COMPARATIVE STUDY ON ANTIOXIDANTS AND SYNTHETIC PLANT GROWTH REGULATORS EFFECTS FOR REDUCING FLOWER SHEDDING, ENHANCING YIELD IN RELATION TO LEAF ANATOMICAL STRUCTURE OF PEPPER PLANT

ARISHA, H. M. E.[1], K. A. M. NOUR[2] and F. M.A. EL-SAADONY[3]

1. *Hort. Dept., Fac. Agric., Zagazig Univ., Egypt*
2. *Self- Pollination Vegetable Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt*
3. *Agric. Bot. Dept., Fac. Agric., Zagazig Univ., Egypt*

Abstract

Two field experiments were carried out during the two successive summer seasons of 2011 and 2012 at the Experimental Farm, El Kassasein Research Station, Ismailia Governorate, to assess the response of hot pepper plants (*Capsicum annuum* L.) cv. Jalapeno to enhance plant growth, dry weight, fruit setting and yield and its components as well as anatomical structure of leaf during summer seasons under sandy soil conditions. Aqueous solutions of the antioxidants as foliar spray;i.e., ascorbic acid (AA) at 200 and 400ppm, salicylic acid (SA) at 100 and 200 ppm, α -tocopherol (Vit. E) at 100 and 200 ppm in comparison with naphthalene acetic acid (NAA) at 25 and 50 ppm and the control were investigated. Spraying hot pepper plants with different concentrations of antioxidants and NAA had significant effect, in most cases, on plant growth, dry weight, fruit setting percentage and yield and its components as well as it had clear effect on leaflet blade anatomical parameters. In general, the best treatments that recorded the highest values of above-mentioned traits were foliar spraying of hot pepper plants with NAA at 25 followed by ascorbic acid at 400 ppm and α–tocopherol at 200 ppm. While, spraying plants with NAA, ascorrbic acid and Salicylic acid as well as vitamin E at different concentrations had no significant effect on number of both branches and flowers per plant as well as average fruit weight in both seasons.

Key words: hot pepper, antioxidants, ascorbic acid, salicylic acid, α– tocopherol, NAA, yield, growth, fruit setting, anatomical traits.

INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) is a member of the solanaceous fruit vegetables. It is one of the most important, popular and favorite vegetable crops cultivated in Egypt for local consumption and exportation. Peppers are grown as an annual crop in temperate regions. In Egypt, the yield of late summer plantation for harvested pepper crop is yielded in the open field were during June up to August. The optimum temperature favorable for growth of sweet pepper ranges between 20 and 25°C. When temperature falls below 15°C or exceeds 32°C, growth is usually retarded and yield decreases (Saha *et al.,* 2010). In addition, when peppers plants are exposed

to high temperature during the flowering and fruiting period (reproductive phase) leads to shedding of flowers and flower buds as well as young fruits (Erickson and Markhart, 2002).

Fruit set percentage was found to be not more than 8.8 % (Veerappa, 1980) and extent of flower drop ranged from 50 to 95% depending on the climate condition of cultivation season(Usha and Peter,1988).

The role of hormones on sweet pepper fruit growth has been the subject of recent reviews (Serrani *et al.,* 2007). In this regard, Tyburski *et al.* (2009) on tomato found that auxin induced reactions are often enhanced by oxidative stress. Many trails has been carried out for increasing flower set and fruit yield of sweet pepper by using different factors including plant growth regulators and natural extracts as well (El-Desouky *et al.,* 2000; Wanas, 2006). Also, much evidence suggests that auxin is involved in the regulation of fruit development. Auxin is produced in pollen and in the embryo of developing seeds and the initial stimulus for fruit set may result from pollination (Taiz and Zeiger, 2006). Furthermore, the thickness of leaf blade and palisade and spongy tissues of faba beans leaves were significantly improved in α – tocopherol sprayed plants at 0.50 mM compared to unsprayed ones (Semida *et al.,* 2014).

Foliar application of NAA at 100 ppm significantly increased fruit yield, number of fruits and average fruit weight of bell pepper. In addition, total chlorophyll, ascorbic acid and nitrate reductase activity were also increased (Sridhar *et al.,* 2009).

Ascorbic acid is currently considered to be regulators on plant growth and development owing to their effects on cell division and differentiation. Moreover the changes in the level of ascorbic acid in response to ionic stress might be important in the regulation of the ionic environment within the cell (Abd El-Aziz *et al.,* 2006). Foliar application of sweet pepper plant with ascorbic acid at 400 ppm significantly increased plant growth characters, dry weight yield, number of fruits per plant and fruit weight (El-Hifny and El-Sayed, 2011). Application of ascorbic acid at 300 ppm caused a significant increases in leaf anatomical parameters of pepper plants ,i.e., thickness of blade, mesophyll, palisade and spongy tissues compared to untreated plants (Al Sahli *et al.,* 2013).

Salicylic acid (SA) a natural plant product, combines growth enhancement and antisenescence properties (Raskin, 1995) and it involved in eliciting specific responses to biotic and abiotic stresses. Abd El-Al (2009) found that foliar application of salicylic acid plays a great role in improving the productivity of sweet pepper plants. Application of exogenous salicylic acid as a natural phytohormone at non- toxic concentrations has bean shown to be effective in some of the qualitative and

quantitative characters of pepper plants (Elwan and El-Hamahmy, 2009).The highest early, marketable and total yield as well as physical characters of sweet pepper fruits were obtained with 100ppm salicylic acid (Abou El-Yazeid, 2011). Pre-sowing seed soaking in salicylic acid at 0.5mM led to a better treatment for germination percentage and faster growth rate of sweet pepper compared to 0.1mM and the control (Hanieh *et al.,* 2013).

In plants, tocopherols are believed to protect chloroplast membranes from photooxidation and help to provide an optimal environment for the photosynthetic machinery (Munne-Bosch and Algere, 2002). They added also that tocopherols accumulations also occurs in plants suffer from a variety of a biotic stresses including high light, drought, salt and cold and may provide on additional line of protection from oxidative damage. El-Bassiouny *et al.* (2005) reported that foliar spray of faba bean plants with α – tocopherol induced increments in growth parameters and yield components. Plant growth, total dry weight, yield and its components were significantly affected by spraying snap bean plants with vitamin E at 150ppm (Nour *et al.,* 2012) and 0.5mM α – tocopherol on field bean (Semida *et al.,* 2014).

Therefore, the purpose of the present work was to study the effect of some antioxidants and NAA to overcome the adverse effects of high temperature prevailing during the summer season on plant growth, dry weight, flowering, fruit setting and yield and its components as well as anatomical structure of leaf blade of pepper plants.

MATERIALS AND METHODS

The present work was carried out during two successive summer seasons of 2011 and 2012 at the Experimental Farm, El Kassasein Research Station, Ismailia Governorate, to assess the response of *Capsicum annuum* L. cv. Jalapeno (hot pepper) to foliar spray with some antioxidants, i.e., ascorbic acid (AA), salicylic acid (SA) and α -tocopherol (Vit. E) in comparison with naphthalene acetic acid (NAA) for overcoming the adverse effects of high temperature during summer season on plant growth, dry weight, fruit setting and yield and its components as well as anatomical structure of leaf blade of hot pepper plants grown under sandy soil conditions. The soil physical and chemical properties of the experimental site are given in Table1.

Table 1: The physical and chemical properties of the tested soil site during 2011and 2012 seasons.

Physical properties	Values		Chemical properties	Values	
	2011	2012		2011	2012
Sand (%)	96.5	95.6	Organic matter	0.05	0.08
Silt (%)	1.7	1.6	Available K (ppm)	52	64
Clay (%)	1.8	2.8	Available P (ppm)	5.5	6.2
Field capacity	6.5	6.8	Available N (ppm)	5.4	6.9
Wilting point	2.4	2.5	Calcium carbonate (%)	0.18	0.26
Available water	4.5	4.5	pH	8.1	8.1
Water holding capacity	13.8	14.5			

This experiment included 9 treatments as follows: -

1-Control (untreated), 2- Ascorbic acid (AA) 200 ppm,

3- Ascorbic acid (AA) 400 ppm, 4- Salicylic acid (SA) 100ppm,

5- Salicylic acid (SA) 200ppm, 6-α -tocopherol (Vit. E) 100 ppm,

7- α -tocopherol (Vit. E) 200 ppm, 8- Naphthalene acetic acid (NAA) 25ppm,

9- Naphthalene acetic acid (NAA) 50 ppm

The treatments were arranged in a complete randomized block design with three replications.

Pepper Jalapeno M (hot) seeds were obtained from Ferry-Morse Co. (USA) and sown on March 23rd and 25th and seedling were transplanted on 24th and 25th of April in 2011 and 2012 seasons, respectively. The area of experimental plot was 10.5m^2. Every plot consisted of 5 dripper lines 3m in length and 0.7m in width. Plants were spaced at, 40 cm apart with about 40 plants in every plot. One dripper line was left between each two experimental plots without spraying as a guard row to avoid the overlapping of spraying solution. Two dripper lines (4.2m^2) was earmarked for samples and the other three dripper lines (6.3m^2) were earmarked for determining yield and its components. The normal agriculture practices of pepper under drip irrigation system were followed according to the recommendations of Agriculture Ministry. The foliar application treatments were sprayed (at a rate of 2 L /plot) twice during the growth period of plant at 30 and 45 days after transplanting the untreated plants (control) were sprayed with tap water. Local meteorological data at El-Kassasin region during 2011 and 2012 seasons is shown in Figures 1and 2.

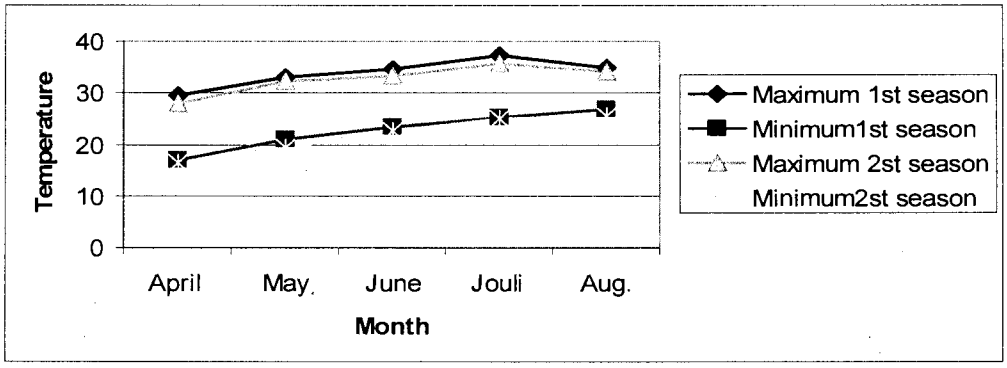

Fig. (1): Maximum and minimum temperature at El-Kassasin region during 2011 and 2012 seasons

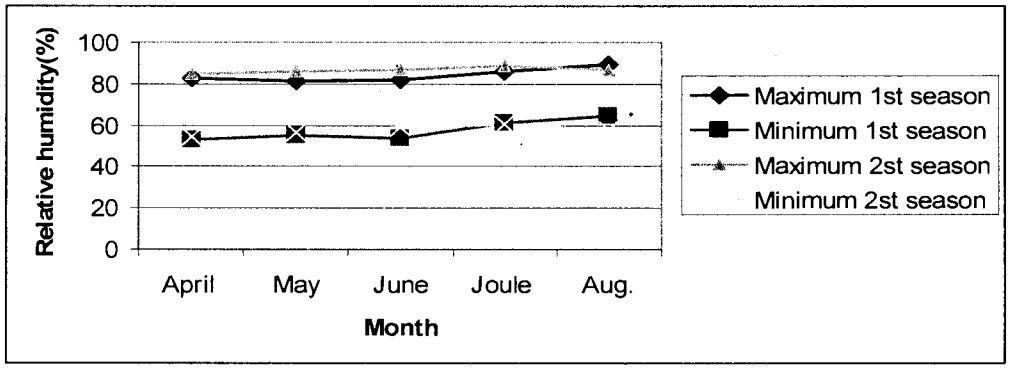

Fig. (2): Maximum and minimum relative humidity at El-Kassasin region during 2011 and 2012 seasons

Data recorded

1. Growth parameters

A random sample of three plants was randomly taken from every plot at 60 days after transplanting in both seasons of study for measuring the growth characters of pepper plants as follows: plant height, number of both leaves and branches / plant, leaf area / plant, dry weight of different plant parts. For measuring plant dry weight, the samples of different plant parts were dried in an electric oven at 70°C till constant weight then dry weight was recorded.

2. Flowering characters

Random sample of six plants from each plot were labeled and the following data were recorded: total number of flowers / plant, total number of fruits / plant tell the end of the harvesting date and fruit set percentage was calculated according to the following equation:

$$\text{Fruit set percentage} = \frac{\text{Total number of fruits/ plant}}{\text{Total number of flowers/ plant}} \times 100$$

3. Yield and its components

Fruits of each plot were harvested at marketable maturity stage, counted and weighed and the following data were calculated: average numbers of fruits/plant, average fruit weight, yield per plot and total yield /fed.

4. Anatomical study

Specimens from the midrib region of the leaf blade of the 4th upper leaf on the main stem of each treatment were taken of at 60 days from sowing (flowering stage) in the second season (2012). These specimens (1cm long) were killed and fixed for 48 h at least in plant fixative which is known as FAA (formalin acetic alcohol). The selected material were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series, embedded in paraffin wax of melting point 52-54°C. Sections were prepared using EPMA a rotary microtome at 15-17 microns, stained with both safranin and light green, cleared in xylene and finally mounted in Canada balsam (Berlyn and Miksche 1976). Selected sections were examined using light microscope and photographed by using light microscope (Olympus) with digital camera (Canon power shot S80) connected to computer; the photographs were taken by Zoom Browser Ex Program. The dimensions of leaflet blade sections were measured by using Corel Draw program ver.11. 6.

The following anatomical parameters were recorded: midvein thickness (µ), midrib vascular bundle Width (µ), phloem layer thickness (µ), xylem vessel number, Blade thickness (µ), palisade tissue thickness (µ) and spongy tissue thickness (µ) .

5. Statistical analysis

Obtained data were subjected to the analysis of variance according to Snedecor and Cochran (1980). Duncan`s multiple range test was used for the comparison among treatments (Duncan, 1958).

RESULTS AND DISCUSSION

Growth Characters

Data presented in Table 2 show clearly the effect of spraying pepper plants with some antioxidants; i.e., ascorbic acid, salicylic acid and α -tocopherol in comparison with naphthalene acetic acid (NAA) on plant height, number of leaves and branches / plant as well as leaf area during both seasons of study. Such data indicate that spraying pepper plants with NAA at different tested concentrations (25 and 50ppm), ascorbic acid at 400ppm and α –tocopherol at 200ppm significantly enhanced all studied vegetative growth parameters compared to the control treatment, except

number of branches per plant in both seasons and leaf area / plant in the second one. The highest values in this respect were recorded with NAA at 50 and 25ppm followed by α–tocopherol at 200ppm then ascorbic acid at 400ppm without significant differences among them. The stimulating effect due to antioxidants foliar application (ascorbic acid and α–tocopherol) may be related to its antioxidative function as demonstrated by diminished lipid peroxidation, $H_2 O_2$ and superoxide radical production and increased antioxidants enzymes (peroxidase and phenoloxidaes) and higher contents of chlorophyll than the control Krieger-Liszkay and Trebst (2006) and Bosch (1995).

Similar findings were obtained by El-Hifny and El-Sayed, (2011) and Al Sahli *et al.* (2013) they found that foliar application of ascorbic acid at 300ppm enhanced most of pepper plant growth parameters.

In addition, the obtained results with α–tocopherol are in a harmony with those reported by El-Bassiouny *et al.* (2005) and Semida *et al.* (2014) on faba bean and Nour *et al.* (2012) on snap bean. In addition, the obtained results with NAA foliar application are agree with those of Sridhar *et al.* (2009) on pepper plant.

Dry weight

Results in Table 3 illustrate the effect of spraying with some antioxidants in comparison with NAA on dry weight of pepper plant; i.e., leaves and stems dry weight as well as total dry weight per plant. The data show clearly that there were significant differences among using abovementioned materials and the control regarding dry weight of different plant parts and total dry weight per plant during the two growing seasons. In this connection, the highest values of leaves and stems dry weight as well as total dry weight per plant were recorded as a result of spraying pepper plants with NAA at 50 and 25 ppm followed by α–tocopherol at 200ppm then ascorbic acid at 400ppm without significant differences among the four treatments in most cases, while the lowest values in this regard were recorded with the control treatment.

The enhancing effect of the above mentioned antioxidants and NAA treatments on dry weight may be due to the increasing palisade tissues of leaf and this in tern enhance the photosynthesis process and translocation of photosynthesis assimilates rate and consequently increased vegetative growth and this reflected on increasing dry weight of plant. Similar findings with ascorbic acid foliar application were obtained by El-Hifny and El-Sayed (2011) and Al Sahli *et al.* (2013) on pepper plant. In addition, the obtained results with α–tocopherol are in a harmony with those reported by El-Bassiouny *et al.* (2005) on faba bean and Nour *et al.* (2012) on snap bean.

Table 2. Effect of antioxidant treatments in comparison with synthetic growth regulators (NAA) on vegetative growth characters of hot pepper plants during summer seasons of 2011 and 2012

Parameters / Treatments	Growth characters / plant							
	Plant height (cm)		Leaves No.		Branches No.		Leaf area (cm^2)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	43.7d	45.3cd	72.7e	81.0c	4.00a	4.33a	636.5d	709.2cd
Ascorbic acid 200ppm	49.0b-d	46.7c	81.7d	86.7bc	5.33a	5.00a	715.4c	757.8c
Ascorbic acid 400ppm	54.3ab	52.7ab	95.3bc	98.7a	5.33a	4.67a	835.1ab	666.4d
Salicylic acid 100 ppm	44.3d	46.7c	78.3de	84.3bc	5.33a	5.33a	687.2cd	742.1cd
Salicylic acid200 ppm	43.9d	42.7d	74.7e	82.7bc	5.33a	5.00a	651.8cd	721.8cd
α –Tocopherol 100ppm	48.3cd	48.3c	90.3c	89.7b	5.33a	5.00a	795.4b	793.4bc
α –Tocopherol 200ppm	51.3a-c	52.7ab	96.7b	98.3a	5.33a	5.00a	849.8ab	864.3ab
Naphthalene acetic acid25 ppm	53.3a-c	54.3ab	98.0ab	101.0a	5.00a	5.33a	861.2ab	889.5a
Naphthalene acetic acid50ppm	55.7a	56.8a	103.1a	105.7a	5.33a	5.33a	904.6a	930.7a

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

Table 3. Effect of antioxidant treatments in comparison with synthetic growth regulators (NAA) on dry weight of hot pepper plants during summer seasons of 2011 and 2012

Parameters / Treatments	Dry weight (g)					
	leaves		stems		Total	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	11.11b	12.38d	23.46f	25.95d	34.57d	38.33e
Ascorbic acid 200ppm	12.49ab	13.29b-d	26.36d-f	28.56cd	38.85cd	41.85cd
Ascorbic acid 400ppm	14.58ab	15.19a-c	30.78a-d	33.59a	45.36ab	48.78b
Salicylic acid 100 ppm	11.97b	12.89cd	25.27ef	27.79cd	37.24d	40.68de
Salicylic acid200 ppm	11.42b	12.62cd	27.53c-f	29.58bc	38.95cd	43.50c
α –Tocopherol 100ppm	13.87ab	13.79b-d	29.32b-e	29.32b-d	43.19bc	43.11cd
α –Tocopherol 200ppm	14.83ab	15.17a-c	31.47a-c	32.47ab	46.30ab	47.64b
Naphthalene acetic acid25 ppm	14.98ab	15.63ab	32.78ab	33.38a	47.67ab	49.01b
Naphthalene acetic acid50ppm	16.00a	16.76a	34.18a	35.81a	50.18a	52.57a

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 4. Effect of antioxidant treatments in comparison with synthetic growth regulators (NAA) on anatomical characteristics of pepper plant leaves at 60 days after sowing during 2012 season

Parameters / Treatments	Parameters						
	Midvein thick. (µ)	Midrib V.B. Width. (µ)	Phloem layer thick. (µ)	xylem vessel number	Blade thick. (µ)	Palisade tissue thick. (µ)	Spongy tissue thick. (µ)
Control	810	660	30	18	180	60	100
Ascorbic acid 200ppm	920	740	20	20	200	70	100
Ascorbic acid 400ppm	1000	750	30	20	240	80	130
Salicylic acid 100 ppm	810	760	30	16	210	70	110
Salicylic acid 200 ppm	850	660	30	16	210	70	110
α –Tocopherol 100ppm	840	740	30	20	220	60	130
α –Tocopherol 200ppm	880	740	20	20	240	70	130
Naphthalene acetic acid 25 ppm	740	490	20	16	280	120	140
Naphthalene acetic acid 50ppm	770	490	20	16	290	120	150

Leaf anatomical features

Data presented in Table 4 and Fig. 3; show clearly that spraying pepper plants with some antioxidants, i.e., ascorbic acid, salicylic acid, α-tocopherol and naphthalene acetic acid at different concentrations had stimulative effect on anatomical characters ,i.e., thickness of medvein vascular bundle, thickness of phloem layer, xylem vessel number, thickness of leaf blade and both palisade and spongy tissue. Also; spraying pepper plants with NAA at 50ppm recorded the highest values of blade, palisade and spongy tissue thickness. The increment in blade and spongy tissue thickness were about 61.11% and 50% in plants sprayed with 50 ppm NAA over the control, followed by NAA at 25ppm and α –tocopherol at 200ppm. The increase in leaf blade thickness may be due to the increase in thickness of both palisade and spongy tissues as compared to the control. Moreover, spraying pepper plants with ascorbic acid at 400ppm recorded the highest values of midvein thickness where the increase in midvein thickness reached 23.45% over the control, followed by ascorbic acid at 200ppm, On the other side, spraying pepper plants with naphthalene acetic acid at 25ppm gave the lowest values in this respect compared to control. Spraying pepper plants with salicylic acid at 100 and 200 ppm had little enhancement effect on the above mentioned leaf anatomical traits compared to control, except leaf blade thickness at the two tested concentrations.

All enhanced leaf anatomical parameters (thickness of medvein vascular bundle, thickness of phloem layer, xylem vessel number, thickness of leaf blade and both palisade and spongy tissue(Table 4 and Figure 3) due to foliar application with α – tocopherol, ascorbic acid and/or NAA reflected on a good translocation of the observed water and nutrients into cell to be used in different metabolic process which positively affected on photosynthesis process activity and accumulation of photoassimilates, thereby helping in better retention of flowers and fruits and this in turn increased yield under prevailing high temperature over 35 ^{0}C during reproduction stage in summer season as shown in Figure 1 .

These results of enhancement effect of α–tocopherol, ascorbic acid (AA) and NAA on leaf anatomy were also reported by Al Sahli *et al.* (2013) on pepper; Semida *et al.* (2014) on faba bean and Sridhar *et al.* (2009) on pepper regarding of α–tocopherol, ascorbic acid (AA) and NAA, respectavily.

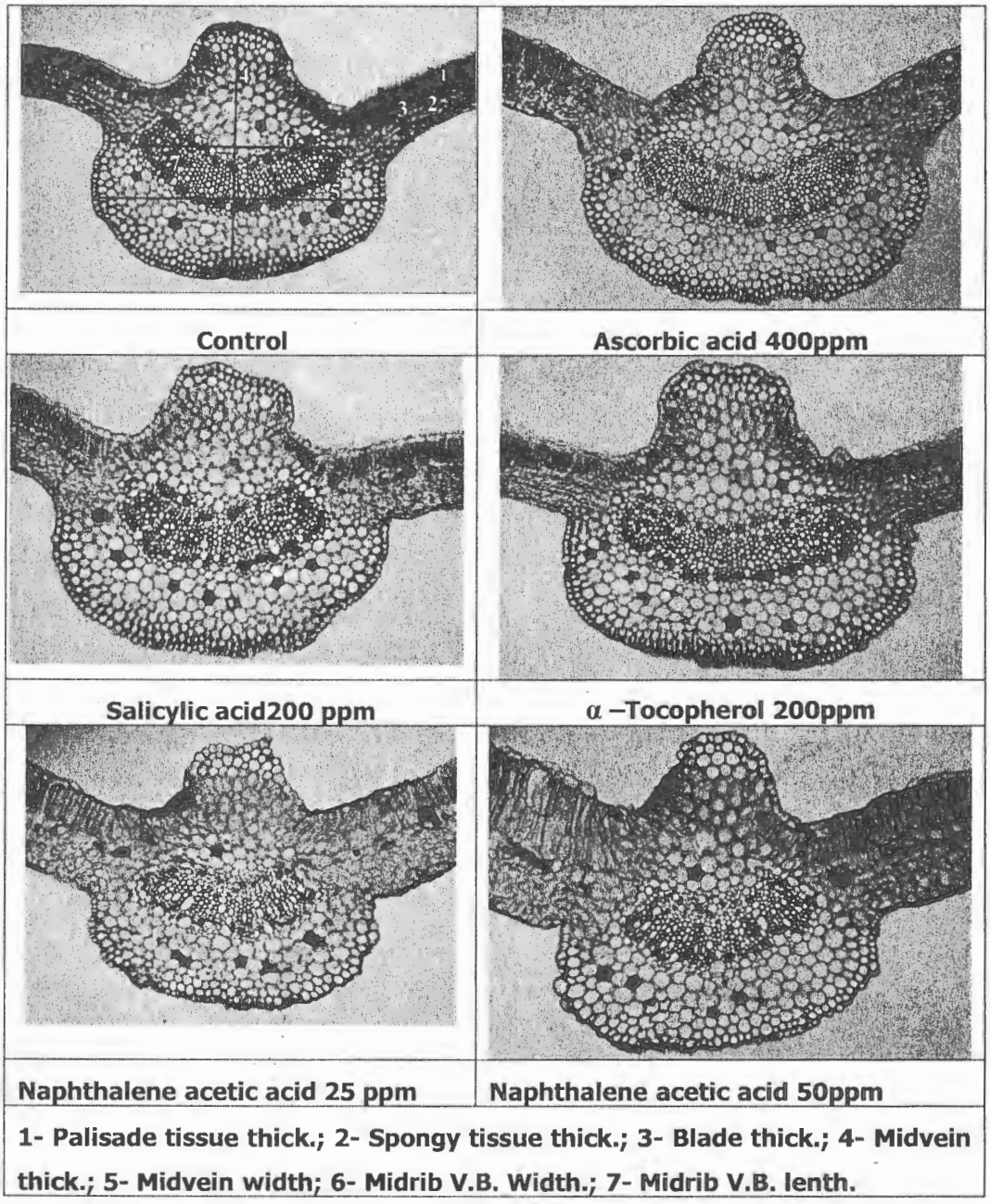

Fig. (3): Shows the effects of antioxidant treatments and NAA on measurements of certain anatomical feature in cross section of leaflet blade of pepper plant (The bar for all plates = 0.5 mm)

Flowering and fruit setting

Data presented in Table 5 show clearly the effect of spraying with ascorbic acid, salicylic acid and α -tocopherol in comparison with synthetic plant growth regulators (NAA) on flowering and fruit setting of hot pepper plants cv. Jalapeno expressed as number of flowers per plant, number of fruits per plant and fruit setting percentage. Such data indicate that there were significant differences among the used treatments

and the control in number of fruits per plant and fruit setting percentage during the two seasons of growth, while number of flowers per plant were not significantly affected. In this connection, the highest values of fruit setting percentage and number of fruits per plant were recorded, generally, as a result of spraying pepper plants with ascorbic acid at 400 ppm followed by NAA at 50 and 25 ppm and α –tocopherol at 200ppm without significant differences among them, on the other hand the lowest values of fruits number and fruit setting (%) were recorded by the control treatment. Increasing flower setting (Table 5) due to treating pepper plants with NAA, α–tocopherol and AA might be attributed to the role of these treatments in bioregulation of physiological process and stimulation of photo assimilates and water translocation which help in better retention of flowers and fruits and increased fruit setting under high prevailing temperature in summer (Figure 1) .

The increase in fruit set percentage is possibly due to the enhancement of these treatments for the resistance against flower drop which further increase the number of fruits/plant (Fletcher *et al.*, 2000). NAA also showed the positive effect on the number of flower clusters due to higher calcium contents in tomato plant. NAA reduces pre harvest fruit drop by reducing the effect of ethylene and resulted in the appearance of higher fruit set percentage (Yuan and Carbaugh, 2007).

Yield and its components

Data show the effect of spraying with some antioxidants; i.e., ascorbic acid, salicylic acid and α -tocopherol in comparison with synthetic plant growth regulators (NAA) on yield and its components of hot pepper plants expressed as number of fruits per plant, average fruit weight and yield per plot as well as total yield per feddan are presented in Table 6. Such data indicate that there were significant differences among the tested treatments and the control in number of fruits per plant, yield per plot as well as total yield per feddan during the two seasons of growth, while average fruit weight was not significantly affected. In this connection, the highest values of number of fruits per plant and yield per plot as well as total yield per feddan were recorded, generally, as a result of spraying hot pepper plants with NAA at 50ppm followed by ascorbic acid at 400 ppm and α –tocopherol at 200ppm without significant differences among them. On the contrary, the lowest values in this connection were recorded from untreated plants.

Table 5. Effect of antioxidant treatments in comparison with synthetic growth regulators (NAA) on flowering and fruit setting of hot pepper during summer seasons of 2011 and 2012

Parameters / Treatments	Flowering and fruit setting (%)					
	No. of flowers / plant		No. of fruits / plant		Fruit setting (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	59.7a	63.9a	30.6c	34.3e	51.3e	53.7b
Ascorbic acid 200ppm	55.8a	60.7a	31.3c	35.4de	55.7d	58.3ab
Ascorbic acid 400ppm	58.3a	61.4a	37.1ab	39.5ab	63.7a	64.3a
Salicylic acid 100 ppm	62.7a	64.7a	36.0ab	38.6a-c	57.4cd	59.7ab
Salicylic acid200 ppm	60.4a	59.3a	35.6ab	36.4c-e	58.9b-d	61.3a
α –Tocopherol 100ppm	57.6a	61.3a	34.5b	37.9b-d	59.8a-d	61.9a
α –Tocopherol 200ppm	58.9a	63.8a	37.0ab	39.3ab	62.9ab	61.9a
Naphthalene acetic acid25 ppm	60.3a	65.3a	36.4ab	39.7ab	60.3a-c	60.9ab
Naphthalene acetic acid50ppm	63.9a	64.9a	38.1a	40.5a	59.7a-d	62.4a

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

The increases of total yield might be attributed to the enhancement effect of the abovementioned treatments on increasing plant growth parameters (Table 2) and dry matter accumulation (Table 3) as well as leaf thickness and palisade tissue thickness (Table 4 and Figure 3) this in turn increased number of fruits / plant and fruit setting percentage (Table 5). The increased yield could be attributed to higher dry matter in reproductive parts, higher fruit set and hence increased yield (Sridhar *et al.,* 2009). Similar findings with ascorbic acid foliar application were obtained by El-Hifny and El-Sayed (2011) on sweet pepper.

In addition, the obtained results with α–tocopherol are in a harmony with those reported by El-Bassiouny *et al.,* (2005) on faba bean and Nour *et al.,* (2012) on snap bean. Also, the effect of NAA foliar application on yield of pepper are in agreement with those of Sridhar *et al.,* (2009)

Correlation study

Data presented in Table 7 show the simple correlation coefficient between total yield (ton/fed.) and number of flowers per plant. The results indicated that total yield (ton/feddan), showed positive and highly significant correlation with number of fruits per plant and total yield per plot, but it did not reflect any significant correlation with number of flowers per plant in both seasons. On the other hand it negatively detected insignificant association with average fruit weight (g) in the first season (-0.469^{NS}) and showed highly and negatively significant correlation in the second season (-0.690^{*}). These results are in a good line with those reported by Ismail and Mohamed (2014). Number of flowers per plant did not reflect any significant correlation with number of fruits per plants and yield per plot while, it showed highly and negatively significant correlation with average fruit weight in the first season (-0.609^{*}) and negatively insignificant in the second one (-0.203^{NS}). Number of fruits per plant exhibited positive and highly significant correlation with each of average fruit weight (g) and yield per plot (kg) in both seasons of study. Moreover, average fruit weight (g) recorded negatively insignificant association with yield per plot (kg) in first season (-0.470^{NS}) and showed highly and negatively significant correlation in the second one (-0.470^{*}).

CONCLUSION

From the previous results of this investigation, it could be concluded that spraying hot pepper plants cv. Jalapeno Grown in summer season under sandy soil conditions with NAA at 25ppm followed by ascorbic acid at 400 ppm and α – tocopherol at 200ppm significantly enhanced plant growth, dry weight and yield and its components. Also, using the abovementioned treatments reduced flower shedding and increased fruit setting and affected positively on leaf structure.

Table 6. Effect of antioxidant treatments in comparison with synthetic growth regulators (NAA) on yield and its components of hot pepper plants during summer seasons of 2011 and 2012

Parameters / Treatments	Yield and its components							
	No. of fruits/ plant		Aver. fruit weight(g)		Yield / plot (kg)		Total yield (ton/ fed.)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	31.7d	32.3c	14.1a	14.4a	17.823c	18.567c	7.129c	7.427c
Ascorbic acid 200ppm	32.7cd	35.7b	14.6a	13.5a	19.089b	19.281bc	7.636b	7.713bc
Ascorbic acid 400ppm	36.3b	36.3b	13.7a	13.8a	19.829ab	20.103ab	7.931ab	8.041ab
Salicylic acid 100 ppm	35.0bc	36.3b	13.3a	13.4a	18.667bc	19.390bc	7.467bc	7.756bc
Salicylic acid200 ppm	36.3b	35.7b	13.3a	13.5a	19.324ab	19.264bc	7.730ab	7.706bc
α –Tocopherol 100ppm	35.7bc	36.3b	13.2a	13.1a	18.849bc	19.052bc	7.539bc	7.621bc
α –Tocopherol 200ppm.	37.7ab	40.3a	12.7a	12.8a	19.140b	20.661a	7.656b	8.264a
Naphthalene acetic acid25 ppm	37.7ab	37.7ab	13.1a	13.2a	19.670ab	19.882ab	7.868ab	7.953ab
Naphthalene acetic acid50ppm	40.3a	40.3a	12.7a	12.9a	20.443a	20.818a	8.177a	8.327a

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. Some correlation coefficient between yield and its components and number of flowers of pepper plants during summer seasons of 2011and 2012

Characters		Season 2011				Season 2012			
		1	2	3	4	1	2	3	4
Y	Total yield (ton/fed.)	$0.291^{N.S}$	0.840^{**}	$-0.469^{N.S}$	1.000^{**}	$0.365^{N.S}$	0.926^{**}	-0.690^{*}	1.000^{**}
1	No. of flowers/plant		$0.537^{N.S}$	-0.609^{*}	$0.289^{N.S}$		$0.347^{N.S}$	$-0.203^{N.S}$	$0.365^{N.S}$
2	No. of fruits/plant			0.871^{**}	0.840^{**}			0.910^{**}	0.926^{**}
3	Average fruit weight(g)				$-0.470^{N.S}$				-0.690^{*}
4	Yield /plot (kg)								

NS= Not significant * = Significant **= Highly significant

REFERENCES

1. Abd El-Al, F. S. (2009). Effect of urea and some organic acids on plant growth, fruit yield and its quality of sweet pepper (*Capsicum annuum* L.). Res. J. Agric. Biloigi. Sci., 5(4):372-379.
2. Abd El-Aziz, N. G., A. A. M. Mazher and E. El-Habba(2006). Effect of foliar spraying with ascorbic acid on growth and chemical constituents of *Khaya senegalensis* grown under salt condition. American-Eurasian J. Agric. & Environ. Sci., 1(3): 207-214.
3. Abou El-Yazeid, A., (2011). Effect of foliar application of salicylic acid and chelated zinc on growth and productivity of sweet pepper (*Capsicum annuum* L.) under autumn planting. Res. J. Agric. and Biologi. Sci., 7(6):423-433.
4. Al Sahli, A. A., M. A. Al-Muwayhi, A. R. Doaigey, M. O. Basalah, H. M. Ali, M. El-Zaidy and A.M. Sakran (2013). Effect of Ozone and Ascorbic Acid on the Anatomical, Physiological and Biochemical Parameters of Pepper (*Capsicum frutescens* L.). J. Pure and Appl. Microbio. 7: 159-168.
5. Berlyn, G. P. and J.P. Miksche (1976). Botanical Microtechnique and Cytochemistry. The Iowa State University Press, Ames, Iowa, pp.326.
6. Bosch, S.M. (1995). The role of α –tocopherol in plant stress tolerance. J. Plant Physiology. 162: 743-748.
7. Duncan, B.D. (1958). Multiple range and multiple F-test Biometrics, 11:1-42.
8. El-Desouky, S.A., El-S. Fathy and S. Farid (2000). High temperature tolerability in tomato: evaluation of some genotypes for late summer plantings. Ann. Agric. Sci., Moshtohor. 38(1): 179-197.
9. El-Hifny, I. M. M. and M. A. M. El-Sayed (2011). Response of sweet pepper plant growth and productivity to application of ascorbic acid and biofertilizers under saline conditions. Australian J. Basic Appl. Sci., 5(6):1273-1283.
10. El-Bassiouny, H.M.S.; M.E. Gobarah and A.A. Ramadan (2005). Effect of antioxidants on growth, yield, favism causative agents in seeds of *Vicia faba* L. plants grown under reclaimed sandy soils. J. Agron., 4: 281-287.
11. Elwan, M. W. M. and M. A. M. El-Hamahmy (2009). Improved productivity and quality associated with salicylic acid application in green house pepper. Sci. Hort. 122:521-526.
12. Erickson, A. N. and A. H. Markhart (2002). Flower development stage and organ sensitivity of bell pepper (*Capsicum annuum* L.) to elevated temperature. Plant, cell and environment 25, 125-130.

13. Fletcher, R.A., A. Gilley, N. Sankhla and T.D. Davis (2000). Triazoles as plant growth regulators and stress protectants. *Hortic. Rev.,* 24: 55-138.
14. Hanieh, A., D. Mojtaba, Z. Zabihollah and A. Vahid (2013). Effect of pre-sowing salicylic acid seed treatment on seed germination and growth of green house sweet pepper plants. Indian J. Sci. and Technol., 6(1):3868-3871.
15. Ismail, H. E. M. and O. O. Mohamed (2014). Impact of foliar spray with potassium on the productivity, quality and storability of some sweet pepper hybrids grown in plastic houses. J. Product. & Dev. 19(2):155 – 180.
16. Krieger-Liszkay, A. and A. Trebst (2006). Tocopherol is the scavenger of singlet oxygen produced by the triplet states of chlorophyll in the PSII reaction centre. J. Experimental Botany 57: 1677–1684.
17. Munne-Bosch, S. and L. Alegre (2002). The function of tocopherol and tocotrienols in plants. Crit Rev. plant Sci., 21:31-57.
18. Nour, K. A. M, N. T. S. Mansour, and G. S.A. Eisa (2012). Effect of some antioxidants on some physiological and anatomical characters of snap bean plants under sandy soil conditions. New York Sci. J., 5(5):1-9.
19. Raskin, I. (1995). Salicylic acid in: Davis P.J. (Ed) Plant Hormones Kluwer Academic Publishers. The Netherlands, pp. 188-205.
20. Saha, S. R., M. M. Hossain, M. M. Rahman, C. G. Kuo and S. Abdullah (2010). Effect of high temperature stress on the performance of twelve sweet pepper genotypes. Bangladesh J. Agril. Res. 35(3) : 525-534.
21. Semida, W.M., R.S. Taha, M.T. Abdelhamid and M.M. Rady (2014). Foliar-applied α-tocopherol enhances salt-tolerance in *Vicia faba* L. plants grown under saline conditions. South African J. Botany 95:24-31.
22. Serrani, J.C., M. Fos, A. Atare and J.L. Garcl (2007). Effect of gibberellin and auxin on parthenocarpic fruit growth induction in the cv Micro-tom of tomato. J Plant Growth Regul., 26: 211-221.
23. Snedecor, G. W. and W. G. Cochran (1980). Statistical Methods. 7th Ed. The Iowa State Univ., Press, Amer., Iowa , USA .
24. Sridhar, G., R.V. Koti, M.B. Chetti and S.M. Hiremath (2009). Effect of naphthalene acetic acid and mepiquat chloride on physiological components of yield in bell pepper (*Capsicum annuum* L.). J. Agric. Res., 47(1):53-62.
25. Taiz, L. and. E. Zeiger (2006). Plant Physiology, Sinauer Associates Inc. Publishers, Massachusetts.
26. Tyburski, J., K. Dunajska, P. Mazurek, B. Piotrowska and A. Tretyn (2009). Exogenous auxin regulates H_2O_2 metabolism in roots of tomato (*Lycopersicon esculentum* Mill.) seedlings affecting the expression and activity of Cu Zn-

superoxide dismutase, catalase, and peroxidase. Acta Physiol. Plant., 31: 249-260.

27. Usha, P. and K. V. Peter (1988). Control of flower fall through stimulants and regulation in Chilli. Veg. Sci. 15:185-189.
28. Veerappa, D.B. (1980). Studies on relative performance of different genotypes of sweet pepper (*Capsicum annuum* L. var. Grossum Send.). M.Sc. Agri. Thesis, USA, Bangalore.
29. Wanas, A.L. (2006). Trails for improving growth and productivity of tomato plants grown in winter. Annals. Agric. Sci. Moshtohor 44(3): 214-231.
30. Yuan, R. and D.H. Carbaugh (2007). Effects of NAA, AVG and 1- MCP on maturity, and quality of 'Golden supreme' and 'Golden ethylene biosynthesis, preharvest fruit drop, fruit delicious' apples. Hort. Sci., 42: 101-105.

دراسة مقارنة تأثير مضادات الأكسدة و منظمات النمو الصناعية للحد من تساقط الأزهار، و زيادة المحصول وعلاقة ذلك بالتركيب التشريحى لأوراق الفلفل

حامد محمد الهادى عريشة[1] ، خالد عطية محمود نور[2] و فتحى محمد عبده السعدونى[3]

١- قسم البساتين – كلية الزراعة – جامعة الزقازيق – مصر.
٢- قسم بحوث الخضرذاتية التلقيح – معهد بحوث البساتين – مركز البحوث الزراعية – مصر .
٣- قسم النبات الزراعي- كلية الزراعة- جامعة الزقازيق – مصر .

أجريت تجربتان حقليتان خلال العروة الصيفية لعامى ٢٠١١ و ٢٠١٢ فى مزرعة التجارب البحثية بمحطة بحوث البساتين بالقصاصين ، محافظة الأسماعيلية ، لدراسة إستجابة نباتات الفلفل الحار صنف چلابينو لمقاومة التأثير الضار لدرجات الحرارة المرتفعة فى العروة الصيفية للرش الورقى ببعض مضادات الأكسدة مثل حمض الأسكوربيك بتركيز ٢٠٠ ، ٤٠٠ جزء فى المليون ، وحمض السالسيلك بتركيز ١٠٠ ، ٢٠٠ جزء فى المليون والفا توكوفيرول (فيتامين هـ) بتركيز ١٠٠ ، ٢٠٠ جزء فى المليون للمقارنة بنفثالين حمض الخليك بتركيز ٢٥ ، ٥٠ جزء فى المليون بالإضافة إلى الكنترول على النمو ، والوزن الجاف ، وعقد الثمار ، والمحصول ومكوناته والتركيب التشريحى لورقة لنباتات الفلفل النامية تحت ظروف الأراضى الرملية.

أظهرت معاملة رش نباتات الفلفل بالتركيزات المختلفة لمضادات الأكسدة ونفثالين حمض الخليك تأثيرا معنويا بالنسبة لكل من النمو الخضرى ،و الوزن الجاف الكلى ، والنسبة المئوية لعقد الثمار، و المحصول ومكوناته وكذلك التركيب التشريحى للأوراق متمثلا فى سمك النصل ، سمك النسيج العمادى والأسفنجى وأيضا سمك العرق الوسطى مقارنة بمعاملة الكنترول.

وعموما كانت أفضل المعاملات التى سجلت أعلى القيم هى الر ش بنفثالين حمض الخليك بتركيز ٢٥ ، ٥٠ جزء فى المليون يلية الرش بحامض الأسكوربيك بتركيز ٤٠٠ جزء فى المليون ثم ألفا توكوفيرول بتركيز ٢٠٠ جزء فى المليون.