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Effect of Foliar Sprays with Ascorbic Acid on Flowering, Fruit Set and Yield of Washington Navel Orange Trees

Mahmoud, T. A.
Citrus Dept., Hort. Inst., Agric. Res. Center. Giza, Egypt.

ABSTRACT

In the two seasons of 2013/2014 and 2014/2015, 10 years old Washington navel orange trees (*Citrus sinenses)*, on sour orange rootstock (*Citrus aurantium* L.), received ascorbic acid (AA) spry at 0 (control), 50, 100, 150, 200 ppm on three physiological stages: 1- at the beginning of flowering; 2- at full bloom; 3- at fruitlet diameter of 0.5-1.0 cm. All experimental trees received with about 7 liters of the spray solution at each spray time. The main goal of this study was to pilot AA effects on orange trees and to determine the most effective concentration. The data reveal that, increasing AA concentration enhanced mixed flower bud and bud opening percentages as well as total number of inflorescences, number of leafy inflorescences as well as total number of solitary flowers per twig in both seasons. The uppermost AA concentration (200 ppm) significantly increased number of fruits per tree since it reached 195.83 and 223.25 fruits / tree in the 1st and 2nd seasons, respectively compared with 56.17 and 61.78 fruits / tree, respectively with the control. The yield per tree recorded 41.11 and 48.23 kg in the 1st and 2nd seasons, respectively with AA 200 ppm against only 14.73 and 16.01 kg, respectively for the control. In addition, the higher AA concentrations significantly increased IAA concentration in mature leaves, flowers and fruitlets.

INTRODUCTION

The economic value put the citrus trees in the top with other important fruit crops. World citrus production and consumption have witnessed a period of strong growth since 1980 (FAO, 2012).

Citrus trees are the most important fruit crop in the World and in Egypt. They has an outstanding economic importance among fruit crops in Egypt, particularly for exportation (Statistics of the Ministry of Agric., 2014). The total area under citrus trees is 541,723 feddan, out of them 439,024 feddan are fruitful producing 4,098,590 tons (43.00% of the total production of fruit trees) with average of 9.34 tons per feddan. The total area under Washington navel orange trees is 185,892 feddan out of them 157,793 feddan are fruitful producing 1,531,952 tons with average of 9.71 tons per feddan. The total exports of orange fruits are about 1,027,554 tons representing 25.07 % of the total citrus production. (M. A. L. R. 2014).

Vitamins could be considered as bio-regulator compounds which in low concentrations exerted a profound influence upon plant growth. Ascorbic acid is a vitamin known as growth regulating factor which influences many biological processes. It is currently considered to as plant growth regulator due to its effect on cell division, differentiation and various growth factors. Ascorbic acid increases nucleic acid content, especially RNA and acts as co-enzyme in the enzymatic reactions by which carbohydrates, proteins are metabolized and involved in photosynthesis and respiration (Price,1966, Ascorbic stimulation of RNA synthesis; Patil and Lall, 1973, on wheat plants ; Robinson, 1973, Vitamins In Phytochemistry; Reda *et al.,* 1977, on *Ammi visnaga* L. plants; Fadl *et al.,*1978, on *Ammi visnaga* L plants; Abdel-Halim,1995, on tomato plants; Talaat, 1998, on lavender plants; Tarraf *et al.,* 1999, on lemongrass plants; Youssef *et al.,*2003, on rosemary plants; Gamal, 2005, on sunflower plants; Talaat, Iman, 2005, on periwinkle plants; Eid, Rawia *et al.,*2006, on croton plants; Abd el-Aziz, Nahed *et al.,*2007, on *Syngonium podophyllum* L plants; Farahat *et al.,* 2007, on *Cupressus sempervirens* L plants; Mazher, Azza *et al.,* 2011, on *Codiaeum variegatum L* plants; Masoud and El-Sahrawy, 2012, on Washington navel orange trees).

Literature reports on the effective concentration of AA show a clear variation. Many authors used relatively low concentrations between 10 and 300 ppm (Yossef and Talaat, 2003, on Rosemary plants; Talaat, Iman and Aziz, Eman, 2005, on Matriearia plants; Eid, Rawia and Bedour Abu-leila, 2006, on croton plants; Farahat *et al.,* 2007, on *Cupressus sempervirens* plants; Abd El-Aziz, nahed *et al.,* 2007, on Syngonium pado phylum plants; Abd-El-Aziz *et al.,* 2009, on gladiolus plants and Mazher, Azza, *et al.,* 2011, on *Codiaeum variegatum L* plants. On the other hand, some studies used much higher concentrations between 1000 and 3000 ppm (Ali, 2000, on grape vines; Maksoud *et al.,* 2009, on olives; Ahmed, Dorria, 2012, on date palms; El-Badawy, 2013, on apricot, and El- Sayed omima, 2014 on olives).

The main goal of the present investigation was to show the response of growth and fruiting of Washington navel orange trees to three AA sprays at beginning of flowering, at full bloom and at fruitlet diameter of 0.5 – 1 cm. the tested concentration were: 0 (cont.), 50, 100, 150 and 200 ppm.

MATERIALS AND METHODS

The present investigation has been carried out to study the effect of ascorbic acid concentration on flowering, fruit set and yield of Washington navel orange trees (*Citrus sinenses)* budded on sour orange (*Citrus aurantium*) rootstock during two successive seasons (2013/2014 & 2014/2015). The experimental trees were 10 years old and grown at 4×5 meter, in sandy loam soil under drip irrigation system by Nile river water in private orchard at Belbeis region – El Sharqia Governorate Egypt.

The experiment comprised five ascorbic acid (AA) concentrations (control, 50, 100, 150 and 200 ppm) during three physiological stages: 1- at the

beginning of flowering; 2- at full bloom; 3- at fruitlet diameter of 0.5-1.0 cm. All experimental trees received the three foliar applications. Each tree received about 7 liters of the spray solution at each spray time. The experimental trees were arranged in a complete randomize block design with 5 treatments, three replicates and 2 trees for each replicate.

The tested treatments were evaluated throw the following parameters:

1-Bud behaviour

The numbers of: leaf buds, mixed flower buds and dormant buds as well as the bursted buds and total number of buds per twig were counted and recorded. In addition, the percentage of each bud type was calculated.

2- Flowering and fruit set

The numbers of leafy and leafless inflorescences as well as solitary flowers per twig were counted and recorded. In addition, the numbers of flowers on each inflorescence type and solitary flowers were recorded. The numbers of set fruitlets on leafy and leafless inflorescences as well as from solitary flowers per twig were counted and recorded. Finally, the fruit set percentage in each case was calculated. The percentage of leafy inflorescences to the total number of inflorescences was calculated.

3- Yield components

At harvesting date (Early September), the numbers of harvested fruits per tree were counted, the total weight of all fruits per tree (the yield/tree, in kg) was determined and recorded and the hypothetic yield/ fed. [on basis of 200 trees/fed. (4x5m apart)] was calculated.

4- Fruit physical properties

Samples of 15 fruits per each replicate were randomly taken, the studied parameters involved: fruit weight (g), fruit volume (cm^3), fruit height (cm), fruit diameter (cm), peel weight (g), peel thickness (mm), fruit pulp weight (g), juice weight / fruit (g) and juice volume / fruit (cm^3).

5- Chemical constituents of the fruit juice

The following parameters were considered total soluble solids percentage (TSS) was determined using a hand refractometer, total titratable acidity as g citric acid / 100 ml of juice was determined by titration against 0.1 N sodium hydroxide in presence of phenol phthalin as an indicator, values of the TSS /acid ratio was calculated, ascorbic acid content (mg / 100 ml of juice) was determined by titration against 2,6-dichlorophenol indophenol (mg/ 100 ml) following the method illustrated in the A.O.A.C. (1985).

6-Auxins study:

The leaf samples were taken and treated according to Abbas *et al.,* (1995) and the auxins (IAA) were determined using the method of Abbas and Fandi (2001).

7-Statistical analysis:

Data obtained throughout this study were statistically analyzed using the analysis of variance method as reported by Snedecor and Cochran, (1980). The differences between means were differentiated by using Duncan's range test. (Duncan, 1955).

RESULTS AND DISCUSSION

1. Bud behaviour:

Data present in table (1) show the effect of ascorbic acid foliar application with different concentrations on some bud behaviour characteristics of Washington navel orange trees budded on sour orange rootstock and grown in newly reclaimed sandy soil (2013/2014 – 2014/2015 seasons).

Total number of buds, number of dormant buds and dormant bud percentage

In the two seasons of investigation, all the tested treatments gave no clear and significant effect on the above characteristics.

Leaf buds number and percentage

In the two seasons of investigation, all the tested treatments produced significant decrease, in leaf buds number and percentage compared to the control. The two experimental seasons indicated greater numbers of leaf buds with the control; the values being: 1.22 & 0.73 for leaf bud numbers and 9.46& 4.72% for leaf bud percentage in the first and second seasons, respectively. The corresponding values for AA 200 ppm were 0.1 leaf buds in booth seasons and 0.59 and 0.49 %, respectively for leaf buds percentage.

Flower bud number and percentage

All the tested treatments recorded significant increases in number of flower buds over the control especially with the highest AA concentration (200 ppm). The two experimental seasons indicated greater numbers and percentages of flower buds with AA 200 ppm; the values being: 12.35 &15.47for flower buds and 72.69 & 75.83 for flower bud percentage in the first and second seasons, respectively. The corresponding values for the control were: 6.85 & 8.93 for numbers and 53.10 & 57.80 %, respectively for flower buds percentages.

Numbers of opened buds and opened buds percentage

All the tested treatments gave, significant increases in the number of opened buds over the control especially with the highest concentration of AA. The two experimental seasons indicated greater numbers of opened buds and bud opening percentage with the highest concentration of ascorbic acid (200 ppm); the values being: 12.45 & 15.57 for numbers of opened buds and 73.27 & 76.32 for opened bud percentage in the first and second seasons, respectively.

These results are in line with Price, (1966) who reported that ascorbic acid increased nucleic acid contents, especially RNA and protein content (Robinson, 1973). It also affected the synthesis of enzymes, and proteins. In addition, it acts as co-enyme in metabolic changes. Generally, ascorbic acid had positive effects on growth parameters by increasing carbohydrates and content of macronutrients (N, P and K) in plants (Tarraf *et al.,* 1999, on lemongrass plants, Talaat, 2003, on sweet pepper plant and Mazher, Azza *et al.,* 2011, on *Codiaeum variegatum*).

Table (1) Effect of ascorbic acid foliar application on bud behavior of Washington navel orange trees on sour orange rootstock grown in newly reclaimed sandy soil (2013/2014-2014/2015 seasons).

Characteristics		Ascorbic acid concentrations									
		Control		050 ppm		100 ppm		150 ppm		200 ppm	
First season (2013/2014)											
Total number of buds	Value	12.90	A	11.82	A	12.81	A	14.56	A	16.99	A
	*±%	NS		NS		NS		NS		NS	
Number of leaf buds	Value	1.22	A	0.14	B	0.10	B	0.10	B	0.10	B
	±%	-		-88.52		-91.80		-91.80		-91.80	
Percentage of leaf bud	Value	9.46	A	1.18	B	0.78	B	0.69	B	0.59	B
	±%	-		-8.27		-8.68		-8.77		-8.87	
Number of flower buds	Value	6.85	D	8.18	C	9.04	C	10.54	B	12.35	A
	±%	-		19.42		31.97		53.87		80.29	
Percentage of flower buds	Value	53.10	B	69.20	A	70.57	A	72.39	A	72.69	A
	±%	-		16.10		17.47		19.29		19.59	
Number of dormant buds	Value	4.83	A	3.50	A	3.67	A	3.92	A	4.54	A
	±%	NS		NS		NS		NS		NS	
Percentage of dormant buds	Value	37.44	A	29.61	A	28.65	A	26.92	A	26.72	A
	±%	NS		NS		NS		NS		NS	
Numbers of opened buds	Value	8.07	D	8.32	D	9.14	C	10.64	B	12.45	A
	±%	-		3.10		13.26		31.85		54.28	
Percentage of opened buds	Value	62.56	C	70.39	B	71.35	B	73.07	A	73.27	A
	±%	-		7.83		8.79		10.51		10.71	
Second season (2014/2015)											
Total number of buds	Value	15.45	A	14.61	A	16.00	A	17.60	A	20.40	A
	±%	NS		NS		NS		NS		NS	
Number of leaf buds	Value	0.73	A	0.10	B	0.10	B	0.10	B	0.10	B
	±%	-		-86.30		-86.30		-86.30		-86.30	
Percentage of leaf bud	Value	4.72	A	0.68	B	0.63	B	0.57	B	0.49	B
	±%	-		-4.04		-4.10		-4.16		-4.23	
Number of flower buds	Value	8.93	D	9.76	C	11.19	C	12.54	B	15.47	A
	±%	-		9.29		25.31		40.43		73.24	
Percentage of flower buds	Value	57.80	B	66.80	A	69.94	A	71.25	A	75.83	A
	±%	-		9.00		12.14		13.45		18.03	
Number of dormant buds	Value	5.79	A	4.75	A	4.71	A	4.96	A	4.83	A
	±%	NS		NS		NS		NS		NS	
Percentage of dormant buds	Value	37.48	A	32.51	A	29.44	A	28.18	A	23.68	A
	±%	NS		NS		NS		NS		NS	
Numbers of opened buds	Value	9.66	D	9.86	D	11.29	C	12.64	B	15.57	A
	±%	-		2.61		21.28		38.90		77.15	
Percentage of opened buds	Value	62.52	D	67.49	C	70.56	B	71.82	B	76.32	A
	±%	-		7.95		12.86		14.88		22.07	

***±% = increase or decrease % in relation to control.**

2. Characteristics of leafy inflorescences:

Total numbers of inflorescences per twig

The greatest total number of inflorescences per twig were always obtained by the higher AA concentration since, it produced 11.45 & 15.50 in the first and second seasons, respectively compared to control which gave 6.71 & 9.76, respectively.

Number and percentage of leafy inflorescences.

Data from the two seasons indicated that greater numbers and percentages of leafy inflorescences dah obtained with higher AA concentration (200 ppm) so, the values being: 8.10 & 11.14 for the numbers and 70.74 & 71.87% for the percentage of leafy inflorescences in the first and second seasons, respectively. The corresponding values for the control were: 3.18 and 4.63 for the number and 47.39 and 47.44%, respectively.

Number of flowers on leafy inflorescence

In it is clear from the table that AA concentration (200 ppm) produced the greatest numbers of flowers on the leafy inflorescences since, it gained the values were 7.92 & 7.84 in the first and second seasons, respectively. The corresponding values of the control were 5.46 & 5.42 flowers, respectively.

Number of fruitlets on leafy inflorescence

The greatest numbers of set fruitlets on leafy inflorescence was recorded when trees sprayed with ascorbic acid 150 ppm (1.00 & 0.81) and 200 ppm (1.34

& 1.19) fruitlets in the first and the second seasons, respectively, without significant differences between them.

Fruit set percentage

The greatest fruit set percentage on leafy inflorescences were recorded by ascorbic acid 150 ppm (13.79 & 11.17%) &200 ppm (16.94 & 15.16%) in the first and the second seasons, respectively, without significant differences between them in both seasons. The corresponding values for the control were 1.83 and 1.85 in the first and the second seasons, respectively.

3. Characteristics of leafless inflorescences:

Total number of inflorescences per twig

As shown in table (3) total number of inflorescences per twig was always obtained by the uppermost AA concentration (11.45 & 15.50 in the first and second seasons, respectively) compared to control (6.71 & 9.76, respectively).

Number of leafless inflorescences per twig

In the two seasons of investigation, all the tested treatments failed to induce any significant effect on number of leafless inflorescences per twig. The values ranged from 3.35 to 3.53 in the first season and from 4.36 to 5.13 in the second one.

Percentage of leafless inflorescences

The two experimental seasons indicated greater values of leafless inflorescences percentage with the control in the first and second seasons (52.61 & 52.56 %, respectively), compared to all AA treatments. The corresponding value with AA at 200 ppm were: 29.26 and 7 28.13%, respectively.

Number of flowers on leafless inflorescence

In the two seasons of investigation, all the tested treatments failed to induce any significant effect on number of flowers on leafless inflorescences. The values ranged from 4.50 to 5.67 flowers per leafless inflorescence in both seasons.

Number of fruitlets on leafless inflorescence

The greatest numbers of set fruitlets on leafless inflorescence were recorded by ascorbic acid 200 ppm (0.61 & 0.37 fruitlets in the first and the second seasons, respectively). The other tested concentrations recoded inferior values in both seasons.

Fruit set percentage on leafless inflorescences

The greatest fruit set percentages on leafless inflorescences were recorded by ascorbic acid 200 ppm (10.76 & 6.53% in the first and the second seasons, respectively). The other tested concentrations recoded inferior values in both seasons.

Table (2) Effect of ascorbic acid foliar application on leafy inflorescence characteristics of Washington navel orange trees on sour orange rootstock grown in newly reclaimed sandy soil (2013/2014-2014/2015 seasons).

Characteristics		Ascorbic acid concentrations									
		Control		050 ppm		100 ppm		150 ppm		200 ppm	
First season (2013/2014)											
Total number of inflorescences per twig	Value	6.71	D	8.01	CD	8.40	B	9.38	B	11.45	A
	*±%	-		19.37		25.19		39.79		70.64	
Number of leafy inflorescences per twig	Value	3.18	D	4.67	CD	5.05	B	5.95	B	8.10	A
	±%	-		46.86		58.81		87.11		154.72	
Percentage of leafy inflorescences	Value	47.39	C	58.30	B	60.12	B	63.43	B	70.74	A
	±%	-		11.03		12.88		16.10		22.88	
Number of flowers on leafy inflorescence	Value	5.46	D	6.00	CD	6.50	C	7.25	B	7.92	A
	±%	-		9.89		19.05		32.78		45.05	
Number of fruitlets on leafy inflorescence	Value	0.10	C	0.21	B	0.40	B	1.00	A	1.34	A
	±%	-		110.00		300.00		900.00		1242.00	
Fruit set percentage on leafy inflorescences	Value	1.83	C	3.50	B	6.15	B	13.79	A	16.94	A
	±%	-		1.71		4.26		11.97		14.86	
Second season (2014/2015)											
Total number of inflorescences per twig	Value	9.76	D	10.62	CD	11.55	B	12.92	B	15.50	A
	±%	-		8.81		18.38		32.38		58.81	
Number of leafy inflorescences per twig	Value	4.63	D	6.07	CD	7.05	B	8.55	B	11.14	A
	±%	-		31.10		52.35		84.67		140.60	
Percentage of leafy inflorescences	Value	47.44	C	57.16	B	61.05	B	66.18	B	71.87	A
	±%	-		9.72		13.61		18.74		24.43	
Number of flowers on leafy inflorescence	Value	5.42	D	6.17	CD	6.83	C	7.25	B	7.84	A
	±%	-		13.84		26.07		33.76		44.61	
Number of fruitlets on leafy inflorescence	Value	0.10	C	0.29	B	0.48	B	0.81	A	1.19	A
	±%	-		190.00		375.00		710.00		1088.00	
Fruit set percentage on leafy inflorescences	Value	1.85	C	4.70	B	6.95	B	11.17	A	15.16	A
	±%	-		2.86		5.11		9.33		13.31	

***±% = increase or decrease % in relation to control.**

Table (3) Effect of ascorbic acid foliar application on leafless inflorescences characteristics of Washington navel orange trees on sour orange rootstock grown in newly reclaimed sandy soil (2013/2014-2014/2015 seasons).

Characteristics		Ascorbic acid concentrations									
		Control		050 ppm		100 ppm		150 ppm		200 ppm	
First season (2013/2014)											
Total number of inflorescences per twig	Value	6.71	D	8.01	CD	8.40	B	9.38	B	11.45	A
	*±%	-		19.37		25.19		39.79		70.64	
Number of leafless inflorescences per twig	Value	3.53	A	3.34	A	3.35	A	3.43	A	3.35	A
	±%	NS		NS		NS		NS		NS	
Percentage of leafless inflorescences	Value	52.61	A	41.70	B	39.88	B	36.57	C	29.26	C
	±%	-		-10.91		-12.73		-16.04		-23.35	
Number of flowers on leafless inflorescence	Value	4.50	A	4.50	A	4.92	A	5.42	A	5.67	A
	±%	NS		NS		NS		NS		NS	
Number of fruitlets on leafless inflorescence	Value	0.08	B	0.09	B	0.11	B	0.12	B	0.61	A
	±%	-		12.50		37.50		50.00		662.50	
Fruit set percentage on leafless inflorescences	Value	1.78	B	2.00	B	2.24	B	2.21	B	10.76	A
	±%	-		0.22		0.46		0.44		8.98	
Second season (2014/2015)											
Total number of inflorescences per twig	Value	9.76	D	10.62	CD	11.55	B	12.92	B	15.50	A
	±%	-		8.81		18.38		32.38		58.81	
Number of leafless inflorescences per twig	Value	5.13	A	4.55	A	4.50	A	4.37	A	4.36	A
	±%	NS		NS		NS		NS		NS	
Percentage of leafless inflorescences	Value	52.56	A	42.84	B	38.95	B	33.82	C	28.13	C
	±%	-		-9.72		-13.61		-18.74		-24.43	
Number of flowers on leafless inflorescence	Value	4.50	A	4.50	A	5.00	A	5.08	A	5.67	A
	±%	NS		NS		NS		NS		NS	
Number of fruitlets on leafless inflorescence	Value	0.08	B	0.09	B	0.11	B	0.11	B	0.37	A
	±%	-		12.50		37.50		37.50		362.50	
Fruit set percentage on leafless inflorescences	Value	1.78	B	2.00	B	2.20	B	2.17	B	6.53	A
	±%	-		0.22		0.42		0.39		4.75	

***±% = increase or decrease % in relation to control.**

4. Effect of ascorbic acid on solitary flowers and total flowers characteristics:

Total number of solitary flowers per twig

From Table (4) it is clear that the greatest numbers of solitary flowers per twig were obtained by ascorbic acid 200 ppm (1.99 and 1.62 in the first and second seasons, respectively) compared with 0.20 and 0.21 solitary flower in the first and second seasons, respectively for the control.

Number of fruitlets from solitary flowers per twig

In the two experimental seasons, the higher ascorbic acid concentration (200 ppm) gave significantly greater numbers of set fruitlets from solitary flowers (0.40 and 0.25 fruits in the first and second seasons, respectively) compared with 0.10 fruits in both seasons for the control.

Fruit set percentage from solitary flowers

In the two experimental seasons, fruit set percentage from solitary flowers was greater with the control and the lower two ascorbic acid concentrations 50 & 100 ppm since, it produced 50.00, 47.83 and 40.00 % in the first season and 47.62, 43.48 and 41.67 % in the second one, respectively). The uppermost AA concentrations (200 ppm) recorded 20.10 and 15.43 %, respectively

Total number of flowers per twig

In both experimental seasons the tested ascorbic acid treatments exerted significant increasing effect on number of flowers / twig in comparison with the control, especially with the uppermost concentration 200 ppm (85.14 & 113.66 flowers, respectively for AA 200 ppm) against 33.45 & 48.39 flowers for the control.

Total number of set fruitlets per twig

The number of fruitlets per twig always positively and significantly increased with AA concentration being 14.52 & 13.01 fruitlet, respectively with AA 200 ppm against only 0.63 and 0.62 fruitlet with the control.

Overall fruit set percentage

In both seasons of study, it is clear that continuous promotions in the percent of fruit set were obtained as the ascorbic acid concentration was increased from 0 to 200 ppm specially with the highest concentration: the values were: 1.88 & 1.28 % for the control (0 ppm) and 17.05 & 11.45 % for AA 200 ppm in the first and second seasons, respectively.

These results are in harmony with those results obtained by Ahmed, *et al.*, 2007, on Sewy date palms trees; Desouky *et al.*, 2007, on date palm trees; , Khayyat *et al.*, 2007, on date palm trees; Fekry, 2011, on Romy grapevines; Masoud and El-Sahrawy, 2012, on Washington navel orange trees; Ahmed *et al.*, 2012, on Amhat date palm trees and El-Gammal and Salama, 2014, on Manzanillo olive trees.

Generally, such increments in flowering and fruit set might be attributed to the increase in leaf photosynthetic pigments content and consequently on photosynthesis process and led to an increase in carbohydrates content of plant (Romheld and Marschner, 1991, on function of micronutrients in plant

and Tarraf *et al.*, 1999, on lemongrass). Shadded *et al.*, 1999, on *Lupinus termis* and *Vicia faba* plants) assumed that the effect of ascorbic acid on plant growth might be due to substantial role of ascorbic acid in many metabolic and physiological processes. In addition El-Kobisy *et al.*, 2005, on pea plants, stated that ascorbic acid is synthesized in the higher plants and affects plant growth and development, it is a product of D-glucose metabolism which affects some nutritional cycles activity in higher plants and play an important role in the electron transport system.

Antioxidants such as ascorbic acid has auxinic action and also synergistic effect on flowering and fruiting of fruit trees. Recently antioxidants used instead of auxins and other chemicals for enhancing growth and fruiting of various fruit trees(El Sayed *et al*., 2000, on grapevine; Hegab, 2000, on mandarin; Ahmed, 2001, on Hindy Bisinnara mango trees; Gobara, 2004, on Washington navel orange; Badran and Ahmed, 2009, on Taimour mango trees; Masoud and El-Sahrawy, 2012, on Washington navel orange and El-Sayed, Omima *et al*., 2014 on Manzanillo olive trees)

Table (4) Effect of ascorbic acid foliar application on number of solitary flowers, number of fruitlets from solitary flowers, fruit set percentage from solitary flowers and total flowers per twig of Washington navel orange trees on sour orange rootstock grown in newly reclaimed sandy soil (2013/2014-2014/2015 seasons).

Characteristics		Ascorbic acid concentrations									
		Control		050 ppm		100 ppm		150 ppm		200 ppm	
First season (2013/2014)											
Total number of solitary flowers per twig	Value	0.20	B	0.23	B	0.25	B	0.62	B	1.99	A
	*±%	-		15.00		25.00		210.00		895.00	
Number of fruitlets from solitary flowers per twig	Value	0.10	B	0.11	B	0.10	B	0.10	B	0.40	A
	±%	-		10.00		0.00		0.00		300.00	
Fruit set percentage for solitary flowers	Value	50.00	A	47.83	A	40.00	A	16.13	B	20.10	B
	±%	-		-2.17		-10.00		-33.87		-29.90	
Total number of flowers per twig	Value	33.45	D	43.28	D	49.56	CD	62.35	B	85.14	A
	±%	-		29.40		48.16		86.40		154.54	
Total number of set fruitlets per twig	Value	0.63	D	1.32	C	2.42	C	6.43	B	14.52	A
	±%	-		109.52		284.13		920.63		2204.76	
Overall fruit set percentage per twig	Value	1.88	E	3.05	D	4.88	C	10.31	B	17.05	A
	±%	-		1.17		3.00		8.43		15.17	
Second season (2014/2015)											
Total number of solitary flowers per twig	Value	0.21	B	0.23	B	0.24	B	0.58	B	1.62	A
	±%	-		9.52		14.29		176.19		671.43	
Number of fruitlets from solitary flowers per twig	Value	0.10	B	0.10	B	0.10	B	0.10	B	0.25	A
	±%	-		0.00		0.00		0.00		150.00	
Fruit set percentage for solitary flowers	Value	47.62	A	43.48	A	41.67	A	17.24	B	15.43	B
	±%	-		-4.14		-5.95		-30.38		-32.19	
Total number of flowers per twig	Value	48.39	E	58.16	D	70.94	C	84.77	B	113.66	A
	±%	-		20.18		46.60		75.18		134.88	
Total number of set fruitlets per twig	Value	0.62	D	1.53	C	2.83	C	5.81	B	13.01	A
	±%	-		146.77		356.45		837.10		1998.39	
Overall fruit set percentage per twig	Value	1.28	E	2.63	D	3.99	C	6.85	B	11.45	A
	±%	-		1.35		2.71		5.57		10.17	

***±% = increase or decrease % in relation to control.**

5. Yield components

Number of fruits per tree

From table (5) it is clear that the greatest numbers of fruits per tree were recorded by ascorbic acid 200 ppm treatment since, it peoduced 260.46 & 296.92 in the first and second seasons, respectively which surpassed the control by 248.66 and 261.36 %, respectively.

The yield per tree and per feddan

It is clear that the greatest yield per tree and per feddan were obtained by ascorbic acid 200 ppm being 54.68 & 64.15 kg / tree in the first and second seasons, respectively against only 19.59 & 21.40 kg, respectively for control tree.

In the two seasons, the greatest hypothetic yield per feddan was obtained by ascorbic acid 200 ppm being 11.48 & 13.47 tons /feddan, respectively against only 4.11 & 4.49 tons in the first and second seasons, respectively for the control.

Fruit weight

The two experimental seasons indicated greater fruit weight with the control in the first and second seasons being 262.28 & 260.39 (g), respectively against only 209.94 & 216.06 (g), respectively with AA at 200 ppm. It is generally observed that fruit weigh has a negative relationship with number of fruits / tree.

The abovementioned results agree with those obtained by Ahmed, *et al.*, 2007, on Sewy date palm trees; Desouky *et al.*, 2007, on date palm trees; , Khayyat *et al.*, 2007, on date palm trees; Fekry, 2011, on Romy grape vines; Masoud and El-Sahrawy, 2012, on Washington navel orange trees; Ahmed *et al.*, 2012, on Amhat date palm trees and El-Gammal and Salama, 2014, on Manzanillo olive trees.

These results could be explained on the light that ascorbic acid acts as coenzyme by which carbohydrates, fats are proteins are metabolized. Vitamin C led to increase nucleic acids content especially RNA. Smirnoff and Wheeler (2000) reported that ascorbic acid is an abundant component of plants. It reaches a concentration of over 20 mm in chloroplasts and occurs in all cell compartments including cell wall. It was suggested that ascorbic acid functions in photosynthesis, as an enzyme cofactor. Abdel-Aziz *et al.*, (2006), on *Khaya senegalensis* and Abdel Aziz *et al.,* (2009), on *Gladiolus grandiflora* L. indicated that application of ascorbic acid significantly increased all growth parameters as well as some chemical constituents. In addition, Maksoud *et al.,* (2009) on olive Trees stated that ascorbic acid as antioxidants appears to be a powerful tool for improving yield, fruit weight and flesh oil content of olive trees (Chemlali Cv.) planted in calcareous soil

Table (5) Effect of ascorbic acid foliar application at different concentrations on yield component characteristics of Washington navel orange trees budded on sour orange rootstock grown in newly reclaimed sandy soil (2013/2014-2014/2015 seasons).

Characteristics		Ascorbic acid concentrations									
		Control		050 ppm		100 ppm		150 ppm		200 ppm	
		First season (2013/2014)									
Number of fruits per tree	Value	74.70	E	165.81	D	203.92	C	232.09	B	260.46	A
	*±%	-		121.96		172.98		210.68		248.66	
Tree yield (kg)	Value	19.59	E	35.92	D	43.27	C	48.79	B	54.68	A
	±%	-		83.36		120.85		149.02		179.09	
Hypothetic yield per fed. (ton)	Value	4.11	E	7.54	D	9.09	C	10.25	B	11.48	A
	±%	-		83.36		120.85		149.02		179.09	
Fruit weight(g)	Value	262.28	A	216.67	B	212.19	B	210.22	B	209.94	B
	±%	-		-17.39		-19.10		-19.85		-19.95	
		Second season (2014/2015)									
Number of fruits per tree	Value	82.17	E	184.05	D	228.39	C	259.94	B	296.92	A
	±%	-		123.99		177.95		216.35		261.36	
Tree yield (kg)	Value	21.40	E	39.57	D	48.09	C	54.31	B	64.15	A
	±%	-		84.94		124.75		153.85		199.84	
Hypothetic yield per fed. (ton)	Value	4.49	E	8.31	D	10.10	C	11.41	B	13.47	A
	±%	-		84.94		124.75		153.85		199.84	
Fruit weight(g)	Value	260.39	A	215.00	B	210.55	B	208.94	B	216.06	B
	±%	-		-17.43		-19.14		-19.76		-17.03	

***±% = increase or decrease % in relation to control.**

6. Physical fruit characteristics:

Fruit volume

Data in table (6) show clear that in the two experimental seasons, greater fruit volume came from the control being 207.50 & 202.50 cm^3 in the first and second seasons, respectively against 161.11 & 158.06 cm^3 for AA 200 ppm, respectively.

Fruit length

The two experimental seasons indicated greater fruit length for the control being 8.13 & 8.14 cm in the first and second seasons, respectively against 7.36 & 7.33 cm, respectively for fruit of AA 200 ppm.

Fruit diameter

The two experimental seasons indicated greater fruit diameter for the control being 7.63 & 7.64 cm in the first and second seasons, respectively against 7.27 & 7.35 cm, respectively for a fruit of AA at 200 ppm.

Fruit shape index, peel weight and peel thickness

In the two seasons of investigation, all the tested treatments failed to induce any significant effect on the above characteristics.

Pulp weight

The two experimental seasons indicated greater pulp weight with the control being 217.78 & 214.89 (g) in the first and second seasons, respectively against 174.22 & 179.11 g with AA 200 ppm, respectively.

7. Juice volume and juice chemical constituents

Juice volume and weight per fruit, Juice TSS and ascorbic acid contents

In the two seasons of investigation, all the tested treatments failed to induce any significant effect on the above characteristics.

Juice acidity

In the two experimental seasons, greater juice acidity came from the control (1.09% in both seasons), while the least values were recorded for AA 200 ppm (0.90 & 0.92 % in the first and second seasons, respectively).

TSS/acid ratio

In the two experimental seasons, greater TSS/acid ratio came from ascorbic acid treatments with the concentrations 100, 150 and 200 ppm being 16.88 & 18.26, 19.72 & 19.45, 17.20 & 16.80 in the first and second seasons, respectively, against 13.79 for the control in both seasons.

From the abovementioned results, it could be concluded that, foliar spray with ascorbic acid at 200 ppm three times (i.e. at the beginning of flowering, at full bloom and at fruitlet diameter of 0.5-1.0 cm) is the recommended treatment to obtain high yield with good quality of Washington navel orange trees.

Table (6) Effect of ascorbic acid foliar application on some physical fruit characteristics of Washington navel orange trees on sour orange rootstock grown in newly reclaimed sandy soil (2013/2014-2014/2015 seasons).

Characteristics		Ascorbic acid concentrations									
		Control		050 ppm		100 ppm		150 ppm		200 ppm	
		First season (2013/2014)									
Fruit volume (cm^3)	Value	207.50	A	148.61	B	151.29	B	143.89	B	161.11	B
	*±%	-		-28.38		-27.09		-30.66		-22.36	
Fruit length (L) (cm)	Value	8.13	A	7.51	B	7.69	BC	7.54	BC	7.26	D
	±%	-		-7.59		-5.44		-7.19		-10.73	
Fruit diameter(D) (cm)	Value	7.63	A	7.28	B	7.16	B	7.19	B	7.27	B
	±%	-		-4.52		-6.14		-5.76		-4.73	
Fruit shape index(L/D)	Value	1.07	A	1.03	A	1.07	A	1.05	A	1.00	A
	±%	NS		NS		NS		NS		NS	
Peel weight (g)	Value	44.50	A	42.94	A	40.59	A	42.44	A	35.72	B
	±%	-		-3.50		-8.79		-4.62		-19.73	
Peel thickness (mm)	Value	2.96	A	3.69	A	3.86	A	3.32	A	3.08	A
	±%	NS		NS		NS		NS		NS	
Pulp weight (g)	Value	217.78	A	173.72	B	171.60	B	167.78	B	174.22	B
	±%	-		-20.23		-21.20		-22.96		-20.00	
		Second season (2014/2015)									
Fruit volume (cm^3)	Value	202.50	A	153.06	B	161.74	B	156.94	B	158.06	B
	±%	-		-24.42		-20.13		-22.50		-21.95	
Fruit length (L) (cm)	Value	8.14	A	7.41	B	7.87	BC	7.51	BC	7.33	D
	±%	-		-9.01		-3.27		-7.78		-9.96	
Fruit diameter(D) (cm)	Value	7.64	A	7.27	B	7.15	B	7.21	B	7.35	B
	±%	-		-4.87		-6.36		-5.60		-3.78	
Fruit shape index(L/D)	Value	1.07	A	1.02	A	1.10	A	1.04	A	1.00	A
	±%	NS		NS		NS		NS		NS	
Peel weight (g)	Value	45.50	A	41.22	A	41.84	A	42.72	A	36.94	B
	±%	-		-9.40		-8.04		-6.11		-18.80	
Peel thickness (mm)	Value	2.87	A	3.69	A	3.83	A	3.14	A	3.12	A
	±%	NS		NS		NS		NS		NS	
Pulp weight (g)	Value	214.89	A	173.78	B	168.71	B	166.22	B	179.11	B
	±%	-		-19.13		-21.49		-22.65		-16.65	

***±% = increase or decrease % in relation to control.**

Table (7) Effect of ascorbic acid foliar application on some chemical constituents of fruit juice of Washington navel orange on sour orange rootstock grown in newly reclaimed sandy soil (2013/2014-2014/2015 seasons).

Characteristics		Ascorbic acid concentrations									
		Control		050 ppm		100 ppm		150 ppm		200 ppm	
		First season (2013/2014)									
Juice volume/ fruit (cm^3)	Value	85.53	A	79.07	A	67.74	A	84.44	A	84.15	A
	*±%	NS		NS		NS		NS		NS	
Juice weight/ fruit (g)	Value	82.39	A	76.17	A	65.25	A	81.33	A	81.06	A
	±%	NS		NS		NS		NS		NS	
Juice TSS (%)	Value	15.00	A	15.56	A	15.32	A	15.78	A	15.44	A
	±%	NS		NS		NS		NS		NS	
Juice acidity (%)	Value	1.09	A	1.04	A	0.91	BC	0.80	BC	0.90	C
	±%	-		-0.05		-0.18		-0.29		-0.19	
TSS/acid ratio	Value	13.79	C	15.03	B	16.88	A	19.72	A	17.20	A
	±%	-		9.02		22.40		43.05		24.74	
Ascorbic acid (mg/100 ml)	Value	36.30	A	37.58	A	31.30	A	35.20	A	32.08	A
	±%	NS		NS		NS		NS		NS	
		Second season (2014/2015)									
Juice volume/ fruit (cm^3)	Value	84.03	A	74.75	A	73.37	A	86.34	A	78.50	A
	±%	NS		NS		NS		NS		NS	
Juice weight/ fruit (g)	Value	80.94	A	72.00	A	70.67	A	83.17	A	75.61	A
	±%	NS		NS		NS		NS		NS	
Juice TSS (%)	Value	15.00	A	15.78	A	15.65	A	15.56	A	15.39	A
	±%	NS		NS		NS		NS		NS	
Juice acidity (%)	Value	1.09	A	1.08	A	0.86	BC	0.80	BC	0.92	C
	±%	-		-0.01		-0.23		-0.29		-0.17	
TSS/acid ratio	Value	13.79	C	14.65	B	18.26	A	19.45	A	16.80	A
	±%	-		6.26		32.42		41.04		21.86	
Ascorbic acid (mg/100 ml)	Value	36.30	A	34.47	A	32.90	A	36.58	A	33.64	A
	±%	NS		NS		NS		NS		NS	

***±% = increase or decrease % in relation to control.**

8. IAA concentrations(mg / 100g F. W.) in the leaves, flowers and fruitlets

In leaves

Five leaf samples for IAA determination were taken on mid Feb., beginning of Mar., mid Mar., beginning of Apr. and mid Apr. in each season.

Data in table 8 show that the greatest IAA concentrations in leaves were obtained by ascorbic acid 200 ppm being 5.824, 5.882, 5.882, 6.170 and 6.214 (mg / 100g F. W.) for the five samples, respectively against only 3.090, 3.355, 3.380, 3.488 and 3.527 (mg / 100g F. W.), respectively for the control in the first season.

In the second season, also, the greatest IAA concentrations in mature leaves were obtained by ascorbic acid 200 ppm being 5.836, 5.852, 6.008, 6.214 and 6.277 (mg / 100g F. W.) for the five samples, respectively against only 3.190, 3.308, 3.426, 3.711 and 3.814 (mg / 100g F. W.), respectively for control.

In of flowers and fruitlets

As shown in table (9), flowers and fruitlets samples were taken on mid Mar. and mid Apr. of each season.

It is clear that the greatest IAA concentrations in flowers and fruitlets were obtained by ascorbic acid at 200 ppm being 7.093 and 6.384 (mg / 100g F. W.), respectively against only 1.842 and 2.303 (mg / 100g F. W.), respectively for control mid of March and mid of April, respectively in the first season.

In the second season, the greatest IAA concentrations in flowers and fruitlets were obtained by ascorbic acid 200 ppm being 8.217 and 9.031(mg / 100g F. W.), respectively against only 2.719 and 3.274 (mg / 100g F. W.), respectively for control.

Table (8) Effect of ascorbic acid foliar application on IAA concentrations (mg / 100 g F. W.) of mature leaf of Washington navel orange on sour orange rootstock grown in newly reclaimed sandy soil (2013/2014-2014/2015 seasons).

Sampling date		Ascorbic acid concentrations									
		Control		050 ppm		100 ppm		150 ppm		200 ppm	
First season (2013/2014)											
Mature leaf IAA concentration at mid of February	Value	3.090	D	3.834	C	4.699	B	5.384	A	5.824	A
	*±%	-		24.078		52.071		74.239		88.479	
Mature leaf IAA concentration at first of March	Value	3.355	D	3.969	C	4.886	B	5.581	A	5.882	A
	±%	-		18.301		45.633		66.349		75.320	
Mature leaf IAA concentration at mid of March	Value	3.380	E	4.331	D	4.886	C	5.590	B	5.882	A
	±%	-		28.136		44.556		65.385		74.024	
Mature leaf IAA concentration at first of April	Value	3.488	E	4.553	D	5.039	C	5.680	B	6.170	A
	±%	-		30.533		44.467		62.844		76.892	
Mature leaf IAA concentration at mid of April	Value	3.527	E	4.560	D	5.135	C	5.689	B	6.214	A
	±%	-		29.288		45.591		61.299		76.184	
Second season (2014/2015)											
Mature leaf IAA concentration at mid of February	Value	3.190	D	3.889	C	4.745	B	5.425	A	5.836	A
	±%	-		21.912		48.746		70.063		82.947	
Mature leaf IAA concentration at first of March	Value	3.308	D	3.915	C	4.774	B	5.467	A	5.852	A
	±%	-		18.349		44.317		65.266		76.904	
Mature leaf IAA concentration at mid of March	Value	3.426	E	4.526	D	4.986	C	5.625	B	6.008	A
	±%	-		32.107		45.534		64.186		75.365	
Mature leaf IAA concentration at first of April	Value	3.711	E	4.560	D	5.166	C	5.737	B	6.214	A
	±%	-		22.878		39.208		54.594		67.448	
Mature leaf IAA concentration at mid of April	Value	3.814	E	4.674	D	5.384	C	5.760	B	6.277	A
	±%	-		22.549		41.164		51.023		64.578	

***±% = increase or decrease % in relation to control.**

Table (9) Effect of ascorbic acid foliar application on IAA concentrations (mg / 100 g F. W.) of flowers and fruitlets of Washington navel orange on sour orange rootstock grown in newly reclaimed sandy soil (2013/2014-2014/2015 seasons).

Sampling date		Ascorbic acid concentrations									
		Control		050 ppm		100 ppm		150 ppm		200 ppm	
First season (2013/2014)											
Flowers IAA concentration at mid of March	Value	1.842	E	2.828	D	4.325	C	5.312	B	7.093	A
	±%	-		53.529		134.799		188.382		285.071	
Fruitlet IAA concentration at mid of April	Value	2.303		3.916		5.346		6.020		6.384	
	±%	-	E	70.039	D	132.132	C	161.398	B	177.204	A
Second season (2014/2015)											
Flowers IAA concentration at mid of March	Value	2.719	E	4.300	D	4.757	C	6.938	B	8.217	A
	±%	-		58.146		74.954		155.167		202.207	
Fruitlet IAA concentration at mid of April	Value	3.274	E	4.452	D	5.744	C	6.176	B	9.031	A
	±%	-		35.980		75.443		88.638		175.840	

***±% = increase or decrease % in relation to control.**

The obtained results agree with Palmieri and Giovinazzi (2006) who stated that in the presence of excess ascorbic acid, the indole-acetic acid oxidation catalysis is apparently blocked.

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تاثير الرش الورقي بحمض الاسكوربيك على التزهير و عقد الثمار ومحصول اشجار البرتقال صنف واشنجطن نافال

طارق علي محمود سليمان

قسم الموالح – معهد بحوث البساتين- مركز البحوث الزراعية – الجيزة – مصر.

اجري هذا البحث خلال موسمي ٢٠١٣ /٢٠١٤ ، ٢٠١٤/٢٠١٥ حيث تم رش اشجار البرتقال صنف واشنجطن نافال على اصل نارنج بمحلول حمض الاسكوربيك بتركيز صفر (مقارنة) ٥٠، ١٠٠، ١٥٠، ٢٠٠ جزء في المليون في ثلاث مراحل فسيولوجية عند- بداية التزهير وعند قمة التزهير وكذا عندما تصل قطر ثمرة ٠.٥ – ١سم٣ و قد تلقت كل اشجار التجربة الثلاث رشات و كان حجم محلول الرش للشجرة الواحدة حوالى ٧ لترات في كل رشة. ولقداظهرت النتائج انه تحت ظروف زيادة التركيز ارتفاعا في نسبة البراعم المختلطة و في نسبة تفتح البراعم و في العدد الكلي للنورات الزهرية و عدد النورات الورقية و عدد الازهار المنفردة على الفرع و كان ذلك واضحا في الموسمين. و قد سبب التركيز الاعلى من حمض الاسكوربيك(٢٠٠ جزء في المليون) زيادة معنوية عي عدد الثمار للشجرة ليصل الى ١٩٥.٨٣ ، ٢٢٣.٢٥ ثمرة في الموسم الاول و الثاني على التوالى مقارنة معاملة المقارنة التي انتجت ٥٦.٧٠ ، ٦١.٧٨ ثمرة على التوالى . و كان محصول الشجرة ٤١.١١ ٤٨.٢٣ كجم في الموسم الاول و الثاني على التوالى مع الرش بحمض الاسكوربيك ٢٠٠ جزء في المليون مقابل ٤١.٧٣ ، ١٦.٠١ كجم على التوالى لشجرة المقارنة. وبالإضافة إلى ذلك وجد أن أعلى تركيزات لحمض الاسكوربيك زادت معنويا من تركيزات اندول حمض الخليك في الاوراق و الازهار و العقد.