as foliar sprays applied to apples.

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