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EFFECT OF FOLIAR APPLICATION OF ANTIOXIDANTS ON VEGETATIVE GROWTH AND LEAF MINERAL CONTENT OF CHINESE TANGERINE YOUNG TREES BUDDED ON SOME CITRUS ROOTSTOCKS GROWN UNDER SALINE CONDITIONS

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ABSTRACT

Filed experiment was conducted at El Alamin – Wady El Natroun high way (Beer Hooker Area) in a private orchard in a sandy soil under drip irrigation system with saline water. in 2015 and 2016 seasons. Chinese tangerine (*Citrus tangerine*) transplant were budded on three rootstocks namely sour orange (*Citrus aurantum, mion*), volkamer lemon (*Citrus volkameriana*, Tem) and X639 hybrid between (Cleopatra mandarin × *Ponicurus trifoliata*) grown under saline conditions to study the effect of foliar application of antioxidants namely ascorbic and salicylic acid on vegetative growth and leaf mineral contents. Results showed that, Volkamer lemon rootstock surpassed sour orange and x639 rootstocks under saline conditions, the highest incremental percentage young tree height, stem diameter, number of leaves per shoot and leaf area were registered by Chinese tangarine scion budded on Volkamer lemon rootstock. Among selected antioxidants ascorbic acid at the concentrations of 800 ppm recorded the highest significant values for vegetative growth parameters and surpassed salicylic acid. Also Chinese mandarin scion budded on volkamer lemon accumulated the highest concentrations of nitrogen (N), phosphorus(P), magnesium(Mg), and chloride (Cl^-) and the lowest concentration of sodium (Na^+). Chinese mandarin scion budded on sour orange rootstock accumulated the highest concentrations of potassium (K) while Chinese tangerine scion budded on x639 accumulated the highest concentrations of sodium (Na).

INTRODUCTION

Citrus grown in many areas of the world. It's a subtropical crop that's not tolerant to freezing temperature or salinity. According to the United Nations of food and agriculture (**FAO, 2016)** there were 140 citrus producing countries, producing 115,650,545 tons around 70% of the world's total citrus production is grown in northern hemisphere, in particular countries around the Mediterranean and United Nations. Citrus even when irrigated water is of good quality, the use of fertilizers and other agro-chemicals raises the likelihood of salt building up in the soil causing salinity stress (**Syvertsen et al 1995**). Relative to many crop plants, citrus trees have been classified as a salt sensitive crop (**Story and Walker, 1999)**, because saline irrigation water reduced citrus tree growth and fruit yield relatively more than in many other crops (**Grieve et al 2007**). All citrus varieties must have budded on selected rootstocks and no signal rootstock is suitable for all sites or for all varieties. Rootstock can have a large effect on many aspects of production including yield, fruit quality, tree size, tolerance to salts and scion compatibility. The general tolerance and fruit quality effects of various citrus rootstocks. Thus, it is quite imperative to identify alternative such as rootstocks that can be tolerant to salinity levels, where rootstock vary in their relative resistance to salinity in Egypt, increasing the cultivated area by reclaiming desert are the challenges of near future. Ascorbic acid is

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one of non-enzymatic molecule which plays a substantial role in counteracting oxidative stress caused by stresses. It is a small, water soluble antioxidant molecule which act as a primary substrate in the cyclic pathway for enzymatic detoxification, it acts directly to neutralize superoxide radicals, signal oxygen or superoxide as a secondary antioxidant during reduction cycling of the oxidized for α tocopherol which another lipophilic antioxidant molecule (**Noctor and Foyer, 1998**). Ascorbic acid has been associated with several types of biological activities in plants such as enzyme Co-Factor and as a donor/acceptor in electron transport in plasma membrane or in chloroplast. Much evidence has suggested that ascorbic acid effects biosynthesis, level and signaling of many phytohormones including ethylene, gibberellic acid acid and abscisic acid (**Barth et al 2006**), all of which are related to oxidative stress resistance **Conklin, (2001), Hussein and Alva (2014**) **Çavuşoğlu and Bilir (2015), El-Sayed and Abdel-Rahman et al (2015), Alhasnawi et al (2015)** and **Kostopoulou et al (2015)**.Salicylic acid (SA) or orthohydroxy benzoic acid is distributed in whole plant kingdom. Salicylic acid is considered to be protect plant hormone (**Raskin, 1992**) because of its divers regulating roles in plant metabolism **Popova, et al (1997).** Salicylic acid is an endogenous plant growth regulator of phenolic nature that possesses an aromatic ring with hydroxyl group or its functional derivate. The effect of exogenous salicylic acid on growth and bio productivity and may be plays a key role in regulating their growth and productivity. The main object of the present work is to study the effect of salinity on growth, some water relations and chemical constitutes of Chinese mandarin (Chinese tangerine) budded on three citrus rootstocks to test the effect of foliar application with two antioxidants (Salicylic acid and ascorbic acid) on improving their tolerance ability.

MATERIALS AND METHODS

In this was carried out during a two successive seasons of (2014 /2015) and (2015/2016), to evaluate the response of foliar application of some antioxidants on Citrus rootstocks for Chinese tangerine young trees grown under irrigation with saline water. Chinese tangerine (*Citrus Tangerine*), were budded on three citrus rootstocks namely sour orange (*Citrus aurantum, mion*), Volkamer lemon (*Citrus volkameriana*, Tem) and X639 hybrid between (*Cleopatra mandarin* × *Ponicurus trifoliata*). The experiment was conducted at El Alamin – Wady El Natroun high way (Beer Hooker Area) in a private orchid in a sandy soil under drip irrigation system with saline water (1700 ppm).

Experimental design

The experiment of Chinese tangerine included 24 treatments which were three rootstocks (sour orange, volkamer lemon and X639) arranged in split split plot design with a replicate allocated randomly in main plots, the two antioxidants in the sub main plot and the four concentrations (0, 400, 600, 800 ppm), were distributed randomly in the sub submain plots. Thus the design of the experiment was split split plot with three replicates. The transplants were planted in 28/5/2014 at 5×5 meters apart. The young Chinese tangerine transplants received citrus fertilization program included organic matter fertilizer at 20 m^3 /fed/year and calcium superphosphate (15.5% P_2O_5) in February of each experiment year. Potassium sulfate (48% K_2O) at 200 kg /fed/year in March and September according to the recommendations of Ministry of Agriculture and Land Reclamation (MALR,) of Egypt.

Antioxidant Treatments

The selected antioxidants materials namely ascorbic and salicylic acid were used in the experiments as Foliar spraying two times in both the two seasons (2015 and 2016). The first foliar application at 15^{th} of June and the second foliar application was 15 days later in the first time. The foliar application was conducted at the early morning using back spryer (25 Liter). The volume of the spraying solution was maintained just to cover completely the seedling until drop The selected antioxidant materials were used as Follows**:**

3.2.1. Tap water (control)

3.2.2. Salicylic acid (SA)

It is a poorly soluble in water, thus it was soluble in ethyl alcohol and then in distilled water at four concentrations (0,400,600 and 800 ppm).

3.2.3. Ascorbic Acid (ASA)

It was diluted in distilled water and used at four concentrations (0,400,600 and 800 ppm).

Recorded Data

Growth Parameters

At the first week of September the following data were measured:

Young tree height (cm)

The transplant height was measured prior to treatments application (L^1), then at the end of the growing season (1st week of September) (L^2) and the difference was recorded as an increase in transplant height for each treatment :

% Increment in transplant height =

$$\frac{L2-L1}{L1}\times 100$$

Stem diameter (mm): The diameter of the trunk was measured prior to treatments (dia^l) then at the end of the growing season (1st week of September) (dia^2) and the difference was recorded as incremental percentage in diameter for each treatment.

$$\frac{D2-D1}{D1}\times 100$$

Number of leaves per young tree

At 1st week of September leaves of each branch were counted, the percentage of increment of leaves was calculated the mean number of the leaves per tree was recorded.

Leaf area (cm^2)

Was calculated in random samples were taken from the most recently fully mature leaves from the fourth to the sixth leaves from the top of the selected shoots (three leaves per shoot x five shoots) using the equation:

Leaf area = 2/3 length x width., according to **Singh and Snyder (1984).**

Chemical Analysis

Samples of twenty mature leaves were selected at random from outer middle of the spring cycle tagged shoots (1st week of September), then they cleaned with piece of cloth to remove dust after that washed twice with tap water, rinsed three times with distilled water and ground in staleness steel mill to avoid contamination with any minerals. Samples dried to a constant weight at 70°c in an electric oven and then 0.2g of the ash was digested in a mixture of 5:1 perchloric acid and sulphoric acid **(Jackson, 1973)**.

1. Total nitrogen was determined by Micro-Kjeldahl method according to **(Jackson, 1973)**.

2. Total phosphorus was determined calorimetrically by ascorbic acid reduction method according to **(Murphy and Riley, 1962)**, as modified by **(Watanabe and Olsen, 1965)**.

3. Total potassium was determined by using flame photometer according to **Brown and Lilleland, (1946)**.

4. Calcium, magnesium, sodium and chloride were determined by titration against versant solution (**Chapman and Pratt, 1961)**.

Statistical analysis

The obtained data in 2015 and 2016 seasons were subjected to analysis of variance. Means was differentiated using multiply Rang test at the 0.05 level **(Duncan, 1955)**.

RESULTS AND DISCUSSION

Effect of foliar application of both salicylic and ascorbic acids and their interactions on vegetative growth of Chinese tangerine budded on volkamer lemon, sour orange and X639 rootstocks grown under saline conditions.

1. Vegetative growth parameters

1.1. Effect of rootstocks

It is evident from presented data in **(Table 1, 2, 3 and 4)** that Chinese tangerine budded on volkamer lemon rootstock under saline conditions surpassed the other rootstocks and gave the significantly highest values for young tree % increment of height, % increment of stem diameter, % increment of leaf number and leaf area (cm^2) compared with other rootstocks namely sour orange which ranked in between and X639 which recorded the lowest values.

Thus, it mean that, there is a great variation in ability of citrus rootstocks to tolerant salinity .In this respect **Muhamed and AkberAnjun (2008)** recorded that reduction in fresh weight were more in troyer citrange as compared with Cleopatra mandarin under saline conditions , this revealed that in our study volkamer lemon rootstock is most tolerant than sour orange and X639 , there may be that the growth and yield of citrus crop inhibited due to the high ratio of Na /Ca and Na/K under saline conditions . These results hold true with the finding of **Zikri and Parsonss (1992)** on citrus. In these respect, **Storey, (1995)** recorded that, the tolerance of different species of citrus can be determined by their ability to exclude the potentially toxic Na^+ and Cl^- ions.

1.2. Effect of antioxidants and their concentrations

In the present study foliar application of ascorbic acid surpassed salicylic acid in increasing vegetative growth parameters i.e young tress increment % of height, increment % of stem diameter, increment % of leaf number and leaf area (cm^2) compared with the control salinized rootstocks. However, the increase in growth parameters were associated with the increase in antioxidants concentrations up to 800 ppm dose, it could be concluded that foliar application of ascorbic acid reduced the damage effect of salinity on vegetative growth procedure, associated the rate growth and reversed the effect of salinity more than salicylic acid.

1.3. Interaction effect of rootstock, antioxidants and their concentration

The interaction between studied rootstocks, antioxidants and their different concentrations, the data revealed that, volkamer lemon rootstock interacted with ascorbic acid at the concentration of 800 ppm in both seasons and gave the highest significant values for young tress increment % of height, increment % of stem diameter, increment % of leaf number per shoot and leaf area (cm^2). In our results ascorbic acid surpassed salicylic acid. These results are in agreement with **Muhamed Akber (2008)** who reported that ascorbic acid application not only mitigate the inhibitory effect of salt stress but also induced stimulatory effect on all of the studied growth parameters of *soccum spp*, hybrid cv., HSF-24 grown under salt stress. Moreover ascorbic acid in regard as one of the most effective growth regulator against abiotic stress**.** Ascorbic acid not only acts as antioxidants but also cellular level of ascorbic acid are correlated with the activation of complex biological defense mechanism**.** Further more experimental studies on different plants have shown that exogenous application of ascorbic acid may reduce salt induced adverse effect and results insignificant increments on growth and yield **Salma, 2009 and Athar et al 2009).**

2. Leaf Mineral Contents

Regarding the ion uptake by stressed rootstocks all studied were achieved to determine whether the differential plants response to salinity can correlated with the modification of plant mineral composition and the obtained results indicated that under stress conditions more cations and less anions were accumulated by young tress of Chinese tangerine leaves. Our results in **(Table 5)** revealed that nitrogen(N) concentration in Chinese tangerine budded on volkamer lemon rootstock was the highest while sour orange rootstock recorded the lowest value however, x639 ranked in between.

Table (6) show that phosphorus (P) concentration was the highest for Chinese tangerine budded on volkamer lemon rootstock while x639 tended to be the lowest one. The highest potassium (K) concentration **(Table 7)** was registered for x639 rootstock followed in descending order by volkamer lemon rootstock. In this study lowest values registered by sour orange rootstock. **(Table 8)** show that calcium content (Ca) for x639 rootstock recorded the highest values .Whereas sour orange recorded the lowest values compared with the other rootstocks, in theses respect volkamer lemon rootstock ranked in between. The highest magnesium (Mg) concentration **(Table 9)** was registered for Chinese tangerine budded on Volkamer lemon rootstock, while sour orange rootstock recorded the lowest value of magnesium (Mg) concentration. As for sodium (Na) **(Table 10)** concentration X639 significantly values of Na the lowest mean values recorded for Chinese tangerine budded on volkamer lemon rootstock.

Chloride (Cl^-) concentration recorded the lowest mean values for Chinese tangerine budded on sour orange rootstock, while Chinese tangerine budded on volkamer lemon rootstock registered the highest mean value despite of the lowest value of sodium Na.

Thus, it means that there are great differences between the studied rootstocks to accumulate nutrients under saline conditions. The stimulatory effect of low salinity level on some minerals N, P, and K of many plants were reported by **Heikal et al (1980).** The observed increase in sodium Na under saline condition was reported by **Storey (1995)** who observed that the accumulation of Na by plant under saline conditions may be attributed to the damage of protoplasm of plant cells and as a result, the selective salt absorption in replace by passive absorption which causes abnormal

Table 1. Effect of antioxidant foliar application and rootstocks on tree height increment percentage of Chinese tangerine young trees under saline conditions

Treatments		First season, 2015					Second season; 2016				
Rootstock	Antioxidant	0	400ppm	600ppm	800ppm	MeanAxB	0	400ppm	600ppm	800ppm	MeanAxB
Sour orange	SA	10.14k	11.56ij	15.13d-f	15.80cd	13.16DE	14.21j	14.96hi	16.97f	21.23d	16.84D
	ASC	10.20k	12.13i	16.25bc	16.89ab	13.86C	12.87k	15.23hi	17.43f	22.65c	17.05D
Volkamer Lemon	SA	13.26g	14.86d-f	15.47c-e	16.23bc	14.95B	15.56gh	17.09f	21.22d	24.17b	19.51B
	ASC	14.70ef	14.27f	15.20d-f	17.56a	15.43A	16.14g	16.99f	22.51c	26.18a	20.45A
X639	SA	10.86jk	12.32hi	13.14gh	14.86d-f	12.79E	14.18j	15.16hi	16.89f	19.07e	16.32E
	ASC	11.47ij	11.91i	14.34f	15.74cd	13.36D	14.55ij	16.85f	18.88e	21.17d	17.86C
Mean (A x C)		10.17G	11.84E	15.69B	16.35A		13.54I	15.09G	17.20E	21.94B	
		13.98CD	14.57C	15.33B	16.90A		15.85F	17.04E	21.87B	25.17A	
		11.16F	12.11E	13.74D	15.30B		14.36H	16.00F	17.89D	20.12C	
Mean (B x C)		11.42F	12.91D	14.58C	15.63B		14.65G	15.73F	18.36D	21.49B	
		12.12E	12.77D	15.26B	16.73A		14.52G	16.36E	19.61C	23.33A	
Mean (C)		11.77D	12.84C	14.92B	16.18A		14.59D	16.05C	18.98B	22.41A	
Mean (B)		13.63B		14.32A			17.56B		18.45A		
Mean A		13.51B	15.19A		13.08C		16.94B	19.98A		17.09B	

Mean in each row, colum or interaction having the same letter (s) are not significantly different at 5% level.
A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant
B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.
SA= Salicylic acid ASC= Ascorbic acid

Table 2. Effect of antioxidant foliar application and rootstocks on tree stem diameter increment percentage of Chinese tangerine young trees under saline conditions

Treatments		First season, 2015					Second season; 2016				
Rootstock	Antioxidant	0	400ppm	600ppm	800ppm	MeanAxB	0	400ppm	600ppm	800ppm	MeanAxB
Sour orange	SA	12.81gh	14.91d-f	15.20de	16.85b	14.94B	12.61k	15.21g	16.42de	16.86cd	15.28D
	ASC	11.97i	14.78ef	16.11bc	16.14bc	14.75B	12.43k	15.35fg	18.59b	17.53c	15.97C
Volkamer Lemon	SA	13.25g	15.08de	15.59cd	17.94a	15.47A	13.94j	16.24de	17.42c	18.34b	16.49B
	ASC	12.91g	14.43ef	17.78a	17.95a	15.77A	14.03j	15.23g	18.73b	19.47a	16.87A
X639	SA	12.03i	13.50g	14.22f	14.61ef	13.59C	12.24k	14.11ij	14.79g-i	15.97ef	14.28E
	ASC	12.16hi	13.15g	13.17g	14.41ef	13.22D	12.89k	14.36h-j	15.21g	15.03gh	14.37E
Mean (A x C)		12.39G	14.85D	15.65C	16.50B		12.52G	15.28DE	17.51C	17.19C	
		13.08F	14.76D	16.69B	17.94A		13.99F	15.73D	18.08B	18.91A	
		12.09G	13.32EF	13.69E	14.51D		12.57G	14.23F	15.00E	15.50DE	
Mean (B x C)		12.70E	14.50D	15.00C	16.47A		12.93E	15.19D	16.21C	17.06B	
		12.35E	14.12D	15.69B	16.17A		13.12E	14.98D	17.51A	17.34AB	
Mean (C)		12.52D	14.31C	15.34B	16.32A		13.02D	15.08C	16.86B	17.20A	
Mean (B)		14.67A		14.58A			15.35B		15.74A		
Mean A		14.85B	15.62A		13.40C		15.63B	16.68A		14.33C	

Mean in each row, Colum or interaction having the same letter (s) are not significantly different at 5% level.
A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant
B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.
SA= Salicylic acid ASC= Ascorbic acid.

Table 3. Effect of antioxidant foliar application and rootstocks on % of increment of leaves number of Chinese tangerine young trees grown under saline conditions

Treatments		First season, 2015					Second season; 2016				
Rootstock	Antioxidant	0	400ppm	600ppm	800ppm	MeanAxB	0	400ppm	600ppm	800ppm	MeanAxB
Sour orange	SA	13.21o	15.61h-k	15.49i-k	21.88d	16.55C	15.22r	15.61qr	18.98gh	20.17e	17.49E
	ASC	14.34mn	14.82lm	22.81c	23.57b	18.88B	16.41op	16.50n-p	19.22fg	23.59ab	18.93C
Volkamer Lemon	SA	16.09g-j	18.14e	24.59a	24.94a	20.94A	17.26lm	19.64ef	21.07d	22.50c	20.12B
	ASC	16.40fg	16.93f	24.54a	24.82a	20.67A	17.05mn	18.31ij	23.29b	23.88a	20.63A
X639	SA	14.04n	15.63h-k	16.08g-j	16.17g-i	15.48D	15.93pq	16.88m-o	17.86jk	19.24fg	17.48E
	ASC	15.12kl	15.84g-j	16.19gh	15.45jk	15.65D	15.92pq	17.71kl	18.50hi	19.34fg	17.87D
Mean (A x C)		13.77I	15.21G	19.15C	22.73B		15.82F	16.06F	19.10C	21.88B	
		16.25E	17.53D	24.57A	24.88A		17.16E	18.97C	22.18B	23.19A	
		14.58H	15.74F	16.14EF	15.81EF		15.93F	17.30E	18.18D	19.29C	
Mean (B x C)		14.45F	16.46C	18.72B	21.00A		16.14F	17.37D	19.30C	20.64B	
		15.29E	15.86D	21.18A	21.28A		16.46E	17.51D	20.34B	22.27A	
Mean (C)		14.87D	16.16C	19.95B	21.14A		16.30D	17.44C	19.82B	21.45A	
Mean (B)		17.66B		18.40A			18.36B		19.14A		
Mean A		17.72B	20.81A		15.57C		18.21B	20.37A		17.67C	

Mean in each row, colum or interaction having the same letter (s) are not significantly different at 5% level.

A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant

B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.

SA= Salicylic acid ASC= Ascorbic acid.

Table 4. Effect of foliar application of antioxidants and rootstock on leaf area (cm^2) of Chinese tangerine young trees grown under saline conditions

Treatments		First season, 2015					Second season; 2016				
Rootstock	Antioxidant	0	400ppm	600ppm	800ppm	MeanAxB	0	400ppm	600ppm	800ppm	MeanAxB
Sour orange	SA	10.33fg	11.00ef	13.33b	13.33b	12.00B	12.33ef	13.33cd	14.00bc	14.33b	13.50B
	ASC	11.00ef	10.33fg	13.33b	13.00bc	11.92B	12.33ef	13.00de	13.33cd	14.67b	13.33B
Volkamer Lemon	SA	12.00d	12.00d	13.00bc	14.67a	12.92A	13.00de	13.00de	14.33b	16.00a	14.08A
	ASC	11.00ef	12.00d	13.00bc	14.67a	12.67A	12.66fg	13.33cd	14.67b	16.00a	14.00A
X639	SA	10.00g	10.67fg	12.33cd	11.67de	11.17C	11.67fg	12.33ef	13.33cd	13.33cd	12.67C
	ASC	11.00ef	12.00d	12.33cd	12.33cd	11.92B	11.33g	12.00fg	13.33cd	14.00bc	12.67C
Mean (A x C)		10.67F	10.67F	13.33B	13.17B		12.33D	13.17C	13.67C	14.50B	
Mean (A x C)		11.50DE	12.00CD	13.00B	14.67A		12.50D	13.17C	14.50B	16.00A	
Mean (A x C)		10.50F	11.33E	12.33C	12.00CD		11.50E	12.17D	13.33C	13.67C	
Mean (B x C)		10.78C	11.22BC	12.89A	13.22A		12.33D	12.89C	13.89B	14.56A	
		11.00BC	11.44B	12.89A	13.33A		11.89E	12.78C	13.78B	14.89A	
Mean (C)		10.89D	11.33C	12.89B	13.28A		12.11D	12.83C	13.83B	14.72A	
Mean (B)		12.03A		12.17A			13.42A		13.33A		
Mean A		11.96B	12.79A		11.54C		13.42B	14.04A		12.67C	

Mean in each row, Colum or interaction having the same letter (s) are not significantly different at 5% level..

A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant

B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.

SA= Salicylic acid ASC= Ascorbic acid.

Table 5. Effect of foliar application of antioxidants and rootstocks on leaf nitrogen percentage (%) of Chinese tangerine young trees grown under saline conditions

Treatments		First season, 2015					Second season; 2016				
Rootstock	Antioxidant	0	400ppm	600ppm	800ppm	MeanAxB	0	400ppm	600ppm	800ppm	MeanAxB
Sour orange	SA	2.13h	2.14h	2.22gh	2.24gh	2.18D	2.14j	2.24ij	2.27ij	2.28h-j	2.23D
	ASC	2.30fg	2.40ef	2.74a	2.66a-c	2.53B	2.32g-j	2.46d-h	1.87k	2.69a-c	2.33C
Volkamer Lemon	SA	2.30fg	2.64a-c	2.66a-c	2.72a	2.58AB	2.35f-i	2.68a-c	2.70a-c	2.82a	2.64AB
	ASC	2.52c-e	2.52c-e	2.69ab	2.77a	2.63A	2.52c-f	2.64a-d	2.79ab	2.77ab	2.68A
X639	SA	2.25gh	2.44d-f	2.53c-e	2.56b-d	2.45C	2.42e-i	2.55c-e	2.60b-e	2.67a-c	2.56B
	ASC	2.42d-f	2.52c-e	2.53c-e	2.67a-c	2.54B	2.47d-g	2.64a-d	2.68a-c	2.69a-c	2.62AB
Mean (A x C)		2.22I	2.27HI	2.48D-F	2.45EF		2.23G	2.35F	2.07H	2.49DE	
		2.41FG	2.58B-D	2.68AB	2.75A		2.44EF	2.66BC	2.75AB	2.80A	
		2.34GH	2.48D-F	2.53C-E	2.62BC		2.45EF	2.60CD	2.64BC	2.68A-C	
Mean (B x C)		2.23C	2.41B	2.47B	2.51B		2.30D	2.49BC	2.52BC	2.59B	
		2.41B	2.48B	2.65A	2.70A		2.44C	2.58B-D	2.45C	2.72A	
Mean (C)		2.32C	2.44B	2.56A	2.60A		2.37C	2.54B	2.48B	2.65A	
Mean (B)		2.40B		2.56A			2.48B		2.55A		
Mean A		2.35C	2.60A		2.49B		2.28C	2.66A		2.59B	

Mean in each row, colum or interaction having the same letter (s) are not significantly different at 5% level.

A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant

B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.

SA= Salicylic acid ASC= Ascorbic acid.

Element	**N (%)**	**Obreza et al (1992)**
Deficient	<2.2	
Low	2.2-2.4	
Optimum	2.5-2.7	
High	2.8-3.0	
Excess	>3.0	

Table 6. Effect of foliar application of antioxidants and rootstocks on leaf phosphorus (%) of Chinese tangerine young trees grown under saline conditions

Treatments		First season, 2015					Second season; 2016				
Rootstock	Antioxidant	0	400ppm	600ppm	800ppm	MeanAxB	0	400ppm	600ppm	800ppm	MeanAxB
Sour orange	SA	0.090h-j	0.100g-i	0.110f-h	0.110f-h	0.103C	0.080i	0.110fg	0.120f	0.077i	0.097E
	ASC	0.100g-i	0.100g-i	0.083h-j	0.120e-g	0.101C	0.090hi	0.110fg	0.300a	0.110fg	0.153A
Volkamer Lemon	SA	0.100g-i	0.120e-g	0.140c-e	0.180ab	0.135AB	0.110fg	0.110fg	0.140e	0.170bc	0.133BC
	ASC	0.110f-h	0.130d-f	0.150cd	0.190a	0.145A	0.100gh	0.120f	0.160cd	0.180b	0.140B
X639	SA	0.090h-j	0.110f-h	0.140c-e	0.160bc	0.125B	0.080i	0.120f	0.150de	0.170bc	0.130CD
	ASC	0.070j	0.080ij	0.140c-e	0.140c-e	0.108C	0.080i	0.090hi	0.160cd	0.160cd	0.123D
Mean (A x C)		0.095FG	0.100EF	0.097FG	0.115DE		0.085GH	0.110E	0.210A	0.093FG	
		0.105EF	0.125CD	0.145B	0.185A		0.105EF	0.115E	0.150D	0.175B	
		0.080G	0.095FG	0.140BC	0.150B		0.080H	0.105EF	0.155CD	0.165BC	
Mean (B x C)		0.093D	0.110C	0.130B	0.150A		0.090E	0.113D	0.137C	0.139C	
		0.093D	0.103CD	0.124B	0.150A		0.090E	0.107D	0.207A	0.150B	
Mean (C)		0.093D	0.107C	0.127B	0.150A		0.090D	0.110C	0.172A	0.144B	
Mean (B)		0.121A		0.118A			0.120B		0.138A		
Mean A		0.102C	0.140A		0.116B		0.125B	0.136A		0.126B	

Mean in each row, colum or interaction having the same letter (s) are not significantly different at 5% level.
A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant
B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.
SA= Salicylic acid ASC= Ascorbic acid.

Element	P (%)	Obreza et al (1992)
Deficient	<0.09	
Low	0.09-0.11	
Optimum	0.12-0.16	
High	0.17-0.30	
Excess	>0.30	

Table 7. Effect of foliar application of antioxidants and rootstocks on leaf potassium percentage (%) of Chinese Tangerine young trees grown under saline conditions

Treatments		**First season, 2015**					**Second season; 2016**				
Rootstock	**Antioxidant**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**
Sour orange	**SA**	0.660h	0.680h	0.720f-h	0.770d-g	0.708C	0.800h-j	0.890h	1.120g	1.200e-g	1.003E
	ASC	0.670h	0.720f-h	0.897ab	0.810c-e	0.774B	0.720j	0.880hi	1.823a	1.190e-g	1.153BC
Volkamer Lemon	**SA**	0.700gh	0.820b-e	0.880a-c	0.850b-d	0.813AB	0.750ij	0.890h	1.240d-g	1.340b-d	1.055DE
	ASC	0.740e-h	0.850b-d	0.880a-c	0.940a	0.853A	0.880hi	1.150fg	1.270c-f	1.390bc	1.173AB
X639	**SA**	0.770d-g	0.820b-e	0.820b-e	0.860a-c	0.818AB	0.840h-j	0.880hi	1.320b-e	1.370b-d	1.102CD
	ASC	0.740e-h	0.770d-g	0.840b-d	0.800c-f	0.788AB	0.880hi	1.280b-f	1.340b-d	1.410b	1.227A
Mean (A x C)		0.665F	0.700EF	0.808A-D	0.790B-E		0.760G	0.885F	1.472A	1.195D	
		0.720D-F	0.835A-C	0.880AB	0.895A		0.815FG	1.020E	1.255CD	1.365B	
		0.755C-F	0.795A-E	0.830A-C	0.830A-C		0.860F	1.080E	1.330BC	1.390B	
Mean (B x C)		0.710C	0.773BC	0.807AB	0.827AB		0.797F	0.887E	1.227C	1.303B	
		0.717C	0.780BC	0.872A	0.850AB		0.827EF	1.103D	1.478A	1.330B	
Mean (C)		0.713C	0.777B	0.839A	0.838A		0.812C	0.995B	1.352A	1.317A	
Mean (B)		0.779A		0.805A			1.053B		1.184A		
Mean (A)		0.741B	0.833A		0.803A		1.078B	1.114B		1.165A	

Mean in each row, colum or interaction having the same letter (s) are not significantly different at 5% level..

A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant

B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.

SA= Salicylic acid ASC= Ascorbic acid.

Element	**K (%)**	**Obreza et al (1992)**
Deficient	<0.7	
Low	0.7-1.1	
Optimum	1.2-1.7	
High	1.8-2.4	
Excess	>2.4	

Table 8. Effect of foliar application of antioxidants and rootstocks on leaf calcium percentage a (%) of Chinese tangerine young trees grown under saline conditions

Treatments		First season, 2015					Second season; 2016				
Rootstock	**Antioxidant**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**
Sour orange	**SA**	1.44i	2.10f	2.84d	2.92b-d	2.33D	2.22j	2.82e-g	2.98c-e	2.95d-f	2.74B
	ASC	1.72h	2.88b-d	3.05a-d	3.07a-d	2.68C	1.82k	2.68f-h	2.31j	3.16b-d	2.49C
Volkamer Lemon	**SA**	1.76gh	2.86cd	2.94b-d	3.22a	2.70BC	1.84k	2.57g-i	3.17b-d	3.31ab	2.72B
	ASC	1.98fg	3.02a-d	3.14ab	3.14ab	2.82A	2.45h-j	3.25a-d	3.31ab	3.34ab	3.09A
X639	**SA**	2.14f	2.99a-d	3.04a-d	3.06a-d	2.81AB	2.25j	3.27a-c	3.22a-d	3.49a	3.06A
	ASC	2.44e	2.87b-d	3.13a-c	3.10a-d	2.89A	3.21a-d	2.94d-f	3.25a-d	3.34ab	3.18A
Mean (A x C)		1.58F	2.49C	2.94B	2.99B		2.02F	2.75DE	2.65E	3.06BC	
		1.87E	2.94B	3.04AB	3.18A		2.15F	2.91CD	3.24AB	3.33A	
		2.29D	2.93B	3.09AB	3.08AB		3.73DE	3.11BC	3.24AB	3.42A	
Mean (B x C)		1.78F	2.65D	2.94BC	3.07AB		2.10D	2.89B	3.12A	3.25A	
		2.05E	2.92C	3.11A	3.10A		2.49C	2.96B	2.96B	3.28A	
Mean (C)		1.91C	2.79B	3.02A	3.09A		2.30D	2.92C	3.04B	3.27A	
Mean (B)		2.61B		2.80A			2.84B		2.92A		
Mean A		2.50C	2.76B		2.85A		2.62C	2.91B		3.12A	

Mean in each row , Colum or interaction having the same letter (s) are not significantly different at 5% level..

A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant

B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.

SA= Salicylic acid ASC= Ascorbic acid.

Element	**Ca (%)**	**Obreza et al (1992)**
Deficient	<1.5	
Low	1.5-2.9	
Optimum	3.0-4.9	

Table 9. Effect of foliar application of antioxidants and rootstocks on leaf magnesium percentage (%) of Chinese tangerine young trees grown under saline conditions

Treatments		First season 2015					Second season 2016				
Rootstock	**Antioxidant**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**
Sour orange	**SA**	0.440f-i	0.410hi	0.407hi	0.390i	0.412D	0.430e	0.440de	0.450de	0.440de	0.440C
	ASC	0.290j	0.510d-h	0.530d-g	0.580b-e	0.478C	0.270f	0.520b-d	0.527b-d	0.590ab	0.477C
Volkamer Lemon	**SA**	0.510d-h	0.630bc	0.660ab	0.640ab	0.610A	0.520b-d	0.650a	0.660a	0.650a	0.620A
	ASC	0.470f-i	0.510d-h	0.540c-f	0.730a	0.532B	0.490c-e	0.550bc	0.590ab	0.550bc	0.545B
X639	**SA**	0.460f-i	0.480f-i	0.520d-g	0.600b-d	0.515C	0.480c-e	0.470c-e	0.550bc	0.640a	0.535B
	ASC	0.430g-i	0.490e-i	0.520d-g	0.500d-h	0.485C	0.450de	0.540bc	0.590ab	0.590ab	0.543B
Mean (A x C)		0.365G	0.460EF	0.468EF	0.485D-F		0.350C	0.480B	0.488B	0.515B	
		0.490D-F	0.570BC	0.600B	0.685A		0.505B	0.600A	0.625A	0.600A	
		0.445F	0.485D-F	0.520C-E	0.550B-D		0.465B	0.505B	0.570A	0.615A	
Mean (B x C)		0.470C	0.507BC	0.529B	0.543B		0.477C	0.520B	0.553AB	0.577A	
		0.397D	0.503BC	0.530B	0.603A		0.403D	0.537AB	0.569A	0.577A	
Mean (C)		0.433C	0.505B	0.529B	0.573A		0.440C	0.528B	0.561A	0.577A	
Mean (B)		0.512A		0.508A			0.532A		0.521A		
Mean A		0.445C	0.586A		0.500B		0.458C	0.583A		0.539B	

Mean in each row, Colum or interaction having the same letter (s) are not significantly different at 5% level.
A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant
B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.
SA= Salicylic acid ASC= Ascorbic acid.

Element	**Mg (%)**	**Obreza et al (1992)**
Deficient	<0.20	
Low	0.20-0.29	
Optimum	0.30-0.49	
High	0.50-0.70	
Excess	>0.70	

Table 10. Effect of foliar application of antioxidants and rootstocks on leaf sodium percentage (%) of Chinese tangerine young trees grown under saline conditions

Treatments		First season, 2015					Second season; 2016				
Rootstock	**Antioxidant**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**
Sour orange	**SA**	0.110g	0.090h	0.060i	0.030jk	**0.073D**	0.090gh	0.060i	0.040j	0.020kl	0.053D
	ASC	0.160e	0.090h	0.090h	0.040j	**0.095C**	0.120f	0.080h	0.090gh	0.020kl	0.078C
Volkamer Lemon	**SA**	0.150ef	0.110g	0.040j	0.020kl	**0.080D**	0.130ef	0.100g	0.030jk	0.020kl	0.070C
	ASC	0.140f	0.040j	0.020kl	0.010l	**0.053E**	0.077h	0.030jk	0.020kl	0.010l	0.034E
X639	**SA**	0.180d	0.500a	0.300b	0.200c	**0.295A**	0.140de	0.400a	0.200c	0.100g	0.210B
	ASC	0.160e	0.500a	0.200c	0.200c	**0.265B**	0.150d	0.400a	0.200c	0.317b	0.267A
Mean (A x C)		0.135E	0.090F	0.075G	0.035H		0.105D	0.070E	0.065E	0.020F	
		0.145E	0.075G	0.030H	0.015I		0.103D	0.065E	0.025F	0.015F	
		0.170D	0.500A	0.250B	0.200C		0.145C	0.400A	0.200B	0.208B	
Mean (B x C)		0.147C	0.233A	0.133D	0.083F		0.120C	0.187A	0.090E	0.047F	
		0.153C	0.210B	0.103E	0.083F		0.116C	0.170B	0.103D	0.116C	
Mean (C)		0.150B	0.222A	0.118C	0.083D		0.118B	0.178A	0.097C	0.081D	
Mean (B)		0.149A		0.138B			0.111B		0.126A		
Mean A		0.084B	0.066C		0.280A		0.065B	0.052C		0.238A	

Mean in each row , colum or interaction having the same letter (s) are not significantly different at 5% level.
A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant
B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.
SA= Salicylic acid ASC= Ascorbic acid.

Table 11. Effect of foliar application of antioxidants and rootstocks on leaf chloride percentage Cl^- (%) of Chinese tangerine young trees grown under saline conditions

Treatments		First season, 2015					Second season; 2016				
Rootstock	**Antioxidant**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**	**0**	**400ppm**	**600ppm**	**800ppm**	**MeanAxB**
Sour orange	**SA**	0.500c	0.010g	0.010g	0.010g	0.133B	0.300c	0.010f	0.010f	0.010f	0.083C
	ASC	0.400d	0.050fg	0.033fg	0.010g	0.123B	0.300c	0.030ef	0.043ef	0.010f	0.096C
Volkamer Lemon	**SA**	0.600b	0.090fg	0.040fg	0.040fg	0.193A	0.200d	0.080e	0.030ef	0.020f	0.0825C
	ASC	0.600b	0.070fg	0.010g	0.010g	0.173A	0.300c	0.050ef	0.010f	0.010f	0.093C
X639	**SA**	0.700a	0.010g	0.010g	0.010g	0.183A	0.500b	0.010f	0.010f	0.010f	0.133B
	ASC	0.100f	0.200e	0.200e	0.010g	0.128B	0.600a	0.300c	0.333c	0.010f	0.311A
Mean (A x C)		0.450B	0.030DE	0.022E	0.010E		0.300B	0.020F	0.027F	0.010F	
		0.600A	0.080CD	0.025E	0.025E		0.250C	0.065E	0.020F	0.015F	
		0.400B	0.105C	0.105C	0.010E		0.550A	0.155D	0.172D	0.010F	
Mean (B x C)		0.600A	0.037D	0.020D	0.020D		0.333B	0.033D	0.017D	0.013D	
		0.367B	0.107C	0.081C	0.010D		0.400A	0.127C	0.129C	0.010D	
Mean (C)		0.483A	0.072B	0.051B	0.015C		0.367A	0.080B	0.073B	0.012C	
Mean (B)		0.169A		0.141B			0.099B		0.166A		
Mean A		0.128C	0.183A		0.155B		0.089B	0.088A		0.222A	

Mean in each row , colum or interaction having the same letter (s) are not significantly different at 5% level.
A= Rootstocks B= Antioxidants C= Concentrations A×B= Rootstocks × Antioxidant
B×C= Antioxidant ×Concentrations A ×B×C = Rootstocks × Antioxidant ×Concentrations.
SA= Salicylic acid ASC= Ascorbic acid.

accumulation of salt in plant oragns. He also added that under saline condition Na in flux a cross the plasma lamina to the vacuole might play a major role in permitting turgor maintenance. Some crops showed marked beneficial of sodium Na specially if the potassium K supply is limited .Those crops take up large amount of sodium Na which contributed the osmotic potential of the leaves and increases resistance to water stress salinity. In this respect the effect of salt stress on mineral ions content were recorded by **Tsabarducas et al (2015)** reported that the highest chloride (Cl^-) and Sodium (Na) quantities have been absorbed by lesson lemon cultivar seedling while the lowest one by Maglini lemon cultivar seedling under salt stress. **Kohoshbakht et al (2015)** investigated the influence of different salinity concentrations (0.2,50 and 75 Mm) on nine citrus rootstocks (Cleopatra mandarin, Carrizo citrange, Macrophylla, Iranian mandarin Bakraii, Rangpur lime, Rough lemon, sour orange, *swingle citrange* and Trifoliate orange) in greenhouse experiment. They found that, ion concentration of Cl^- and Na increased by salinity treatment salinity also increased Mg content in roots and reduced Ca and Mg concentrations in leaves. Also, salinity makes decline in K concentration. They concluded sour orange and Cleopatra mandarin were the most tolerant rootstocks to salinity of all the nine rootstocks studied. In addition, Trifoliata orange, Carrizo citrange and swingle citrumelo were most sensitive to salt stress followed by the rough lemon and macrophylla.

1.2. Interaction effect on Mineral ions concentrations

Our results show that **Table (5, 6, 7, 8, 9 and 10)** in both seasons Chinese tangerine budded on volkamer lemon rootstock interacted with antioxidants salicylic acid and/ or ascorbic acid at the concentration 800 ppm and gave the highest nitrogen concentration.

Phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca) contents affected greatly by the interaction where the highest Ca **Table (8)** and Magnesium **Table (9)** were registered by the interaction between volkamer lemon rootstock interacted with 800 ppm salicylic acid and / or ascorbic acid to give the highest concentration in both seasons .On the other hand the least concentration of Na^+ was recorded in Chinese tangerine budded on volkamer lemon rootstock interacted with the antioxidants Salicylic acid and /or Ascorbic acid. However the highest Na^+ achieved by X639 rootstock interacted with the antioxidants 800 ppm dose.

Phosphorus and Potassium greatly affected by rootstocks, Chinese tangerine budded on sour orange showed the highest concentration of phosphorus (P) **Table (6)** when interacted with ascorbic acid of the concentration of 600 ppm.

Chloride Cl greatly affected with the interaction between rootstocks, antioxidants and their different concentrations. The highest mean values were recorded for salinized rootstock and zero antioxidants (Control).

We could conclude that salt damage to Chinese tangerine young tress has been mainly attributed to excessive accumulation of chloride Cl and Sodium Na in leaves and may be due to nutritional imbalance in plant metabolism.

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