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IMPROVEMENT OF SWEET PEPPER (*Capsicum annuum* L.) PRODUCTIVITY USING SOME ANTIOXIDANTS UNDER SALINITY CONDITIONS OF SOUTH SINAI

II. FRUIT QUALITY AND CHEMICAL CONSTITUENTS

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ABSTRACT

At Ras-Suder Research Station, South Sinai, Desert Research Center, two field experiments were conducted during summer seasons of 2012 and 2013. The main object of this research was improving the productivity of sweet pepper plant (*Capsicum annuum* L.) hybrid "Sonar" using some antioxidant treatments on fruit quality and chemical constituents of fruits. Aqueous solutions of antioxidants as foliar spray; *i.e.*, ascorbic acid (Vitamin C), Oxalic acid, Salicylic acid (SA), and Tocopherol (Vitamin E) within four different concentrations of these antioxidants (0.0, 200, 400 and 600 ppm) were applied at 20, 40 and 60 days after transplanting. Obtained results indicated that the best antioxidant treatments which gave the highest values of fruit quality (V.C, T.S.S, fruit size, fruit length, diameter and shape) and chemical content (N, P, K, Ca, Mg and carbohydrates) were spraying sweet pepper plants with salicylic acid followed by ascorbic acid with 400 ppm of both antioxidants.

Key words: Ascorbic acid, oxalic acid, salicylic acid, tocopherol, fruit quality, chemical composition, sweet Pepper.

INTRODUCTION

Sweet Pepper (*Capsicum annuum* L.) is an important vegetable crop, not only because of its economic importance, but also for the nutritional value of its fruits, mainly due to the fact that it is an excellent source of natural colures and antioxidant compounds (**Howard *et al.,* 2000**). Pepper fruits is considered an excellent source of bioactive nutrients such as carotenoids, vitamin C and phenolics compounds **(Navarro *et al.,* 2006).**

The application of ascorbic acid can mitigate the harmful effects of salt stress and may have stimulatory effects on plants, for example, ascorbic acid is synthesized in 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 **(El-Kobisy *et al.*, 2005).**

Oxalic acid application has received much attention in relation to induced disease systemic resistance and its antioxidant capability **(Zhang *et al.*, 1999).** Salicylic acid (AS) can play a significant role in plant water relations, photosynthesis and growth in plants (**Arfan *et al.*, 2007**). SA has been proven to be a major component in signal transduction systems,

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which can induce particular enzymes catalyzing biosynthetic reactions and essential for the development of systemic acquired resistance. **(Vanloon and Antoniw, 1982).** Enzyme activities such as amylase and nitrate reductase were increased by SA application **(Sharma *et al.*, 1986; Chen *et al.*, 1993)**. Vitamin E is considered as highly antioxidant at the membrane site **(Hess, 1983)** which is a highly effective antioxidant at the membrane site, and has a positive effect on chlorophyll content of bean plants **(Schmitz and Noga, 1998).** This research aimed to study the effect of applying some antioxidants on sweet pepper (*Capsicum annuum* L., hybrid "Sonar") to alleviate the harmful effect of salinity under South Sinai conditions and fruit quality and chemical composition of fruits.

MATERIALS AND METHODS

Two field experiments were carried out during the summer seasons of 2012 and 2013 at The Experimental Farm, Research Station Ras Suder, South Sinai Desert Research Center. The research aimed to study the role of some antioxidants and their concentrations to increase resist of pepper plant to alleviate harmful effect of salinity which reflected on fruit quality and chemical composition of sweet pepper plants under sandy loam soil conditions using drip-irrigation system.

The mechanical and chemical analyses of the experimental soil are presented in Table 1. The soil analysis was carried out according to **Richards (1954), Black and Editor (1965) and Jackson (1967).**

The hybrid "Sonar" was used in this study. Seeds of sweet pepper were sown on 10^{th} February in seedling trays under a plastic greenhouse conditions. The transplants were set up into the field on 1^{st} of April in both of 2012 and 2013 seasons. Seedlings were transplanted besides dripper lines, the distance between every two dripper lines were 100 cm. The distance between plants in the same line was 50 cm. The plot area was 12 m^2 (1m width x12 m length). The fertigation method was used in the experiment by water pumped from a well; the analysis of irrigation water is presented in Table 2. The experiment included 16 treatments which were all combinations between 4 antioxidants and 4 concentrations:

Antioxidants materials were: Ascorbic acid, Oxalic acid, Salicylic acid, and Tocopherol.

Concentration of antioxidants were: 1) Control, 200 ppml^{-1}, 400 ppm l^{-1}, and 600 ppm l^{-1}.

The antioxidants were applied as spraying on sweet pepper plants three times at 20, 40 and 60 days after transplanting. The design of the experiment in the field was split plot design with three replications. Antioxidants were distributed randomly in main plots, while their concentrations were allowed randomly for sub plots. Conventional culture practices were done as needed and were similar to those used in commercial pepper production in the open field in South Sinai region.

Data Recorded

Fruit quality

Samples from eight fruits at the green ripe stage of the third picking were randomly taken from each sub plot and the following date were recorded:

1) Ascorbic acid content (Vit. C), it was determined in fruit juice (as mg/100ml juice) using 2, 4 diclorophenol endophenpol as described in **AOAC (1990)**. Total soluble solids (TSS%) it was measured using a hand refractometer. 3) Fruit size (cm^3),; 4) Fruit length (L) (cm); 5) Fruit diameter (D in cm); 6) Fruit shape (L/D), fruit length and diameters were measured by using a caliper. Fruit shape "fruit length/ diameter (L/D) was calculated, 7) fruit chlorophyll

Table (1): Chemical properties of the experimental soil.

Depth (cm)	pH	E.C dS/m^2	Saturation soluble extract (mg/100g)							Total nutrients (mg Kg^{-1})			
			Cations			Anions							
			Ca^{++}	Mg^{++}	Na^{+}	Co^{--}_3	HCO^-_3	So_4^{--}	Cl^-	N	P	K	Fe
0-30	7.7	8.65	24.5	5.2	56.5	0.00	6.0	19.0	61.5	26.0	5.1	51.5	4.2
30-60	7.9	7.35	16.8	3.8	52.4	0.00	3.5	21.0	49.0	23.5	3.4	35.3	3.4

Table (2): Chemical analysis of irrigation water.

pH	EC dS/m^{-2}	Soluble ions (meq.1^{-1})							
		Cations				Anions			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^-	HCO_3^-	CO_3^{--}	SO_4^{--}
7.77	7.85	20.5	8.6	48.89	0.35	57.5	5.0	0.0	16.2

reading (Chlorophyll was determined in fruit using a digital chlorophyll meter (model Minolta Chlorophyll Meter SPAD-502 manufactured by Minolta Company, Japan).

Fruit Chemical Composition

1) Nitrogen content (It was determined by modified micro Kjeldahl method according to **Peach and Tracey (1956), 2) Phosphorus content (**The determination method depends on the formation of blue complex between ammonium molybdate in the presence of ascorbic acid (reducing agent) according to **Rowell (1993).** The samples were measured with spectrophotometer at 880 nm, **3) Potassium and Sodium content** potassium and sodium were measured by flam photometer as described by **Irri (1976), 4) Calcium content** it was determined by flam photometerically method according to the method described by **Brown and Lilliland (1964), 5) Magnesium content** magnesium was estimated by the versenate titration method as described by **Jackson (1967).**

Statistical analysis

Statistical analysis of the obtained data was carried out according to Statistical analysis of variance according to **Snedecor and Cochran (1980).** Duncan s multiple range tests was used for comparison among means **(Duncan, 1958).**

RESULTS AND DISCUSSION

Fruit quality

Effect of Antioxidants

Application of antioxidants on sweet pepper had significant affects on fruit quality parameters Table 3, the highest values for vitamin C content were recorded with application of salicylic acid or ascorbic acid in first season as well as tocopherol in second season.

Application of salicylic acid in both seasons recorded the highest content of T.S.S (%) in pepper fruit.

No significant differences were observed among application of antioxidants on fruit size and fruit shape in both growing seasons. Under Ras Suder condition application of ascorbic acid, salicylic acid, and tocopherol gave the best values for fruit length, fruit diameter and total chlorophyll in both seasons, except fruit diameter in the second season.

Table (3): Effect of antioxidants on the fruit quality of sweet pepper during 2012 and 2013 seasons.

Character / Treatment	V.C (mg/ 100mg)	TSS (%)	Fruit size (cm^3)	Fruit length (L) (cm)	Fruit diameter (D) (cm)	Fruit shape (L/D)	Total chlorophyll reading (SPAD)
			First season (2012)				
Ascorbic acid	223.75a	7.47b	7.47b	5.65a	4.03a	1.40a	42.63ab
Oxalic acid	175.00c	6.86d	6.86d	4.65b	3.50b	1.33a	39.68b
Salicylic acid	224.58a	7.65a	7.65a	6.23a	4.34a	1.44a	43.74a
Tocopherol	206.25b	7.09c	7.09c	5.55a	3.85ab	1.45a	42.29ab
			Second season (2013)				
Ascorbic acid	225.00a	7.57b	94.16a	5.81a	4.25a	1.33a	43.33a
Oxalic acid	177.50b	6.97d	82.08a	4.73b	3.61a	1.31a	40.03b
Salicylic acid	230.00a	7.72a	97.91a	6.39a	4.52a	1.41a	44.74a
Tocopherol	214.16a	7.16c	90.41a	5.70a	3.97a	1.44a	42.86a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level o significance, according to **Duncan's** multiple range test.

Effect of antioxidants concentration

Data in Table 4 show significant effects for spray of antioxidant concentrations on all fruit quality of sweet pepper, except fruit shape in both seasons. Spraying with 200, 400 and 600 ppm gave the highest values compared with control treatment in both growing seasons. However, application of 400 and 200 ppm best concentration for all studied traits followed by spraying with 600 ppm.

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Effect of interaction between antioxidants and their concentration

Data in Table 5 show significant effect for interaction between antioxidants and their concentrations on fruit quality of sweet pepper, except fruit shape in both seasons. The best interaction treatments were ascorbic acid with 600 ppm and salicylic acid with both 400 and 600 ppm in both seasons for vitamin C content. For other traits, combination between salicylic acid and 400 ppm recorded the best values followed by 600 ppm and 200 ppm, respectively. Plants which treated with the salicylic acid, ascorbic acid and tocopherol had the best chemical fruit quality in a comparison with control.

Many researchers studied the response of vegetable fruits yield to the foliar application of some antioxidant treatments and their reports are in good accordance with that which written here **(El-Hifny and El-Sayed, 2011** on sweet pepper; **Ghurbat, 2013** on pepper plant**; Abd El-Gawad and Bondok, 2015** on tomato and **Shabana, Abeer *et al.,* 2015** on sweet pepper).

In this respect, **Hayat and Ahmed, (2007)** found that salicylic acid is a plant growth regulator that increases plant bioproductivity. **Akbarimehr *et al.* (2013**) reported that SA has a significant effect on fruit weight and size of sweet pepper plant. Bigger fruit has more amount of water inside its cells, so TSS9 (%) decreases. This result is different from an experiment that was carried out on tomato plants in which TSS increased **(Yildirim and Dursun, 2009).** In this study TSS/TA decreases which

Table (4): Effect of antioxidant concentrations (ppm) on the fruit quality of sweet pepper during 2012 and 2013 Seasons.

Character / Treatment	V.C (mg/100 mg)	TSS (%)	Fruit size (cm3)	Fruit length (L) (cm)	Fruit diameter (D) (cm)	Fruit shape (L/D)	Total chlorophyll reading (SPAD)
First season (2012)							
0.0	136.66b	6.44d	68.33c	4.50c	3.17b	1.43a	39.05c
200	222.08a	7.63b	92.91a	6.02a	4.24a	1.42a	43.49ab
400	233.75a	7.89a	94.43a	6.18a	4.34a	1.42a	44.51a
600	237.08a	7.11c	83.88b	5.38b	3.96a	1.36a	41.29bc
Second season (2013)							
0.0	138.33b	6.51d	75.00b	4.57b	3.29b	1.36a	39.10b
200	228.33a	7.75b	98.75a	6.16a	4.41a	1.40a	44.05a
400	239.16a	7.95a	99.16a	6.25a	4.47a	1.40a	45.50a
600	240.83a	7.21c	91.66a	5.64a	4.19a	1.35a	42.31ab

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level o significance, according to **Duncan's** multiple range test.

Table (5): Effect of interaction between some antioxidant and their concentration (ppm) on the fruit quality of sweet pepper during 2012 and 2013 seasons.

Character / Treatment		Vitamin C (mg/100 mg)	TSS (%)	Fruit size (cm^3)	Fruit length (L) (cm)	Fruit diameter (D) (cm)	Fruit shape (L/D)	Total chlorophyll reading (SPAD)
First season (2012)								
Ascorbic acid	**0.0**	143.3h	6.43k	65.0h	4.50f	3.20fg	1.42a	39.23g-i
	200	225.0d	7.74d	95.0bc	5.83cd	4.23b-d	1.39a	43.56b-e
	400	253.3bc	8.55b	100.5ab	6.86ab	4.63ab	1.48a	46.03ab
	600	273.3a	7.16h	86.6cde	5.43de	4.06b-e	1.34a	41.70d-g
Oxalic acid	**0.0**	143.3h	6.41k	68.3h	4.43f	3.23fg	1.37a	38.66i
	200	205.0e	7.23gh	83.3de	5.03ef	3.73d-g	1.35a	41.36e-h
	400	185.0f	7.05i	78.3e-g	4.66f	3.63d-g	1.30a	40.33f-i
	600	166.6g	6.75j	73.3f-g	4.50f	3.40e-g	1.32a	38.36i
Salicylic acid	**0.0**	128.3h	6.46k	70.0gh	4.56f	3.10g	1.51a	39.43g-i
	200	250.0bc	8.15c	96.6b	6.93ab	4.70ab	1.47a	44.93bc
	400	258.3ab	8.66a	106.6a	7.40a	5.06a	1.46a	48.26a
	600	261.6ab	7.32ef	95.5bc	6.03cd	4.50a-c	1.34a	42.33c-f
Tocopherol	**0.0**	131.6h	6.48k	70.0gh	4.53f	3.16g	1.44a	38.86hi
	200	208.3e	7.38e	96.6b	6.30bc	4.30b-d	1.47a	44.10b-d
	400	238.3cd	7.30fg	92.2b-d	5.80cd	4.03b-e	1.44a	43.43c-e
	600	246.6bc	7.23gh	80.0ef	5.56de	3.90c-f	1.44a	42.76c-f
Second season (2013)								
Ascorbic acid	**0.0**	146.6gh	6.56k	73.33g	4.53e	3.23g	1.25a	39.20e
	200	230.0de	7.93d	105.00ab	6.03c	4.56a-d	1.32a	44.60bc
	400	246.6bcd	8.59b	103.33a-c	7.00ab	4.86ab	1.45a	47.30ab
	600	276.6a	7.22h	95.00b-e	5.70cd	4.36b-e	1.30a	42.23c-e
Oxalic acid	**0.0**	136.6hi	6.51k	75.00g	4.50e	3.36g	1.33a	38.93e
	200	213.3ef	7.35fg	88.33c-g	5.13de	3.70fg	1.40a	41.46c-e
	400	196.6f	7.10i	83.33d-g	4.70e	3.76e-g	1.25a	40.66de
	600	163.3g	6.91j	81.66e-g	4.60e	3.63fg	1.27a	39.06e
Salicylic acid	**0.0**	126.6i	6.43l	78.33fg	4.60e	3.30g	1.40a	39.46e
	200	250.0bc	8.28c	101.66a-c	7.06ab	4.93ab	1.43a	45.33bc
	400	263.3ab	8.78a	113.33a	7.40a	5.13a	1.44a	50.06a
	600	280.0a	7.38f	98.33a-d	6.50bc	4.73a-c	1.38a	44.10b-d
Tocopherol	**0.0**	143.3hi	6.53k	73.33g	4.66e	3.26g	1.43a	38.80e
	200	220.0e	7.46e	100.00a-c	6.43bc	4.46b-d	1.45a	44.83bc
	400	250.0bc	7.34fg	96.66b-e	5.93c	4.13c-f	1.45a	43.96b-d
	600	243.3cd	7.31g	91.66b-f	5.76cd	4.03d-f	1.44a	43.86b-d

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to **Duncan's** multiple range test.

can be favored by some people who like sour-sweet taste. **ElWan and El-Hamahamy (2009)** found that foliar treatment of SA increased the amount of vitamin C in pepper fruit, however it had no significant effect in this study which might be because of higher concentrations in comparison to theirs.

Fruit Chemical Composition

Effect of antioxidants

Data in Table 6 show significant effects of antioxidants on fruit content of N, P, K, Na, Ca, Mg and total carbohydrates in both growing seasons. As regard to content of N, P, K, Ca, Mg and total carbohydrates the highest effects were with appling salicylic acid followed by ascorbic acid and tocopherol, respectively in both seasons. Concerning the content of Na, the highest effect was found with applying oxalic acid.

Effect of antioxidants concentrations

Data in Table 7 show significant effects for concentrations on all studied traits in both seasons. The highest effects were recorded with application of antioxidants at 400 or 200 ppm for N, P, K, Ca, Mg and total carbohydrates, while the highest content of pepper fruit from Na was recorded with control treatment (without antioxidants).

Effect of interaction between antioxidants and their concentration

Data in Table 8 show significant effects for interaction treatments in the first and second season. The application of salicylic acid at 400 ppm had the highest effects followed by ascorbic acid at 400 ppm for N, P, K, Ca, Mg and total carbohydrates in pepper fruits, while the highest content of pepper fruit from Na was recorded with control treatment (without antioxidants).

These results indicate that antioxidants had positive effects on chemical contents of leaves and fruits of pepper plants as reported by **Hamada and Al-Hakimi (2001)** who observed positive effects of SA in the Na, K, Ca and Mg content of wheat plants grown under salinity. SA application inhibited Na accumulation in salinity condition. Application of salicylic acid at 150 mg l^{-1} increased the uptake of N, P and K in wheat grains over the control **(Zaghlool, *et al.* 2001). Also, Sarang, *et al.* (2003)** found that N and protein content, increased in *Phaseolus vulgaris* by foliar application of salicylic acid at 0.1%. In addition, **Günes *et al.* (2005)** that found SA treatments stimulated N accumulation in plants and P, K, Mg and Mn concentrations of SA received plants were increased in the stress conditions.

The effects of SA were explanted by **Javaheri *et al.* (2012)** who reported that the role of salicylic acid may be improve membrane permeability, absorption and utilization of mineral nutrients and transport of assimilates on tomato plant. On the other hand, SA treatment increased soluble sugar content, proline and free amino acids content as compared with SA untreated stressed-plants (**Abbaspour, 2012).** In addition, **Yildirim *et al.* (2008)** on cucumber reported that SA facilitated the maintenance membrane functions. This function could be attributed to the induction of antioxidant responses and elevated Ca uptake that protects the plant from the oxidative damage by SA **(El-Tayeb, 2005).** Application of SA increases the accumulation of Ca^{+2} which can maintain membrane integrity **(Khan *et al.*, 2010).** Applied SA completely counteracted the harmful effects of salinity stress **(Abdul Qados, Amira, 2015)**.

Moreover, the exogenously applied SA seems to be carried away from the sites of its initial application to different other tissues of the plants to generate response (**Raskin, 1992**). It is well documented that phenolic compounds exert their influence

Table (6): Effect of antioxidant on the chemical content of sweet pepper fruits during 2012 and 2013 seasons.

Character / Treatment	Chemical contents (%)						
	N	P	K	Na	Ca	Mg	Carbohydrates (mg/g D.W)
				First season (2012)			
Ascorbic acid	1.63a	0.320a	2.62a	0.90c	1.54ab	0.304ab	518.4a
Oxalic acid	1.36b	0.254b	2.38c	1.04a	1.28c	0.243c	494.28b
Salicylic acid	1.67a	0.335a	2.59ab	0.89c	1.56a	0.321a	527.05a
Tocopherol	1.57a	0.319a	2.52b	0.93b	1.52b	0.295b	517.60a
				Second season (2013)			
Ascorbic acid	1.71a	0.325a	2.67a	0.90c	1.54ab	0.312ab	532.42ab
Oxalic acid	1.45b	0.261b	2.47b	1.04a	1.34c	0.250c	501.91c
Salicylic acid	1.76a	0.327a	2.66a	0.88c	1.60a	0.326a	534.32a
Tocopherol	1.62ab	0.300ab	2.60ab	0.93b	1.53b	0.301b	524.23b

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to **Duncan's** multiple range test.

Table (7). Effect of antioxidant concentrations (ppm) on the chemical content of sweet pepper fruits during 2012 and 2013 seasons.

Character / Treatment	Chemical contents (%)						
	N	P	K	Na	Ca	Mg	Carbohydrates (mg/g D.W)
				First season (2012)			
0.0	1.14c	0.219c	2.01c	1.14a	1.15c	0.226c	483.55c
200	1.78a	0.354a	2.80a	0.85c	1.59a	0.330a	535.30a
400	1.77a	0.357a	2.76a	0.85c	1.62a	0.330a	531.14a
600	1.54b	0.297b	2.54b	0.913	1.45b	0.278b	507.41b
				Second season (2013)			
0.0	1.18c	0.227c	2.09c	1.14a	1.20c	0.231c	496.66c
200	1.87a	0.362a	2.88a	0.85c	1.64a	0.337a	539.02a
400	1.86a	0.363a	2.82a	0.85c	1.68a	0.336a	540.65a
600	1.61b	0.306b	2.61b	0.91b	1.49b	0.286b	516.56b

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to **Duncan's** multiple range test.

Table (8): Effect of interaction between antioxidant and their concentrations (ppm) on the chemical content of sweet pepper fruits during 2012 and 2013 seasons.

Treatment \ Character		Chemical contents (%) N	P	K	Na	Ca	Mg	Carbohydrates (mg/g D.W)
		First season (2012)						
Ascorbic Acid	0.0	1.12g	0.218g	1.99g	1.15a	1.13h	0.224e	463.83g
	200	1.84bc	0.376bc	2.89b	0.78g	1.53d	0.348b	545.83ab
	400	1.97ab	0.392ab	2.98a	0.78gh	1.73b	0.354ab	553.20a
	600	1.60e	0.290d	2.60cd	0.89d	1.44e	0.254c	511.00de
Oxalic acid	0.0	1.14g	0.218g	2.02g	1.15a	1.13h	0.218e	487.43f
	200	1.65de	0.291d	2.64c	0.99c	1.42e	0.262c	511.66de
	400	1.41f	0.265e	2.48e	1.00bc	1.33f	0.246cd	492.46ef
	600	1.25g	0.242f	2.40f	1.02b	1.24g	0.246cd	485.56f
Salicylic Acid	0.0	1.15g	0.222g	2.03g	1.14a	1.16h	0.227e	491.56ef
	200	1.86bc	0.374bc	2.85b	0.76h	1.74b	0.358ab	544.40ab
	400	2.04a	0.395a	2.97a	0.76h	1.83a	0.369a	554.80a
	600	1.63de	0.288d	2.53de	0.89d	1.53d	0.263c	517.46cd
Tocopherol	0.0	1.15g	0.219g	1.99g	1.14a	1.18h	0.233de	491.40ef
	200	1.76cd	0.377bc	2.82b	0.87de	1.68b	0.351b	539.30abc
	400	1.69de	0.374bc	2.62c	0.87e	1.62c	0.350b	524.10bcd
	600	1.70de	0.370c	2.64c	0.84f	1.61c	0.348b	515.63d
		Second season (2013)						
Ascorbic acid	0.0	1.17h	0.225f	2.06e	1.16a	1.20i	0.231e	500.48g
	200	1.92cd	0.381b	2.96a	0.78i	1.62de	0.360ab	550.22b
	400	2.09ab	0.397ab	3.00a	0.77ij	1.81b	0.362ab	559.02ab
	600	1.65f	0.298c	2.67b	0.89ef	1.48f	0.26cd	519.96de
Oxalic acid	0.0	1.18h	0.226f	2.20d	1.14ab	1.19i	0.225e	496.14g
	200	1.75ef	0.298c	2.70b	0.99d	1.48f	0.271c	513.38ef
	400	1.48g	0.271d	2.52c	1.02c	1.39g	0.252d	503.08fg
	600	1.39g	0.251e	2.46c	1.02c	1.29h	0.251d	495.04g
Salicylic acid	0.0	1.20h	0.230f	2.05e	1.13b	1.20i	0.234e	498.52g
	200	2.01bc	0.383b	2.94e	0.76jk	1.76b	0.366ab	552.80ab
	400	2.14a	0.402a	3.04a	0.75k	1.87a	0.373a	563.58a
	600	1.69f	0.294c	2.60bc	0.89e	1.58e	0.276c	522.39de
Tocopherol	0.0	1.18h	0.226c	2.06e	1.13b	1.21i	0.233e	491.50g
	200	1.81de	0.386ab	2.91a	0.87fg	1.68c	0.352b	539.68c
	400	1.75ef	0.381b	2.72b	0.86g	1.66cd	0.351b	536.91c
	600	1.73ef	0.380b	2.71b	0.84h	1.63cde	0.351b	528.83cd

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to **Duncan's** multiple range test.

on physiological and biochemical processes including, photosynthesis, ion uptake, membrane permeability, enzyme activities, flowering, heat production and growth and development of plants. One, such a natural compound is SA that may function as a plant growth regulator **(Arberg, 1981).**

Production of free amino acids, especially proline by plant tissue during drought, salt and water stress is an adaptive response. Increasing the amount of proline and sugars in the plants would lead to the resistance against loosing water, protect turger, reduce the membrane damage and accelerate the growth of plants under stress conditions **(Amin *et al.*, 2009; Gallie, 2012).** As regard to the effects of ascorbic acid, it was reported that ascorbic acid increased the potassium concentration in shoot and root of sweet pepper plants growing under normal and saline conditions. In this respect, **Shawky, Neveen (2003).** suggested that the protection of sweet pepper plants against salt stress by an exogenous supply of Vitamin C is believed to be caused indirectly as a result of its effect on K^+ uptake which plays an essential role in many metabolic processes; such as, may be induce the synthesis of stress proteins as a "messenger" (chitinase, glucanase, peroxidase, peroxidismutase), in general it is the induction of PR-proteins.

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الملخص العربي

تحسين إنتاجية الفلفل الحلو باستخدام بعض مضادات الأكسدة تحت ظروف الملوحة بجنوب سيناء

٢. جودة الثمرة والتركيب الكيماوي

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أجريت تجربتين حقليتين في الموسم الصيفي لعامي ٢٠١٢، و٢٠١٣ في المحطة البحثية برأس سدر بجنوب سيناء والتابعة لمركز بحوث الصحراء. كان الهدف الرئيسي هو تحسين إنتاجية محصول الفلفل صنف هجين "سونار" عن طريق استخدام بعض مضادات الأكسدة ودراسة تاثيرها على جودة الثمار ومحتواها الكيماوي لمحصول الفلفل هجين " سونار".تم الرش بمحلول من مضادات الأكسدة التالية: حمض الأسكوربيك (فيتامين ج)، وحمض الأوكسالك، وحمض السلسيلك، والتيكوفيرول (فيتامين هـ) وذلك بأربع تركيزات من كل من هذه المواد وهي: بدون رش، و٢٠٠%، و٤٠٠%، و٦٠٠ ppm، وتم رشها بعد ٢٠، و٤٠، و٦٠ يوماً بعد الشتل. أوضحت النتائج أن أفضل مضادات الأكسدة التي نتج عنها أعلى القيم لصفات جودة الثمرة (المحتوى من فيتامين ح، والمواد الصلبة الذائبة الكلية، وحجم الثمرة، وطول الثمرة، وقطر وشكل الثمرة)، والمحتوى الكيماوي للثمرة (النيتروجين، الفوسفور، والبوتاسيوم، والكالسيوم، والمغنسيوم، والكربوهيدرات) هي الرش بحمض السلسيلك تليها حمض الأسكوربيك بتركيز ٤٠٠ جزء في المليون من أي منهما.

الكلمات الاسترشادية: الفلفل الحلو، مضادات الأكسدة، الملوحة، جنوب سيناء، جودة الثمرة، والتركيب الكيماوي.

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