__Original Research Article__

The efficiency of Calcium Boron and Carpox-K Sprays on fruit quality of Washington Navel Orange Trees

ABSTRACT

This research was conducted during seasons 2018 & 2019 on nine-years-old Washington navel orange trees. These trees were ~~budded~~ grafted on Sour orange rootstock, planted at 5 x 5 meters apart, under surface irrigation conditions, ~~of~~ in 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 fruit quality. The obtained data revealed that all investigated treatments increased fruit quality parameters (physical and chemical properties). 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. From the obtained results, It can be concluded that the use of RD+ Calcium boron 3 ~~cm3~~ cm^3 / L + Carpox-K 1.5g / L or RD+ Calcium boron 2 ~~cm3~~ cm^3/ L + Carpox-K 1g / L could be safely recommended under similar environmental and horticultural practises adopted in this experiment.

Keywords: Washington navel orange, Calcium boron, Carpox-K and Fruit quality

INTRODUCTION

Citrus fruits are the most important fruits types in the world. In Egypt, it has a great economic importance, compared to the other types of fruit. “Washington” navel orange (*Citrus sinensis* L.) is one of the most important citrus fruits grown in Egypt.

Total fruitful area approximately 144,427 Fed. producing about 1,489,536 tons / year [1]. “Washington” navel orange fruits are the 1st and popular fruit, where, it has the greatest nutritional values and its global reputation in foreign markets.

Many researchers have studied the influence of foliar application boron on fruit trees, [2], reported that fruit set and yield of sour cherry (*Prunus cerasus* L.) were increased with foliar application of boron [2], [3] indicated that flowers and fruits are more likely to be B deficient than the vegetative parts of the tree [3], [4] found that yield as well as physical and chemical properties of “Canino” apricot improved as a result of boron spray [4].

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, [5]. It is an effective element of a fruit’s physiological resistance [6], increases cell turgor pressure [7], and stabilizes the cell membrane [8]. Calcium disorders prevent physiological maturity before harvesting, such as delay and decrease in the quality of the fruit within many fruit species [9]. Foliar calcium applications may extend the aging process significantly [10], however, little is known about the effect of foliar calcium application on yield and quality [11].

Potassium is necessary for essential physiological functions, such as the formation of sugars and starch, synthesis of proteins, and cell division and growth [12,13]. It is also important in forming and functioning proteins, fats, carbohydrates, chlorophyll and in maintaining the balance of salts and water in plant cells, [14]. Nutritional need for potassium centers on four physiological biochemical roles, enzyme activation, membrane transport process, anion neutralization and osmotic potential [15].

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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 [16]. 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 [17]. 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 [18].

This study aimed to investigate the effects of the spraying of Calcium Boron and Carpox-K at different concentrations and their combinations to improve the fruit quality of the navel orange trees in Washington.

MATERIALS AND METHODS

This study was carried out during the 2018 ~~&~~ and 2019 seasons, on nine-years-old Washington navel orange trees ~~budded~~ grafted on Sour orange rootstock, planted at 5 x 5 meters apart (168 trees/fed.), under surface irrigation regime, ~~of~~ in 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 fruit quality (physical and chemical properties) 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 [19]. As shown in Table ~~(A)~~1.

Table ~~A~~ 1: 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			

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Soil pH	7.2	Available P 11.94 mg/kg
E.C, ds/m	1.60	
Organic matter	3.4%	Available K 170.5 mg/kg

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).

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 in a scientific and technological way 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

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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:

Fruit physical properties:

In this regard, average fruit dimensions (polar & and equatorial diameters i.e., length & and width in cm.); fruit shape index (length: width); peel/rind thickness (mm) and juice percentage were the fruit physical characteristics investigated in this regard.

Fruit chemical properties:

Fruit juice, total soluble solids percentage (TSS %) was determined using Carl Zeins hand refractometer. Total acidity as gms of anhydrous citric acid per 100 ml fruit juice was determined after [20]. The total soluble solids/-acid ratio was also estimated. total Total sugars % were determined after the method described by [21]. Moreover, Ascorbic acid/-Vitamin C content was determined using 2, six dichlorophenol indophenol indicator for titration after [20].

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Statistical analysis:

All data obtained during both seasons for two experiments included in this investigation were subjected to analysis of variance according to [22]. In addition, significant differences among means were differentiated according to the Duncan, multiple test range [23] where letter/s were used for distinguishing means of different treatments for each investigated characteristic.

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RESULTS AND DISCUSSION

Fruit physical characteristics:

In this regard, fruit dimensions (equatorial ~~&~~ and polar diameters) and fruit shape index, Peel thickness and juice percentage, were the evaluated fruit physical characteristics of Washington navel orange cv. in response to the differential investigated fertilizer treatments. Data obtained during both the 2018 ~~&~~ and 2019 experimental seasons are presented in Tables ~~(~~1~~)~~ and ~~(~~2~~)~~.

Fruit dimensions (equatorial & polar diameters) and fruit shape index :

The polar and equatorial fruit diameters of Washington navel orange cv. were investigated two fruit dimensions regarding their response to the differential bio and organic nutritive compounds. Table ~~(~~1~~)~~ shows obviously that both parameters responded significantly to all treatments. However, seven treatment (RD+ Calcium boron ~~2Cm /L~~ 2 cm^3/L+ Carpox-K 1g/L.) was superior and resulted significantly in the tallest polar and equatorial diameters~~.~~, statistically followed by the ~~6th treatment (~~T6 variant - RD+ Calcium boron 2Cm /L + Carpox-K 1g/L.~~)~~. The reverse was true with (control) which induced significantly the in the shortest polar and equatorial diameters during both experimental seasons. Such trend was true during both experimental seasons for both polar and equatorial fruit diameters, however, the rate of response was relatively higher with the former fruit dimension (polar diameter) than the other one (equatorial). Concerning the fruit shape index (polar diameter: equatorial diameter) of Washington navel orange cv. in response to differential investigated treatments, results showed clearly that the variances were relatively too few to be taking into consideration from the statistical point of view. Herein, variations in fruit shape indices due to the differential investigated fertilizers

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could be logically explained on the unparalleled response of two fruit dimensions (~~-~~polar ~~&~~ and equatorial diameters~~-~~) to a given treatment. Since, in most cases, the increase in fruit length (~~-~~height or polar diameter~~-~~) was relatively higher than those resulted in fruit width (~~-~~equatorial diameter~~-~~) as the response to each treatment was individually (~~—~~separately~~—~~) taking into consideration. Anyhow, it could be declared that fruits of treated Washington navel orange trees with calcium boron or Carpox-K foliar application fertilizers either solely or combined each other tended relatively to be slightly oblong in their shape as compared to the analogous ones of control. The difference was more pronounced in fruits of treated trees ~~with (7th treatment)~~ in T7 variant, during both the 2018 ~~&~~ and 2019 experimental seasons.

Fruit Peel thickness :

~~concerning~~ Concerning the response of fruit Peel thickness to the various investigated fertilizers treatments, Table ~~(~~2~~)~~, Washington navel orange fruits of subjected trees to ~~7th~~ T7 treatment (RD+ Calcium boron ~~2Cm~~ 2cm^3 /L + Carpox-K 1g/L~~.~~) had significantly the thickest fruit Peel thickness i.e., 3.26 ~~&~~ and 3.22 mm during 1st ~~&~~ and 2nd experimental seasons, respectively. Moreover, ~~6th treatment~~T6 variant (RD+ Calcium boron ~~2Cm~~ 2cm^3 /L + Carpox-K 1g/L~~.~~) ranked statistically second as the influence on fruit Peel thickness was concerned. On the contrary, the least fruit Peel thickness value was significantly in concomitant control treatment during both seasons. In addition, other investigated treatments were in between the aforesaid extremes i.e., 7th treatment (superior) and control (inferior) during both experimental seasons.

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Average fruit juice volume

The response of fruit juice percentage to various investigated treatments as shown in Table ~~(2)~~2 declared that all investigated treatments increased significantly over control (RD) during both experimental seasons of study. Generally, it could be noticed the superiority of 7th treatment (RD+ Calcium boron ~~2Cm~~ $2cm^3$ /L + Carpox-K 1g/L) during both experimental seasons. Moreover, 6th treatment (RD+ Calcium boron ~~2Cm~~ $2cm^3$ /L + Carpox-K 1g/L) ranked statistically second as the influence on fruit juice % was concerned. The reverse was true with the fruit juice % of 1st treatment (control) which induced significantly the poorest fruits in their juice % content during both experimental seasons. In addition, other investigated treatments were in between the abovementioned two extremes with a relative tendency of variance pointed out the higher effectiveness of 5th treatment (RD+ Carpox-K 1.5g/L) over other members of such intermediate category of treatments. Such trend was true during both experimental seasons.

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Table 1. Effect of Calcium boron and Carpox-K foliar application on polar diameter (cm), equatorial diameter (cm) and fruit shape index of Washington navel orange trees during 2018 and 2019 experimental seasons.

Parameters / Treatments	Polar diameter (cm)		Equatorial diameter (cm)		Fruit shape index	
	2018	2019	2018	2019	2018	2019
T1- Control or recommended doses (RD).	7.89E	7.97D	7.92F	7.94E	0.9962C	1.0042A
T2 – RD+ Calcium boron 2Cm / L.	8.04D	8.09D	8.07E	8.10D	0.996C	0.998A
T3 - RD+ Calcium boron 3Cm /L.	8.18C	8.26C	8.20D	8.22C	0.998BC	1.006A
T4 - RD+ Carpox-K 1g/L.	8.26C	8.29C	8.27CD	8.30C	0.998ABC	0.999A

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T5 - RD+ Carpox-K 1.5g/L.	8.38B	8.37BC	8.37BC	8.39B	1.001AB	0.998A
T6 - RD+ Calcium boron 2Cm /L + Carpox-K 1g/L.	8.44B	8.42AB	8.43B	8.44B	1.001AB	0.998A
T7 - RD+ Calcium boron 2Cm /L + Carpox-K 1g/L.	8.56A	8.51A	8.54A	8.54A	1.002A	0.997A

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 peel thickness (mm) and juice %of Washington navel orange trees during 2018 and 2019 experimental seasons.

Treatments / Parameters	Peel thickness (mm)		Juice %	
	2018	2019	2018	2019
T1- Control or recommended doses (RD).	2.85G	2.82G	38.53G	38.12G
T2 – RD+ Calcium boron 2Cm / L.	2.92F	2.89F	39.10F	38.86F
T3 - RD+ Calcium boron 3Cm /L.	3.02E	3.00E	39.60E	39.83E
T4 - RD+ Carpox-K 1g/L.	3.08D	3.02D	40.14D	41.14D
T5 - RD+ Carpox-K 1.5g/L.	3.14C	3.09C	41.60C	42.20C
T6 - RD+ Calcium boron 2Cm /L + Carpox-K 1g/L.	3.20B	3.18B	43.88B	43.77B
T7 - RD+ Calcium boron 2Cm /L + Carpox-K 1g/L.	3.26A	3.22A	44.87A	44.52A

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

Fruit chemical properties :

In this regard fruit juice total soluble solids (TSS) %, total acidity %, TSS / acid ratio, total sugars % and ascorbic acid (vitamin C) contents were the five investigated fruit juice chemicals properties for Washington navel orange cv. regarding their response to the evaluated fertilizers treatments. Data obtained during both the 2018 and 2019 experimental seasons are presented in Tables 3 and 4.

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Tables ~~(~~3 ~~&~~ and 4~~)~~ displays obviously that the six investigated treatments increased significantly increased fruit quality parameters (fruit chemical characteristics) over control. However, T7 variant (RD+ Calcium boron ~~2Cm~~ 2cm^3 /L + Carpox-K 1g/L) was statistically superior in this concern during both the 2018 and 2019 experimental seasons. However, the 6th treatment (T6 (RD+ Calcium boron ~~2Cm~~ 2 cm^3 /L + Carpox-K 1g/L) ranked statistically second, descendingly followed by T5 (~~—~~RD+ Carpox-K 1.5g/L). On the contrary, the least values of the abovementioned parameters were usually in concomitant to 1st treatment or recommended doses (RD) which ranked statistically last during both seasons of study. On the other side, all investigated nutritive fertilizer treatments resulted significantly in reducing total acidity as compared to control (RD). The most effective treatment for reducing total acidity was in close relationship to Washington navel orange cv. trees subjected to the RD+ Calcium boron ~~2Cm~~ 2cm^3 /L + Carpox-K 1g/L (7th treatment) during both 2018 ~~&~~ and 2019 experimental seasons. Whereas the highest reduction in total acidity was exhibited. On the contrary, RD+ Calcium boron ~~2Cm~~ 2 cm^3 / L (2nd treatment.) was significantly the inferior, Whereas the least reduction in total acidity below control was observed during both seasons of study.

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Table 3. Effect of Calcium boron and Carpox-K foliar application on T.S.S %, total acidity %and TSS/Acid ratio of Washington navel orange trees during 2018 and 2019 experimental seasons.

Parameters / Treatments	T.S.S %		Total acidity %		TSS/Acid ratio	
	2018	2019	2018	2019	2018	2019
T1- Control or recommended doses (RD).	9.98E	9.87G	1.12A	1.10A	8.89D	8.95E
T2 – RD+ Calcium boron 2Cm / L.	10.22E	10.25F	1.08A	1.07AB	9.44D	9.56E

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T3 - RD+ Calcium boron 3Cm /L.	10.61D	10.72E	0.99B	1.02BC	10.73C	10.51D
T4 - RD+ Carpox-K 1g/L.	11.46C	11.39D	0.95BC	0.97CD	12.07B	11.73C
T5 - RD+ Carpox-K 1.5g/L.	11.99B	12.24C	0.97B	0.95CDE	12.41B	12.90B
T6 - RD+ Calcium boron 2Cm /L + Carpox-K 1g/L.	12.30B	12.64B	0.96B	0.93DE	12.81B	13.57B
T7 - RD+ Calcium boron 2Cm /L + Carpox-K 1g/L.	12.64A	12.96A	0.89C	0.89E	14.31A	14.55A

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 total sugars % and juice % of Washington navel orange trees during 2018 and 2019 experimental seasons.

Treatments Parameters	Total sugars %		V.C	
	2018	2019	2018	2019
T1- Control or recommended doses (RD).	8.00G	7.97F	53.03G	53.83F
T2 – RD+ Calcium boron 2Cm / L.	8.15F	8.16E	54.37F	54.53F
T3 - RD+ Calcium boron 3Cm /L.	8.30E	8.33E	55.45E	55.34E
T4 - RD+ Carpox-K 1g/L.	8.46D	8.58D	56.45D	56.26D
T5 - RD+ Carpox-K 1.5g/L.	8.78C	8.97C	57.54C	57.37C
T6 - RD+ Calcium boron 2Cm /L + Carpox-K 1g/L.	8.93B	9.33B	58.92B	59.17B
T7 - RD+ Calcium boron 2Cm /L + Carpox-K 1g/L.	9.16A	9.87A	61.08A	61.74A

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

Discussion

The increase in fruit yield may be attributed to the increase in vegetative growth whole enhancement in yield and yield attributing parameters may be due to the increased auxin production and subsequent translocation from source to sink [24]. Borax acts as a catalyst in the oxidation and reduction processes and also has great importance in the sugar metabolism; it might have improved the physical characters of guava fruit and thus increased the yield per tree assumed in our finding. Heavier fruits with more fruit weight under Borax treatment might be due to the high level of auxin in the various parts of the fruit plant maintained by Borax. Borax spray increased the fruit weight because it is an essential micronutrient and it is considered indispensable for the growth of all organisms [25, 26, 27] also observed that foliar spray of borax improved the fruit yield in guava cv. L-49. In the context of a study [28], was observed that foliar application of borax increased yield up to 30 percent in apple.

Also, [29,30] improved flesh weight and weight, length and diameter with the spraying of Borax 0.6 % + sugar 2 g/l, and potassium nitrate 1 and 2% and potassium sulphate at 1 and 2% and potassium citrate at 3%. Spraying calcium + micronutrient + amino chelate produced greater date palm fruit Kabkab cv weight, diameter and length in the khalal stage [31]. Additionally, Kinnow (*Citrus reticulate* Blanco) fruit weight, length and flesh weight were increased when fruits sprayed borax 0.4% and potassium and Zn sulphate as reported by [32 , 33, 34] .

The present results are in general harmony with [35], who found that juice T.S.S, T.S.S/acid ratio and ascorbic acid content increased significantly with increasing applied potassium of Washington navel orange trees in both seasons. Meanwhile, juice acidity decreased with increasing the level of applied potassium. [36] indicated that foliar spraying of Valencia orange trees with Chelated calcium, Chelated zinc and boron significantly increased fruit quality in comparison to control and other treatments. [37] on sweet orange and [38] on Clementine who reported that fruit juice %, TSS % and V.C. were improved by boron and Zn treatments.

Anyhow, ~~The~~ the obtained results are similar to those of [39] and [40] reported that using Boron at 100 g /tree improved total soluble solids in both seasons.~~,~~ An obtained result about the quality of the fruits exhibited by investigated fertilizers treatments were in general agreement with the findings of [41] on Barhi date palm**,** [42] on Keitt Mango trees, [43, 44, 45, 46, 47, 48] on Washington Navel orange trees**.**

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