Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 06 | Issue : 01 | Jan.-Mar. | 2017
Pages: 87-98

Effect of Some Antioxidants and Nutrients Treatments on Vegetative Growth and Nutritional Status of Washington Navel Orange Trees

[1]El-Badawy H. E. M, [1]El-Gioushy S. F., [2]Baiea M. H. M, and [1]EL-Khwaga, A. A.

[1]*Hort. Dept. Fac. of Agric. Benha Univ. Egypt.*
[2]*Horticultural Crops Technology Dept. National Research Center. Dokki. Giza. Egypt.*

Received: 15 January 2017 / Accepted: 10 March 2017 / Publication date: 12 March 2017

ABSTRACT

The present study was conducted on 11-year-old Washington navel orange trees budded on sour orange rootstock grown in loamy sand soil under surface irrigation system at a private orchard, Toukh region, Qalubia Governorate, Egypt during 2015 &2016 seasons, to investigate the influence of foliar application with citric acid (CA) 1g/L, ascorbic acid (AA) 1g/L, mixture of micronutrients 1.5g/L and mixture of macronutrients 3g/L on vegetative growth (No. of shoots/ one-meter limb, shoot length & thickness, No. of leaves per shoot, leaf area and assimilation area per one shoot) and nutritional status (leaf N, P, K, Ca, Mg % and Fe, Mn and Zn ppm). Anyhow, the treatment T_{12} (ascorbic acid 1g/L+ mixture of micronutrients 1.5g/L + Mixture of macronutrients 3g/L) was statistically the superior for Washington navel orange trees during two experimental seasons. Also, T_{11}(citric acid 1g/L+ mixture of micronutrients 1.5g/L+ mixture of macronutrients 3g/L) came second. The reverse was true with the water sprayed treatment (control) which ranked statistically the last rank during the two experimental seasons. On the other hand, the remained investigated treatments were in-between the aforesaid two extremes, in spite of the statistically varied as compared to the abovementioned superior (T_{12}) and inferior (T_1) treatments during two experimental seasons.

Key words: Washington navel orange, citric acid, ascorbic acid, micronutrients, macronutrients vegetative growth and nutritional status.

Introduction

Citrus is considered to be one of the world's most common popular and favorite fruit. In Egypt, (420333.6 faddans = one faddan = 0.42ha) (more than 39% from total fruit area) are planted with citrus trees. The production of citrus in Egypt was increased to 3980151 tonnes in 2012 (FAO, Statistics 2015). Thus, Egypt is considered to be one of the ten largest producers of citrus in the world. Thereby, strenuous efforts have always been exerted for increasing production of citrus through a better understanding of its reaction to environment and mineral nutrition.

The small antioxidant molecule vitamin C (L-ascorbic acid, AA) fulfils essential metabolic functions in the life of animals and plants. Some fungi can synthesize erythro-ascorbic acid, a vitamin C analogue with similar metabolic functions (Arrigoni and De Tullio, 2002).

Ascorbic acid is a regulator of plant growth and development owing to its effects on cell division and differentiation and it involves in wide range of important functions such as antioxidants defense, photo protection and regulation of photosynthesis and growth regulation. El- Sayed *et al.,* (2000) reported that ascorbic acid gave the best yield and bunch quality on Flame seedless grapevine.

Citric acid plays an essential role in signal transduction system, membrane stability and functions, activating transporter enzymes, metabolism and translocation of carbohydrates (Smirnoff, 1996). Also, citric acid as antioxidant is suggested mainly for improving yield and fruit in terms of increasing fruit weight, total soluble solids%, and total reducing sugar and in decreasing pear fruit firmness and total acidity as compared with unsprayed one (Mansour *et al.,* 2008).

Many investigations studied the effect of spraying macro and micronutrients on growth, yield and fruit quality. such as nitrogen, phosphorus, potassium &magnesium (Abd Ela, 1991, Akl, *et al.,* 1993a & 1993b, and Gobara 2001). Also, zinc (Nijjar 1985 and Kabeel *et al.,* 1998) Cupper and iron (Hanson 1991a); manganese (El Shazly, 1999) were highly effective in improving, nutritional status, yield and quality of different pear and apple trees.

Corresponding Author: S. F. EL-Gioushy, Horticulture Department Faculty of Agriculture, Benha University, Egypt. E-mail: sherif.elgioushy@fagr.bu.edu.eg

Thus, this study aimed to investigate the influence of foliar application with citric acid (CA), ascorbic acid (AA), mixture of micronutrients and mixture of macronutrients on vegetative growth and nutritional status of Washington navel orange trees budded on Sour orange rootstock.

Materials and Methods

This study was carried out during 2015 & 2016 seasons on 11-year-old Washington navel orange trees budded on Sour orange rootstock grown at 5.0 meters a parts in loamy sand soil 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 & pest control) adopted in the region according to the recommendation of the Ministry of Agriculture. It was devoted to investigate the influence of foliar application with citric acid (CA), ascorbic acid (AA), mixture of micronutrients (Zn 7.06%, Mn 4.20, Fe 2.80%, Cu 2% and B 0.6%) and mixture of macronutrients (N 5%, P 5% and K 36.5%) in addition to tap water as control treatment. The treatments used in this study as follow:

T1- Water spray (control).
T2- Citric acid (CA) 1g/L
T3- Ascorbic acid (AA) 1g/L
T4- Mixture of micronutrients 1.5g/L (Zn 7.06%, Mn 4.20, Fe 2.80%, Cu 2% and B 0.6%)
T5- Mixture of macronutrients 3g/L. (N 5%, P 5% and K 36.5%)
T6- (CA) 1g/L+ Mixture of micronutrients 1.5g/L
T7- (CA) 1g/L+ Mixture of macronutrients 3g/L
T8- (AA) 1g/L+ Mixture of micronutrients 1.5g/L
T9- (AA) 1g/L+ Mixture of macronutrients 3g/L
T10- Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L
T11- (CA) 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L
T12- (AA) 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L

Experiment layout:

The complete randomized block design with three replications was employed for arranging the twelve investigated fertilization treatments, whereas each replicate was represented by a single tree. Consequently, 36 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 vigour into three categories (blocks) each included 12 similar trees for receiving the investigated 12 fertilization treatments (a single tree was randomly subjected to one treatment).

Taking into consideration that spray treatments were applied covering the whole foliage of each tree canopy, whereas 5 liters found to be sufficient in this concern. Periodically applied 6 times/season at one-month interval (in 1st week of February, March, April, May, June and July).

Methodology as has been reported in this study in order to evaluate the response to various investigated treatments was carried out through determining changes in different measurements of the following examined characteristics:

On late March 2015 and early April 2016 four main branches (limbs/scaffolds) well distributed around each tree periphery were carefully selected and tagged during 1st and 2nd seasons, respectively. Moreover, 20 newly spring developed shoots were also labeled.

Vegetative growth measurements:

On mid October 2015 and 2016 years the following vegetative growth parameters were determined during 1st and 2nd experimental seasons, respectively.

In this regard, average number of newly developed shoots per one meter of every tagged limb, average (length & thickness) and number of leaves, per each labeled shoot were estimated. Besides, average leaf area (cm^2) on the weight basis was also determined. Hence, twenty mature leaves from the previously labeled shoots per each limb were randomly collected. Then 20 disks each of one cm. area were 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 average leaf area in cm^2 was calculated. Moreover, assimilation area per one shoot according to the following equation:

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

Leaf chemical analysis:

Total chlorophyll content:

Total chlorophyll content in fresh leaves were 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:

a. Total Nitrogen:

Total leaf (N) was determined by the modified micro Keldahl method mentioned by (Pregl, 1945).

b. Total phosphorus:

Total leaf (P) was determined by wet digestion of plant materials after the methods described by using sulphoric and perichloric acid which has been strongly recommended by (Piper, 1958).

c. Total potassium:

Total leaf (K) was determined photometrically in the digested material according to the method described by (Brown and Lilliand, 1946).

Calcium and Mg percentage as well as Iron, Manganese and Zinc were determined using the Atomic absorption spectrophotometer "Perkin Elmer -3300" according to Chapman and Pratt (1961).

Statistical analysis:

All data obtained during both seasons were subjected to analysis of variance according to Snedecor and Cochran, 1977. In addition, significant differences among means were differentiated according to the Duncan, multiple test range (Duncan, 1955) where capital letters 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, average shoot length and diameter, number of leaves per shoot, average leaf area and assimilation area were the investigated growth parameters in response to the differential treatments. Data obtained during both 2015 and 2016 experimental seasons are presented in Tables (1& 2).

Number of shoots per one-meter length limb:

Referring the influence of differential investigated treatments on number of shoots per one-meter length limb, Table (1) displays obviously that the response was clearly pronounced, whereas all investigated treatments resulted in number of shoots per one- meter length limb as compared to control (water spray). Such trend was true during both 2015 and 2016 experimental seasons. However, T_{11}(Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) and T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) were statistically the superior for Washington navel orange trees during the two seasons. The reverse was true with T_1 (water spray) treatment during 2015& 2016 seasons. On the other hand, other investigated treatments could be significantly arranged into the following descending order: T_{10}(Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) ranked the third followed by T_9 (Ascorbic acid 1g/L.+ Mixture of macronutrients 3g/L) 3rd one during both experimental seasons.

Shoot length (cm):

Concerning the response of shoot length to the differential investigated treatment, Table (1) shows obviously a considerable variation in this respect. Herein, the tallest developed shoots of Washington navel orange trees during both seasons were recorded when T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) and T12 (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) were used. On the contrary, the shortest was usually concomitant to the water sprayed (T_1) Washington navel orange trees (control) which ranked statistically last during both 2015 and 2016 experimental seasons. In addition, the other investigated treatments were In-between the aforesaid two extremes. In spite of the statistically varied as compared to the abovementioned superior and inferior treatments during the two experimental seasons.

Shoot diameter (thickness) (cm):

Concerning the response of shoot diameter to the differential investigated treatments Table (1) displays obviously that the response was clearly pronounced whereas all investigated treatments resulted in the increase shoot thickness as compared to control treatment (water spray). Such trend was true during the two seasons. However, the treatment T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L + Mixture of macronutrients 3g/L) was statistically the superior for Washington navel orange trees during two experimental seasons. Also, T_{11}(Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) came second, especially during 2nd season. The reverse was true with the water sprayed treatment (control) which gave the thinnest shoot during the two experimental seasons. On the other hand, nine other investigated treatments were in-between the aforesaid two extremes, in spite of the statistically varied as compared to the abovementioned superior and inferior treatments during two experimental seasons.

Table 1: Effect of some antioxidants, micro and macro nutrients on number of shoots, shoot length and shoot diameter of Washington navel orange trees during 2015 and 2016 experimental seasons.

Parameters	No. of shoots		Shoot length (cm)		Shoot diameter (cm)	
Treatments / Seasons	1st	2nd	1st	2nd	1st	2nd
T1: Control (Water spray)	14.33 f	14.67 g	24.00 h	24.40 g	2.27 f	2.31 g
T2: Citric acid 1g/L	15.33 ef	15.33 fg	26.03 fg	26.37 f	2.43 e	2.51 f
T3: Ascorbic acid 1g/L	15.33 ef	16.00 efg	25.17 gh	26.33 f	2.45 e	2.71 de
T4: Micro elements 1.5g/L	16.33 df	17.00 ef	27.33 ef	28.13 e	2.55 de	2.61 ef
T5: Macro elements 3g/L	17.00 d	17.33 e	27.40 e	28.27 e	2.59 d	2.74 cd
T6: Citric 1g/L+ Micro 1.5 g/L	19.67 c	19.33 d	27.93 de	28.63 de	2.60d	2.67 de
T7: Citric 1g/L+ Macro 3g/L	20.00 c	20.33 d	28.37 de	28.60 de	2.63 d	2.74 cd
T8: Ascorbic 1g/L+ Micro 1.5g/L	19.00 c	20.00 d	29.23 cd	29.70 d	2.62 d	2.73 d
T9: Ascorbic 1g/L+ Macro 3g/L	20.00 c	20.67 cd	30.30 c	31.27 c	2.68 d	2.84 c
T10: Macro 3g/L + Micro 1.5g/L	21.66 b	22.33 bc	31.77 b	33.30 b	2.97 c	3.13 b
T11: Citric 1g/L + Micro 1.5g/L + Macro 3g/L	23.33 a	23.00 ab	35.43 a	34.50 b	3.32 b	3.71 a
T12: Ascorbic 1g/L+ Micro 1.5g/L+ Macro 3g/L	23.67 a	24.33 a	36.5 a	36.90 a	3.62 a	3.78 a

Values within each column followed by the same letter/s are not significantly different at 5% level.

Number of leaves per shoots:

AS for the influence of differential investigated treatments on the average number of leaves per individual shoot of Washington navel orange trees followed to great extend the same trend previously detected with three former growth parameters. Hence, the greatest number of leaves per one shoot was significantly in closed relationship to the treatments T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) and T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L.+ Mixture of macronutrients 3g/L) during both 2015&2016 experimental seasons. Moreover, T_{10} (Mixture of micronutrients 1.5g/L + Mixture of macronutrients 3g/L) ranked statistically 3rd pertaining its efficiency followed by T_9 (Ascorbic acid 1g/L + Mixture of macronutrients 3g/L) and T_8 (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L) which came statistically third in this concern. On the contrary, the least number of leaves per one individual shoot of Washington navel orange trees was statistically coupled with T_2 (Citric acid 1g/L), T_3 (Ascorbic acid 1g/L) and T_1 (water spray (control) during both experimental seasons. In addition, T_2 (Citric acid 1g/L) and T_3 (Ascorbic acid 1g/L) were the least effective investigated treatments during both experimental seasons.

Average leaf area (cm^2):

Table (2) shows obviously that the response of average leaf area followed a similar trend previously detected the former four vegetative growth parameters.

The greatest leaf area was significantly coupled with Washington navel orange trees subjected to T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) during 2015 and 2016 experimental seasons. Moreover, T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L.+ Mixture of macronutrients 3g/L) ranked statistically 2nd regarding its efficiency. On the contrary, the smallest leaf area was significantly induced by water sprayed (control). In addition, other investigated treatments were in-between the aforesaid two extremes.

Table 2: Effect of antioxidants, micro and macro nutrients on number of leaf/shoot, leaf area (m^2) and assimilation area (m^2/shoot) of Washington navel orange trees during 2015 and 2016 experimental seasons.

Parameters	No. of leaf/shoot		Average leaf area (cm^2)		Assimilation area (m^2/shoot)	
Treatments / Seasons	1st	2nd	1st	2nd	1st	2nd
T1: Control (Water spray)	20.33d	19.67f	14.77i	14.80j	3.00f	2.91f
T2: Citric acid 1g/L	2300cd	22.33e	15.06hi	15.25i	3.46ef	3.40e
T3: Ascorbic acid 1g/L	23.67cd	23.67de	15.03hi	15.2i	3.56def	3.60e
T4: Micro elements 1.5g/L	23.33cd	23.67de	15.33gh	15.45hi	3.58def	3.66de
T5: Macro elements 3g/L	25.33c	26.33c	15.64fg	15.74gh	3.96cde	4.15c
T6: Citric 1g/L+ Micro 1.5 g/L	25.00c	25.33cd	15.92ef	16.12ef	3.98cde	4.08cd
T7: Citric 1g/L+ Macro 3g/L	25.33c	26.00cd	16.54c	16.95d	4.19cd	4.41c
T8: Ascorbic 1g/L+ Micro 1.5g/L	26.33c	27.66c	16.02de	15.95fg	4.22cd	4.41c
T9: Ascorbic 1g/L+ Macro 3g/L	26.33bc	27.00c	16.29cd	16.38e	4.29c	4.42c
T10: Macro 3g/L + Micro 1.5g/L	30.00bc	30.67b	17.61b	17.63c	5.28b	5.41b
T11: Citric 1g/L + Micro 1.5g/L + Macro 3g/L	33.33a	34.67a	17.92ab	18.06b	5.98a	6.26a
T12: Ascorbic 1g/L+ Micro 1.5g/L+ Macro 3g/L	33.67a	35.33a	18.18a	18.55a	6.12a	5.56a

Values within each column followed by the same letter/s are not significantly different at 5% level.

Assimilation area per one shoot (m^2/shoot):

Table (2) shows obviously that the response of assimilation area per one shoot followed the same trend previously detected with the five growth parameters. Anyhow, the greatest values of assimilation area per one shoot subjected to T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) and T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) which ranked statistically 1st during 2015 and 2016 experimental seasons. Moreover, T_{10} (Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) ranked statistically 2nd regarding its efficiency to increase assimilation area per one shoot during 2015 and 2016 experimental seasons.

On the contrary, the least value of assimilation area per one shoot was significantly induced by T_1 water spray (control) during two experimental seasons. In addition, other investigated treatments were in-between the aforesaid two extremes.

The improving effect of ascorbic and citric acid on growth might be attributed to its auxinic action that was reflected on enhancing cell division as well as its effect on simulating the biosynthesis of carbohydrates. Auxinic action of both ascorbic and citric acid on enhancing cell division and cell enlargement which reflected positively on leaf area was concluded by Ahmed *et al.,* (1998) and Omar (1999). The benefits of ascorbic acid on controlling various disorders give another interpretation (Khiamy, 2003). The obtained results of ascorbic and citric acid on vegetative growth are in agreement with those of Ali (2000), Ahmed *et al.,* (2002), Sayed (2002), Khiamy (2003) and Wassel *et al.,* (2007) on different grapevine cultivars. They pointed out that antioxidants such as ascorbic acid and citric acid were very effective in enhancing growth parameters namely shoot length, number of leaves/shoot and leaf area.

Enhancing growth characters in response to the foliar application of micronutrients may be due to their positive action on increasing cell division in the meristematic tissues and accelerating carbohydrates and proteins formation (Ghanta and Metra, 1993). Also, these elements play an important role in the multi-biological processes such as the role of Zn in the synthesis of IAA (Nijjar, 1985). The obtained results concerning the positive effect of foliar sprays with the mixture of micronutrients (Fe, Zn and Mn) on some vegetative growth parameters of Washington navel orange trees go in line with the findings of Gendiah and Hagagy (2000), Kumar and Jayakumar (2001), Wassel *et al.,* (2007), Maklad (2010) and Seyam (2012). Moreover, El-Shewy and Abdel-khalek (2014) on peach, Fouad (2014) on Valencia orange, Baiea *et al.,* (2015a) on Hindi mango cv., Baiea *et al.,* (2015b) on Keitt Mango trees and EL-Gioushy, and Baiea, (2015) on Canino Apricot. They mentioned that spraying the different studied of fruit crop species with K, Fe, Mn and Zn alone or in combinations enhanced many vegetative growth parameters.

Leaf chemical analysis:

Leaf total chlorophyll content (mg/g F. Wt.):

Table (3) displays obviously that all investigated treatments of using macro and micro elements fertilizers resulted significantly in increasing leaf total chlorophyll level. However, T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/) was statistically the superior and showed the highest total chlorophyll level i.e. 10.215 and 10.342 mg/g. during 2015 and 2016 experimental seasons respectively. Moreover, T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) and T_{10} (Mixture of micronutrients 1.5g/L+ Mixture of macro nutrients 3g/L) ranked statistically 2nd and 3rd after the aforesaid superior treatment during 2015 and 2016 experimental seasons.

In addition, other investigated (from T_2 to T_9) treatments were in-between the aforesaid extremes i.e., (T_{12}) superior and (control) inferior during both 2015 and 2016 experimental seasons.

Leaf mineral composition:

In this regard leaf N, P, K, Ca, Mg, Fe, Mn, Zn contents of Washington navel orange trees as influenced by the differential investigated treatments were the concerned leaf mineral composition as indicator for nutritional status of tree under study. Data obtained during both 2015 and 2016 experimental seasons are presented in Tables (3&4).

Leaf nitrogen content:

Tabulated data in Table (3) revealed that all investigated that representative of foliar application with macro elements solely or combined to microelements and /or any antioxidants source resulted significantly in increasing leaf N% of Washington navel orange trees as compared to other investigated treatments.

On the other side, T_1 (water spray (control)), T_2 (Citric acid 1g/L) and T_3 (Ascorbic acid 1g/L) did not affect leaf N% as compared to control. Such trend was true during both 2015 and 2016 experimental seasons.

Table 3: Effect of some antioxidants, micro and macro nutrients on total chlorophyll (mg/g F. Wt.), Nitrogen (%) and phosphorus (%) of Washington navel orange trees during 2015 and 2016 experimental seasons.

Parameters	Total chlorophyll (mg/g f.wt)		N (%)		P (%)	
Treatments \ Seasons	1st	2nd	1st	2nd	1st	2nd
T1: Control (Water spray)	8.738 i	8.717 i	2.15 d	2.14 i	0.121 b	0.121b
T2: Citric acid 1g/L	8.848 h	8.981 h	2.18 d	2.18 h	0.123 b	0.123b
T3: Ascorbic acid 1g/L	8.969 g	8.958 h	2.18 d	2.2 g	0.123 b	0.124b
T4: Micro elements 1.5g/L	9.548 f	9.543 g	2.31 c	2.31 f	0.126 b	0.125b
T5: Macro elements 3g/L	9.589 ef	9.639 f	2.53 b	2.56 c	0.154 a	0.157a
T6: Citric 1g/L+ Micro 1.5 g/L	9.585 ef	9.585 ef	2.34 c	2.36 d	0.127 b	0.129b
T7: Citric 1g/L+ Macro 3g/L	9.698 d	9.745 e	2.55 b	2.60 b	0.156 a	0.158a
T8: Ascorbic 1g/L+ Micro 1.5g/L	9.651 de	9.760 e	2.32 c	2.34 e	0.13 b	0.131b
T9: Ascorbic 1g/L+ Macro 3g/L	9.726 d	9.844 d	2.53 b	2.58 b	0.158 a	0.160a
T10: Macro 3g/L + Micro 1.5g/L	9.941 c	10.048 c	2.8 a	2.8 a	0.163 a	0.165a
T11: Citric 1g/L + Micro 1.5g/L + Macro 3g/L	10.038 b	10.127 b	2.77 a	2.79 a	0.166 a	0.168a
T12: Ascorbic 1g/L+ Micro 1.5g/L+ Macro 3g/L	10.215 a	10.342 a	2.78 a	2.81 a	0.167 a	0.169a

Values within each column followed by the same letter/s are not significantly different at 5% level.

Leaf phosphorus content:

Regarding the influence of the differential investigated treatments on leaf P% of Washington navel orange trees, tabulated data in Table (3) displays clearly that all treatments with macro elements solely or combined to other investigated treatments resulted significantly in increasing leaf P% of Washington navel orange trees as compared to control (T_1) and the other treatments. Herein, all the investigated treatments with macro elements solely or combined to other treatments T_5 (Mixture of macronutrients 3g/L), T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L), and T_{10} (Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) were superior.

Generally, it could be safely concluded that all investigated treatments increased leaf P% content over control. Such trend was true during 2015 and 2016 experimental seasons.

Leaf potassium content:

As for the influence of different fertilizers treatments investigated during 2015 and 2016 seasons on leaf K% of Washington navel orange trees, Table (4) reveals obviously that the highest level of K (%) was significantly in closed relationship to such trees subjected to T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) during 2015 and 2016 experimental seasons. However, T_1 water spraying (control) tended to be the least effective in this regard. In addition, other treatments were in-between the aforesaid two extremes.

Leaf calcium content:

Regarding the response of leaf Ca (%) to the differential investigated fertilizers treatments, data in Table (4) displayed that Washington navel orange trees subjected to T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) had statistically the richest leaves Ca (%) content i.e. 4.890 and 5.030 during 2015 and 2016 experimental seasons, respectively. However, T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L.+ Mixture of macronutrients 3g/L) ranked statistically second during the two experimental seasons. On the contrary, T_1 (water spray (control)), T_2 (Citric acid 1g/L) and T_3 (Ascorbic acid 1g/L) were significantly the inferior. In addition, other investigated treatments were in-between the abovementioned two extremes during both 2015 and 2016 experimental seasons.

Table 4: Effect of some antioxidants, micro and macro nutrients on potassium (%), Calcium (%) and Magnesium (%) of Washington navel orange trees during 2015 and 2016 experimental seasons.

Parameters	K (%)		Ca (%)		Mg (%)	
Treatments / Seasons	1st	2nd	1st	2nd	1st	2nd
T1: Control (Water spray)	1.29h	1.31g	4.180 g	4.207g	0.323h	0.333h
T2: Citric acid 1g/L	1.31g	1.32g	4.250 f	4.257fg	0.363g	0.373g
T3: Ascorbic acid 1g/L	1.31g	1.32g	4.280 f	4.30f	0.367g	0.377g
T4: Micro elements 1.5g/L	1.35e	1.34f	4.410 e	4.430e	0.437f	0.450f
T5: Macro elements 3g/L	1.55d	1.59e	4.563 d	4.617d	0.510d	0.530d
T6: Citric 1g/L+ Micro 1.5 g/L	1.32fg	1.31g	4.423 e	4.453e	0.453f	0.460ef
T7: Citric 1g/L+ Macro 3g/L	1.59c	1.61d	4.597 d	4.640d	0.587c	0.593c
T8: Ascorbic 1g/L+ Micro 1.5g/L	1.34ef	1.35f	4.413 e	4.467e	0.473e	0.473e
T9: Ascorbic 1g/L+ Macro 3g/L	1.60c	1.63d	4.613 cd	4.667d	0.573c	0.577c
T10: Macro 3g/L + Micro 1.5g/L	1.67b	1.68c	4.667 c	4.777c	0.623b	0.623b
T11: Citric 1g/L + Micro 1.5g/L + Macro 3g/L	1.71a	1.71b	4.823 b	4.887b	0.647a	0.653a
T12: Ascorbic 1g/L+ Micro 1.5g/L+ Macro 3g/L	1.72a	1.74a	4.890 a	5.030a	0.66a	0.663a

Values within each column followed by the same letter/s are not significantly different at 5% level.

Leaf magnesium content:

Regarding the influence of the differential investigated fertilizers treatments on Mg (%) of Washington navel orange trees tabulated data in the Table (4) revealed that all treatments resulted data in significant increase over control (T_1). Such trend was true during 2015 and 2016 experimental seasons. However, T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) and T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) were statistically the superior and they resulted significantly in the highest Mg(%) during 2015 &2016 experimental seasons. Meanwhile, T_{10} (Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) ranked statistically second rank. and T_9 (Ascorbic acid 1g/L+ Mixture of macronutrients 3g/L) ranked statistically third rank. such trend was true during both 2015 and 2016 experimental seasons. In addition, other investigation treatments were significantly similar as their efficiency on leaf Mg (%) content was concerned. However, water spray (control) treatment tended to be the least effective in this regard.

Leaf iron content (ppm):

Tabulated data in Table (5) revealed that all investigated that representative of foliar application with micro elements solely or combined to macro elements and/or antioxidants (citric acid or ascorbic acid) resulted significantly in increasing Fe content of Washington navel orange trees as compared to other investigated treatments. However, T_{10} (Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) was statistically the superior and showed the highest level of Fe content i.e., (80.55 and85.01ppm) during 2015 and 2016 experimental seasons, respectively. Moreover, T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) and T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) ranked statistically similar rank with the aforesaid superior treatments during 2015 and 2016 experimental seasons.

In addition, T_8 (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L) ranked statistically 2nd after the aforesaid treatments. On the contrary, the least leaf Fe content was significantly in concomitant to water sprayed Washington navel orange trees (control) during 2015 and 2016 experimental seasons.

Leaf Mn continent (ppm):

Concerning the response of leaf Mn content of fruitful Washington navel orange trees to the differential investigated treatments, Table (5) reveals obviously that all treatments resulted in increasing its level than (T_1) control water spraying. The rate of increase differed from one treatment to another. Anyhow, T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L.+ Mixture of macronutrients 3g/L) was significantly the superior, descendingly followed by T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L), T_{10} (Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L), T_9 (Ascorbic acid 1g/L+ Mixture of macronutrients 3g/L), T_8 (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L), T5 (Mixture of macronutrients 3g/L), T_7 (Citric acid 1g/L+ Mixture of macronutrients 3g/L) and T_4 (Mixture of micronutrients 1.5g/L).

Leaf Zn content (ppm):

Regarding the influence of the differential investigated fertilizers treatments on Zn content of Washington navel orange trees, tabulated data in Table (5) revealed that all treatments resulted in significant increase over control (T_1). Such trend was true during both experimental seasons. However, T_{12} (Ascorbic acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) was statistically the superior and resulted significantly in the highest Zn content during 2015 and 2016 experimental seasons. Meanwhile, T_{11} (Citric acid 1g/L+ Mixture of micronutrients 1.5g/L+ Mixture of macronutrients 3g/L) ranked statistically second rank. Such trend was true during both experimental seasons. However, (T_1) water spray treatment tended to be the least effective in increasing leaf Zn content of Washington navel orange trees during 2015 and 2016 experimental seasons. In addition, other investigated treatments were in-between two extremes (the highest one T_{12} and the least effective one T_1 control).

Table 5: Effect of some antioxidants, micro and macro nutrients on Iron (ppm), Manganese (ppm) and Zinc (ppm) of Washington navel orange trees during 2015 and 2016 experimental seasons.

Parameters	Fe (ppm)		Mn (ppm)		Zn (ppm)	
Seasons / Treatments	1st	2nd	1st	2nd	1st	2nd
T1: Control (Water spray)	64.38 g	65.78 e	29.18 f	30.22 f	21.54 g	21.99 i
T2: Citric acid 1g/L	67.34 f	67.91 d	31.10 e	31.84 e	22.32 fg	22.71 h
T3: Ascorbic acid 1g/L	68.3 f	68.12 d	32.08 e	32.77 e	23.22 f	23.41 g
T4: Micro elements 1.5g/L	78.12 c	81.58 b	42.45 c	46.83 bc	31.38 d	33.82 e
T5: Macro elements 3g/L	70.64 e	72.30 c	36.68 d	37.02 d	27.07 e	27.27 f
T6: Citric 1g/L+ Micro 1.5 g/L	78.62 bc	82.68 b	42.39 c	47.31 b	3.98 d	33.81 e
T7: Citric 1g/L+ Macro 3g/L	72.08 de	72.35 c	38.09 d	37.02 d	27.37 e	27.48 f
T8: Ascorbic 1g/L+ Micro 1.5g/L	79.02 abc	81.26 b	43.02 c	46.23 c	33.38 c	34.70 d
T9: Ascorbic 1g/L+ Macro 3g/L	73.64 d	73.66 c	37.58 d	36.89 d	27.36 e	27.42 f
T10: Macro 3g/L + Micro 1.5g/L	80.55 a	85.01 a	46.92 b	51.45 a	34.42 b	35.62 c
T11: Citric 1g/L + Micro 1.5g/L + Macro 3g/L	80.51 ab	84.28 a	47.89 ab	50.98 a	35.29 ab	36.65 b
T12: Ascorbic 1g/L+ Micro 1.5g/L+ Macro 3g/L	80.29 ab	85.60 a	49.24 a	51.16 a	35.77 a	36.94 a

Values within each column followed by the same letter/s are not significantly different at 5% level

The enhancing effect of ascorbic and citric acids on nutritional status of Washington navel orange trees was surely reflected on improving nutritional status. These results are in harmony with those of Mansour *et al.,* (2006) and Ahmed and Abdelaal (2007) on Anna apple trees, Khiamy (2003), Wassel *et al.,* (2007) and Fayed (2010) on grapevines and Mansour *et al.,* (2010) on four mango cultivars.

Foliar sprays of micronutrients mixture (Fe, Zn and Mn) that gave positive effects on nutritional status go in line with the findings of Hammam *et al.,* (2001) on Taimour and Mabrouka mango cvs., Saleh and Abd El-Monem (2003) on Fagri Kelan mango cv., Dutta (2004) on Himsagar mango cv., Tariq *et al.,* (2007) on sweet orange, Ranjit *et al.,* (2008) on Amrapali mango cv., El-Kosary *et al.,* (2011) on some mango cultivars, Seyam (2012) on Balady mandarin and El-Badawy (2013) on Canino apricot cv. Moreover, El-Shewy and Abdel-khalek (2014) on peach, Fouad (2014) on Valencia orange, Baiea *et al.,* (2015a) on Hindi mango cv. and EL-Gioushy (2016) on Washington navel orange trees.

References

Abd Ela, A.H., 1991. Effect of soil and foliar application of nitrogen phosphorus and potassium on some vegetative and fruiting characteristics in White Banaty seedless M. Sc. Thesis, Fac. Agric. Minia Univ.

Ahmed, F.F., O.H. Darwish, A.A. Gobara and A.H. Ali, 2002. Physiological studies on effect of ascorbic and citric acids combined with some micronutrients on Flame seedless grapevines. Minia J. of Agric. Res. & Develop, 22(1): 105-114.

Ahmed, F.F. and A.M.K. Abdelaal, 2007. Influence of spraying seaweed extract and citric acid on yield and fruit quality of Anna apple trees. The 1st Inter. Conf. on Desert cultivation 27-29 Mar. El-Minia Univ., El-Minia, Egypt.

Ahmed, F.F., A.M. Akl, A.A. Gobara and A.E.M. Mansour, 1998. Yield and quality of Anna apple trees (*Malusdomestica,* L.) in response to foliar application of Ascorbine and Citrine fertilizers. Egypt. J. Hort., 25(2): 203-208.

Akl, A.M., A.M. Eid, F.F. Ahmed and A.H. Abd Elal, 1993a. The effect of soil and foliar application N, P and K on vegetative and fruiting characteristics in White Banaty seedless grapevines. 11 – Bud behavior, yield and fruit quality. Minaia First Conf. for Hort. Crop 2nd and part pp: 432-453.

Akl, A.M., A.M. Eid, F.F. Ahmed and A.H. Abd El-al, 1993b. The effect of soil and foliar application of N, P and K on vegetative and fruiting characteristics in White Banaty seedless grapevine, Vegetative growth and leaf nutrients content. Minia First Conf. for Hort. Crops nd, Part pp: 409-431.

Ali, A.H., 2000. Response of Flame seedless grapevines to spraying with ascorbic acid and boron. Minia J. of Agric. Res. & Develop, 20(1): 159-174.

Arrigoni, O., M.C. De Tullio, 2002. Ascorbic acid: much more than just an antioxidant. Biochimica et Biophysica Acta 1569, 1-9.

Baiea, M.H.M., T.F. El-Sharony, A.A. Eman, Abd El- Moneim, 2015a. Effect of different forms of potassium on growth, yield and fruit quality of mango cv. Hindi. International Journal of ChemTech Research, 8(4): 1582-1587.

Baiea, M.H.M., H.E.M. El-Badawy and S.F. El-Gioushy, 2015b. Effect of Potassium, Zinc and Boron on Growth, Yield and Fruit Quality of Keitt Mango Trees. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 6(4): 800-812.

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.

Chapman, H.D. and P.F. Pratt, 1961. Methods of Analysis for Soil, Plant and Waters. Univ. of Calif. Division of Agric. Sc. 6$^{\underline{th}}$ Ed. pp: 56-64.

Duncan, D.B., 1955. Multiple range and multiple F. tests. Biometrics, 11: 1-42.

Dutta, P., 2004. Effect of foliar boron application on panicle growth, fruit retention and physio-chemical characters of mango cv. Himsagar. Indian J. Hort., 61: 265-266.

El-Badawy, H.E.M., 2013. Effect of some antioxidants and micronutrients on growth, leaf mineral content, yield and fruit quality of Canino apricot trees. Journal of Applied Sciences Research, 9(2): 1228-1237.

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-Gioushy, S.F. and M.H.M. Baiea, 2015. Partial Substitution of Chemical Fertilization of Canino Apricot by Bio and Organic Fertilization. Middle East Journal of Applied Sciences, 5(4): 823-832.

El-Kosary, S., I.E. El-Shenawy and S.I. Radwan, 2011. Effect of microelements, amino and humic acid on growth, flowering and fruiting of some mango cultivars. Journal of Horticultural Sciences &Ornamental Plants, 3(2): 152-161.

El-Sayed, M.A., M.A. Ahmed and A.H. Ali, 2000. Response of Flame seedless grapevine to application of ascorbic acid. The2nd Conf. Sci. Assuit, Egypt, pp: 317-340.

El-Shazly, S.M., 1999. Response of Anna apple trees to foliar sprays of chelated iron, Manganese and zinc. J. Agric. Sci. Mansour Univ., 24(12): 7595-7591.

El-shewy, A.A. and A. Iman- Abdel-khalek, 2014. Physiological studies on The effect of foliar sprayes with some Micronutrients on Leaf Mineral contenet, Yield and fruit Quality of Florida prince and Deserted peach trees.

Fayed, T.A., 2010. Effect of some antioxidants on growth, yield and bunch characteristics of Thompson seedless grapevine. American-Eurasian J. Agric. & Environ Sci., 8(3): 322-328.

FAO statistics 2015: Food and Agriculture Organization. www.FAO.org.

Fouad, M., 2014. Response of Valencia orange trees to antioxidants and bio fertilizations. Ph.D. thesis Faculty of Environmental Agricultural El-Arish, Suez Canal University.

Gendiah, H.M. and N.A.A. Hagagy, 2000. Physiological studies on the effect of some micronutrients foliar fertilization treatments on nutritional status, growth and fruiting of Washington navel orange trees. Annals of Agric. Sc., Moshtohor, 38(2): 1811-1194.

Ghanta, P.K. and S.K. Metra, 1993. Effect of micronutrients on growth, flowering, leaf nutrient content and yield of banana cv., Giant cavandishii. Crop Research, 2: 284-287.1236 J. Appl. Sci. Res., 9(2): 1228-1237.

Gobara, A.A., F.F. Ahmed and M.S. El – Shammaa, 2001. Effect of varying N. K. and Mg application ratio on productivity of Banaty grapevines. The fifth Arabian Horticulture conf. Ismallia Egypt, pp: 83-90.

Hammam, M.S., A.M.T. Sabour and E. Sanaa, 2001. Trials for alleviating inflorescence malformation in Taimour and Mabrouka mango trees. Annals of Agri. Sci., Cairo, 46: 753-766.

Hanson, E.J., 1991. Sour cherry trees response to foliar boron applications. Hort Sci., 26: 1142.

Kabeel, H., H. Mokhtar and M.M. Aly, 1998. Effect of foliar application of different macro –and micro nutrients on yield, fruit quality and leaf mineral composition of L-Conte pear. J Agric. Sci. Mansoura Univ., 23 (7): 3317-3325.

Khiamy, A.O., 2003. Response of Flame seedless grapevines growing in sandy soil to different pruning date and application of urea and ascorbic acid. Ph.D. Thesis Fac. of Agric., Minia Univ., Egypt.

Kumar, N. and P. Jayakumar, 2001. Influence of micro nutrients on growth and yield of banana *(Musa sp.)* cv. Robusta (AAA). Plant-Nutrition-Food Security and substainabilit of Agro-ecosystems-through-basic and Applied Research. Fourteenth International Plant Nutrition Colloquium. Itannover, Germany, pp: 354-355.

Maklad, T.N.A., 2010. A comparative study on effect of source, rate and application method of some fertilizers on growth and yield of banana plant. Ph. D. Dissertation. Fac. Agric. Benha University. Egypt.

Mansour, A.E.M., F.F. Ahmed, E.A. Shaaban and Amera A. Fouad, 2008. The beneficial of using citric acid with some nutrients for improving productivity of le-Conte pear trees. J. Agric. and bio. Sci., 4(3): 245-250.

Mansour, A.E.M., G.P. Cimpoies and F.F. Ahmed, 2006. The use of some antioxidants to improve yield and fruit quality of Anna apple trees. Agrarian Sci. J. of the Agrarian State Univ. of Moldova, Moldova, 2: 21-35.

Mansour, A.E.M., M.S. El-Shamma, E.A. Shaaban and M.A. Maksoud, 2010. Influence of some antioxidants on yield and fruit quality of four mango cultivars. Research Journal of Agriculture and Biological Sciences, 6(6): 962-965.

Nijjar, G.S., 1985. Nutrition of fruit trees Mrs Usho Raj Kumar. Kalyani, New Delhi, pp: 10-20.

Omar, A. Kh., 1999. Response of Red Roomy (*Vitis vinifera,* L.) to some antioxidants and bio-fertilizer treatments. M. Sc. Thesis. Fac. Agric. Minia Univ. Egypt

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

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

Ranjit, K., K. Pawan and U.P. Singh, 2008. Effect of foliar application of nitrogen, zinc and boron on flowering and fruiting of mango *(Mangifera indica,* L.) cv. Amrapali. Environment and Ecology, 26(4B): 1965-1967.

Saleh, M.M.S. and E. Abd El-Monem, 2003. Improving the productivity of "Fagri Kelan" mango trees grown under sandy soil conditions using potassium, boron and sucrose as foliar spray. Annals of Agri. Sci., Cairo, 48: 747-756.

Sayed, M.F., 2002: Effect of some horticultural practices on yield and fruit quality of White Banaty grapevines.

Seyam, G.A.A., 2012. Response of Balady mandarin trees to some horticultural treatments. Ph.D. Thesis Fac. of Agric., Benha Univ., Egypt.

Smirnoff, N., 1996. The function and metabolism of ascorbic acid. Plant.Ann. Bot., 87: 661-669.

Snedecor, G.W. and W.G. Cochran, 1977. Statistical Methods, Eight Edition, Iowa State University Press.

Tariq, M., M. Sharif, Z. Shah and R. Khan, 2007. Effect of foliar application of micronutrients on the yield and quality of sweet orange *(Citrus sinensis,* L.). Pakistan Journal of Biological Sci., 10(1): 1823-1828.

Wassel, W.A.H., M. Abd El-Hameed, A. Gobara and M. Attia, 2007. Effect of some micronutrients, gibberllic acid and ascorbic acid on growth, yield and quality of White Banaty seedless grapevines. African Crop Science Conference Proceedings, 8: 547-553.