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Effect of Foliar Application with Calcium, Potassium and Zinc Treatments on Yield and Fruit Quality of Washington Navel Orange Trees

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ABSTRACT

Yield and fruit quality of Washington navel orange trees in response to spraying both calcium chloride and zinc sulphate at 0.5, 1 and 1.5% and potassium sulphate at 1, 2 and 3% were evaluated during two successive seasons, 2013 and 2014 at Abou–EL Matamier, Beheira Governorate, Egypt. The experiments were designed as randomized complete block design with five replications. Results showed that all treatments were very effective in improving yield as well as average fruit weight (g), average fruit volume (cm^3), average fruit diameter (cm), average fruit length (cm), vitamin C and TSS (%) rather than control. Also, the used treatments led to significant decreases in the juice acidity percentage compared to the control treatment. The best results with regard to yield and fruit quality were significantly obtained due to spraying Washington navel orange trees with 2 and 3% potassium sulphate treatments.

Key words: Citrus; orange tree; yield; fruit; foliar; quality; calcium; potassium; zinc

Introduction

Citrus is an important fruit crop in tropical and subtropical countries, it is considered the first among economic fruit crops in Egypt as well as all over the world. Washington navel orange (*Citrus sinensis* L. Osbeck) is one of the most popular citrus fruit in Egypt; for its delicious, taste and nutrition, besides being rich in vitamin C and minerals. The total Washington Navel orange cultivated area in Egypt reached 157793 feddans producing 1531952 tons of fruits annually according to the Annual Book of Agricultural Statistics, Cairo (2013).

Potassium is one of the most important macro-elements which highly mobile in plants at all levels, from individual cell to xylem and phloem transport. This cation plays a major role in: enzyme activation, protein synthesis, stomatal function, stabilization of internal PH, photosynthesis, turgor-related processes and transport of metabolites. Potassium improves fruit quality by enhancing fruit size, juice contents, color, size and juice flavor (Tiwari, 2005 and Ashraf *et al.,* 2010). In contrast, K deficiency produces small fruits with thin peel. Application of potassium increased mineral content and crop yield (El-Safty *et al*., 1998), also improved crop quality (Wei and Hua, 2002).

Zinc (Zn) is one of the micronutrient required for normal plant growth. It is well known that zinc acts a co–factor of many enzymes and affects many biological processes such as photosynthesis reactions, nucleic acids metabolism, protein and carbohydrate biosynthesis (Marschner, 1996). Application of ZnSO4 (0.5%) significantly improved physical and chemical fruit properties and increased final yield (Dawood *et al*., 2000 and El-Baz, 2003).

Calcium is one of the essential elements in plant nutrition. It plays an important role in improving yield and fruit quality EL-Shobaky and Mohamed (2000).

The purpose of this work is to study the effect of foliar application of calcium, potassium and zinc applied three times in different concentrations on yield and fruit quality of Washington navel orange trees.

Materials and Methods

This study was carried out during two successive seasons (2013 and 2014) on 20 years old Washington navel orange trees (*Citrus sinensis* L. Osbeck). The trees grown in a private farm at Abou–EL Matamier, Beheira Governorate. The trees were planted at 5 × 5 m apart grown in loamy sand soil, using surface irrigation system. Fifty trees as uniform as possible were selected for achieving this study.

The selected trees were sprayed as follows:

(1) Control (Spraying with tap water) (2) 0.5% Zinc sulphate ($ZnSO_4$) (3) 1% Zinc sulphate ($ZnSO_4$)
(4) 1.5% Zinc sulphate ($ZnSO_4$) (5) 0.5% Calcium chloride ($CaCL_2$) (6) 1% Calcium chloride ($CaCL_2$)
(7) 1.5% Calcium chloride ($CaCL_2$) (8) 1% Potassium sulphate (K_2O_4) (9) 2% Potassium sulphate (K_2O_4)
(10) 3% Potassium sulphate (K_2O_4)

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The experiments were designed as randomized complete block design with five replications. Treatments sprayed with the specified solutions till run off on trees three times yearly. The first spray was at the beginning of March, The second spray was at the mid of May and the third spray was at the mid of July. Foliar sprays were applied using a hand pressure sprayer. Each treatment was surrounded with two rows as guard trees.

Measurements and Determination

A- Yield

Fruit yield were recorded on each replicate tree at harvest stage (December) in both seasons which was expressed as number of fruits/tree, weight of fruits in kg/tree and yield weight (tons/feddan).

B- Fruit quality:

Sample of 5 fruits per tree from each replicate (tree) was collected randomly at harvest time in both seasons, and then transported quickly to the laboratory to determine some physical properties as average fruit weight (g), average fruit volume (cm^3), average fruit diameter (cm) and average fruit length (cm). Also, some chemical properties were determined as vitamin C (mg/100 ml juice) according to (A.O.A.C., 1985), TSS (%) by using hand refractometer according to Chen and Mellenthin (1981) and acidity (%) fruit juice was determined according to the (A.O.A.C., 1985) by titration with 0.1 N sodium hydroxide using phenolphthalein as an indicator and expressed as citric acid percentage.

Generally, all the previous treatments were arranged in randomized complete block design on 50 trees as 10 treatments were applied. Each treatment comprised of five replicates and each tree was considered a replicate. Results of the measured parameters were subjected to computerized statistical analysis using COSTAT package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 according to Snedecor and Cochran (1990).

Results and Discussion

A- Yield Characters

Data of the present investigation in Table (1) showed that in both seasons all treatments significantly increased average fruit weight, average number of fruits per tree, weight of fruits per tree (kg) and yield weight/feddan (kg) compared with control treatment. In addition, the statistical analysis showed that potassium sulphate (K_2SO_4) treatments gave the best results as for average weight of fruit, followed by calcium chloride ($CaCL_2$) and finally zinc sulphate (ZnSO4) treatments in both seasons, but, 2 and 3% K_2SO_4 treatments gave the highest values of average number of fruits per tree in both seasons. While, the control treatment gave the lowest value of average number of fruits per tree among all treatments in both seasons.

Table 1: Effect of foliar application with calcium, potassium and zinc treatments on yield as average fruit weight (g), number of fruits/tree, weight of fruits/tree (kg) and yield weight/feddan (ton) of Washington navel orange trees in 2013 and 2014 seasons.

Treatments	Average fruit weight (g)		No. fruits / tree		Weight of fruits / tree (kg)		Yield weight / feddan (ton)	
	2013	2014	2013	2014	2013	2014	2013	2014
Control	215.98^{h}	218.59^{h}	271.00^{f}	282.40^{g}	58.56^{g}	61.61^{f}	9.84^{g}	10.35^{f}
0.5% $ZnSO_4$	227.90^{g}	231.01^{g}	296.40^{e}	302.20^{f}	67.52^{f}	69.81^{e}	11.34^{f}	11.73^{e}
1% $ZnSO_4$	238.18^{f}	241.57^{efg}	313.80^{d}	320.60^{de}	74.74^{e}	77.44^{d}	12.56^{e}	13.01^{d}
1.5% $ZnSO_4$	244.17^{e}	246.82^{def}	325.60^{bc}	329.40^{c}d	79.48^{d}	81.26^{d}	13.35^{d}	13.65^{d}
0.5% $CaCL_2$	232.44^{g}	236.31^{fg}	294.60^{e}	306.40^{ef}	68.48^{f}	72.40^{e}	11.53^{f}	12.16^{e}
1% $CaCL_2$	244.98^{e}	247.96^{de}	317.80^{cd}	325.20^{d}	77.84^{de}	80.64^{d}	13.08^{de}	13.55^{d}
1.5% $CaCL_2$	262.14^{c}	261.87^{c}	333.60^{b}	341.60^{bc}	87.41^{c}	90.58^{c}	14.68^{c}	15.22^{c}
1% K_2SO_4	252.31^{d}	252.79^{cd}	315.80^{cd}	323.60 ^{d}	79.68^{d}	81.88^{d}	13.35^{d}	13.75^{d}
2% K_2SO_4	272.82^{b}	274.76^{b}	348.80 ^{a}	355.40^{ab}	95.16^{b}	97.67^{b}	15.99^{b}	16.41^{b}
3% K_2SO_4	288.99^{a}	286.68^{a}	355.60^{a}	367.80^{a}	102.76^{a}	105.42^{a}	17.26^{a}	17.70^{a}

Means not sharing the same letter(s) within each column for each are significantly different at 0.05% level probability.

In addition, no significant differences were found between 2 and 3 % K_2SO_4 treatments in average number of fruits per tree in both seasons. Concerning, 3% K_2SO_4 treatment caused a higher and significant increasing in weight of fruits per tree (kg) and yield weight(kg)/ feddan in both seasons, while 0.5% $ZnSO_4$ treatment caused a significantly increase also, but the lowest value of weight of fruits per tree (kg) and yield weight/ feddan (kg) as compared with control treatment in both seasons.

These results are in agreement with the finding of Hafez and El-Metwally (2007), who studied the influence of some elements as 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 were 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.

B- Fruit quality

Physical properties:

The obtained data in Table (2) cleared that, all treatments increased average fruit volume, average fruit diameter and average fruit length as compared with control treatment in both seasons, and this increasing in average fruit volume, average fruit diameter and fruit length are big enough to be significant for all foliar applications except 0.5% $ZnSO_4$ treatment compared with control treatment in both seasons.

The data also showed that, both 3and 2% K_2SO_4 treatments followed by 1.5% $CaCL_2$ and 1% K_2SO_4 treatments respectively achieved significantly the highest values of average fruit volume compared with control treatment in both seasons. Also, 3% K_2SO_4 gave the highest values of average fruit volume, average fruit diameter and average fruit length in both seasons and these values were significant as compared with control treatment. While, 0.5% ZnSO4 gave the lowest value of average in both seasons. Also, it was noticed that, no significant differences were found among 1 and 1.5 % $CaCL_2$ treatments in average fruit diameter in both seasons.

These results partially agreed with the findings of Khafagy *et al.* (2010) found that Zn was very effective in stimulating yield as well as physical and chemical characters of fruits rather than control. Spraying trees with 4.0% yeast extract combined with 1.0 % zinc sulphates was more effective in improving total yield and fruit numbers beside increasing fruit weight, length and fruit volume. Abd El-Rahman *et al.* (2012) found that all treatments increased fruit size as comparing with control especially with high concentration of potassium nitrate in the first and second season (2008 and 2009).

Table 2: Effect of foliar application with calcium, potassium and zinc treatments on some fruit physical characteristics of Washington navel orange trees in 2013 and 2014 seasons.

Treatments	Average fruit volume (cm^3)		Average fruit diameter (cm)		Average fruit length (cm)	
	2013	2014	2013	2014	2013	2014
Control	198.40^{e}	201.40^{e}	6.99^{h}	7.16^{f}	7.21^{f}	7.44^{g}
0.5% $ZnSO_4$	200.20^{e}	206.20^{e}	7.16^{g}	7.26^{f}	7.36^{f}	7.57^{fg}
1% $ZnSO_4$	218.00^{d}	224.36^{cd}	7.48^{e}	7.57^{d}	7.69^{de}	7.75^{ef}
1.5% $ZnSO_4$	223.00^{d}	227.96^{c}	7.60^{d}	7.69^{cd}	7.78^{cd}	7.83^{de}
0.5% $CaCL_2$	206.20^{e}	209.36^{cd}	7.32^{f}	7.42^{e}	7.56^{e}	7.64^{efg}
1% $CaCL_2$	223.20^{d}	226.40^{c}	7.73^{c}	7.80^{bc}	7.91^{c}	8.02^{cd}
1.5% $CaCL_2$	234.36^{c}	237.80^{c}	7.84^{c}	7.88^{b}	8.20^{b}	8.28^{b}
1% K_2SO_4	226.40^{cd}	226.40^{c}	7.74^{c}	7.85^{b}	8.10^{b}	8.19^{bc}
2% K_2SO_4	260.48^{b}	259.20^{b}	7.99^{b}	8.05^{a}	8.39^{a}	8.32^{b}
3% K_2SO_4	275.40^{a}	277.96^{a}	8.23^{a}	8.20^{a}	8.48^{a}	8.60^{a}

Means not sharing the same letter(s) within each column for each are significantly different at 0.05% level probability.

C- Chemical properties

Data in Table (3) also demonstrated that all treatments achieved significantly increased vitamin C content and TSS % as compared with control treatment in both seasons, and this increasing in vitamin C (mg/100 ml juice) is big enough to be significant for all foliar applications except $CaCL_2$ treatments compared with control treatment in both seasons. In addition, data indicated that 2 and 3% K_2SO_4 treatments were more effective in increasing vitamin C (mg/100 ml juice) content and TSS % than all other treatments. In general it was noticed that increasing rates of nutrients applied caused increasing in TSS % fruit content in both seasons. On the other hand, all potassium treatments decreased fruit juice acidity compared with control treatment. Also data showed that 2 and 3% K_2SO_4 concentrations gave the lowest value of acidity % in both seasons as compared with control treatment, while the control treatment gave the highest value of acidity among all treatments.

The present results are in a general harmony with Zaied *et al*. (2006), 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. Baghdady *et al*. (2014) 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.

Sajida and Hafeez (2000) on sweet orange and Abd El-Razik and Abdrabboh (2008) on Clementine who reported that fruit juice %, TSS % and V.C. were improved by boron and Zn treatments.

Table 3: Effect of foliar application with calcium, potassium and zinc treatments on some fruit chemical characteristics of Washington navel orange trees in 2013 and 2014 seasons

Treatments	Vitamin C (mg/100 ml juice)		TSS (%)		Acidity (%)	
Control	40.81^{f}	41.41^{f}	11.20^{h}	11.24^{h}	0.704^{a}	0.724^{ab}
0.5% $ZnSO_4$	42.45^{e}	43.35^{e}	11.79^{g}	11.98^{g}	0.698^{ab}	0.724^{ab}
1% $ZnSO_4$	44.77^{d}	45.12^{d}	12.29^{de}	12.42^{d}	0.677^{c}	0.686^{c}
1.5% $ZnSO_4$	47.02^{c}	47.48^{c}	12.85^{bc}	13.05^{b}	0.640^{d}	0.650^{d}
0.5% $CaCL_2$	41.67^{ef}	41.84^{f}	11.67^{g}	11.74^{g}	0.708^{a}	0.737^{a}
1% $CaCL_2$	41.35^{ef}	41.84^{f}	12.01^{ef}	12.15^{ef}	0.680^{bc}	0.712^{abc}
1.5% $CaCL_2$	41.24^{ef}	41.34^{f}	12.61^{c}	12.67^{c}	0.664^{c}	0.694^{bc}
1% K_2SO_4	44.95^{d}	46.55^{c}	12.31^{d}	12.35^{de}	0.632^{d}	0.650^{d}
2% K_2SO_4	48.62^{b}	50.05^{b}	13.06^{b}	13.19^{ab}	0.602^{e}	0.607^{e}
3% K_2SO_4	51.94^{a}	53.06^{a}	13.51^{a}	13.43^{a}	0.580^{f}	0.600^{e}

Means not sharing the same letter(s) within each column for each are significantly different at 0.05% level probability.

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