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CALCIUM BORON AND CARPOX-K SPRAYS FOR IMPROVING GROWTH, NUTRITIONAL STATUS AND PRODUCTIVITY OF WASHINGTON NAVEL ORANGE TREES

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Abstract

This study was carried out during the 2018 & 2019 seasons on 9-year-old Washington navel orange trees. These trees were budded on Sour orange rootstock planted at 5×5 meters apart under surface irrigation of a private orchard at Manzala village, Toukh region, Qalubia Governorate, Egypt. The seven treatments were used for comparison as follows: T_1-100% of chemical NPK (NPK fertilization program adopted at 5, 3 and 1 kg/tree from $(NH_4)_2SO_4$, superphosphate and K_2SO_4, respectively) according to the Ministry of Agriculture Recommendation (Control or recommended doses RD). T_2-RD+Calcium boron 2 cm^3 /L, T_3-RD+Calcium boron 3 cm^3/L, T_4-RD+Carpox-K 1g/L, T_5-RD+Carpox-K 1.5g/L, T_6-RD+Calcium boron 2 cm^3 /L +Carpox-K 1g/L and T_7-RD+Calcium boron 3 cm^3/L +Carpox-K 1.5g/L. The main goal of this investigation was directed towards increasing Washington navel orange trees growth, Nutritional Status and productivity. Moreover, All the obtained data revealed that all investigated treatments increased growth parameters (number, length, the thickness of developed shoots, number of leaves/shoot and leaf area), leaf total chlorophyll and leaf nutritional status (N, K, Ca, Mg, Fe, Mn and Zn) were also positively responded fruit (set % and retention %) and yield/tree was also improved. However, T7- RD + Calcium boron 3 cm^3/L + Carpox-K 1.5g/L was statistically superior. On the contrary, T_1- Control or recommended doses (RD) ranked statistically the lowest treatment in this concern. Generally. From the obtained results, it can be concluded that using of RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L or RD + Calcium boron 2 cm^3/L + Carpox-K 1g/L could be safely recommended under similar environmental conditions and horticulture practices adopted in the present experiment.

Key words: Washington navel orange, Calcium boron, Carpox-K, Nutritional Status, Productivity

Introduction

According to Annual Reports of Statistical Institute and Agricultural Economic Research in Egypt, (2016) Citrus is one of the most important horticultural crops in Egypt due to its high economic value for the local markets and export. The total exportation of citrus reached 1, 667, 750 and 1, 616, 821 tons of fruits through 2016 and 2017, respectively. The total area occupied by citrus in 2016 was 485, 940 feddans that produced 4, 272, 886 tons of fruits. From such area; 163, 932 feddans were cultivated by Washington navel orange trees representing 33.74% of the total area; producing 1, 489, 536 tons of fruits; representing about 34.86% of total citrus production. Oranges take the foreground of citrus varieties, especially Washington navel orange (*Citrus sinensis* L. Osbeck). Navel orange plays a dominant role not only in the local market but also for exportation as one of the major citrus fruit crops in Egypt. June drop and pre-harvest fruit drop are extensive in many Egyptian orchards, as the navel orange is a parthenocarpic cultivar and consequently eliminating yield and fruit quality (Saleem *et al.,* 2007).

Washington Navel orange is the most favorite and the popular fresh fruits in Egypt due to its seedless, large size, nutritive value, flavor and aroma characteristics. It is also a valuable source of early-season income for citrus growers in some commercial citrus areas of the world.

Costs of mineral fertilizers have been significantly going up. As a result, it has become necessary to seek

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alternatives that would supply the poor soil with more economical sources of fertilizers (Wardowski *et al.,* 1985). Moreover, one of the most important cultural practices is the fertilization program. Foliar fertilizer rates are typically lower than soil fertilizer rates, but applications can be more costly. These applications that only minimally added to production costs were able to increase returns by several pounds per acre yearly. Foliar fertilization also reduces nutrient accumulation in soil, groundwater, where they contribute to salinity with negative consequences to humans and the environment.

The calcium element builds and strengthens a cell wall membrane in plants. The cell wall membrane surrounds the cell cytoplasm and helps in maintaining the structure and shape of the cell. Reduction of the calcium element in cells causes holes or cracks in the cell which allows salts concentrations in the cytoplasm to flow out from the cell. Calcium salts are also able to prevent a few plant diseases. Calcium promotes early root formation and growth, improves general plant vigor, stiffness of stalks and improves fruit integrity. It also influences the uptake of other nutrients such as phosphorous, manganese, iron, zinc and boron, (Polevoiy, 1979). It is an effective element of a fruit's physiological resistance (Faust, 1989), increases cell turgor pressure (Mastrangelo *et al.,* 2000) and stabilizes the cell membrane (Picchioni *et al.,* 1995). Calcium disorders prevent physiological maturity before harvesting, such as delay and decrease in the quality of the fruit within many fruit species (Hernandez-Munoz *et al.,* 2006). Foliar calcium applications may extend the aging process significantly (Pooviah, 1979), however, little is known about the effect of foliar calcium application on yield and quality (Ramezanian *et al.,* 2009).

Potassium is necessary for essential physiological functions such as the formation of sugars and starch, synthesis of proteins and cell division and growth (Obreza, 2003; Abbas and Fares, 2008). It is also important in forming and functioning proteins, fats, carbohydrates, chlorophyll and in maintaining the balance of salts and water in plant cells, (Achilea, 1998). Nutritional need for potassium centers on four physiological biochemical roles, enzyme activation, membrane transport process, anion neutralization and osmotic potential (Clarkson and Hanson, 1980).

Boron is an essential nutrient and although leaves can tolerate toxic levels of this element, boron deficiency can cause serious problems such as defective fruit development, less yield and poor fruit quality (Maurer and Truman 1999). Boron foliar applications have also been applied successfully within a limited number of studies for reducing the breakdown of fruit, fruit cracking, controlling boron levels and plant bioregulators (PBR) applications (Singh *et al.,* 2003). Numerous plants require to boron fertilization all through the developing season. It is essential for the progression of the plant's meristem. Its expansion increments the synthesis and movement of carbohydrates, particularly sucrose from the takes off to the roots and fruiting buds (Varduni *et al.,* 2014).

Thereupon, this work was designed to examine the results of foliar spraying to Washington' navel orange trees with Calcium boron and Carpox-K on enhancing vegetative growth, nutritional status and increasing fruit set and yield.

Materials and Methods

This study was carried out during 2018 & 2019 seasons on 9-year-old Washington navel orange trees budded on Sour orange rootstock planted at 5×5 meters apart (168 trees/fed.) under surface irrigation of a private orchard at Manzala village, Toukh region, Qalubia Governorate, Egypt. All trees were subjected to the same horticultural practices (irrigation, fertilization, weeds and pest control) adopted in the area according to the recommendation of the Ministry of Agriculture. It was devoted to investigating the influence of Calcium boron and Carpox-K foliar application on growth, nutritional status and productivity of Washington navel orange trees. Before starting the 1st season (2018), mechanical and chemical analysis of orchard soil surface (0.40cm. depth) were determined according to Black *et al.,* (1982). As shown in table A.

The seven treatments involved in this study were summarized as follows

T_1- Chemical NPK (as fertilization program adopted at 5, 3 and 1 kg/tree from $(NH_4)_2SO_4$, superphosphate and K_2SO_4, respectively) according to the Ministry of Agriculture Recommendation (Control or recommended doses RD).

Table A: Physical and chemical properties of the investigated soil.

Physical analysis	Value	Chemical analysis			
		Cations meq/l		Anions meq/l	
Coarse sand	11 %	Ca^{++}	8.8	$CO3^{--}$	Zero
Fine sand	18.2%	Mg^{++}	3.25	$HCO3^-$	4.5
Silt	18.2%	Na^+	4.30	Cl^-	6.45
Clay	51.4 %	K^+	1.08	SO4—	8.00
Texture class	Clay loam	Available N 24.5 mg/kg			
Soil pH	7.2	Available P 11.94 mg/kg			
E.C, ds/m	1.60	Available K 170.5 mg/kg			
Organic matter	3.4%				

T_2 – RD+ Calcium boron 2 cm^3/L.

T_3 - RD+ Calcium boron 3 cm^3/L.

T_4 - RD+ Carpox-K 1g/L.

T_5 - RD+ Carpox-K 1.5g/L.

T_6 - RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L.

T_7 - RD+ Calcium boron 3 cm^3 /L + Carpox-K 1.5g/L.

Carbox-k (commercial name for potassium fertilizer compound) is a foliar fertilizer with a high content of potassium and it's formulated with high-quality nutrients elements, obtaining a high solubility and perfect assimilation by plants. It is effervescent granules that contain a high percentage of potassium and chelated carboxylic acids scientifically and technologically that helps the plants to take full advantage of all the elements present in the compound. It can be used in all different growth stages of plant life. It works to increase the synthesis of pigments responsible for coloring fruits, the effectiveness of avital tonic to regulate physiological processes installed the flowers and capacity of plants and also to increase of information fruit sugar

Calcium boron (commercial name for calcium and boron fertilizer compound)

Experiment layout

The complete randomized block design with three replications was employed for arranging the seven investigated fertilization treatments, whereas a single tree represented each replicate. Consequently, 21 healthy fruitful Washington navel orange trees were carefully selected, as being healthy, disease-free and in the on-year state. Chosen trees were divided according to their growth vigor into three categories (blocks) each included seven similar trees for receiving the investigated seven treatments (a single tree was randomly subjected to one treatment).

The following measurements were recorded

In late March 2017 and early April 2018, four main branches (limbs/scaffolds) well distributed around each tree periphery were carefully selected and tagged during the 1st and 2nd seasons, respectively. Moreover, 20 newly spring developed shoots were also labeled.

Devoted trees for each treatment were sprayed five times with the corresponding solution five times at a one-month interval starting from full-bloom during each season.

Vegetative growth measurements

In mid-October 2018 and 2019 years, the following vegetative growth parameters were determined during the 1st and 2nd experimental seasons, respectively.

In this regard, the average number of newly developed shoots per one meter of every tagged limb, average length and thickness and the number of leaves per each labeled shoot were estimated. Besides, the average leaf area (cm^2) on a weight basis was also determined. Hence, 20 mature leaves from the previously labeled shoots per each limb were randomly collected. Then 20 disks each in one square cm of the area was taken and oven-dried together with the rest leaves at 80°C till constant weight. Based on the known dry weight of a known surface area of leaves, *i.e.*, 20 leaf discs from one hand and the total weight of 20 leaves from the other, then the average leaf area in cm. was calculated. Moreover, assimilation area per one shoot according to the following equation:

Assimilation area (m^2) = leaf area × No. of leaves per one shoot.

Nutritional status measurements

Total chlorophyll content: (mg/100g f.w.)

Total chlorophyll content in fresh leaves was determined by using Minolta meter SPAD-502.

Leaf mineral composition

Representative samples of fourth and fifth leaves from the base of spring shoots were collected from each replicate in October during both seasons. The samples were thoroughly washed with tap water, rinsed twice with distilled water and oven-dried at 80°C till a constant weight and finely ground for determination of:

1- Total Nitrogen: Total N in leaves was determined by the modified micro Kjeldahl method mentioned by (Pregl, 1945).

2- Total phosphorus: Total P in leaves was determined by wet digestion of plant materials after the methods described by using sulphuric and perchloric acid, which has been strongly recommended by (Piper, 1958).

3- Total potassium: Total K in leaves was determined photometrically in the digested material according to the method described by (Brown and Lilliand, 1946).

4- The percentage of Calcium, Magnesium, Iron and Zinc was determined using the Atomic absorption spectrophotometer "Perkin Elmer -3300" after Chapman and Pratt (1961).

Productivity measurements

Fruit set percentage

At full bloom during each experimental season, the number of perfect flowers per each tagged limb was counted. After 75% of petal fall fruit set as a percentage of perfect flowers were estimated according to the following equation:

$$\text{Fruit set \%} = \frac{Number\ of\ set\ fruitlets}{Number\ of\ perfect\ flowers} \times 100$$

Fruits retention %

At a given date on December during each experimental season, Percentage of retained fruits were estimated according to the following equations:

Fruits retention % =

$$\frac{Number\ of\ presented\ (remained)\ fruits\ at\ a\ given\ date}{Number\ of\ perfect\ flowers} \times 100$$

Yield

In mid-December 2018 and 2019, fruits of each tree were separately harvested, then counted and weighed. Tree productivity (yield) was estimated as either a number or weight (kg) of harvested fruits per each tree. Besides, yield per each tree (Kg) as well as yield per feddan (ton).

Statistical analysis

All data obtained during both seasons for two experiments included in this investigation were subjected to analysis of variance according to (Snedecor and Cochran, 1980). Besides, significant differences among means were differentiated according to the Duncan, multiple test range (Duncan, 1955) where letter/s were used for distinguishing means of different treatments for each investigated characteristic.

Results and Discussion

Vegetative growth measurements

In this respect number of developed shoots per one meter of each tagged main branch (limb/scaffold), average shoot length and diameter, number of leaves per shoot, average leaf area and total assimilation area per shoots were investigated as growth parameters in response to the differential treatments. Data obtained during both 2018 and 2019 seasons are presented in tables 1 and 2.

Concerning the response of the above-mentioned numbers to the various investigated nutrient compound treatments; tables 1 and 2 show a considerable variation in this respect. Herein, the highest number of values was significantly coupled with the Washington navel orange trees subjected to T_7 - RD + Calcium boron 3 cm^3/L + Carpox-K 1.5 g/L. Moreover, the 6th treatment (RD+

Table 1: Effect of Calcium boron and Carpox-K foliar application on the number of new shoots, shoot length and shoot diameter of Washington navel orange trees during 2018 and 2019 experimental seasons.

Parameters	Number of new shoots		Shoot length (cm)		Shoot Diameter (mm)	
Treatments	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
T_1- Control (recommended doses (RD).	21.67 d	20.67 e	25.67 e	24.67 f	2.60 g	2.63 g
T_2 – RD+ Calcium boron 2 cm^3/L.	23.67 c	23.67 cd	26.34 e	28.00 e	2.75 f	2.77 f
T_3 - RD+ Calcium boron 3 cm^3/L.	24.67 abc	23.34 d	29.67 d	30.67 d	2.91 e	2.88 e
T_4 - RD+ Carpox-K 1g/L.	23.67 c	24.67 bc	32.67 c	33.67 c	3.01 d	2.98 d
T_5 - RD+ Carpox-K 1.5g/L.	24.34 bc	25.00 ab	33.67 c	35.67 b	3.12 c	3.16 c
T_6 - RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L.	25.34 ab	25.34 ab	36.00 b	37.00 b	3.24 b	3.29 b
T_7 - RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L.	25.67 a	26.00 a	41.00 a	41.67 a	3.40 a	3.41 a

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Table 2: Effect of Calcium boron and Carpox-K foliar application on the number of leaves/shoot, Leaf area and Assimilation area of Washington navel orange trees during 2018 and 2019 experimental seasons.

Parameters	Number of leaves/shoot		Leaf area (cm^2)		Assimilation area (m^2/shoot)	
Treatments	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
T_1- Control (recommended doses (RD).	22.00 f	22.33 g	15.25 f	15.27 g	3.36 g	3.42 g
T_2 – RD+ Calcium boron 2 cm^3/L.	24.67 e	25.33 f	15.33 f	15.61 f	3.78 f	3.96 f
T_3 - RD+ Calcium boron 3 cm^3/L.	27.33 d	28.33 e	15.68 e	15.83 e	4.29 e	4.49 e
T_4 - RD+ Carpox-K 1g/L.	34.67 c	33.00 d	16.06 d	16.35 d	5.57 d	5.40 d
T_5 - RD+ Carpox-K 1.5g/L.	35.67 c	34.67 c	16.31 c	16.64 c	5.81 c	5.77 c
T_6 - RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L.	37.33 b	37.00 b	16.73 b	16.98 b	6.25 b	6.29 b
T_7 - RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L.	40.00 a	41.00 a	17.09 a	17.37 a	6.84 a	7.13 a

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Calcium boron 2 cm^3/L + Carpox-K 1g/L) ranked statistically the 2nd for its efficiency. On the contrary, the least values of the abovementioned parameters were usually in concomitant to T_1- Control or recommended doses (RD), which ranked statistically last during both seasons of study.

The remaining four investigated treatments (2nd, 3rd, 4th and 5th) were in between the previously mentioned two extremes. Such four intermediate nutritive compound treatments had no significant differentiation from each other, despite their statistical variations from the abovementioned superior and inferior treatments during two experimental seasons.

Leaf chemical analysis

Leaf total chlorophyll (mg/100g f.w.)

Table 3 displays obviously that all investigated treatments of using fertilizers resulted significantly in increasing total chlorophyll. However, T_7 - RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L were statistically the superior and showed the highest total chlorophyll levels during 2018 & 2019 seasons, respectively. Other investigated fertilizers treatments could be descendingly arranged about their efficiency as follows: T_6 - RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L, T_5 - RD+ Carpox-K 1.5g/L and T_4 – RD+ Carpox-K 1g/L. On the contrary, the least values of the abovementioned parameters were usually in concomitant to T_1- Control or recommended doses (RD) which ranked statistically last during both seasons of study.

Leaf mineral composition

In this regard, leaf N, P, K, Ca, Mg, Fe, Mn and Zn contents of Washington navel orange trees as influenced by different foliar spray treatments were the concerned leaf mineral composition as an indicator for nutritional states of tress under study. Data obtained during both 2018 and 2019 experimental seasons are presented in tables 3, 4 and 5. Tabulated data revealed that all investigated treatments that representative with chemical T_7- RD+ Calcium boron 3 cm^3/L+ Carpox-K 1.5g/L and T_6 - RD+ Calcium boron 2 cm^3/L+ Carpox-K 1g/L. resulted significantly in increasing the Leaf mineral composition of Washington navel orange trees as compared to the other treatments. In addition, the remaining four investigated treatments (2nd, 3rd, 4th and 5th) were the least effective treatments in spite of they exceeded statistically the recommended dose (control) during both 2018 and 2019 experimental seasons. Such a trend was actual during both the 2018 & 2019

Table 3: Effect of Calcium boron and Carpox-K foliar application on total chlorophyll, N, and P percentages of Washington navel orange trees during 2018 and 2019 experimental seasons.

Parameters / Treatments	Total Chlorophyll (mg/100g F.W.)		N%		P%	
	2018	2019	2018	2019	2018	2019
T_1- Control (recommended doses (RD).	8.56 g	8.637 g	2.35 f	2.31 f	0.160 a	0.164 a
T_2 – RD+ Calcium boron 2 cm^3/L.	8.97 f	8.960 f	2.36 f	2.36 f	0.156 ab	0.160 ab
T_3 - RD+ Calcium boron 3 cm^3/L.	9.24 e	9.280 e	2.49 e	2.51 e	0.152 abc	0.150 bc
T_4 - RD+ Carpox-K 1g/L.	9.40 d	9.640 d	2.61 d	2.65 d	0.150 bc	0.147 c
T_5 - RD+ Carpox-K 1.5g/L.	9.65 c	9.853 c	2.75 c	2.75 c	0.145 cd	0.142 c
T_6 - RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L.	9.84 b	10.233 b	2.92 b	2.86 b	0.139 de	0.140 c
T_7 - RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L.	10.18 a	10.397 a	3.03 a	2.99 a	0.133 e	0.137 c

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Table 4: Effect of Calcium boron and Carpox-K foliar application on K, Mg, and Ca percentages of Washington navel orange trees during 2018 and 2019 experimental seasons.

Parameters	K%		Mg%		Ca%	
Treatments	2018	2019	2018	2019	2018	2019
T_1- Control (recommended doses (RD).	1.38 e	1.39 g	0.41 g	0.42 g	4.16 g	4.19 g
T_2 – RD+ Calcium boron 2 cm^3/L.	1.44 e	1.45 f	0.42 f	0.44 f	4.29 f	4.27 f
T_3 - RD+ Calcium boron 3 cm^3/L.	1.52 d	1.52 e	0.43 e	0.50 e	4.40 e	4.39 e
T_4 - RD+ Carpox-K 1g/L.	1.64 c	1.60 d	0.44 d	0.47 d	4.48 d	4.51 d
T_5 - RD+ Carpox-K 1.5g/L.	1.69 c	1.66 c	0.46 c	0.48 c	4.59 c	4.64 c
T_6 - RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L.	1.79 b	1.73 b	0.49 b	0.50 b	4.69 b	4.71 b
T_7 - RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L.	1.87 a	1.85 a	0.51 a	0.53 a	4.76 a	4.80 a

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Table 5: Effect of Calcium boron and Carpox-K foliar application on Fe, Mn and Zn (ppm) contents of Washington navel orange trees during 2018 and 2019 experimental seasons.

Parameters	Fe (ppm)		Mn (ppm)		Zn (ppm)	
Treatments	2018	2019	2018	2019	2018	2019
T_1- Control (recommended doses (RD).	66.27 g	67.58 g	35.63 g	36.66 g	23.11 g	22.54 g
T_2 – RD+ Calcium boron 2 cm^3/L.	67.28 f	69.29 f	37.04 f	38.15 f	24.98 f	24.28 f
T_3 - RD+ Calcium boron 3 cm^3/L.	69.78 e	71.53 e	39.14 e	40.39 e	26.54 e	25.99 e
T_4 - RD+ Carpox-K 1g/L.	72.62 d	73.67 d	41.82 d	42.08 d	28.83 d	28.76 d
T_5 - RD+ Carpox-K 1.5g/L.	75.11 c	75.47 c	44.15 c	43.74 c	31.34 c	32.16 c
T_6 - RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L.	76.59 b	77.88 b	47.13 b	45.91 b	33.82 b	33.45 b
T_7 - RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L.	78.04 a	79.50 a	49.20 a	48.58 a	35.51 a	36.14 a

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

experimental seasons with one exception in P % which took the opposite trend during two seasons.

Fruits set and retention %

Table 6 displays obviously that the six investigated treatments increased significantly the fruits set and retention % over control. However, T_7 - RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L was statistically superior in this concern during both 2018 and 2019 experimental seasons. However, the 6th treatment (RD+ Calcium boron 2 cm^3/L+ Carpox-K 1g/L) ranked statistically second, descendingly followed by T_5- RD+ Carpox-K 1.5g/L and T_4- RD+ Carpox-K 1g/L. On the contrary, the least values of the abovementioned parameters were usually in concomitant to T_1 - Control or recommended doses (RD) which ranked statistically last during both seasons of study.

Tree productivity (yield)

Data obtained during seasons are presented in table 7. Herein, the cropping parameters of tree productivity followed the same trend, where T_7 - RD+ Calcium boron 3cm^3/L+ Carpox-K 1.5g/L surpassed all other treatments statistically during both seasons of study. However, T_6 -

Table 6: Effect of Calcium boron and Carpox-K foliar application on the percentage of fruit set and fruit retention of Washington navel orange trees during 2018 and 2019 experimental seasons.

Parameters	Fruit set (%)		Fruit retention %	
Treatments	2018	2019	2018	2019
T_1- Control (recommended doses (RD).	14.82 e	15.05 f	10.62 f	10.78 f
T_2 – RD+ Calcium boron 2 cm^3/L.	17.22 d	17.58 e	12.60 e	12.89 e
T_3 - RD+ Calcium boron 3 cm^3/L.	18.46 c	18.59 c	13.74 c	13.86 cd
T_4 - RD+ Carpox-K 1g/L.	17.69 cd	17.90 d	12.89 d	13.37 de
T_5 - RD+ Carpox-K 1.5g/L.	18.10 c	18.18 d	13.80 c	14.08 c
T_6 - RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L.	19.76 b	20.68 b	15.57 b	15.58 b
T_7 - RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L.	21.57 a	22.38 a	16.07 a	16.60 a

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Table 7: Effect of Calcium boron and Carpox-K foliar application on the number of fruits/tree, average fruit weight (g), yield (kg) /tree and yield (kg) /Feddan of Washington navel orange trees during 2018 and 2019 experimental seasons.

Parameters / Treatments	Number of fruit/tree		Average fruit weight (g)		Yield (kg) /tree		Yield (kg) /Feddan	
	2018	2019	2018	2019	2018	2019	2018	2019
T_1- Control (recommended doses (RD).	120.67 f	119.67 g	241.67 f	241.00 g	29.16 g	28.85 g	4.90 g	4.85 g
T_2 – RD+ Calcium boron 2 cm^3/L.	123.33 f	124.00 f	247.67 e	251.00 f	30.56 f	31.13 f	5.13 f	5.23 f
T_3 - RD+ Calcium boron 3 cm^3/L.	134.67 e	133.00 e	258.33 d	257.33 e	34.80 e	34.24 e	5.84 e	5.75 e
T_4 - RD+ Carpox-K 1g/L.	145.00 d	140.33 d	267.67 c	268.67 d	38.83 d	37.71 d	6.52 d	6.34 d
T_5 - RD+ Carpox-K 1.5g/L.	157.67 c	154.33 c	276.33 b	272.33 c	43.58 c	42.04 c	7.32 c	7.06 c
T_6 - RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L.	165.67 b	162.67 b	282.33 a	276.33 b	46.78 b	44.95 b	7.86 b	7.55 b
T_7 - RD+ Calcium boron 3 cm^3/L + Carpox-K 1.5g/L.	170.00 a	169.67 a	285.33 a	283.67 a	48.51 a	48.13 a	8.15 a	8.08 a

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

RD+ Calcium boron 2 cm^3/L + Carpox-K 1g/L ranked statistically second. On the contrary, T_1- Control or recommended doses only ranked statically last in this regard during both seasons of study.

In addition, four other investigated treatments were in between the aforesaid two extremes in spite of their statistical variations from the abovementioned superior and inferior treatments during the two experimental seasons.

Discussion

Calcium is an essential and major plant nutrient and is required as a divalent cation (Ca^{+2}) in a varied role, such as structural function in the cell wall and membranes, as a counter ion for inorganic and organic anions in the vacuole, as a cytoplasmic secondary messenger related to environmental or developmental stimuli to their physiological responses (Sugimura *et al.,* 1999; White, 2001). Several Ca-deficiency disorders occur in horticulture when sufficient Ca is momentarily unavailable to developing fruit tissues. These take place because Ca not be mobilized from older tissues and redistribute itself via the phloem and therefore the immediate supply of Ca is in the xylem, which in turn depends on the unidirectional transpiration stream (White and Broadley, 2003). The low soil Ca levels may increase the frequency of Ca deficiency in a crop, but most often problems observed are rather a matter of poor Ca translocation within the plant than one of low soil Ca levels (Camberato and Pan, 2000). The Ca uptake is restricted to roots tips and it occurs at greater rates in actively growing meristematic regions than in older root sections delivery to the xylem is larger in regions of the root where the Casparian band is discontinuous or ruptured (White, 2001). This is why when soil Ca supply suffices there is no restriction for its absorption provided there is radical growth.

Applications of calcium and boron may partially help to over-come this problem. The application of calcium inhibits fruit abscission and delays its senescence development (Poovaiah and Leopold, 1973), increase fruit pulls force and firmness (Faust, 1975). On the other hand, boron plays a major role in enhancing cell division, biosynthesis of carbohydrates and proteins, flowers pollination and fertilization. It plays an important role in improving fruit setting by encouraging germination and growth of pollen grains (Chiu and Change 1985). Regarding the similarity of boron functions to other plant nutrients, the Ca-B relationship is outstanding. Both elements play an important role in cell wall metabolism and are required for auxin transport process (Dela-Fuente *et al.,* 1986). Additionally, boron is involved in physiological and biochemical processes inside the plant cell, altering the concentration and translocation of nutrients (Tariq and Mott, 2007).

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, color, size, acidity and roughness. Excessively high K levels result in large fruit with coarse, thick peel and poor color. Moreover, early and intensive re-greening 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.

A similar tendency was found with the application of boron as borax or boric acid source (Kodua, 1980; Singh and Singh 1981) on mandarin, El-Hagab *et al.,* 1983 on Navel orange and Balady mandarin trees, Ahmed *et al.,* 1991 on Balady mandarin. Also, Ahmed *et al.,* 1996 reported that spraying borax or boric acid on Washington navel orange trees at 0.025 to 0.2 caused a remarkable promotion in leaf area, length and diameter of shoot in the spring growth cycle and promoted the percentage of fruit setting. They found that using boric acid caused slight promotion on the growth. Also, Habasy *et al.,* (2016) found that application for both Ca and B had an announced effect on growth, yield, percentages of N, P and K in the leaves, leaf content of pigments and nutrients owing to spraying the trees with a mixture of chelated-Ca at 0.03 and chelated-B at 0.025% three times (1^{st} week of March, last week of April and 3^{rd} week of May).

The obtained results are in agreement with the finding of Hafez and El-Metwally (2007), who studied the influence of some elements as a foliar spray (Zinc at 0.4% in the form of Chelate, potassium at 1% in the form of Salent liquid, Zinc + Potassium and control which sprayed with tap water). They found that the number of fruits/tree and yield was increased with foliar application of potassium. EL-Saida (2001) and EL-Baz (2003) found that the increase in fruit weight, number of fruits/ tree and yield/tree could be rendered by spraying Washington navel orange trees with Zn + K. Baghdady *et al*., (2014) indicated that foliar spraying of Valencia orange trees with chelated calcium, chelated zinc and boron significantly increased fruit weight (g), number of fruits/ tree and the estimated yield (kg/tree) at harvest in comparison to control and other treatments. Moreover, An obtained result about the increase in Vegetative growth, nutritional status and productivity measurements exhibited by investigated fertilizers treatments were in general agreement with the findings of Baiea *et al.,* (2015) on Keitt Mango trees, Abdelaal *et al.,* (2010), Sharaf *et al.,* (2011), EL-Gioushy, (2016), El-Badawy *et al.,* (2017a), El-Badawy *et al.,* (2017b) and El-Gioushy and Eissa (2019) on Washington Navel orange trees.

Conclusion

Conclusively, from the obtained results, it can be concluded that using of RD+ Calcium boron 3 cm/L + Carpox-K 1.5g/L or RD+ Calcium boron 2 cm/L+ Carpox-K 1g/L could be safely recommended, as their beneficial effects on vegetative growth, nutritional status and productivity of Washington navel orange trees grown under similar environmental conditions and horticulture practices adopted in the present experiment.

Abbreviations

RD: recommended doses.

References

Abbas, F. and A. Fares (2008). Best management practices in citrus production, *Tree for. Sci. Biotech.,* **3:** 1-11.

Abdelaal S.H., M.H. El-Sheikh, H.S.A. Hassan and S.S. Kabeil (2010). Microbial bio-fertilization approaches to improve yield and quality of Washington navel orange and reducing the survival of nematode in the soil. *Journal of American Science,* **6(12):** 264-271.

Achilea, O. (1998). Citrus and tomato quality is improved by optimized K nutrition. In: Improved Crop Quality by Nutrient Management. D. Anac and P. Martin – prevel (eds). Kluwer Academic Publishers. 1998, PP: 19-22.

Ahmed, F.F., O.H. Darwish and M.A. El-Sayed (1991). Could alternate bearing of Balady mandarin trees (*Citrus reticulate* Blanco) be controlled by boron and magnesium. *Minia J. Agric. Res. Dev.,* **13:** 31-48.

Ahmed, F.F., M.A. Ragab and G.M. El-Dawwey (1996). Response of Balady mandarin trees grown on new reclaimed sandy soil to spraying boron. Fourth Arabic Conf. for Hort. Crops, El-Minia, Egypt Part 11, Pomology. pp. 1009-1018.

Annual Reports of Statistical Institute and Agricultural Economic Research in Egypt (2016).

Baghdady, G.A., A.M. Abdelrazik, G.A. Abdrabboh and A.A. Abo-Elghit (2014). Effect of foliar application of GA_3 and some nutrients on yield and fruit quality of Valencia orange trees. *Nature and Science,* **12(4):** 93-100.

Baiea, M.H.M., S.F. EL-Gioushy and T.F. El-Sharony (2015). Effect of feldspar and bio- fertilization on growth, productivity and fruit quality of banana *cv.* Grande Naine. *International Journal of Environment,* **4(4):** 210-218.

Black, C.A., D.O. Evans, L.E. Ensminger, J.L. White, F.E. Clark and R.C. Dinauer (1982). Methods of soil analysis. Part 2. Chemical and microbiological properties. 2^{ed}. Soil Sci., Soc. of Am. Inc. Publ., Madison, Wisconsin, U. S.A.

Brown, J.D. and O. Lilliand (1946). Rapid determination of potassium and sodium in plant material and soil extract by flam photometer. *Proc. Amer. Soc. Hort. Sci.,* **48:** 341-346.

Camberato, J. and W. Pan (2000). Bioavailability of calcium, magnesium and sulfur. In: Handbook of Soil Science, ed. M. E. Sumner, pp., 53–61. Boca Raton, FL: CRC Press.

Chapman, H.D. and P.F. Pratt (1961). Methods of Analysis for Soil, Plant and Waters. Univ. of Calif. Division of Agric. Sc., 6th Ed. P: 56-64.

Chiu, T.F. and S.S. Chang (1985). Diagnosis and correction of boron deficiency in a citrus orchard of Taiwan. Tech. Bull. Food and Fertilizer Tech. Bull. *Food and Fertilizer Tech. Center.,* **91:** pp. 1-11.

Clarkson, D.T. and J.B. Hanson (1980). The mineral nutrition of higher plants. *Ann. Rev. Plant Physiol.,* **31:** 239-298.

Dela-Fuente, R.K., P.M. Tang and C.C. Guzman (1986). Plant growth substances, Plant-environment interactions.

Duncan, D.B. (1955). Multiple ranges and multiple F. test. *Biometrics,* **11:** 1-42.

Du-Plesis, S.F. and T.J. Koen (1988). The effect of N and K fertilization on yield and fruit size of Valencia. *Proceeding of the International Soci. of Citriculture,* **2:** 663-672.

El-Badawy H.E.M., S.F. El-Gioushy, M.H.M. Baiea and A.A. EL-Khwaga (2017a). Effect of some antioxidants and nutrients treatments on vegetative growth and nutritional status of Washington navel orange trees. *Middle East Journal of Agriculture Research,* **6(1):** 87-98.

El-Badawy H.E.M., S.F. El-Gioushy, M.H.M. Baiea and A.A. EL-Khwaga (2017b). Impact of citric acid, ascorbic acid and some nutrients (Folifert, Potaqueen) on fruit yield and quality of Washington navel orange trees. *Asian Journal of Advances in Agricultural Research,* **4(3):** 1-13.

El-Baz, E.E.T. (2003). Effect of foliar sprays of zinc and boron on leaf mineral composition, yield and fruit storability of Balady mandarin trees. *J. Agric. Sci. Mansoura Univ.,* **28:** 6911-6926.

EL-Gioushy, S.F. and M.A. Eissa (2019). Effectiveness of different NPK fertilization sources on growth, nutritional status, productivity and fruit quality of Washington navel orange trees. *Journal of Horticultural Science & Ornamental Plants,* **11(2):** 134-143, DOI: 10.5829/idosi.jhsop.2019.134.143.

EL-Gioushy, S.F. (2016). Productivity, fruit quality and nutritional status of Washington navel orange trees as influenced by foliar application with salicylic acid and potassium silicate combinations. *Journal of Horticultural Science & Ornamental Plants,* **8(2):** 98-107.

El-Hagab, M.H., A.M. Higazi, S.Z. El-Naggar, S.A. Ahmed and A.M. Hassan (1983). Effect of soil and foliar fertilization on growth of navel orange and Balady mandarin trees. *Minufiya J. Agric. Res.,* **7:** 261-279.

EL-Saida, S.A.G. (2001). Effect of some growth regulators and zinc sulphate treatments on yield and fruit quality of Washington navel orange. *Annals of Agricultural Science,* **39:** 1199-1212.

Erner, Y., B. Artzi, E. Tagari and M. Hamou (2002). Potassium affects citrus tree performance. The Volacni Center, Institute of Horticulture, Department of Fruit Trees Report pp. 405-413.

Faust, M. (1975). The role of calcium in the respiratory mechanism and senescence of apples. *Res. Scientific,* **238:** 87-92 (Hort. Abs., 46: 2911).

Faust, M. (1989). Physiology of Temperate Zone Fruit Trees. Awalley- Interscience Publication, USA.

Habasy, R.E.Y., M.E. Helal, A.M. Abd El-Rahman and F.F. Ahmed (2016). Effect of calcium and boron sources and methods of application on growth, yield and fruit quality of Washington navel orange trees. *J. Agric. Sci. Ain Shams Univ.,* **24(1):** 185-193.

Hafez, M. Omaima and I.M. El-Metwally (2007). Efficiency of zinc and potassium sprays alone or in combination with some weed control treatments on weeds growth, yield and fruit quality of Washington navel orange orchards. *J. of Applied Sci. Resh.,* **3(7):** 613-621.

Hernandez-Munoz, P., E. Almenar, M.J. Ocio and R. Gavara (2006). Effect of calcium dips and chitosan coating on postharvest life of strawberries (*Fragaria - ananassa*). *Postharvest Biol. Technol.,* **39:** 247-253.

Kodua, M.A. (1980). Effect of boron and manganese on mandarin yield and quality. *Referativnyl Zhurnal,* **11:** 540-546.

Malavolta, E. (1992). Leaf analysis in Brazil-present and perspectives. *Processing of the Inernational Soc. of Citriculture,* **2:** 570-574.

Mastrangelo, M.M., A.M. Rojas, M.A. Castro, L.N. Gerschenson and S.M. Alzamora (2000). Texture and structure of glucose-infused melon. *Journal Science of Food and Agriculture,* **80:** 769-776.

Maurer, M. and J. Truman (1999). Effect of foliar boron sprays on yield and fruit quality of navel oranges in 1998 and 1999. Citrus and Deciduous Fruit and Nut Research Report. 1-6, http://hdl.handle.net/10150/223840.

Obreza, T.A. (2003). Importance of potassium in a Florida citrus nutrition program. *Better Crops.,* **87:** 19-22.

Picchioni, G.A., S.A. Weinbaum and P.H. Brown (1995). Retention and the kinetics of uptake and export of foliage-applied labeled boron by apple, pear, prune and sweet cherry leaves. *J. Amer. Soc. Hort. Sci.,* **120:** 28-35.

Piper, C.S. (1958). Soil and Plant Analysis. Inter. Sci. Publishers. New York. 213-217.

Polevoiy, V.V. (1979). Calcium-related physiological disorders of plants. *Ann. Rev. Phytopathol.,* **17:** 971-22.

Poovaiah, B.W. and A.C. Leopold (1973). Role of calcium in prolonging the storage life of fruits and vegetables, food Technology. 267-270.

Pooviah, B.W. (1979). Role of calcium in ripening and senescence. *Commun. Soil Sci. Plant Anal.,* **10:** 83–88.

Pregl, E. (1945). Quantitative Organic Micro Analysis. 4th Ed. Chundril, London.

Ramezanian, A., M. Rahemi, M.R. Vazifehshenas (2009). Effects of foliar application of calcium chloride and urea on quantitative and qualitative characteristics of pomegranate fruits. *Scientia Horticulturae,* **121:** 171-175.

Saleem, B.A., A.U. Malik and M. Farooq (2007). Effect of exogenous growth regulators application on June fruit drop and fruit quality in *citrus sinensis cv.* Blood Red. *Pak. J. Agric. Sci.,* **44(2):** 289-294.

Sharaf, M.M., Kh. A. Bakry and S.F. EL-Gioushy (2011). The influence of some bio and organic nutritive addenda on growth, productivity, fruit quality and nutritional status of Washington navel orange trees. *Egypt. J. of Appl. Sci.,* **26(9):** 2011.

Singh, D.B., B.D. Sharma and R. Bhargava (2003). Effect of boron and GA_3 to control fruit cracking in pomegranate (*Punica granatum*). Central Institute. *Current Agriculture,* **27(1/2):** 125-127.

Singh, R. and R. Singh (1981). Effect of nutrient sprays on granulation and fruit quality of Dancy Tangerine mandarin. *Hort. Abst.,* **51:** 73-86.

Snedecor, G.W. and W.G. Cochran (1980). Statistical Methods. Oxford and J.B.H. publishing com., 7th edition, 593 p.

Sugimura, Y., V.T. Mori, I. Nitta, E. Kotani, S. Furusawa, M. Wada and Y. Morita (1999). Calcium deposition in idioblasts of Mulberry leaves. *Annals of Botany,* **83:** 543–550.

Tariq, M. and C.J.B. Mott (2007). Effect of Boron on the Behavior of Nutrients in Soil-Plant Systems Review. *Asian Journal of Plant Science,* **6:** 195-202.

Varduni, T.V., T.M. Minkina, E.A. Buraeva, S.N. Gorbov, S.S. Mandzhieva, G.V. Omel'chenko, E.I. Shimanskaya, A.A. V'yukhina and S.N. Sushkova (2014). Accumulation of radionuclides by pylaisiella moss (*Pylaisia polyantha*) under urboecosystem conditions. *Am. J. App. Sci.,* **11(10):** 1735-1742.

Wardowski, W.F., S. Nagy and W. Grierson (1985). Fresh citrus fruit. Avi. Publ. Co. Inc. Westport, U.S.A.79-83.

White, P. and M. Broadley (2003). Calcium in plants. *Annals of Botany,* **92:** 487–511.

White, P. (2001). The pathways of calcium movement to the xylem. *Journal of Experimental of Botany,* **52:** 891–899.