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Yield and fruit quality of Washington Navel orange as influenced by preharvest application of giberellic, citric, ascorbic and salicylic acids

El-Khayat HM
Citriculture Division, Horticulture Research Institute, Agric. Res. Center (ARC), Egypt

Corresponding author: Elkhayat _h_m66 @ yahoo.com

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ABSTRACT

Aim: The study was carried out to investigate effect on tree yield and fruit quality characteristics at harvest and during shelf life.

Materials and Methods: The study was conducted during 2015 and 2016 seasons on ten years old Washington navel orange trees grown in clay soil which were sprayed three times in July, September and November with gibberellic acid at 30ppm and ascorbic acid, citric acid and salicylic acid each at 400ppm (for all spraying times). Trees were harvested in the end of January (late season).

Results: All sprayed substances delayed fruit peel ageing, fruit color break and decreased preharvest fruit drop. It was also indicated that gbberellic acid treatment increased canopy volume index, shoot length, fruit peel thickness, leaf calcium and fruit peel resistance. Moreover ascorbic acid sprays led to an access in fruit length, fruit diameter, leaf nitrogen, potassium and calcium, V.C., TSS and TSS /Acidity. Citric acid increased leaf area whereas ascorbic acid and citric acid treatments gave higher trunk across, total and reducing sugars. Salicylic acid application enhanced chlorophyll a and b, yield, fruit peel thickness, acidity and fruit peel resistance. Application of previous antioxidants then storage at room temperature for a week and two weeks revealed that ascorbic acid application increased VC, TSS, TSS/acidity and total sugar. Also, ascorbic acid and citric acid treatments increased reduced and unreduced sugar. Citric acid spraying led to an increase of weight loss than all other treatments. Gibberellic acid and salicylic acid application enhanced Fruit peel resistance. All antioxidants treatments reduced decay as compared with control. The TSS, TSS/Acidity, total and non reducing sugars, fruit weight loss percentage decay of citrus fruits were increased whereas, acidity ,reduced sugar and fruit peel resistance were decreased gradually and significantly by increasing storage periods.

Conclusion: It was concluded that gbberellic acid treatment increased canopy volume index, shoot length, fruit peel thickness, leaf calcium and fruit peel resistance. Moreover ascorbic acid sprays led to an access in fruit length, fruit diameter, leaf nitrogen, potassium and calcium, V.C., TSS and TSS /Acidity.

Keywords: Fruit quality, navel orange, preharvest sprays, shelf life.

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Introduction

Washington navel orange is the leading citrus variety in Egypt. Its cultivation reached an area of 156514 f with total production estimated to be1697222 tons of orange fruits according to the statistics of Ministry of Agriculture, Egypt (2015). Generally, citrus face several quality fruit disorders such as creasing, splitting, puffing and peel pitting which would all affect its marketing and keeping quality such as Navel orange. In Egypt it is mainly fresh consumed either in the local market or for exportation.

Therefore, producing a Navel orange fruit with the best external and internal quality characteristics at harvest and during marketing is a main objective of growers. Thus, Preharvest foliar application with some agrochemicals that may play an important role in enhancing fruit quality would be investigated. Several studies to overcome fruit quality deterioration at and after harvest by using different types of agrochemicals were reported by Marzouk and Kassem **(**2011). The plant growth regulators such as gibbrellic acid may be a tool for enabling a good quality produce (Ismail 1997). Gibberellic acid is known to slow down fruit ripening and to delay fruit senescence. It is proven to be effective in

retarding citrus fruit maturation and quality disorders such as rind softening, creasing, peel pitting and puffing (Agusti et al 2002; Tumminelli et al 2005). Similarly, salicylic acid is reported to retard quality disorders and decrease disease infection especially fungal in many fruit species (Rizk-Alla et al., 2001, 2006). It is a phenolic compound that regulates a number of processes in plants such as inhibiting ethylene biosynthesis (Leslie and Romani.1988, 2003), regulating expression of pathogenesis related protein genes, and provides resistance against pathogen attack (Srivastava and Dwivedi, 2000). In the mean time, exogenous application of salicylic acid is reported to reduce decay, delay ripening and extend storage life of various fruits such as banana and Kiwi (Zhang et al., 2003). Gibberellins are known to delay ripening and senescence of fruits. Moreover, ascorbic acid is an abundant component of plants which occurs in all cell compartments, including the cell wall. It is considered as an antioxidant and in association with other components of the antioxidant system. It protects plants against oxidative damage resulting from aerobic metabolism, photosynthesis and a range of pollutants (Smirnoff, 1996). Further, Citric acid plays an essential role in signal activating transporter enzymes, metabolism and translocation of carbohydrates, transduction system, membrane stability and functions, (Bhaskaran *et al*., 1985 and Smirnoff, 1996). Salicylic participates in the regulation of physiological processes in plants such as growth, development, transpiration as well as uptake and transport of nutrients, ethylene production and photosynthesis, nitrate metabolism, (Van-Huijsduijnen *et al*., 1986 and Hayat and Ahmed, 2007). In addition, it provides protection against biotic and abiotic stresses (Kaya *et al*., 2002). Also, salicylic acid may also have a role in enhancing the antioxidant defense system against the free radical damages of plant cells, which would slow fruit tissues deterioration and senescence.

In accordance to the above discussed, the present study was conducted to investigate the effect of gibberellic acid, salicylic acid, ascorbic acid, citric acid and salicylic acid preharvest foliar sprays on the navel orange fruit quality at harvest and after keeping for 7 and 14 days at room temperature.

Materials and Methods

Plant materials and statistical design

The present study was carried out during the two successive seasons of 2015 and 2016 on ten years old Washington Navel orange (*Citrus sinensis*, L.) budded on sour orange rootstock (*Citrus. aurantium, L.*) grown in clay soil in a private orchard, in Kafr El Dawar, El Behera governorate, Egypt. The trees were spaced at 5 x 5 m and received similar cultural practices adopted in the orchard. Sixty trees were selected as uniform as possible in growth, productivity and appearance. Trees were sprayed three times In July ,September and November with gibberellic acid (GA_3) at 30ppm and Salicylic acid (SA), ascorbic acid (AA) and Citric acid (CA) each at 400 ppm (for all spraying times) and water as control . The Triton B emulsifier at a rate of 0.2 % was used with each spray solution as wetting agent to have best solution penetration. Trees were sprayed until runoff. Five treatments were arranged in a randomized complete block design (RCBD) with 4 replicates per treatment and three trees per replicate. In the spring of each season, 20 non –fruiting shoots of spring cycle were tagged at constant height and at all directions of each tree .In September, the average length of tagged shoots was measured.

-The canopy height and diameter at 1 m were measured at the end of both growing seasons (October).

-Shoot length was measured. -The trunk cross sectional area (TCSA) at 20 cm was calculated at the end of both growing seasons. -The leaf area was measured -Chlorophyll a and b were determined according to Wintermans and Mats (1965).

Leaves were oven dried at 70°C to constant weight and then were grounded. To determine the leaf mineral contents, the ground material of each sample was digested with H_2SO_4 and H_2O_2 according to Wolf (1982).

-In the digested solution total nitrogen and phosphorus were determined calorimetrically according to Evenhuis and Dewaard (1976) and Murphy and Riley (1962), respectively. -Potassium was determined by flame photometer as described by Cheng and Bray (1951).-Calcium was determined by atomic absorption according to Carter (1993).

Fruit sampling

After commercial harvest date (when fruit coloring reached about 75%) in the end of

January, a sample of 15 fruit was randomly collected from each replicate in order to determine the effect of the different treatments on fruit quality characteristics at harvest date. Another sample of 30 fruit per replicate was taken and left in room temperature at (22±2°C) for 7 and 14 days in order to investigate the effect of the different treatments on fruit shelf life and keeping quality after harvest

Quality Assessments

At harvest:

-Average fruit weight (g) was recorded then the total yield/ tree (kg) was calculated and average peel thickness (mm) was measured. Fruit peel resistance values were determined using Lfra Texture Analyser in 5 mm depth and 0.2 mm /second speed, for measuring firmness of orange, these values were determined by taking the firmness value of six fruits by two sides and the average of the fruit firmness was calculated as (g/sq. cm) Harold(1985).

-In fruit juice, vitamin C (mg ascorbic acid /100 ml juice) was determined according to A.O.A.C. (1995) the percentage of fruit total soluble solids (TSS) was measured using a hand refractometer. Acidity (%) as citric acid and the TSS: acidity ratio was calculated.

-In addition, total and reducing sugars content (%) was determined according to Malik and Singh (1980). The non-reducing sugars were calculated by the difference between total sugars and reducing sugars.

After 7 and 14 days shelf life:

-Fruit weight loss (WL) was recorded by weighing (g) the fruits before and after shelf life and the percentage of weight loss was calculated as follow:

% weight loss= final weight/initial weight X 100

-Fruit peel resistance

-Ascorbic acid (V.C.) ,fruit TSS , acidity , TSS: acidity and sugars content was measured as mentioned above.

-Fruit decay was detected as fruits defected with any pathological or physiological disorders and the percentage of fruit decay was calculated according to the total number of the fruit.

Statistical analysis

The obtained data of both seasons were subjected to analysis of variance according to Clark and Kempson (1997) .Least significant difference (L.S.D) at 0.05 level of probability (Steel and Torrie, 1984) was used to compare the main effect of the different treatments on fruit quality characteristics at harvest and after keeping at room temperature for 7 and 14 days. Obtained data were analyzed using the SAS 2000 program.

Results and Discussion

Results indicated that gibberellic acid significantly increased canopy volume index in the first season as compared with all other treatments (Table 1). Also, plants sprayed with gibberellic acid had significantly higher shoot length in the first season as compared with trees sprayed with other treatments. However, in the second season, citric acid gave significantly the highest shoot length. Moreover, sprayed plants with citric acid and ascorbic acid treatments indicated a significant increase in trunk cross sectional area when compared with all other treatments. Smirnoff (1996); Lee and Kader (2000) and Pignocchi and Foyer (2003) studied vegetative growth parameters as a result of ascorbic and citric acids application may be due to their auxinic action and its role in many metabolic and physiological processes. Moustafa and Saleh (2006) on "Anna" apple trees, Kassem *et al*. (2010b) and Fathi *et al*. (2011) on "Costata" persimmon trees also reported that shoot length was increased by GA application.

The application of ascorbic acid gave a significant increase in leaf area as compared with gibberellic acid and control in2015 and all other treatments in 2016 (Table1). Abd El Raheem (2013) on navel orange found that, there were significant differences among growth regulators treatment on leaf area whereas, all treatments increased leaf area compared to control treatment.

Moreover, data inTtable1 indicated that, the application of salicylic acid resulted significantly greater Chlorophyll a and b than other applications in both seasons. Abd El Raheem (2013) on navel orange reported that the high concentrations of CPPU at 7.5 or 10 ppm caused the demolition of chlorophyll, decreased the concentrations of leaf chlorophyll (a &b).

Regarding mineral composition (Table 1&2), leaf nitrogen tended to be significantly higher with ascorbic acid application as compared with other applications. These results are in line with those obtained by Ahmed and Seleem (2008) they found that spraying "Thompson seedless" grapevines with antioxidants namely ascorbic acid and citric acid increased leaf N content.

Table 1. Effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid on Canopy volume index, Shoot length, Trunk cross sectional area, Leaf Area, Chlorophyll a &b and Leaf Nitrogen

Treatments	**Canopy volume index (m^3)**		**Shoot length (cm)**		**Trunk cross sectional area (cm^2)**		Leaf Area(cm)		**Chlorophyll a (mg/l)**		**Chlorophyll b (mg/l)**		Leaf Nitrogen	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	b8.8	c9.8	d11.5	c12.9	b49	cd55.1	b17.2	c18.9	c2.00	c2.02	b1.42	b1.35	c2.63	c2.57
Gibberellic acid (GA_3)	a11.3	a11.8	a13.2	b13.4	b49.7	b57.1	b18.2	b24.5	b2.23	b2.27	a1.49	b1.37	cb2.71	c2.55
Ascorbic acid (AA)	b9.5	a11.7	b12.7	a13.9	a54.4	a61.2	a23.9	a28.8	c1.98	c1.98	c1.39	d1.24	a3.91	a3.01
Citric acid (CA)	b8.9	b11.4	c11.8	b13.3	a53.3	a60.8	ab20.3	b24.7	c1.98	c1.94	bc1.41	c1.3	b2.97	b2.72
Salicylic acid (SA)	b9.5	a11.7	c11.7	b13.5	b49.7	c55.2	a22.67	c19.13	a2.35	a2.43	a1.48	a1.47	c2.66	c2.57
LSD.05	1.3085	0.2855	0.1575	0.3420	1.4002	1.3798	4.2117	1.2284	0.0924	0.1353	0.0266	0.0206	0.3017	0.0555

Table 2. Effect of gibberellic acid, ascorbic acid, citric acid and salicylic acid on leaf Phosphorus, potassium and calcium, peel thikness, fruit diameter and fruit length

Treatments	Leaf Phosphorus		Leaf Potassium		Leaf Calcium		Yield (Kg/ tree		Peel thikness		Fruit diameter (cm)		Fruit length (cm	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	bc0.153	a0.145	a1.1	b1.33	c2.5	c2.73	c98.6	94.1c	e5.05	5.16d	a7.5	c11.5	d10.66	a8.9
Gibberellic acid (GA_3)	dc0.151	a0.147	a1.15	b1.27	a3.01	b2.93	a102	a102	5.81b	6.33a	a7.78	d10.66	c11.5	a9.3
Ascorbic acid (AA)	ab0.156	a0.152	a1.25	a1.44	b2.79	a3.1	bc99.5	a104.6	c5.56	5.74b	a7.9	a12.59	a12.59	a9.2
Citric acid (CA)	d0.148	a0.152	a1.12	ab1.36	b2.8	b2.95	ab100.8	a105.9	5.3d	5.46c	a7.56	c11.89	c11.89	a9.0
Salicylic acid (SA)	a0.158	a0.151	a1.11	ab1.35	c2.56	b2.93	a101.6	a105.8	a6.27	6.39a	a7.82	e10.33	e10.33	a9.2
LSD.05	0.0041	0.0075	0.3263	.1078	0.2025	0.1275	1.5454	7.7049	0.0579	0.646	0.923	0.2611	0.2611	0.7944

Also, Fayed (2010, a) on "Manfalouty" pomegranate trees, Fayed (2010b) on "Thompson seedless" grapevine indicated that foliar application of ascorbic acid increased leaf N content. Furthermore, Hassan et al. (2010) on" Hollywood" plum trees and Shahin et al. (2010) on "Anna" apple trees revealed that spraying gibberellic acid increased leaf N content.

As for leaf phosphorus, the data indicated that leaf phosphorus increased significantly with

salicylic acid treatment as compared with citric acid, gibberellic acid and control. These results are partially similar with those obtained by Hassan et al. (2010) he found that spraying "Hollywood" plum trees with GA_3 decreased leaf P content , whereas citric acid enhanced leaf P content . On the other hand , Ahmed and Seleem (2008) ,Fayed (2010, a) on "Manfalouty" pomegranate trees and Fayed (2010b) on "Thompson seedless" grapevines reported that spraying "Thompson seedless" grapevines with antioxidants namely ascorbic acid and citric acid increased leaf P. Also, Shahin *et al*. (2010) on "Anna" Apple trees found that spraying gibberellic acid increased leaf P contents as compared with control.

With regard to leaf potassium, plants treated with ascorbic acid had significantly higher leaf potassium than those treated with gibberellic acid and control. These results are in line with those obtained by Ahmed and Seleem (2008) ,Fayed . (2010, a) on "Manfalouty" pomegranate trees and Fayed (2010, b) on "Thompson seedless" grapevines who found that spraying "Thompson seedless" grapevines with antioxidants namely ascorbic acid and citric acid increased leaf K. On the other hand, Hassan et al. (2010) on" Hollywood" plum trees, Shahin et al. (2010) on "Anna" Apple trees reported that spraying gibberellic acid increased leaf K content as compared with control.

Data of leaf calcium content revealed that gibberellic acid in 2015 and ascorbic acid in 2016 gave significantly highest leaf calcium. These results are similar to those reported by El Shazly et al (2013) who indicated that trees received salicylic acid had significantly less leaf calcium content than those treated with gibberellic acid, ascorbic and citric acids in both seasons.

Tree yield:

As for yield, salicylic acid gave significantly higher yield (therefore increasing the means of fruit weight) as compared with control (Table2). These results are similar to those found by Kabeel (1999),El-Seginy *et al*. (2003) on "Anna" apple trees, Yehia and Hassan (2005) on "Le- Conte" pear trees, Hassan *et al*. (2010) on "Hollywood" plum trees, Kassem *et al*. (2010, b) on "Costata" persimmon trees, Shahin *et al*. (2010) on "Anna" apple trees, and Stino *et al*. (2011) on "Le-Conte" pear trees, Marzouk and Kassem (2011) on Navel Orange gibberelic acid increased total yield as compared with other different agro- chemical.

Fruit quality at harvest:

Fruit physical characters:

As for peel thickness (Table 2) indicated that plants treated with gibberellic acid and salicylic acid had significantly higher peel thickness than those treated with other treatments. Also, peel thickness of control plants fruits was significantly lower than all other treatments. Moreover, ascorbic acid treatment gave significantly higher peel thickness than significantly higher peel thickness than citric acid treatment in both seasons .Furthermore ,the data (Table 2) showed that in 2015 season ascorbic acid treatment had significantly the highest fruit diameter and fruit length. Also, all treatments significantly increased fruit length as compared with control. These findings are in harmony with those obtained by Ahmed *e*t al. (2007) Maksoud *et al.* (2009) on olive trees and Fayed (2010, b) on "Thompson seedless" grapevines revealed that spraying "Sewy" date fruits with ascorbic acid improved fruit length. Also, Burak and Buyukyilmaz (1998) on "Starking Delicious" apple, El-Shaikh et al. (1999) on "Costata" persimmon, Qayum et al. (2002) on "Red Delicious" apples, Usenik and Kastelec (2004) on sweet cherry cultivars "Van and Sunburst", Yehia and Hassan (2005) on "Le- Conte" pear trees and Ismail (2006) on "Desert Red" peach fruits indicated that GA_3 application increased fruit diameter and length.

Concerning data (Table 3), Vitamin C content, Tss and Tss /acidity, fruits of the trees sprayed with ascorbic acid had significantly higher vitamin C, Tss and Tss/acidity as compared with fruits in trees sprayed with all other treatments in both 2015 and 2016. Wereas, plants treated with salicylic acid had higher acidity as compared with all other treatments. These findings are confirmed with those obtained by Ahmed et al. (2007) on "Sewy" dates fruits, Fayed (2010, a) on "Manfalouty" pomegranate trees, Fayed (2010, b) on "Thompson seedless" grapevines, Hafez et al. (2010) on "Le-Conte" pear fruits and Mansour et al. (2010) on mango fruits. They reported that spraying ascorbic and citric acids improved fruit TSS. Moreover, Barakat et al (2012) demonstrated that total soluble solids contents of orange fruits increased by using some Biological treatments.

As for fruit peel resistance, gibberellic acid and salicylic acid treatments gave a significant increase in fruit peel resistance as compared with

all other treatments. Also, using ascorbic acid caused a significant increase in fruit peel resistance as compared with using citric acid in the first season. In the second season, gibberellic acid had significantly higher fruit peel resistance as compared with all other treatments. Moreover, salicylic acid treatment led to a significant increase in fruit peel resistance as compared ascorbic acid and citric acid treatments. Furthermore, fruit peel resistance in fruit with all treatments was significantly higher when compared with control. Trend results are similar to those indicated by Kappel and MacDonald (2002) on sweet cherries, El-Seginy *et al*. (2003) on "Anna" apple trees, Usenik *et al*. (2005) on sweet cherry fruits, Yehia and Hassan (2005) on "Le-Conte" pear trees, Cline and Trought (2007) on "Bing and Sam" sweet cherries, Hassan *et al*. (2010) on "Hollywood" plum trees and Hegazi (2011) on "Le- Conte" pear tree. They reported that gibberellic acid (GA_3) applications increased fruit firmness. Moreover, Kazemi *et al*. (2011, a) on "Jonagold" apple fruits, Kazemi *et al*. (2011, b) on "Hayward" Kiwifruit and Shaaban *et al*. (2011) on "Anna" apple fruits. They found that application of salicylic acid increased fruit firmness.

Fruit chemical characters

Concerning data (Table 3), Vitamin C content, Tss and Tss /acidity, fruits of the trees sprayed with ascorbic acid had significantly higher vitamin C, Tss and Tss/acidity as compared with fruits in trees sprayed with all other treatments in both 2015 and 2016. Whereas, trees treated with salicylic acid had higher acidity as compared with all other treatments. These findings are confirmed with those obtained by Ahmed et al. (2007) on "Sewy" dates fruits, Fayed (2010, a) on "Manfalouty" pomegranate trees, Fayed (2010, b) on "Thompson seedless" grapevines, Hafez et al. (2010) on "Le-Conte" pear fruits and Mansour et al. (2010) on mango fruits. They reported that spraying ascorbic and citric acids improved fruit TSS. Moreover, Barakat et al (2012) demonstrated that total soluble solids contents of orange fruits increased by using some Biological treatments.

With regard to total sugar the data (Table 3) showed that using citric acid gave significantly higher total sugar in comparison with using salicylic acid salicylic acid and gibberellic acid also, significantly higher reduced sugar as compared with salicylic acid salicylic acid and gibberellic acid and control in both seasons. Whereas, no significant differences were found for non reducing sugars. Trend of results obtained are in line with Ahmed *et al*. (2007) on "Sewy" date fruits, Ahmed and Seleem (2008) on "Thompson seedless" grapevines, Fayed (2010, a) on "Manfalouty" pomegranate trees, Hafez *et al*. (2010) on "Le– Conte" pear fruits and Mansour *et al*. (2010) on mango fruits reported that spraying ascorbic acid and citric acid increased fruit total sugars. On the other hand, El-Seginy et al. (2003) and Shahin et al. (2010) on "Anna" apple trees found that GA_3 improved fruit total sugar.

Fruit quality during shelf life:

Fruit weight loss:

Regarding fruit weight loss in Table 4, fruits of plants treated with citric acid had significantly higher fruit weight loss as compared with fruits from plants treated with other treatments. Furthermore, the data obtained that fruit weight loss percentage of citrus fruits were increased gradually and significantly with the increasing of storage periods. These results are in line with those obtained by Hussein *et al*. (2001a) on apple cultivars "Anna" and "Dorset Golden", Samara et al. (2007) on apricot fruits, reported that spraying trees with GA_3 reduced weight loss of fruits during storage. Also, Kazemi et al. (2011a) on "Jonagold" apple fruits, Kazemi *et al*. (2011b) on "Hayward" Kiwifruit, and Tareen et al. (2012) on "Flordaking" peach fruits found that treated fruits with salicylic acid exhibited less weight loss after storage. Moreover, Chien et al (2007) and Barakat et al (2012) illustrated that weight loss percentage of citrus fruits were increased gradually and significantly with the increasing of storage periods.

Concerning data (Table 4) revealed that fruit peel resistance was significantly higher with gibberelic acid and salicylic acid as compared with all other treatments. Also, plants sprayed with ascorbic acid had significantly higher fruit peel resistance fruit peel resistance as compared with citric acid. Moreover all treatments indicated significantly increased fruit peel resistance when compared with control. Moreover fruit peel resistance citrus fruits were decreased gradually and significantly with the increasing of storage periods. These results were in hormoney with Barakat et al. (2012) found that orange fruits firmness was decreased gradually and significantly with the prolongation of storage periods. Also, Yan et al. (1998) on peach fruits, Li and Han (1999) on peach fruits,

Table (3)Effect of gibberellic acid , ascorbic acid , citric acid and salicylic acid on VC, TSS, Acidity, TSS/Acidity, total sugar, reduced, non reduced sugar and fruit peel resistance

Treatments	VC		TSS		Acidity		Tss/Acidity		Total sugar		Reduced sugar		Non reduced sugar		Fruit peel resistance g/sq. cm2).	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	c57	c55	c11.5	b12	b1.3	d1.4	b8.84	b8.57	B6.40	ABC5.74	B2.73	C2.48	A3.68	A3.25	d287.3	e285.2
Gibberellic acid (GA_3)	b69	b67	d10.66	c10.78	a1.52	b1.6	c7.01	c6.74	5.4767	BC5.48	B2.56	C2.3	A3.37	A3.18	a360,47	a342.05
Ascorbic acid (AA)	a81	a82	a12.59	a12.99	b1.21	d1.35	a10.40	a9.62	A7.19	AB6.29	A3.54	B2.92	3.66 A	A3.37	b319.1b	c316.86
Citric acid (CA)	b72	b71	c11.89	b12.32	b1.3	c1.5	b9.15	b8.21	A7.103	A6.55	A3.45	A3.52	A3.65	A3.03	c304.28	d299.66
Salicylic acid (SA)	b68	b66	e10.33	c10.52	a1.52	a1.75	c6.80	d6.01	CB5.99	C5.41	B2.57	C2.32	A3.42	A3.09	a359.57	b327.76
LSD.05T	4.5345	5.0522	0.2611	0.5582	0.1444	0.0835	0.9063	0.6722	0.4403	0.8294	0.3594	0.3926	0.4145	0.5911	3.7276	4.9847

Table (4)Effect of gibberellic acid, ascorbic acid , citric acid and salicylic acid on WEIGHT LOSS and Fruit peel resistance

Treatments	WEIGHT LOSS								Fruit peel resistance g/sq. cm).							
	2015				2016				2015				2016			
	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS
Control	0	5.01	8.4	b4.47	0	4.51	8.72	c4.41	287.3	261	232	260.41d	285.2	256.68	228.16	e256.68
Gibberellic acid (GA_3)	0	4.31	7.95	e4.09	0	4.27	7.5	E3.92	360,47	320.82	291.98	a324.42	342.05	309.56	280.48	a310.7
Ascorbic acid (AA)	0	4.86	8.06	d4.31	0	B 4.33	8.46	d4.26	319.1	290.38	258.47	b289.32	316.86	285.81	259.83	c287.5
Citric acid (CA)	0	5.38	8.43	a4.60	0	4.53	9.36	a4.63	304.28	293.46	249.51	c276.79	299.49	272.54	248.58	d273.59
Salicylic acid (SA)	0	5.43	7.67	c4.37	0	4.12	9.44	b4.52	359.57	323.61	291.25	a324.42	327.76	297.28	265.49	b296.84
Means P	0c	4.99b	8.10a		0	4.35b	8.7a		326.33a	294.48b	264.64c	1.43	314.31a	284.37b	256.51c	3.46
LSD.05	Between T 0.0534	Between P 0.2648	Between TXP 0.1077	Between T 0.0438	Between P 0.1451	Between TxP 0.08831			Between T 1.85	Between P 1.43	Between TXP 3.755		Between T 4.47	Between P 3.46	Between TXP 9.075	

Srivastava & Dwivedi (2000) on banana fruits, Wang et al. (2006 & 2007) on peach fruits, Solaimani et al (2009), on kiwifruit fruits, Kazemi et al.(2011) on apple fruits and Tareen et al (2012) on peach fruits. They demonstrated that postharvest treatments with salicylic acid significantly exhibited higher flesh firmness of fruits during storage.

Chemical characters:

With regard to vitamin C content, Tss and Tss /acidity (Table 5&6), ascorbic acid treatment give significantly higher vitamin C, Tss and Tss/acidity as compared with all other treatments in both 2015 and 2016. Also, the data obtained that TSS and TSS/Acidity percentage of citrus fruits were increased and VC decreased gradually and significantly with the increasing of storage periods. The obtained results were in harmony with Stino et al. (1986) on peach fruits and Facteau (1992) in sweet cherry, they reported that GA_3 delayed TSS accumulation in fruit. Also, These findings are confirmed with those obtained by Ahmed et al. (2007) on "Sewy" dates fruits, Fayed (2010, a) on "Manfalouty" pomegranate trees, Fayed (2010b) on "Thompson seedless" grapevines, Hafez et al. (2010) on "Le-Conte" pear fruits and Mansour *et al.* (2010) on mango fruits. They reported that spraying citric acids improved fruit TSS. Moreover, Barakat et al (2012) demonstrated that total soluble solids contents of orange fruits increased with the increasing of storage periods. On the other side, Yehia and Hassan (2005) on "Le-Conte" pear trees, Ghafir *et al.* (2008, a) on "Stanly "plum fruits and Shahin *et al*. (2010) on "Anna" apple trees found that, total soluble solids content was increased with GA_3 sprays. These results were in harmony with those obtained by Wassel *et al.* (2007) on "White banaty seedless" grapevines, Fayed (2010, a) on "Manfalouty" pomegranate fruits and Fayed (2010, b) on "Thompson seedless" grapevines. They found that spraying ascorbic and citric acids increased TSS: acid ratio Moreover ,Hussein *et al*. (2001, a) on "Anna and Dorset Golden" apples and Wassel *et al.* (2007) on "White banaty seedless" grapevines and Shahin *et al*. (2010) on "Anna" Apple trees. They reported that application of gibberellic acid reduced the ratio between total soluble solids and acidity.

Concerning total acidity (Table 6), the results showed that gibberellic acid and salicylic acid caused a significant increase in tolal acidity as compared with all other treatments and control. Also, total acidity contents of orange fruits significantly decreased gradually and significantly with increasing of storage periods. The results concerning salicylic acid treatment agreed with those found by Al- Obeed (2010) on "Barhee" data palms, Bal and Celik (2010) on "Hayward" kiwifruit, Shaaban *et al*. (2011) on "Anna" apple fruits and Tareen et al. (2012) on "Flordaking" peach fruits,they reported that treating trees with salicylic acid increased fruit total acidity contents. Also, Ahmed et al. (2007) on "Sewy" date fruits, Wassel et al. (2007) on "White banaty seedless" grapevines, Fayed (2010, b) on "Thompson seedless" grapevine and Mansour *et al.* (2010) on mango fruits reported that spraying ascorbic and citric acid reduced total acidity. Moreover, the previous results are in harmony with those demonstrated and Barakat et al(2012) who demonstrated that total acidity contents of orange fruits decreased gradually and significantly the increasing of storage periods .

Regarding total sugar (Table 7&8) indicated that ascorbic acid and citric acid application gave significantly higher total sugar and reduced sugar when compared with all other treatments. Also, ascorbic acid treatment significantly increased non reduced sugar as compared with salicylic acid and gibberellic acid. Moreover, the data revealed that total and non reduced sugar percentage of citrus fruits were increased and reduced sugar decreased gradually and significantly with the increasing of storage periods. Trend of results obtained are in line with those of Awad et al. (2004) on "Anna" apple fruits, On the other hand, El-Seginy et al. (2003) and Shahin et al. (2010) on "Anna" apple trees found that GA3 improved fruit total sugar. Also Nawaz et al. (2008) on "Kinnow" mandarin and Kassem et al. (2011) on "Pu-yun" jujube trees reported that application of GA3 significantly increased fruit reducing sugars. Moreover, Shaaban et al. (2011) on "Anna" apple fruits reported that application of salicylic acid increased non reducing sugars.

Fruit decay:

Data indicated that control treatment showed significantly higher decay percentage as compared with other treatments (Table 8). Also, decay percentage of citrus fruits was increased gradually and significantly with the increasing of storage periods. These results were in agreement with those obtained by Chien *et al* (2007) and Barakat et al (2012).

Table (5)Effect of gibberellic acid, ascorbic acid , citric acid and salicylic acid on VC and TSS

Treatments	VC								TSS							
	2015				2016				2015				2016			
	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	Means	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS
Control	57	53	51	d53	55	55	53	d55	11.5	12.76	13.92	c12.73	12	13.68	14.76	c13.48
Gibberellic acid(GA_3)	69	64	62	c64.33	67	66	64	c66.33	10.66	12.37	12.69	e11.91	10.78	12.5	13.69	d12.32
Ascorbic acid (AA)	81	79	76	a79	82	78	79	a78	12.59	14.1	13.97	a13.55	12.99	14.93	15.74	a14.55
Citric acid (CA)	72	68	66	b68.33	71	69	68	b69.33	11.89	13.56	13.79	b13.09	12.32	14.17	15.15	b13.88
Salicylic acid (SA)	68	63	61	c63.33	66	65	63	c65.33	10.33	11.88	13.93	d12.06	10.52	11.89	13.15	e11.84
Means P	68.2a	65.4a	63.2b		a69.4	a66.6	a64.4		c11.40	b12.94	a13.92		11.72c	13.4b	a14.76	LSD.05
LSD.05	Between T 1.69	Between P 2.66	Between TXP 3.395		Between T 1.465	Between P 5.1095	Between TXP2.951		Between T 0.0962	Between P 0.4065	Between TXP 0.1938		Between T 0.2036	Between P 0.2906	Between TXP 0.4101	

Table 6. Effect of gibberellic acid, ascorbic acid , citric acid and salicylic acid on Acidty and TSS/Acidity

Treatments	ACIDTY								TSS/ACIDTY							
	2015				2016				2015				2016			
	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS
Control	1.3	1.21	0.99	b1.17	1.4	1.3	1.15	c1.27	8.84	11.5	12.89	c11.08	b.57	11.35	11.9	b10.67
Gibberellic acid(GA_3)	1.52	1.3	1.03	a1.28	1.6	1.5	1.34	a1.48	7.01	9.76	12.01	d9.43	6.74	8.73	9.33	c8.27
Ascorbic acid (AA)	1.21	1.07	0.93	c1.07	1.35	1.25	1.21	c1.28	10.40	13.06	15.16	a12.89	9.62	12.59	12.34	a11.52
Citric acid (CA)	1.3	1.16	0.98	b1.15	1.5	1.35	1.2	b1.35	9.15	11.89	13.84	b11.64	8.21	12.12	11.81	b10.72
Salicylic acid (SA)	1.52	1.3	1.12	a1.30	1.75	1.55	1.12	a1.47	6.80	10.72	10.61	d9.60	6.01	8.48	10.62	c8.37
Means	a1.36	b1.2	1.01		1.51a	1.39b	1.20c		8.5c	11.39b	12.90a		7.87c	10.65b	11.21a	
LSD.05	Between T 0.0456	Between P 0.0255	BetweenTXP 0.09377		BetweenT 0.0316	BetweenP 0.0091	BetweenTXP 0.0637		Between T 0.2775	Between P 0.1047	Between TXP 0.5591		BetweenT 0.2256	BetweenP 0.2974	BetweenTXP 0.4544	

Table 7. Effect of ascorbic acid, citric acid, salicylic acid and gibberellic on Total sugar and reduced sugar

Treatments	TOTAL SUGAR								REDUCED SUGAR							
	2015				2016				2015				2016			
	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS
Control	5.4	6.19	6.74	6.11b	6.41	6.49	7.15	b6.68	2.48	2.27	2.05	b2.27	B2.73	2.46	2.35	b2.51
Gibberellic acid(GA_3)	6.57	5.81	5.48	6.57	5.79	6.27	6.91	c6.32	2.3	2.11	2.00	cb2.13	B2.57	2.19	2.05	c2.27
Ascorbic acid (AA)	7.18	7.13	6.63	a6.96	7.19	7.53	7.68	a7.47	3.26	3.07	2.54	a2.96	A3.53	3.31	2.62	a3.18
Citric acid (CA)	6.99	6.89	6.79	a6.89	7.11	7.44	7.56	a7.36	3.42	2.99	2.35	a2.92	A3.45	3.26	2.54	a3.08
Salicylic acid (SA)	6.92	5.16	5.41	c5.83	5.99	6.41	6.74	c6.49	2.32	1.98	1.74	c2.01	B2.57	2.35	2.05	c2.32
Means**P**	5.94c	6.24b	a6.89a		6.5c	6.83b	7.27a		2.76a	2.48ab	b2.12		a2.97	2.73b	2.32c	
LSD.05	Between T 0.0927	Between P 0.0.0718	Between TXP o.1882		Between T 0.1526	Between P 0.1182	Between TXP 0.3097		Between T 0.188	Between P 0.2964	Between TXP 0.3645		Between T 0.116	Between P 0.0759	Between TXP 0.2334	

Table 8. Effect of ascorbic acid, citric acid, salicylic acid and gibberellic on Non reduced sugar and weight loss

Treatments	NON REDUCED SUGAR								Decay							
	2015				2016				2015				2016			
	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS	At harvest	After a week	After two weeks	MEANS
Control	2.92	3.92	4.69	b3.84	3.68	4.03	5.16	a4.02	0	4.56	6.94	a3.83	0	4.05	7.29	a3.78
Gibberellic acid(GA_3)	3.18	3.7	4.52	b3.8	3.22	4.08	4.86	b4.52	0	3.27	4.97	d2.75	0	3.36	6.05	c313
Ascorbic acid(AA)	3.37	4.06	4.64	a4.02	3.66	4.22	5.06	a4.31	0	3.64	5.54	b3.06	0	3.79	6.83	b3.50
Citric acid (CA)	3.37	3.9	4.64	a3.97	3.66	4.18	5.02	a4.29	0	3.74	5.69	b3.14	0	3.98	7.17	a3.72
Salicylic acid (SA)	3.09	3.42	4.94	b3.82	3.42	4.06	4.69	b4.56	0	3.6	5.2	c2.93	0	3.37	6.06	c3.14
MeansP	3.19c	3.80b	4.69a		3.53c	4.11b	a4.96		0	3.76b	5.67a	**LSD0.0 5**0.161	0c	3.71b	6.65a	0.1335
LSD.05	Between T 0.181	Between P 0.0605	Between TXP 0.1588		Between T0.0946	Between P 0.0732	Between TXP 0.6070		Between T 0.118	Between P 0.161	Between TXP 0.2380		Between T 0.0809	Between P 0.0732	Between TXP 0.1629	

It was reported that decay percentage of citrus fruits were increased gradually and significantly with the increasing of storage periods. Yao and Tian, (2005) on sweet cherry fruits, Wang et al (2007) on peach fruits, Kazemi, et al (2011) on apple fruits and Tareen et al (2012) on peach fruits also demonstrated that post harvest application with salicylic acid significantly reduced decay incidence of fruits during storage compared with that of the untreated fruits. Mohamed et al (2012) reported that on naval orange decay percentage increased.

Conclusion

Gbberellic acid treatment increased canopy volume index, shoot length, fruit peel thickness, leaf calcium and fruit peel resistance. Moreover ascorbic acid sprays led to an access in fruit length, fruit diameter, leaf nitrogen, potassium and calcium, V.C., TSS and TSS /Acidity. Citric acid increased leaf area. Ascorbic acid and citric acid treatments gave higher trunk across, total and reducing sugars. Salicylic acid application enhanced chlorophyll a and b, yield, fruit peel thickness, acidity and fruit peel resistance. Applying previous antioxidants then storing at room temperature for a week and two weeks revealed that ascorbic acid application increased VC, TSS, TSS/acidity and total sugar. Ascorbic acid and citric acid treatments also increased reduced and unreduced sugar. Citric acid spraying led to an increase of weight loss than all other treatments. Gibberellic acid and salicylic acid application enhanced Fruit peel resistance. All antioxidants treatments reduced decay as compared with control. The TSS, TSS/Acidity, total and non reducing sugars, fruit weight loss percentage decay of citrus fruits were increased whereas, acidity, reduced sugar and fruit peel resistance were decreased gradually and significantly by increasing storage periods.

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