Effect of Balanced Fertilization and Fertilizer Levels on Navel Orange Yield and Fruit Quality

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ABSTRACT

A field experiment was conducted during two successive seasons of 2007/2008 and 2008/2009 on navel orange mature trees at Metobas district, Kafr El-Sheikh governorate, Egypt, to assess effect of the balanced fertilization and fertilization levels on navel orange yield and fruit quality. Four fertilizer treatments of: 1- complete fertilizer (balanced), 2- fertilizer without Mg, 3- Fertilizer without micronutrients, and 4-fertilizer without K with three fertilizer levels L_1, L_2 and L3 were used compared to the farmer treatment. The obtained results can be summarized as follows:

-The balanced fertilizer (complete) had the highest fruit set (7.8 and 8.1%), lowest pre-harvest fruit drop (7.9 and 7.8%), highest fruit number/tree (405.1 and 391.9), highest fruit yield/tree (86.0 and 93.1 kg/tree), highest SSC% (11.9 and 12.3%) and highest VC (58.2 and 58.4 mg/100 ml juice) in the first and second seasons, respectively.

-Balanced fertilizer increased reducing sugar rates by 22.8 and 41.9%, non-reducing sugar by 44 and 16.7% and total sugars by 34.6 and 31.1% over the farmer treatment in the first and second seasons, respectively.

-Balanced fertilizer increased the rates of chlorophyll A, B and total chlorophyll compared to the farmer treatment. The increase rates in total chlorophyll were 45.8 and 44.0% over the farmer treatment in the first and second seasons, respectively.

-Farmer treatment had the lowest fruit set (5.4 and 5.7%), fruit yield (66.8 and 70.2 kg/tree), highest pre-harvest fruit drop (12.9 and 12.4%), lowest acidity values 0.92 and 0.91%, VC (52.3 and 52.7 mg/100 ml juice), reducing sugars (3.5 and 3.1%), non-reducing sugars (2.5 and 3.0%), total sugars (5.9 and 6.1%), chlorophyll A, B and total chlorophyll, in the first and second seasons, respectively.

-Fertilizer without Mg, micronutrients and potassium gave a high values than the farmer treatment for each fruit set (%), fruit number/tree, fruit yield (kg/tree), acidity (%), VC, reducing, non-reducing, total sugars and total chlorophyll. That values were less than the complete fertilizer during the first and second seasons, respectively.

-The increase value rates compared with the farmer treatment were (29.2 and 28.1%) & (36.5 and 28.1%) & (12.5 and 14.0%) in fruit set, (9.1 and 25.5%) & (19.1 and 15.9%) & (21.9 and 0.0%) in yield kg/tree, (6.5 and 6.5%) & (3.3 and 2.2%) & (2.2 and 2.2%) in acidity (2.9 and 3.2%) & (7.3 and 6.8%) & (7.5 and 5.1%) in VC, (2.9 and 12.9%) & (17.1 and 38.7%) & (5.7 and 16.1%) in reducing sugars, (10.2 and 3.3%) & (22.0- and 21.3%) & (17.8 and 9.8%) in total sugars, (39.5 and 28.6%) & (11.3 and 17.1%) & (38.8 and 37.2%) in total chlorophyll during the two seasons for the three treatments, respectively.

-Farmer treatment showed the highest values for pre-harvest fruit drop (12.9 and 12.4%) and SSC% (11.9 and 11.4%) compared with the four treatments during the first and seconds seasons, respectively.

INTRODUCTION

Citrus is an important fruit crop in more than 135 countries with production about 102.64 million tons annually world wide. It has a great nutritional role in our daily food requirements, being a rich source of vitamin C. Citrus trees require large quantities of mineral nutrients to attain adequate growth and yield, and requirements for some of the nutrients vary with soil fertility and type.

The Egyptian soils varied with respect to their texture from sandy to heavy clay soils. Average value of total soluble N is very low and the organic matter is also low, the soil reaction was slightly alkaline, the available P values are moderate, however, the available K ranged between low and high.

Plant nutrient management for citrus can influence flowering, fruit set, fruit size and the amount of vegetative growth and other plant characteristics. By carefully choosing the components of fertilizer program, the grower can nudge a crop toward earlier, heavier fruit set (Muhammad Yaseen and Manzoor Ahmad, 2010). Fruit yield of citrus is largely dependent on nitrogen fertilization, which plays an important role in tree nutrition.

Sanchez *et al*. (2002) in that one year study on 8 years old lemon trees noted that, just 681 g N per tree was sufficient for maximum yield.

Increasing nitrogen fertilization from 227 g N per tree to 1135 annually on sweet orange significantly increased fruit yield represents 20% (Glenn, 2009).

Beanland *et al*. (2003) reported that, nutrient deficiency or imbalances may alter primary and

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secondary metabolism, and thus faster growth of herbivores.

Phosphorus is the second majour essential macroelements for plants. It plays a key role of energy storage and transferring. Its availability changes quickly after fertilization due to high soil reaction. Earlier research work has demonstrated that, limited phosphorus availability of low fertility soils impairs citrus production (Quaggio *et al*., 2002). Dircenmattos *et al*. (2010) demonstrated that, greater growth of citrus plants corresponded to greater root development as evaluated by root growth rate and architecture. These parameters varied according to phosphorus availability in soil. Excessive phosphorus can adversely affect citrus growth and development, especially fruit quality. High phosphorus fertilization has lowered juice soluble solids concentration and caused delayed external color development and re-greening oranges (Thomas, 2001).

Potassium plays a critical role in citrus trees and it affects many phenomena, both visible and invisible. The requirement for potassium in trees is next to that for nitrogen and ranges from 0.5 to 2.0% of dry matter. According to various sources, one ton of oranges exports an average of 2.5 kg K_2O corresponding to 125-250 kg/ha according to the yield potential (Erner *et al*., 2002). Malavolta (1992) reported that, potassium fertilization increased orange fruit production up to leaf potassium content of 1.5-1.7%. Potassium has dominant effects on external and internal fruit qualities, including yield, colour, size, acidity and roughness. Excessively high K levels result in large fruit with coarse, thick peel and poor colour. Moreover, early and intensive regreening will occur (Erner *et al*., 2002). Du-Plesis and Koen (1988) found that a maximum yield at the high N:K ratio of 2.8 with the N and K contents exceeding 2.1 and 0.8%, respectively.

Magnesium is one of the essential secondary macronutrients. It is taken up by plants as Mg ions. It plays a key role in the photosynthetic process, being an important constituent of chlorophyll, the green pigment in leaves and stems. The presence of other positively charged ions in the soil or their application in fertilizers i.e., calcium, potassium, sodium and ammonium may depress plant uptake of magnesium. So, magnesium fertilizer must applied for balanced fertilization.

Iron, zinc, manganese, copper, boron and molybdenum are essential micronutrients for plants. Under the Egyptian conditions all the micronutrients unavailable except molybdenum. Embelton *et al*. (1973) reported that, zinc applied to alkaline soil is usually adsorbed or precipitated on the surface and does not move readily to the root zone. Further citrus is deep rooted crop, so micronutrient application to soil may be of little value. Foliar application of Zn and Mn alone or in combination with each other significantly increased the fruit yield of sweet oranges compared with the control treatment. The maximum fruit yield of 123.3 kg/tree was obtained from the treatment receiving Zn + Mn (Tariq *et al*., 2007).

Muhammad *et al*. (2010) found that the foliar application of Zn and B significantly influenced, fruit yield/tree, % dieback, % chlorosis and % rosette/plant. The maximum fruit yield/plant was obtained when high concentration of Zn (1% Zn) with low concentration of B (0.02% B).

The objectives of the present study is to investigate the role of nitrogen and phosphorus fertilization levels, and potassium, magnesium and micronutrients presence and levels as a balanced fertilization on navel orange yield and quality under north Delta Egyptian soils.

MATERIALS AND METHODS

A field experiment was conducted at Motobas district, Kafr El-Sheikh governorate, Egypt. The latitude and longitude of the experiment field are 31°27N and 31°32E during two successive seasons of 2007/2008 and 2008/2009, on permanent mature navel orange trees to assess effect of the balanced fertilization on the yield and fruit quality. Randomized complete block design layout was used with four replicates, where one similar tree is one plot. Composite soil sample was collected from the experimental field before conducting the treatments, to investigate some soil physical and chemical as well as nutritional properties of the experimental field according to Black *et al*. (1965). Thirteen fertilization treatment were used as follows:

1. 495 g N + 101.5 g P (232.5 g P_2O_5)/tree/year (farmer treatment).
2. 495 g N + 101.5 g P + 400 g K (480 g K_2O) + 50 g S + 2.5 g Mg + micronutrients (L_1).
3. 990 g N + 203 g P + 800 g K + 50 g S + 5 g Mg + micronutrients/tree/year (L_2).
4. 1485 g N + 304.5 g P + 1200 g K + 50 g S + 7.5 g Mg + micronutrients/tree/year (L_3).
5. 495 g N + 101.5 g P + 400 g K + 50 g S + 0 Mg + Micronutrient/tree/year (L_1 without Mg).
6. 990 g N + 203 g P + 800 g K + 50 g S + 0 Mg + micronutrients/tree/year (L_2 without Mg)
7. 1485 g N + 304.5 g P + 1200 g K + 50 g S + 0 Mg + micronutrients/tree/year (L3 without Mg).
8. 495 g N + 101.5 g P + 400 g K + 50 g S + 2.5 g Mg + 0 micro/tree/year (L_1 without micronutrients).
9. 990 g N + 203 g P + 800 g K + 50 g S + 5 g Mg + 0 Micronutrients/tree/year (L_2 without micronutrients).

10. 1485 g N + 304.5 g P + 1200 g K + 50 g S + 7.5 g Mg + 0 micronutrients/tree/year (L_3 without micronutrients).
11. 495 g N + 101.5 g P + 0 K + 50 g S + 2.5 g Mg + micronutrient/tree/year (L_1 without K).
12. 990 g N + 203 g P + 0 K + 50 g S + 5 g Mg + micronutrient/tree/year (L_2 without K).
13. 1485 g N + 304.5 g P + 0 K + 50 g S + 7.5 g Mg + micronutrient/tree/year (L_3 without K).

Nitrogen was applied as ammonium nitrate 33% N, phosphorus was applied as single super phosphate calcium 15.5% P_2O_5 (6.77% P), potassium was applied as potassium sulphate 48% K_2O (40% K), magnesium was applied as magnesium sulphate (8.9% Mg), sulphur was applied as sulphur metal and micronutrients were applied a mixture of 300, 150, 100, 50 and 50 mg/kg of the applied fertilizer from chelated Fe, Mn, Zn, Cu and B as boric acid, respectively. Just mature leaves samples were collected from the different treated trees, chlorophyll A, B and total chlorophyll were determined according to Moran and Porath (1982).

Yield and fruit characters were determined i.e., fruit set%, pre-harvest fruit drop %, fruit weight (g), fruit number/tree and fruit yield kg/tree. Some fruit physical parameters and juice quality properties were determined i.e., acidity %, vitamin C mg/100 ml juice, reducing, non-reducing and total sugars % as well as SSC% according to AOAC (1985).

RESULTS AND DISCUSSIONS

1. The effect of balanced fertilizers on fruit physical parameters of navel orange:

1.1. Fruit set:

Data presented in Table (2) showed that, balanced fertilizer had high significant effect on citrus fruit set%. In the first season, the highest mean value of 7.8% was obtained with the complete fertilizer. On the other hand, the lowest value of fruit set% of 5.4% was recorded with the farmer treatment. The fertilizer without potassium had the less value of the fruit set% compared to the other three compounds fertilizers of 6.1%. The sequence of fruit set % was complete fertilizer (7.8) > fertilizer without micronutrients (7.4)> fertilizer without Mg (7.0) > fertilizer without K (6.1) > farmer treatment (5.4). In the second season, the data had the same sequence,

where it was 8.1%, 7.3, 7.3%, 6.5% and 5.7%, respectively. In respect to the effect of fertilizer levels on citrus fruit set%, the high level had the highest fruit set values of 7.2 and 7.4% in the first and second season, respectively. The interaction between the fertilizer content and the fertilizer levels on fruit set % showed that the highest fruit set value of 8.45% was obtained with the high fertilizer level (L3) and the complete fertilizer in both seasons. These results showed that, imbalances fertilizers may be due to alter the plants metabolism. These results are agree with those obtained by El-Sabrout and Kassem (2002), Mostafa (2002) on Washington navel orange trees and Beanland *et al*. (2003).

1.2. Pre-harvest fruit drop%:

Data presented in Table (2) showed that, farmer treatment recorded the highest pre-harvest fruit drop value of 12.94 and 12.35% in the first and second season, respectively. The sequence of pre-harvest fruit drop values in the first season was complete fertilizer (7.9%) < fertilizer without Mg (8.4%) < fertilizer without micronutrient (8.5%) < fertilizer without K (10.9%) < the farmer treatment (12.94%). Increasing the fertilizer levels led to increase pre-harvest fruit drop values in both seasons. This may be due to the importance of the nutrients ratio on nutrients storage and its reflect on tree strength. These results are in agreement with those obtained by Du-Plesis and Koen (1988) on Valencia orange trees and Malavolta (1992).

1.3. Fruit weight (g):

Fruit weight affected by the tree strength and the number of fruits on the tree. Data presented in Table (2) showed that, fruit weight (g) was high significantly affected by the used fertilizer. The highest fruit weight in the first season of 243.9 g was recorded with the farmer treatment. This may be due to this treatment had the lowest fruit set% value and the highest pre-harvest fruit drop value %.

Table 1. Some physical, chemical and nutritional properties of the experimental soil

Season	Particle size distribution			Texture	pH	EC	OM%	Available mg/kg		
	Sand%	Silt%	Clay %			dS m^{-1}		N	P	K
2007/ 2008	23.4	43.9	32.7	Silty clay	7.3	1.25	1.8	33	5.9	230
2008/ 2009	23.4	43.9	32.7	Silty clay	7.3	1.32	1.75	37	6.5	245

* pH measured in 1:2.5 soil:water suspension
** EC determined in soil past extract

Table 2. Effect of balanced fertilizers on fruit physical parameters of navel orange

Treatment		Fruit set%		Pre-harvest fruit drop %		Fruit weight (g)		Fruit number/tree		yield (kg/tree)		Δ%	
Levels	Split	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control		5.42 f	5.70 g	12.94 a	12.35 a	243.9 a	205.4 bc	272.7 e	341.75 cd	66.8 d	70.21 d	-	-
L_1	Complete	7.47 abc	7.7 abc	7.88 fg	7.79 ef	210.3 bc	238.9 a	402.7 a	369.0 a-d	84.6 ab	87.9 abc	26.6	25.3
L_2		7.52 abc	8.23 ab	7.63 g	7.67 f	212.9 bc	241.9 a	401.7 a	379.3 abc	85.4 ab	91.8 ab	27.8	30.7
L_3		8.45 a	8.45 a	8.09 efg	7.86 ef	209.4 bc	250.4 a	411.0 a	402.3 a	88.0 a	99.6 a	31.7	41.9
Mean		7.81	8.1	7.9	7.8	210.9	243.7	405.1	391.9	86.0	93.1	28.7	32.6
L_1	Without Mg	6.94 b-e	7.53 bc	7.40 g	7.82 ef	209.8 bc	241.2 a	355.7 bcd	356.3 bcd	74.2 bcd	85.2 bc	11.1	21.4
L_2		6.97 b-e	7.26 cde	8.73 de	8.65 de	196.9 c	243.4 a	360.7 bcd	355.3 bcd	70.8 cd	86.6 bc	5.9	23.3
L_3		7.20 bcd	7.08 cde	8.99 d	9.10 cd	217.1 bc	238.2 a	340.0 d	388.7 ab	73.7 bcd	92.5 ab	10.3	31.8
Mean		7.0	7.3	8.4	8.5	207.9	240.9	351.5	366.8	72.9	88.1	9.1	25.5
L_1	Without	7.95 ab	7.23 cde	9.02 d	7.94 ef	208.7 bc	226.0 ab	388.3 abc	344.7 bcd	81.1 abc	77.9 cde	21.4	10.9
L_2	Micro-	7.38 bc	7.09 cde	8.52 def	7.70 f	220.5 abc	230.9 a	356.3 bcd	366.3 a-d	78.8 a-d	84.6 bc	17.9	20.5
L_3	nutrient	6.79 cde	7.47 bcd	8.10 efg	7.66 f	206.9 bc	229.4 a	382.0 abc	355.3 bcd	78.9 a-d	81.7 bcd	18.1	16.4
Mean		7.4	7.3	8.5	7.8	212.0	228.8	375.5	355.4	79.6	81.4	19.1	15.9
L_1	Without K	6.11 ef	6.51 ef	10.36 c	9.62 c	224.5 abc	204.8 bc	392.0 ab	333.7 cd	86.1 ab	68.4 de	28.8	-2.6
L_2		5.99 ef	6.25 fg	10.78 c	11.35 b	214.9 bc	199.9 c	355.3 bcd	325.0 d	76.5 a-d	65.0 de	14.5	-7.4
L_3		6.24 def	6.65 def	11.84 b	11.56 ab	233.5 ab	226.8 ab	351.0 cd	335.0 cd	81.9 abc	75.8 cde	22.6	8.0
Mean		6.1	6.5	10.9	10.8	224.9	210.5	366.1	331.2	81.5	69.7	21.9	-0.7
Mean L_1		7.1	7.2	8.6	8.3	213.3	227.7	384.2	334.7	81.5	79.9	21.9	13.8
Mean L_2		6.9	7.2	8.9	8.8	211.3	229.0	368.5	356.5	78.0	82.0	16.5	16.8
Mean L_3		7.2	7.4	9.3	9.0	216.7	236.2	371.0	370.3	80.6	87.4	20.7	24.5

The treatment had highest fruit set% and lowest pre-harvest drop value showed the lowest fruit weight. In the second season, the highest fruit weight value of 250.4 g was obtained with the complete fertilizer. Effect of fertilizer levels on fruit weight showed that, the highest fruit weight mean values of 216.7 and 236.2 g were obtained with the highest fertilizer level in the first and second seasons, respectively.In respect to the interaction between fertilizer content and fertilizer levels in the second season, the highest fruit weight value of 250.4 g was obtained with the complete fertilizer and the highest fertilizer level (L3). This may be due to high need of citrus trees to the nutrients. Similar results were reported by Assi *et al*. (1990), on Balady mandarin trees Cicala and Catara (1994) on Tarracco orange trees, Erner *et al*. (2002) and Abd El-Migeed *et al*. (2007) on Washington navel orange trees.

1.4. Fruit number/tree:

Fruit number per tree depended on fruit set and pre-harvest fruit drop. Data in Table (2) cleared that the highest means fruit number of tree 405.1 and 391.9 were obtained with the complete fertilizer in the first and second seasons, respectively. In respect to the interaction between fertilizer content and fertilizer levels showed that, the highest fruit number values of 411.0 and 402.3 were observed with the complete fertilizer and the highest fertilizer level (L3) in the first and second seasons, respectively. These results are in agreement with those obtained by Swietlik (1992) on "Ray Ruby" grape fruit trees, Omran *et al*. (1998), Hikal (2000) and Abd El-Migeed *et al*. (2007) on Washington navel orange trees. This may be due to the increase in fruit set % and the decrease in pre-harvest fruit drop.

1.5. Yield (kg/tree):

Data in Table (2) showed that, complete fertilizer had the highest fruit yield mean values of 86.0 and 93.1 kg/tree in the first and second seasons, respectively. These increase rates were represent 28.7 and 32.6% over the farmer treatment in the first and second season, respectively. The interaction between fertilizer content and fertilizer levels showed that the highest fruit yield of 88.0 and 99.6 kg/tree were obtained with the highest fertilizer level (L_3) with the complete fertilizer in the first and second seasons, respectively. The increase rate of yield (kg/tree) in the other treatments was less than the complete fertilizer. It was 9.1 and 25.5% with fertilizer without magnesium and 19.1 and 15.9 with fertilizer without micronutrients in the first and second seasons, respectively. Similar results were reported by Du-Plesis and Koen (1988), Das and Barual (1997) on Assam lemon trees, Omran *et al*. (1998), Alva *et al*. (2001), Abd El-Migeed *et al*. (2007) and Glenn (2009) on lemon trees.

2. The effect of balanced fertilizers on fruit chemical parameters of navel orange:

2.1.Soluble solids content (SSC%):

Data presented in Table (3) showed that, balanced fertilization and fertilizer levels significantly affected fruit chemical parameters of navel orange. Soluble solids content (SSC%) showed clear response to fertilizer content, where the highest mean values (11.9 and 12.3%) were obtained with the complete fertilizer in the first and second seasons, respectively. The other treatments showed a decrease in SSC% means compared with the balanced treatment, its values were 10.7 and 10.1% with fertilizer without magnesium, 10.9 and 11.0% with fertilizer without micronutrients and 11.8 and 11.6 with fertilizer without potassium compared with 11.9 and 12.3% in farmer treatment during the first and second seasons, respectively. From the mentioned results data clear that, magnesium had rather effect on SSC% than micronutrients and potassium. In respect, the fertilizer levels led to increase SSC%. This may be due to the importance of magnesium and other balanced fertilizer content in photosynthesis and plant metabolism. These results agree with those obtained by Ahmed *et al*. (1988) on Egyptian Balady lime trees, Omran *et al*. (1998), Thomas (2001), Kassem and El-Sabrout (2002), El-Abd (2005) and abd El-Migeed *et al*. (2007) on Washington Navel orange trees.

2.2. Acidity (%):

Results in Table (3) mentioned that, acidity % is significantly affected by fertilizer content and fertilizer levels. The lowest acidity values of 0.92 and 0.91% were recorded with the farmer treatment in the first and second seasons, respectively. The highest mean values of 0.98 and 0.98% were observed with the fertilizer without magnesium. In respect to the fertilizer levels, increasing the fertilizer levels from L_1 to L_2 and L_3 led to increase mean values of the acidity from 0.95, 0.94 to 0.96, 0.95 and 0.97, 0.97% in the first and second seasons, respectively. In the same notice Marschner (1995) reported that the high concentrations of potassium in the cytosol and chloroplast neutralize the soluble and insoluble macromolecular anion and stabilizes the pH in these compartments. These results are in harmony with the obtained by Hikal (2000) and El-Abd (2005) on Washington Navel orange trees.

2.3. Vitamin C content:

Citrus has a great nutritional role in our daily food requirements being a rich source of vitamin C. Data in Table (3) observed that vitamin C is significantly affected by fertilizer contents and fertilizer levels.

Table 3. Effect of balanced fertilizers on fruit chemical parameters of navel orange

Treatment		SSC (%)		Acidity (%)		VC (mg/100 ml juice)		Reducing sugars %		Non-reducing sugars (%)		Total sugars (%)	
Levels	Split	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control		11.9 a	11.4 bc	0.92 f	0.91 f	52.3 f	52.7 e	3.5 e	3.1 c	2.5 b	3.0 bc	5.94 d	6.1 c
L_1	Complete	11.6 a	12.3 a	0.95 de	0.96 cde	57.8 ab	57.9 ab	4.1 abcd	4.6 a	3.6 ab	3.3 abc	7.7 ab	7.9 a
L_2		11.9 a	12.3 a	0.97 bc	0.95 de	58.3 a	57.9ab	4.4 ab	4.3 a	3.6 ab	3.6 ab	8.1 a	7.9 a
L_3		12.2 a	12.4 a	0.99 a	0.98 abc	58.6 a	59.3 a	4.5 a	4.3 a	3.6 ab	3.7 a	8.1 a	8.1 a
Mean		11.9	12.3	0.97	0.96	58.2	58.4	4.3	4.4	3.6	3.5	8.0	8.0
L_1	Without Mg	10.3 b	10.5 cd	0.97 bc	0.96 bcd	53.1 ef	54.7 cde	3.3 e	3.4 c	3.1 ab	3.0 bc	6.3 cd	6.4 bc
L_2		10.3 b	9.9 d	0.98 ab	0.98 abc	53.8 def	53.3 e	3.6 cde	3.4 c	3.0 ab	3.0 bc	6.6 cd	6.4 bc
L_3		11.5 a	9.8 de	0.99 a	0.99 a	54.5 de	55.3 cd	3.8 a-d	3.6 bc	2.8 ab	2.7 c	6.6 cd	6.2 bc
Mean		10.7	10.1	0.98	0.98	53.8	54.4	3.6	3.5	3.0	2.9	6.5	6.3
L_1	Without Micro-nutrient	9.5 b	10.1 d	0.93 ef	0.91 f	55.2 cde	55.8 cd	4.3 a-d	4.1 ab	3.9 a	2.8 c	8.2 a	6.9 b
L_2		11.8 a	11.9 ab	0.95 cd	0.92 f	55.8 bcd	56.6 bc	3.6 b-e	4.3 a	3.0 ab	3.3 abc	6.6 cd	7.5 a
L_3		10.0 b	11.0 c	0.96 cd	0.95 df	57.2 abc	56.5 bcd	4.4 abc	4.4 a	2.6 b	3.5 bc	6.9 bc	7.9 a
Mean		10.4	11.0	0.95	0.93	56.1	56.3	4.1	4.3	3.2	3.2	7.2	7.4
L_1	Without K	11.9 a	12.1 ab	0.93 f	0.91 f	55.2 cde	54.4 de	3.5 de	3.6 bc	3.1 ab	3.1 abc	6.5 cd	6.7 bc
L_2		11.4 a	10.6 cd	0.95 de	0.94 e	55.2 cde	55.6 cd	3.8 a-e	3.6 bc	3.2 ab	3.2 abc	6.9 bc	6.8 bc
L_3		12.1 a	12.1 ab	0.95 de	0.96 cde	58.1 ab	56.2 bcd	3.8 a-e	3.6 bc	3.8 a	3.1 abc	7.6 ab	6.7 bc
Mean		11.8	11.6	0.94	0.94	56.2	55.4	3.7	3.6	3.4	3.1	7.0	6.7
Mean L_1		10.8	11.3	0.95	0.94	55.3	55.7	3.8	3.9	3.4	3.1	7.2	7.0
Mean L_2		11.4	11.2	0.96	0.95	55.8	55.9	3.9	3.9	3.2	3.3	7.1	7.2
Mean L_3		11.5	11.3	0.97	0.97	57.1	56.8	4.1	4.0	3.2	3.3	7.3	7.2

Complete fertilizer (balanced fertilizer) increased VC from 52.3 and 52.7 mg/100 ml juice (farmer treatment) to 58.2 and 58.4 mg/100 ml juice represent 11.3% and 10.8% increase in the first and second seasons, respectively compared with farmer treatment. Fertilizer without magnesium led to increase rate of VC over the farmer treatment by 2.9 and 3.2% in the first and second seasons, respectively, but it was less than the complete fertilizer by 8.4 and 7.6% in the first and second seasons, respectively. Fertilizer without micronutrients increased VC over the farmer treatment by 7.3 and 6.8% in the first and second seasons, respectively, but it was less than the complete fertilizer by 4.0% in both seasons. Fertilizer without potassium increased VC over the farmer treatment by 7.5 and 5.1% in the first and second seasons, respectively, but it was less than the complete fertilizer by 3.8 and 5.7% in the first and second seasons, respectively. In respect to increasing the fertilizer levels from L_1 to L_2 and L_3 led to increase the mean values of VC from 55.3, 55.7 to 55.8, 55.9 and 57.1, 56.8 mg/100 ml juice, represent increase 0.9, 0.4% with L_2 and 3.3, 2.0% with L_3 in the first and second seasons, respectively. The interaction between fertilizer content and fertilizer levels showed that, the highest VC values of 58.6 and 59.3 mg/100 ml juice were obtained with the highest fertilizer level (L_3) and the complete fertilizer (balanced). This may be due to that each macro- or micronutrient had different role on the quality of citrus fruits. These results are in agreement with those obtained by Tariq *et al*. (2007) on Sweet orange trees, who concluded that, VC was increased significantly by the application of Zn + B through foliar spray. Similar results were obtained by Hikal (2000), Mostafa (2002), El-Abd (2005) and Abd El-Migeed *et al*. (2007) on Washington navel orange.

2.4. Sugar contents (%)

Reducing, non reducing and total sugars % are significantly affected by the used fertilizers as recorded in Table (3). All the used fertilizers increased reducing, non-reducing, and total sugars % comparing to the farmer treatment. The increase rates in the reducing sugars over the farmer treatment were (22.8, 41.9%), (2.9, 12.9%), (17.1, 38.7%) and (5.7, 16.1%) with the complete fertilizer, fertilizer without Mg, fertilizer without micronutrients and fertilizer without K in the first and second seasons, respectively. The increase rates in the non-reducing sugars over the farmer treatment were (44.0, 16.7%), (20.0, zero%), (28.0, 6.7%) and (36.0, 3.3%) with complete fertilizer, fertility without Mg, fertility without micronutrients and fertility without K in the first and second seasons, respectively. In the total sugars %, the increase rates over the farmer treatment were (34.7, 31.1%), (9.4, 3.3%), (21.2, 21.3%) and (17.8, 9.8%) with the complete fertilizer, fertilizer without Mg, fertilizer without micronutrients and fertilizer without K in the first and second seasons, respectively. No clear trend was observed with the fertilizer levels on the reducing, non-reducing and total sugars%. The obtained results are in harmony with those obtained by Kassem and El-Sabrout (2002), El-Abd (2005) on Washington Navel orange trees and Tariq *et al*. (2007) on Sweet orange trees who reported that, reducing sugars % was significantly affected by the used elements like Mn.

3. The effect of balanced fertilizers on chlorophyll A, B and total chlorophyll μg/cm^2

Data presented in Table (4) showed that, balanced fertilizer (complete fertilizer) significantly increased chlorophyll A compared to farmer treatment from 61.6 and 68.8 μg/cm^2 to 92.0 and 99.4 μg/cm^2 in the first and second seasons, respectively. The increases in chlorophyll B was from 48.0 and 51.6 μg/cm^2 to 67.7 and 74.0 μg/cm^2 in the first and second seasons, respectively. While, the increase in total chlorophyll was from 109.6 and 120.5 to 159.7 and 173.5 μg/cm$_2$ represent increase rates of 45.8 and 44.0% over the farmer treatment in the first and second seasons, respectively.

The other treatments increased both of chlorophyll A, B and total chlorophyll fertilizer without Mg increased Chl.A to 79.1 and 88.8 μg/cm^2, chl.B to 57.5 and 65.1 μg/cm^2 and total chl. to 153.3 and 155.0 μg/cm^2 compared to the farmer treatment in the first and second seasons, respectively. The increased rates compared with the control were 39.9 and 28.6% during the two seasons, respectively

These values with fertilizer without micronutrient were 70.2 and 81.0 μg/cm^2 in chl.A, 51.9 and 60.0 μg/cm^2 in chl. B. and 122.00 and 141.1 μg/cm^2 in total chl. compared with the farmer treatments in the two seasons, respectively. While treatment without K increased it to 87.4 and 95.0 μg/cm^2 in chl.A, 64.7 and 70.3 μg/cm^2 in chl.B and 152.1 and 165.4 μg/cm^2 in total chl. in the two seasons, respectively. The increase rates of the two treatments compared with the control were 11.3, 17.1% and 38.8, 37.3% during the two seasons, respectively.

In respect the fertilizer levels increased chlorophyll A, B and total chlorophyll in both seasons, L_1 increased total chlorophyll by 26.0 and 28.0% over the farmer treatment. L_2 increased total chlorophyll by 29.9 and 32%, while L_3 increased total chlorophyll by 41.9 and 35.3% in the first and second seasons, respectively. These results are in agreement with those obtained by Du-Plesis and Koen (1988) on Valencia orange trees,

Table 4. Effect of balanced fertilizers on fruit physical parameters of navel orange

Treatment		Chl.A		Chl.B.		Total chl.		Δ%	
Levels	Split	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control		61.6 k	68.8 i	48.0 h	51.6 h	109.6 h	120.5 h	-	-
L_1	Complete	90.7 bc	97.7 bc	63.6 c	73.2 a	154.3 b	170.9 ab	40.8	41.8
L_2		92.3 ab	99.3 ab	69.2 a	74.5 a	161.5 a	173.8 a	47.4	44.2
L_3		93.0 a	101.2 a	70.3 a	74.2 a	163.4 a	175.9 a	49.1	46.0
Mean		92.0	99.4	67.7	74.0	159.7	173.5	45.8	44.0
L_1	Without Mg	75.9 h	86.6 e	54.6 f	62.3 e	130.5 f	148.9 de	19.1	23.6
L_2		78.5 g	88.4 e	57.2 e	65.5 d	135.7 e	153.9 d	23.8	27.7
L_3		83.0 f	91.3 d	60.6 d	67.6 c	193.6 d	162.2 c	60.7	34.6
Mean		79.1	88.8	57.5	65.1	153.3	155.0	39.9	28.6
L_1	Without Micro-	68.1 j	77.3 h	50.4 g	57.3 g	118.5 g	134.8 g	8.1	11.9
L_2	nutrient	69.3 j	81.5 g	51.3 g	60.3 f	120.3 g	141.8 f	9.8	17.7
L_3		73.1 i	84.3 f	54.1 f	62.4 e	127.2 f	146.6 ef	16.1	21.7
Mean		70.2	81.0	51.9	60.0	122.0	141.1	11.3	17.1
L_1	Without K	85.6 e	93.1 d	63.4 c	68.9 c	149.0 c	162.1 c	35.9	34.5
L_2		87.3 de	95.8 c	64.6 bc	70.9 b	151.9 bc	166.7 bc	38.6	38.3
L_3		89.3 cd	96.2 c	66.1 b	71.2 b	155.4 b	167.3 bc	41.8	38.8
Mean		87.4	95.0	64.7	70.3	152.1	165.4	38.8	37.2
Mean L_1		80.1	88.7	58.0	65.4	138.1	154.2	26.0	28.0
Mean L_2		81.9	91.3	60.6	67.8	142.4	159.1	29.9	32.0
Mean L_3		84.6	93.3	62.8	68.9	159.9	163.0	41.9	35.3

Malavolta (1992), El-Sabrout and Kassem (2002), El-Abd (2005), Glenn (2009) on lemon trees, Muhammed Yaseen and Manzoor Ahmad (2010) on Sweet orange trees and Muhammad *et al*. (2010).

CONCLUSION

From the previous data, it could be concluded that the balanced fertilizers (N+ P+ K+ Mg+ micronutrients) are the best tool to improve navel orange growth, fruit set%, fruit number/tree and maximum yield, it increased fruit yield by 32.6% over the farmer fertilization treatment and improved fruit quality, it increased SSC%, VC (mg/100 ml juice), reducing, non-reducing and total sugars.

Potassium deficiency in the fertilization had the lowest effect on increasing fruit yield and quality followed by the micronutrietns deficiency and followed by magnesium deficiency compared with the balanced fertilizers during the two seasons, respectively.

Balanced fertilizers increased fertilizer efficiency under the low, medium and high fertilizer levels compared with the other treatments and the control under the three levels during the two seasons, respectively.

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ا لمخص العر

تأث التسميد ا توازن ومستويات السماد على صول ال تقال أبوسره وجودة الثمار

على السيد زغلول، رمضان إ اعيل كنا

نفذت ربة حقلية خلال ا و ا تعـاقب ٢٠٠٧/٢٠٠٨م، ٢٠٠٨/٢٠٠٩م على أشجار ال تقال أبوسره بالغة ركز مطوبس - افظة كفرالشيخ- مصر لدراسة أثر التسميد ا توازن ومستوياته على إنتاجية ال تقال أبوسره وجودة اره. ذلك لأربع معـاملات أ دة:

١- اد متوازن (كامل).

٢- اد بدون عنصر ا اغنسيوم.

٣- اد بدون العناصر الصغرى.

٤- اد بدون البوتاسيوم

وذلك مع ثلاث مستويات من كل منـها (l_1, l_2, l_3) مقارنـة عاملة ا زارع.

و كن تلخيص النتائج الأتى:

-السماد الكامل (ا توازن) أعطى أعلى نسبة عقد للثمـار (٧,٨، ٨,١%) وأقل نسبة تساقط للثمار قبل ا مع (٧,٩، ٧,٨%) وأعلى عدد للثمار للشجرة (٤٠٥,١، ٣٩١,٩) وأعلى صول بالكيلو جرام للشجرة (٨٦,٠، ٩٣,١) وأعلى تركيز للمـواد الصلبة الذائبة (١١,٩، ١٢,٣%) وأعلى تركيز لفيتـام "ج" (٥٨,٢، ٥٨,٤ م لكل ١٠٠ مل عص) ا وسـم الأول والثا على التوا .

-السماد ا توزن (الكامل) أدى إ رفع معدلات زيادة السكريات ا ختزلة بنسبة (٢٢,٨، ٤١,٩%) والسكريات الغـ تزلـة بنسبة(٤٤,٠، ١٦,٧%) والسكريات الكلية بنـسبة (٣٤,٦، ٣١,١%) زيادة عن معاملة ا زارع ا وسـم الأول والثـا على التوا .

-أدى استخدام السماد الكامل (ا توازن) إ رفع معدل الزيادة كلوروفيل "أ و ب" والكلوروفيل الكلى مقارنة عاملة ا زارع وكانت معدلات الزيادة نسبة الكلوروفيل الكلـى (٤٥,٨، ٤٤,٠%) زيادة عن معاملة ا زارع ا وسـم الأول والثـا على التوا .

-أعطت معاملة ا زارع أقل قيم لنسبة عقد الثمار (٥,٤، ٥,٧%) وأقل صول ار للشجرة (٦٦,٨، ٧٠,٢ كجـم/شـجرة) وأعلى نسبة لتساقط الثمار قبل ا مع (١٢,٩، ١٢,٤%) وأقل نسبة وضة (٠,٩٢، ٠,٩١%) وأقل فيتام "ج" (٥٢,٣ ، ٥٢,٧ م لكل ١٠٠ مل عص) وأقل نسبة سكريات تزلـة (٣,٥، ٣,١%) وأقل نسبة سـكريات غـ تزلـة (٢,٥،

٣,٠%) وأقل نسبة سكريات كليـة (٥,٩، ٦,١%) وأقـل كلوروفيل "أ و ب" وكلوروفيل كلى ا و الأول والثا على التوا .

-استخدام السماد بدون ا اغنـسيوم أو العناصـر الـصغرى أو البوتاسيوم أعطى قيم أعلى من معاملة ا زارع وذلك كل من نسبة العقد وعدد الثمار/شجرة وكمية ا صول كجم/شـجرة ونسبة ا موضة(V.C) والسكريات ا ختزلة وغـ ا ختزلـة والكلية والكلوروفيل الكلى بينما كانت هذه القيم أقل منها حالة استخدام السماد الكامل وذلك خـلال ا ـو الأول والثا على التوا .

-اختلفت معدلات الزيادة هذه ا عاملات بالنـسبه للكنتـرول حيث كانت نـسبة العقـد (٢٩,٢، ٢٨,١%)، (٣٦,٥، ٢٨,١%) و(١٢,٥، ١٤,٠%) وكمية ا صول كجم/شجرة (٩,١، ٢٥,٥%) و (١٩,١، ١٥,٩%)، (٢١,٩، صـفر%) ونسبة ا موضـة (٦,٥، ٦,٥%)، (٣,٣، ٢,٢%)، (٢,٢، ٢,٢%) ونـسبة (V.C)، (٢,٩، ٣,٢%)، (٧,٣، ٦,٨%)، (٧,٥، ٥,١%) والـسكريات ا ختزلـة (٢,٩، ١٢,٩%)، (١٧,١، ٣٨,٧%)، (٥,٧، ١٦,١%) والسكريات الكليـة (١٠,٢، ٣,٣%)، (٢٢,٠، ٢١,٣%)، (١٧,٨، ٩,٨%) والكلوروفيل الكلى (٣٩,٥، ٢٨,٦%)، (١١,٣، ١٧,١%)، (٣٨,٨، ٣٧,٢%) خلال مو ى الدراسة لكل قيم ا عاملات الثلاثة على التوا .

أظهرت معاملة ا زارع أعلى القيم كل من تساقط ما قبـل ا مع(١٢,٩، ١٢,٤%) ونسبة ا واد الـصلبة الذائبـة (١١,٩، ١١,٤%) مقارنة با عاملات الأربع خلال ا وسم الأول والثا على التوا .