Effect of a Mixture from Nitrogen, Potassium and Magnesium levels on Washington Navel and Valencia Orange Production under Drip Irrigation System at Bustan Area, Egypt.

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ABSTRACT

A field experiment was conducted during 2007 and 2008 growing seasons in the sandy soil of Bustan area, Egypt to study the combined effect of three levels of nitrogen, potassium and magnesium on yield, fruit quality, leaf area, leaf mineral and chlorophyll content of Washington Navel and Valencia orange. The tested variables were, T_1: control treatment (traditional method of applying fertilizer in the orchard) :combination of [2kg (N) + 1 kg (k) + 0.25 (Mg)] per tree , T_2 : [2.5kg (N) +1.25 kg (k) + 0.5 kg (Mg)] per tree, T_3 [3kg (N) + 1.5 kg (k) + 0.625kg (Mg)] per tree. Mature 36 trees (7 years old) from Washington navel and Valencia orange trees, budded on sour orange rootstock and spaced 4×5 a part were used. Each replicate consisted from two trees. Results, indicated that number of fruit / tree, yield / kg tree, weight of fruit/g, diameter of fruit/cm and length of fruit/ cm were significantly higher for T_3 than T_2 and T_1, in 2008 season in Washington Navel. Also, number of fruit, yield and weight of fruit were significant increased in T_3 compared with control in 2007 and 2008 season in Valencia orange. Increasing mixture of N + K + Mg levels resulted increasing rind thickness, juice volume, T.S.S and leaf area in 2007 and 2008 seasons in both species. On the other hand, there was no significant effect of treatments on leaf chlorophyll a and b content in both cultivars. The elements N, P, K, Ca and Mg were significantly increased for T_2 and T_3 than control (T_1) in both seasons in Washington navel and Valencia orange.

INTRODUCTION

Citrus is one of the most important horticultural crops in the world, the mean annual world production of about 110 million tons. The Mediterranean countries produce about 25% of the world production (FAO, 2000). In Egypt, citrus centers represents one of the important fruit crops due to its high economic value especially through exportation. The area planted with citrus was about 394548 feddan representing about 35% of the total area planted with fruit crops. About 65% of the area developed to citrus is planted oranges .

According to annual book of Agricultural statistics (2007), Navel orange represented about 138267 feddan, while Valencia orange about 72430 feddan.

Nitrogen, potassium and Magensium are playing an essential role in the mineral nutrition of citrus fruits. Nitrogen is the most important element effecting yield. It has a pronounced effect on the growth and appearance of citrus trees (Roits *et al.*, 1972). Results by El- Boray *et al.*, (1995a) indicated that, increasing rates of N application from 500 to 1500g/tree/year increased fruit weight, size, number of fruits/ tree of Washington and Valencia oranges.

Potassium is one of the essential elements in citrus nutrition that needs to be added regularly in the fertilizer program. It is important for structure and promotes formation of ATP (plant energy), synthesis of amino acids and proteins (Russelt, 1978). Also the highest yield and fruit weight were obtained by potassium addition, (El-Gazzar *et al.*1981) and (Goepfert *et al.* 1987). Indicated that potassium percentage in citrus leaves varied from 0.56 to 1.56% depending on soil condition. Potassium is important in PH stabilization, cell extension and fruit enlargement (Faust, 1989).

Magnesium, play two very essential rules in the plant may be found in the important processes photosynthesis and carbohydrate metabolism. Magnesium is a constituent of the chlorophyll molecule without which photosynthesis would not occur. Many of the enzymes involved in carbohydrate metabolism require magnesium as an activator Also, magnesium is activator for some enzymes involved in the synthesis of the nucleic acids (DNA, RNA) from nucleotide polyphosphates (Nason and McElroy (1963).

The objectives of the present study were to test the effect of three mixed levels from nitrogen, potassium and magnesium with irrigation system on yield, fruit quality, leaf area, leaf mineral contents of Washington Navel orange and Valencia orange.

MATERIALS AND METHODS

The present investigation was carried out in a private orchard located at Tawfik El- Hakeem village. Bustan area, Behera governorate, Egypt during the 2007/2008 and 2008/2009 seasons. The aim of this study was to evaluate the combined effect of mixed levels of nitrogen potassium and magnesium on yield, fruit quality, leaf area minerals, chlorophyll

content of Washington Navel orange and Valencia orange (*Citrus sinersis*. L., Osbeck).

Mature 36 trees (7 years old) from Navel orange and Valencia orange budded on sour orange (*Citrus aurantium* L.) rootstock were used in this study, the selected trees were nearly uniform in vigor and size and spaced 4×5 m apart (200 tree/fed). Surface drip irrigation system is used in the orchard. The irrigation system includes an irrigation pump (6 inches, 120 m^3/h) connected to sand and screen filters. The main line is made of polyethylene (PE) pipe of 101 mm diameter and 100m long. A sub-main line made of PE pipe, consists of two different diameters (76 and 51 mm) each is 50m long. Lateral lines of 16 mm diameter are connected to the sub-main line. Each lateral is 50m long with standard emitters of 8L/h discharge. The system was set up such that 4 emittess/ tree was used. A separate hydraulic fertilizer injector pump was used for each fertilizer application (fertigation) treatment, the source of water the Nile.

Soil samples from three depths of 0-30, 30-60 and 60-90 cm were collected to determine some physical characteristics. Electrical conductivity (EC) and PH values were determined according to Page *et al.*, (1982). Mechanical analysis of the soil (sand and clay percentage and soil texture class) was also determined. Results of the analysis are presented in Table (1)

Table (1) : Electrical conductivity (ds/m), pH values and mechanical analysis of the soil

Soil depth (m)	Ec (ds/m)(1:2.5)	PH (1:2.5)	Mechanical analysis			
			Sand (%)	Silt (%)	Clay(%)	Texture class
0-30	0.315	8.10	94.45	3.10	2.45	Sandy
30-60	0.220	8.30	95.85	1.99	2.16	Sandy
60-90	0.300	8.20	95.90	2.15	1.95	Sandy

The trees in both citrus species in this study were arranged in a Randomized Complete Block Design, each treatment was replicated three times with two trees in each replicate. The obtained data statically analyzed according to Gomez and Gomez (1983). The experimental trees were subjected to the following treatments in both two citrus species through the tested seasons:

1- **The first treatment (T_1) control**: Traditional method of applying fertilizer in the orchard both citrus species were fertilized with 400 kg ammonium nitrate (33.5%N)/ feddan. The amount was divided into two applications, the first was 150 kg/ fed applied through the period from mid-February to mid-April and the second was 250 kg /fed. from May to October. In addition 200 kg potassium sulphate (48% k_2O) / fed. were divided into two doses, the first dose was 100 kg / fed. applied through the period from mid-February to April and the second 100 kg / Fed applied from August to October. Magnesium sulphate (18% MgO) added at the rate of 50 kg / fed., and divided in two equal doses, 25kg / fed. applied during July and the another dose during September.

2- **The second treatment (T_2):** The two citrus species were fertilized with 500 kg ammonium nitrate (33.5% N)/ fed. this amount was applicated as following :

   a- From mid-February to mid April 150 kg/ fed. was applied to trees as control.
   b- From May to October 350kg/ fed. was applied to trees. In addition 250kg/ fed. Potassium sulphate (48% k_2O), this amount was divided in two parts:
      (1) From mid-February to April 100kg/ fed. was applied to trees.
      (2) From May to October 150 kg/ fed. was applied to trees.

Magnesium sulphate was also added at the rate of 100 kg (18% MgO) /fed. and applied with two periods:

(3) At April and May 50kg/fed. was applied.
(4) At August and October 50kg /fed. was applied.

3- **The third treatment (T_3)** : both citrus species received 600 kg ammonium nitrate /fed., also this amount was divided in two parts:

(1) From mid-Feb. to Mid-April 150kg/fed., applied.
(2) From May to October 450kg/fed., applied. Moreover 300kg.

Potassium sulphate /fed. was added and divided into two parts: 100kg/fed., applied as control treatment and 200 kg (K_2SO_4) fed., applied from May to October. Magnesium sulphate was added as a total 125kg/

fed., the amount was added with two parts, the first 50kg/fed., from April to May, the second 75 kg/fed. applied from August to October.
Fertilizer application during the two growing season are presented in Table(2).

Table (2): Application rates of mixed nitrogen, potassium and Magnesium fertilizers (g/tree) during growing seasons for Washington Navel and Valencia orange.

Treatments		Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct
T1 (N:2kg	N(g)	100	150	250	250	200	300	250	250	250
+	K(g)	100	200	200	----	----	----	150	150	200
K: 1kg	Mg(g)	---	---	----	----	----	125	----	125	----
+										
Mg:0.25kg)										
T2 (N: 2.5kg	N(g)	100	150	250	300	300	300	300	400	400
+	K(g)	100	200	200	100	100	150	150	150	100
K: 1.25kg	Mg (g)	----	----	125	125	----	----	125	----	125
+										
Mg: 0.5kg)										
T_3 (N: 3kg	N(g)	100	150	250	350	350	400	400	500	500
+	K(g)	100	200	200	100	100	200	200	200	200
K:1.5kg	Mg(g)	----	----	125	125	----	----	125	125	125
+										
Mg 0.625 kg)										

N as ammonium nitrate (33.5N %), k as potassium sulphate (48% K_2O) and Mg as magnesium sulphate (18% MgO)

In November 2006 and 2007, approximately 40kg of manure + 1kg super phosphate (15.5 P_2O) per tree were added in both species. All other cultural practices for two citrus species production in the area were carried.

In both seasons, twenty–spring, non–fruiting shoots from the outer circumference of each selected tree from both species were labeled for leaf area, leaf mineral, chlorophyll a and b measurements. For leaf area (cm^2) measurements, twenty full-expanded leaves from each tree (five leaves from each side) were collected at December of both seasons and species, leaf area was measured by the planimeter.

Weight and number of fruits per tree were determined at harvest time in both seasons (November 2007 and 2008 for Washington Navel and February 2008 and 2009 for Valencia orange). Samples of ten fruits per

each replicate were used to determine fruit length and diameter, rind thickness and juice volume.

Total soluble solids (TSS) in fruit juice were determined by hand refractometer. Acidity and vitamin C were determined in the juice according to A. O. A. C (1985).

Chlorophyll was determined by using N, N Dimethyl formamide method according to Moran and Porath (1980). Leaf mineral contents were determined as follows: sixty leaves from each replicate were collected in the 1st week of October, washed with tap water, rinsed three times with distilled water and then oven dried at 70°C to a constant weight. The dried materials were ground in a stainless steel rotary knife mill(20 mesh). The ground sample was digested with sulfuric acid and hydrogen peroxide according to Evenhuis and DeWaard (1980).

Suitable aliquots were then taken for the determination of N, P, K Ca and Mg. Nitrogen and phosphorus were determined calorimetrically according to Evenhuis (1976) and Murphy and Rikey (1962) respectively. Potassium was determined using flame photometer, Calcium and magnesium were determined by using Perkin Elemer Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Fruit yield:

Effect of the treatments on number of fruits, yield, weight of fruit, diameter and length of fruit of Washington Navel orange and Valencia orange during the 2007 and 2008 growing seasons are presented in Table (3)

Table (3): Effect of treatments on No. of fruits, yield kg/ tree, weight of fruit/g diameter and length of fruit /cm during 2007 and 2008 seasons in Washington Navel and Valencia orange.

Treatments	No. of fruits /tree		Yield kg/tree		Weight of fruit/g		Diameter of fruit/cm		Length of fruit/cm	
	W.N	V.O	W.N	V.O	W.N	V.O	W.N	V.O	W.N	V.O
2007										
T_1 (control)	191.33	255.33	43.9	46.2	271.3	192.8	7.7	7.1	7.9	7.3
T_2	212	309	55.5	65.6	282	239.3	7.5	7.6	7.7	7.5
T_3	247.3	362.33	59.1	75	257.1	235.4	7.4	7.3	7.8	7.3
L.S .$D_{0.05}$	70.8		24.6		31		N.S		N.S	
2008										
T_1 (control)	220.33	244.67	59.02	47.89	247.73	212.98	7.20	7.18	8.04	7.52
T_2	337.33	264.00	81.55	63.55	268.66	224.10	7.62	7.42	7.6	7.6
T_3	396.67	326.67	97.26	72.69	289.05	253.91	7.65	7.62	7.21	8.5
L.S.$D_{0.05}$	88.07		19.75		37.38		0.24		0.47	

W.N: Washington Navel Orange / VO : Valencia orange

Results of Washington Navel showed that number of fruits/tree was significantly increased in T_3 treatment compared with control T_1 and T_2 in 2008 season. In the same time, results indicated that no significant effect of the treatments on the tested parameters in 2007 season for Washington Navel. Also, the data obtained that in 2008 season weight of fruit, diameter and length of fruit were significantly increased in T_2 and T_3 as compared with control (T_1). Results of Valencia orange showed that the number of fruits, yield and weight of fruit were significantly increased in T_3 compared with control in 2007 and 2008 seasons (Table 3), these results are in line with those reported by Zayan *et al.*,(1989), El–Boray *et al.*, (1995b) and Hassan *et al.*, (2001), they reported similar increase in yield as a response to increasing N, K. levels applied to Washington Navel orange trees. The obtained results agreed also with those of Miller and Hoffman (1984). They stated that there is a significant interaction between N and K in their effect on fruit size. Results, also showed that the diameter of fruits and length of fruits were significantly increased in T_2 and T_3 than control in Washington Navel in 2008 season.

2- Fruit quality:

Effect of treatments on rind thickness, fruit juice volume, total soluble solids (T.S.S), acidity and vitamin C of Washington Navel orange and Valencia orange fruits during 2007 and 2008 seasons are presented in (Table 4)

Table (4): Effect of treatments on some physico-chemical properties of Washington navel and Valencia orange in 2007 and 2008 seasons.

Treatment	Rind thickness (cm)		Juice volume of fruit (cm)		T.S.S %		Acid %		Vitamin C /mg /100ml juice	
	W.N	V.O	W.N	V.O	W.N	V.O	W.N	V.O	W.N	V.O
2007										
T_1 (control)	0.45	0.41	61.12	74.33	10.4	9.26	0.08	0.17	35.6	35.5
T_2	0.62	0.58	68.23	97.2	11.82	10.67	0.13	0.18	39.2	42.1
T_3	0.64	0.57	69.10	84.8	11.85	10.85	0.10	018	37.2	44.4
L.S .$D_{0.05}$	0.15		7.09		1.41		N.S		N.S	
2008										
T_1 (control)	0.47	0.40	55.33	78.00	8.84	9.63	0.09	0.16	35.93	40.80
T_2	0.57	0.50	64.68	84.34	10.70	10.25	0.10	0.18	39.32	41.81
T_3	0.63	0.61	66.57	88.67	10.86	10.50	0.11	0.19	68.70	43.5
L.S.$D_{0.05}$	0.10		9.33		0.61		0.01		1.74	

W.N: Washington Navel Orange / VO : Valencia orange

Results showed that rind thickness values were significantly affected by increasing rates of mixed N, K and Mg as compared to the control treatment in both species in tested seasons, these results agreed with those reported by Zayan *et al.*, (1989) and Hassan *et al.*, (2001). They reported that peel thickness increased with increasing N and K application in citrus trees.

Results showed that in both species juice volume per fruit and T.S.S values in T_2 and T_3 were significantly higher than control treatment in both seasons. The obtained results was in line with those reported by El Safty *et al.*, (1998) and Hassan *et al* (2001). The obtained results showed also that, there were no significant differences between acidity and vitamine C values under the tested treatments in 2007 season in both citrus species. Also, results obtained that acidity, and vitamine C in T_2 and T_3 were significantly higher than control (T_1) in 2008 season in both species, the same results were reported by Hassan *et al.*, (2001)

3- Vegetative growth:

Effect of tested treatment on leaf area (cm^2), leaf chlorophyll a and chlorophyll b of Washington Navel and Valencia leaf orange trees for 2007 and 2008 seasons are presented in Table (5).

Table (5): Effect of treatments on leaf area, chl.a, and chl b. for Washington Navel and Valencia orange in 2007 and 2008 seasons.

Treatment	Leaf area / cm^2		Chl .A / mg /100g leaf fresh weight		Chl.B /mg /100g leaf fresh weight	
	W.N	V.O	W.N	V.O	W.N	V.O
2007						
T_1 (control)	23.72	22.38	239.55	234.03	118.88	106.89
T_2	27.0	35.53	256.21	257.93	112.44	118.79
T_3	31.95	31.29	262.04	248.80	123.52	139.31
L.S .$D_{0.05}$	3.05		N.S		N.S	
2008						
T_1 (control)	20.95	23.33	242.95	203.1	109.99	93.8
T_2	27.67	30.77	257.6	233.12	100.63	103.05
T_3	31.62	39.16	258.64	236.48	114.25	124.29
L.S.$D_{0.05}$	4.72		N.S		N.S	

W.N: Washington Navel Orange / VO : Valencia orange

Results revealed that leaf area increased significantly in T_2 and T_3 treatments as compared to the control (T_1)in Washington Navel and Valencia orange leaves in both seasons

These findings agreed with those reports by El- Boray *et al.*, (1995a) and significant differences between chlorophyll a and b were observed with T_2 and T_3 treatments compared with control in both species in 2007 and 2008 seasons Embleton and Jones (1959) found that, Washington Navel orange tress treated with Mg SO_4 had deeper green color leaves.

4- Leaf mineral content:

Effect of tested treatments on some mineral contents of Washington Navel and Valencia oranges at 2007 and 2008 seasons are presented in Table (6)

Table (6): Effect of treatments on leaf content of N, P, K, Ca and Mg on Washington Navel and Valencia orange for 2007 and 2008 seasons:

Treatments	N%		P%		K%		Ca%		Mg%	
	W.N	V.O	W.N	V.O	W.N	V.O	W.N	V.O	W.N	V.O
2007										
T_1 (control)	2.39	1.12	0.17	0.12	0.90	0.92	2.41	1.97	0.48	0.46
T_2	2.97	1.58	0.20	0.26	1.29	0.82	3.36	2.4	0.50	0.46
T_3	2.90	2.01	0.25	0.27	1.20	0.93	3.21	2.32	0.59	0.61
L.S .$D_{0\,05}$	0.50		0.06		0.25		0.77		0.1	
2008										
T_1 (control)	2.41	1.37	0.19	0.15	1.06	0.66	0.98	2.02	0.56	0.50
T_2	3.99	1.89	0.25	0.31	1.08	0.91	3.47	2.86	0.58	0.56
T_3	3.51	2.49	0.29	0.30	1.25	1.25	2.23	3.62	0.91	0.67
L.S.$D_{0\,05}$	0.59		0.07		0.17		0.67		0.11	

W.N: Washington Navel Orange / VO : Valencia orange

Results of leaf nitrogen content in 2007and 2008 revealed that there were high significant differences between T_2 and T_3 compared with control (T_1) in Washington navel, also in Valencia orange there were high significant differences between T_3 and control (T_1) in both seasons. This results agreed well with those reported by Rabeh and Hemat Kamal (1989), they showed that nitrogen concentration in leaves was related to the amount of N-applied, also Hassan *et al* (2001) reported that, there were significant in N-leaf contents with high nitrogen application in Washington Navel. The tested treatments had a minor effect on P-leaf content. There was a high significant difference in p-leaf content between T_3 and control in Washington Navel in 2007 season, also, the treatments T_2 and T_3 had significantly higher P-leaf contents as compared with control T_1 in 2008. There were significantly higher P-leaf content between T_2 and T_3 compared with control (T_1) in Valencia orange in both seasons. The obtained result agreed with those reported by Hassan *et al.,* (2001), they showed that P-leaf content was increased with high nitrogen and potassium.

Results indicated also that, the effect of applying high mixed of nitrogen, potassium and Magnesium (T_2 and T_3) on K and Ca leaf contents were similar to that found in nitrogen element. K and Ca leaf contents were

significantly increased in Washington navel in 2007 and 2008 seasons, also K and Ca leaf contents were significantly increased in 2008 season for Valencia orange. For Mg-leaf contents the Washington Navel orange revealed that, in both seasons, there were significant differences between T_3 and the control treatment Table (6). For Valencia orange trees, in both seasons, T_3 treatment had significantly higher Mg–leaf content than both T_2 and the control trees (T_1) and the differences between T_2 and T_1 treatments were not significant. The obtained results agreed with those of Tsotsonave (1974) studied the effect of different potassium fertilizers and magnesium rates on nutrient removal by mandarin trees. He found that potassium and magnesium fertilizers enhanced the uptake of soil nitrogen phosphorus, potassium, calcium and magnesium by the fruits. Moreover, Haggag *et al.*, (1987) found that all Mg SO_4 treatments increased the magnesium levels in Washington Navel orange leaves.

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الملخص العربي

تأثير خلط مستويات مختلفة من السماد الأزوتي والبوتاسي والماغنسيومي على إنتاجية البرتقال أبو سرة صنف واشنطن والبرتقال الفالنشيا تحت نظام الرى بالتنقيط بمنطقة البستان.

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أجريت هذه التجربة خلال موسمي 2007 و2008 بمنطقة البستان بقرية توفيق الحكيم بهدف دراسة أثر استخدام خليط من ثلاث مستويات مختلفة من السماد الأزوتي والبوتاسي والماغنسيومي على الإنتاج، نوعية الثمار، محتوى الأوراق من الكلورفيل، جودة الثمار، محتوى الأوراق من العناصر المعدنية وذلك على أشجار البرتقال أبو سرة صنف واشنطن والبرتقال الفالنشيا. كانت المعاملات تحت

الدراسة : 1- كنترول (2 كجم نترات نشادر - 1 كجم سلفات بوتاسيوم + 0.25 ك سلفات ماغنسيوم) للشجرة وهى المعاملة المتبعة بالمزرعة. 2- (2.5 كجم نترات نشادر + 1.25 ك سلفات بوتاسيوم + 0.5ك سلفات ماغنسيوم) للشجرة. 3- (3 كجم نترات نشادر + 1.5 ك سلفات بوتاسيوم + 0.625 ك سلفات ماغنسيوم) للشجرة.

استخدمت أشجار مكتملة النمو عمرها 7 سنوات ومنزرعة على مسافة 4 × 5 م.

ويمكن تلخيص النتائج فيما يلي:

- كان هناك تأثير معنوي للمعاملة رقم 3 بالنسبة لعدد الثمار، المحصول، وزن الثمار، قطر الثمار وكذلك طول الثمار عن المعاملة رقم 2 وكذلك الكنترول المعاملة رقم 1 في عام 2008 بالنسبة للبرتقال أبو سرة وأيضاً كان هناك تأثير معنوي لعدد الثمار، المحصول ووزن الثمار في المعاملة رقم 3 بالمقارنة بالكنترول (معاملة 1) في عامى الدراسة في البرتقال الفالنشيا.
- بزيادة كل من مستويات النتروجين والبوتاسيوم والماغنسيوم زادت سمك القشرة والعصير والمواد الصلبة الكلية ومساحة الورقة في سنتين الدراسية في كل من البرتقال أبو سرة والبرتقال الفالنشيا.
- زاد تركيز العناصر في الأوراق سواء النتروجين أو الفوسفور أو البوتاسيوم أو الكالسيوم أو المغنسيوم في عامى الدراسة لكل من البرتقال أبو سرة والبرتقال الفالنشيا.
- لم يتأثر مستوى الكلورفيل سواء كلورفيل أ أو كلورفيل ب بالمعاملات في خلال الدراسة لكل من البرتقال أبو سرة والبرتقال الفالنشيا.