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Increasing quality of *Zinnia elegans* plants by foliar spraying with ascorbic and salicylic acids

Naglaa F.S. Elbohy[1], K.E. Attia[2] and T.M. Noor El-Deen[1]

[1]*Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt.*
[2]*Medicinal and Aromatic Plants Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt.*

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ABSTRACT

Ascorbic and salicylic acids are considered as endogenous plant growth stimulants that play an important role in many physiological processes. Field experiment was carried out during 2017 and 2018 seasons in the Horticulture Research Station at El-Kassasin, Ismailia Governorate, Egypt to study the effect of different concentrations of ascorbic and salicylic acids, and their combinations on vegetative growth, flowering characters and some chemical constituents including the anthocyanin content of zinnia (*Zinnia elegans*) plants. Ascorbic acid was applied at 0, 150 and 300 ppm, while salicylic acid at 0, 75, 150 and 300 ppm. Both ascorbic and salicylic acids were applied three times as foliar spraying during the vegetative period at 21 days intervals from planting time. Twelve treatments were laid out in a split plot design experiment, with three replicates. The obtained results revealed that the maximum values of plant height, total fresh and dry weights of aerial parts/plant, fresh and dry weights of roots/plant, root length/plant, number of flower heads/plant, flower head diameter, fresh and dry weights of flower heads/plant, chlorophyll "a" and "b" content in leaves in addition to anthocyanin content in flowers were detected in plants treated with 300 ppm ascorbic acid + 300 ppm salicylic acid. Percentage of total indoles and phenols in the leaves decreased with increasing ascorbic acid, and increased with salicylic acid at 300 ppm. The combined treatment of 150 ppm ascorbic acid + 75 ppm salicylic acid resulted in the highest carbohydrates percentage in the leaves. According to this study and to get high quality zinnia plants it is recommended to spray the plants with a combination treatment of ascorbic acid at 300 ppm + salicylic acid at 300 ppm.

***Keywords*:** ascorbic acid, salicylic acid, zinnia, *Zinnia elegans*, indoles, phenols, anthocyanin, carbohydrates.

Introduction

Zinnia, *Zinnia elegans*, Jacq. belongs to Fam. *Asteraceae* is a summer flowering annual plant native to Mexico. The plants are upright, bushy bearing lightly hairy, ovate to lance-shaped leaves, to 8 cm long. Daisy-like, broad-petaled purple flower heads, to 4.5 cm across, are produced in summer. It grows fairly rapidly to 60-75 cm in height and to 30 cm in width. Zinnias are cultivated for their solitary, long-stemmed, daisy-like, terminal flower heads in a wide range of colors, including white, yellow, orange, red, purple, and lilac, some with contrasting eyes. Zinnia plants used in an annual or mixed border, and for cutting. Smaller cultivars are suitable for edging, and for window boxes or containers (Brickell, 1997 and Mills-Hicks, 2007).

To enhance the immune system of cultivated crops and to support plant metabolism a certain substances called bio-stimulants are applied. Such substances could be utilized to reduce the amount of chemicals used in agriculture (Kolomaznik *et al*., 2012).

Ascorbic acid is an antioxidant and, in association with other components of the antioxidant system, protects plants from oxidative damage resulting from aerobic metabolism, photosynthesis and a range of pollutants like ozone, heavy metal and saline stress. In addition, it is not only an antioxidant; it also appears as a co-factor for several metabolic enzymes involved in the fundamental developmental process of plants and a well-known (Mazid *et al.,* 2011).

Salicylic acid (SA) is a plant growth stimulant known as an endogenous signaling molecule, which is involved in various physiological processes in plants, such as growth regulation, photosynthesis, stomatal conductance, nutrient uptake, plant water relations and mechanisms of plant resistance and tolerance to biotic and abiotic stresses (Popova *et al*., 1997 and Hayat *et al*., 2010).

Corresponding Author: Naglaa F.S. Elbohy, Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt.

The aim of this investigation is to obtain the highest vegetative growth, flowering characters and chemical constituents of zinnia plants by applying different concentrations of ascorbic and salicylic acids under sandy soil conditions.

Materials and Methods

Field experiment was done in Horticulture Research Station at El-Kassasin, Ismailia Governorate, Egypt, during two seasons of 2017 and 2018. This research was conducted out to investigate the effect of different concentrations of ascorbic, salicylic acids and their interactions on vegetative growth, flowering characters and some chemical constituents as well as anthocyanin content of zinnia (*Zinnia elegans*) plants. Seeds of zinnia were obtained from the Ornamental Plants Nursery, Fac. Agric., Moshtohor, Benha Univ., Egypt.

Seeds of zinnia were sown in nursery on April 16th and 15th in both seasons, respectively. After germination and vigorous seedlings were established, they have been transplanted to the open field on rows, the distance within rows is 60 cm and within plants at the same row is 30 cm. Drip irrigation system was installed to irrigate the plants.

The experimental plot area was 6.48 m^2 (2.40 × 2.70 m) containing four rows, with 60 cm between them. Each row containing 9 plants, the distance between them was 30 cm, so each plot area contains 36 plants. The mechanical and chemical properties of the used soil are shown in Table (1).

The experimental field received the recommended doses of the chemical fertilization to all experimental area. 200 kg/fed of calcium super phosphate (15.5% P_2O_5) was added during soil preparation. Ammonium nitrate (33.5% N) at 100 kg/fed was divided into two portions, the first was added after 3 weeks from planting time, while the second one was 3 weeks after the first one.

Meanwhile, potassium sulphate (48% K_2O) was added at the rate of 50 kg/fed to all treatments at the flowering stage. Other recommended cultural practices for zinnia plants were followed.

This experiment was set up in a split plot design with three replicates (9 plants/replicate), the main plot was ascorbic acid concentrations and the sub-plot was salicylic acid. Ascorbic acid concentrations were (0, 150 and 300 ppm) and salicylic acids were (0, 75, 150 and 300 ppm). The combination treatments between ascorbic and salicylic acids will be consisted of 12 treatments. Ascorbic and salicylic acids were sprayed three times to the aerial parts of the plant during the vegetative period starting 30 days from planting time and 3 weeks between additions.

Table 1: Physical and chemical analysis of the experimental soil.

Soil contents	Concentration	Soil content	Concentration
Sand %	89.92	**HCO_3^-**	1.00
Silt %	4.00	**Cl^-**	0.50
Clay %	6.08	**SO_4^-**	0.97
Soil texture	Sand	**Macro-elements (ppm)**	
F.C. %	11.20	**N**	81
W.P. %	2.20	**P**	22
Organic matter %	0.42	**K**	108
pH	8.10	**Micro-elements (ppm)**	
E.C. (mmohs/cm)	1.21	**Fe^{++}**	2.0
$CaCO_3$	2.6	**Cu^{++}**	----
Soluble ions (meq/l)		**Zu^{++}**	0.26
Ca^{++}	1.00	**Mn^{++}**	0.80
Mg^{++}	0.40		
Na^+	0.76		
K^+	0.31		

F.C. = Field capacity, W.P. = Wilting point

Data recorded:

Data of vegetative growth parameters and flowering characters were collected at the end of each season, while chemical constituents were determined at the second season only. The obtained data were as follows:

1. Vegetative growth parameters:

Plant height (cm), fresh weigh of aerial parts (g)/plant, dry weigh of aerial parts (g)/plant, roots fresh weight (g)/plant, roots dry weight (g)/plant and root length (cm)/plant.

2. Flowering characters:

Number of flower heads/plant, flower head diameter (cm)/plant, flower heads fresh weight (g)/plant and flower heads dry weight (g)/plant.

3. Chemical constituents:

All chemical constituents were determined at the end of the second season. In dry leaves both total indols (mg/100 g d.w.) according to Larsen *et al.* (1962), total phenols percentage according to Ferrante *et al*. (2008) and total carbohydrates percentage according to Dubois *et al*. (1956) were determined. While in fresh leaves both chlorophyll a and b contents (mg/g f.w.) were determined according to method of A.O.A.C. (1980). Anthocyanin (mg/g d.w.) was determined in dried flowers by using ethyl alcohol as described by Fuleki and Francis (1968), and developed by Du and Frances (1973).

Statistical analysis:

The recorded data were subjected to the analysis of variance procedure using MSTAT computer program. The least significant difference (LSD) test was performed to separate treatment means at 5% level according to Snedecor and Cochran (1980).

Results and Discussion

1. Vegetative growth:

1.1. Plant height:

The data illustrated in Table (2) show that, increasing the ascorbic acid concentrations significantly increased zinnia plant height compared to untreated plants. The tallest plants obtained from the treatment of 300 ppm in the first season, and from 150 ppm in the second one.

It is evident from the results in Table (2) that, plant height of zinnia was increased with increasing salicylic acid levels. Also, all treatments recorded significant increase compared to control. The best result recorded when spraying plants with 300 ppm salicylic acid in the two seasons. These results agree with Faraji-Mehmany *et al.* (2016) on savory (*Satureja hortensis* L.) and Ramtin *et al.* (2015) on carnation.

Results under discussion in Table (3) indicate that, plant height of zinnia significantly was increased with interaction between ascorbic and salicylic acid concentrations compared to control in the two seasons. The tallest plant was observed with the interaction treatment of (150 ppm ascorbic acid + 300 ppm salicylic acid) with non-significant and significant differences with all of (150 ppm ascorbic acid + 150 ppm salicylic acid), (300 ppm ascorbic acid + 300 ppm salicylic acid) and (300 ppm salicylic acid only), in the 1st and 2nd seasons, respectively. These results are in confidant with those of AbdelKader and Hamad (2014) on roselle plant.

1.2. Areal parts fresh weight (g)/plant:

Data reported in Table (2) reveal that, aerial parts fresh weight (g)/plant was increased with increasing ascorbic acid concentration. Furthermore, the highest value was recorded from ascorbic acid at 300 ppm with significant increase compared to control and non-significant with 150 ppm treatment during the two seasons.

It is quite clear from the data in Table (2) that total fresh weight (g)/plant was gradually increased by increasing salicylic acid concentrations and the differences between treatments were significant. The heaviest fresh weight recorded with the treatment of salicylic acid at 300 ppm in both seasons. These results are agreeable with those reported by Ibrahim *et al.* (2016) on maize.

Data in both seasons in Table (3) indicate that, interaction treatments gave significant increase in aerial parts fresh weight (g)/plant compared to control. Furthermore, interaction treatment at 300 ppm ascorbic acid + 300 ppm salicylic acid gave highest fresh weight with significant increase

compared to 300 ppm of salicylic acid or ascorbic acid treatments only. While, the differences between 300 ppm ascorbic acid + 300 ppm salicylic acid and both of 300 ppm ascorbic acid + 150 ppm salicylic acid and 300 ppm ascorbic acid + 75 ppm salicylic acid treatments were non-significant and significant during the first and second seasons, respectively.

Table 2: Effect of foliar application with ascorbic and salicylic acids on vegetative growth of zinnia during 2017 and 2018 seasons.

Treatments	Growth characters / plant					
	Plant height (cm)		Aerial parts fresh weight (g)/plant		Aerial parts dry weight (g)/plant	
Ascorbic acid	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
Untreated	94.25	89.17	665.33	663.02	94.93	85.52
150 ppm	114.42	112.25	792.32	795.87	151.97	145.62
300 ppm	115.92	110.33	795.85	801.32	167.38	168.22
LSD at 0.05	1.19	6.84	22.27	9.52	3.26	5.09
Salicylic acid						
Untreated	92.78	90.56	669.67	675.24	108.64	104.27
75 ppm	105.56	101.44	741.96	745.31	133.67	125.07
150 ppm	113.44	108.89	779.76	774.29	146.64	142.33
300 ppm	121.00	114.78	813.29	818.76	163.40	160.80
LSD at 0.05	5.09	4.45	1.58	13.31	8.81	10.33

Table 3: Effect of interaction between foliar application with ascorbic acid and salicylic acid on vegetative growth of zinnia during 2017 and 2018 seasons.

Treatments		Growth characters / plant					
		Plant height (cm)		Aerial parts fresh weight (g/plant)		Aerial parts dry weight (g/plant)	
Ascorbic acid	**Salicylic acid**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
Untreated	**Untreated**	67.7	61.7	516.1	518.1	54.4	44.1
	75 ppm	91.7	84.7	633.7	635.7	90.9	80.3
	150 ppm	101.0	96.7	716.4	700.2	101.7	98.2
	300 ppm	116.7	113.7	795.1	798.0	132.7	119.5
150 ppm	**Untreated**	102.3	102.0	754.1	763.3	123.2	119.7
	75 ppm	111.3	109.0	788.3	793.6	143.7	135.6
	150 ppm	119.3	114.7	810.4	804.1	164.6	152.1
	300 ppm	124.7	123.3	816.5	822.4	176.3	175.0
300 ppm	**Untreated**	108.3	108.0	738.9	744.3	148.3	149.0
	75 ppm	113.7	110.7	803.8	806.6	166.3	159.3
	150 ppm	120.0	115.3	812.5	818.5	173.7	176.7
	300 ppm	121.7	107.3	828.3	835.9	181.1	187.9
LSD at 0.05		8.82	7.71	27.32	23.05	15.26	17.9

1.3. Areal parts dry weight (g)/plant:

Table (2) reveals that, ascorbic acid levels increased areal parts dry weight (g) per plant. Also, ascorbic acid at 300 ppm gave the highest dry weight with significant differences compared to the other treatment and control, in both seasons.

Data presented in Table (2) indicate that, areal parts dry weight (g)/plant significantly was increased with increasing of salicylic acid levels. The highest concentration treatment (300 ppm) gave significant increases compared to the other treatments and control, during the two seasons. These results were in agreement with those revealed by Bayat *et al.* (2012) on *Calendula officinalis* L.

It is evident from the obtained data in Table (3) that, there was a gradual increase in areal parts dry weight (g)/plant with increasing in the interaction treatments of both ascorbic and salicylic acid concentrations. In addition, the combined treatment of 300 ppm ascorbic acid + 300 ppm salicylic acid recorded the best significant result compared to other interaction treatments, during the two seasons, in most cases. These results are similar with AbdelKader and Hamad (2014) on roselle plant.

1.4. Roots fresh weight (g)/plant:

Data presented in Table (4) indicate that, fresh weight of roots (g)/plant was increased with increasing ascorbic acid levels. Maximum concentration (300 ppm) treatment gave significant increase compared to control and other treatment in the two seasons.

Data listed in Table (4) suggested that, fresh weight of roots per zinnia plant was increased by increasing salicylic acid concentration. The highest value was obtained from the treatment of 300 ppm with significant differences between the other treatments and control, in both seasons.

It is evident from the obtained data in Table (5) that, there was gradual increase in the fresh weight of roots (g)/plant with increasing in the interaction treatments of both ascorbic and salicylic acid concentrations. In addition, the interaction treatment of ascorbic acid at 300 ppm + salicylic acid at 300 ppm recorded the highest and significant fresh weight compared to the other interaction treatments and control, in most cases. Furthermore, there was no significant difference between ascorbic acid at 300 ppm + salicylic acid at 300 ppm and ascorbic acid at 150 ppm + salicylic acid at 300 ppm treatments, during the two seasons.

Table 4: Effect of foliar application with ascorbic and salicylic acids on root system of zinnia during 2017 and 2018 seasons.

Treatments	Root system					
	Roots fresh weight (g)		Roots dry weight (g)		Root length (cm)	
Ascorbic acid	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
Untreated	17.2	15.4	3.93	3.57	13.1	12.9
150 ppm	31.0	29.3	7.17	6.69	18.4	18.6
300 ppm	38.0	28.7	8.94	8.73	21.7	21.0
LSD at 0.05	2.22	3.08	0.47	0.66	1.48	2.41
Salicylic acid						
Untreated	21.4	19.9	4.91	4.52	12.8	13.4
75 ppm	26.1	25.1	5.98	5.72	15.7	15.8
150 ppm	30.6	28.7	7.17	6.62	18.9	18.3
300 ppm	36.8	36.2	8.66	8.44	23.4	22.4
LSD at 0.05	3.70	2.48	0.85	0.63	2.84	2.81

1.5. Roots dry weight (g)/plant:

The data described in Table (4) reveal that, dry weight of roots (g) per plant was increased with increasing ascorbic acid levels. Generally, 300 ppm concentration recorded significant increases compared to the other treatment and control, during the two seasons.

Data of both seasons in Table (4) indicate that, increasing salicylic acid concentrations gradually increased dry weight of roots (g) per plant. Also, salicylic acid at 300 ppm resulted in the highest significant increases in dry weight compared to other treatments during the two seasons. These results were parallel to those obtained by Al-Abbasi *et al.* (2015) on *Zinnia elegans* L.

The obtained data in Table (5) demonstrate that, interaction treatments between ascorbic and salicylic acid concentrations resulted in a significant increases compared to control. Furthermore, the interaction treatment of 300 ppm ascorbic acid + 300 ppm salicylic acid resulted the highest and significant dry weight with the other interaction treatments except the combined treatment of 150 ppm ascorbic acid + 300 ppm salicylic acid, the difference between them was non-significant, during the two seasons.

1.6. Root length (cm)/plant:

Table (4) shows that, there were obvious positive effects of ascorbic acid on root length (cm) in zinnia plant. Furthermore, there were significant differences between all treatments and control. The highest value obtained from the ascorbic acid at 300 ppm which gave significant increase compared to control in the two seasons.

Data presented in Table (4) show that, increasing salicylic acid concentration significantly increased root length (cm). Also, the highest value obtained from the treatment of 300 ppm during both seasons. The results hold true with obtained by Merwad (2015) on sugar beet.

The influence of the interaction treatments between ascorbic and salicylic acids on root length (cm) in zinnia plant was recorded in Table (5) and state that, there were gradually increase when both factors concentrations raises, in most cases. Moreover, the interaction treatment (300 ppm of ascorbic acid + 300 ppm of salicylic acid) significantly resulted in the tallest roots compared to the other interaction treatments and control, in most cases. These finding repeated in the two seasons.

Table 5: Effect of interaction between foliar application with ascorbic and salicylic acids on root system of zinnia during 2017 and 2018 seasons.

Treatments		Root system					
		Roots fresh weight (g)		Roots dry weight (g)		Root length (cm)	
Ascorbic acid	Salicylic acid	1st season	2nd season	1st season	2nd season	1st season	2nd season
Untreated	Untreated	12.1	10.3	2.80	2.30	9.0	8.3
	75 ppm	15.5	13.1	3.47	2.87	10.7	10.3
	150 ppm	18.3	16.0	4.00	3.77	13.3	12.3
	300 ppm	22.7	22.3	5.43	5.33	19.3	20.7
150 ppm	Untreated	20.3	18.7	4.67	4.33	12.3	12.7
	75 ppm	27.0	25.7	6.30	5.77	16.0	16.0
	150 ppm	33.3	31.3	7.77	6.97	20.3	21.3
	300 ppm	43.4	41.5	9.93	9.70	25.0	24.3
300 ppm	Untreated	31.7	30.7	7.27	6.93	17.0	19.3
	75 ppm	35.7	36.7	8.17	8.53	20.3	21.0
	150 ppm	40.3	38.7	9.73	9.13	23.0	21.3
	300 ppm	44.5	44.7	10.60	10.30	26.47	22.3
LSD at 0.05		6.42	4.30	1. 47	1.10	4.29	4.87

2. Flowering characters/plant:

2.1. Number of flower heads/plant:

Data of both seasons in Table (6) indicate that, increasing ascorbic acid concentrations gradually increased number of flower heads per plant. Also, 300 ppm of ascorbic acid gave the highest significant increase in No. of flower heads compared to other treatment and control, in the first and second seasons.

From the data presented in Table (6) it is clear that, there were obvious increases in number of flower heads per plant with increasing salicylic acid concentrations. However, there were significant differences between all treatments and control. The treatment of salicylic acid at 300 ppm gave the highest and significant number compared to the other treatments and control, in both seasons. These results are in accordance with those obtained by Choudhary *et al.* (2016) on African marigold (*Targets erecta* L.) and Al-Abbasi *et al.* (2015) on *Zinnia elegans* L.

As shown in Table (7) there was significant increase in the number of flower heads per plant when using the interaction treatments between ascorbic and salicylic acids concentrations compared to control. Furthermore, the highest value was obtained from the interaction treatment of 300 ppm ascorbic acid + 300 ppm salicylic acid with significant differences when compared with other interaction treatments and control, except the combined treatment of 300 ppm ascorbic acid + 150 ppm salicylic acid, the difference between them was non-significant. Similar results were repeated in the second season as mentioned in the first one.

2.2. Flower head diameter (cm)/plant:

Table (6) shows that, flower head diameter (cm)/plant was increased with increasing ascorbic acid concentrations compared to control. The highest and significant diameter was recorded by spraying plants with 300 ppm ascorbic acid compared to control, during the two seasons.

Data illustrated in Table (6) show that, mostly all salicylic acid concentrations gave significant increases in flower head diameter (cm)/plant. Generally, the treatment of 300 ppm gave the highest diameter compared to the other treatments and control, during the first season. These results are similar to those obtained by Al-Abbasi *et al.* (2015) on *Zinnia elegans* L. and Bayat *et al.* (2012) on *Calendula officinalis* L.

As shown in Table (7) there was significant increases in the flower diameter (cm)/plant when using the interaction treatments between ascorbic and salicylic acids compared to control in both seasons. Furthermore, there was non-significant effect between the combined treatments of 300 ppm ascorbic acid + 300 ppm salicylic acid and 150 ppm ascorbic acid + 300 ppm salicylic acid, during the two seasons.

2.3. Flower heads fresh weight (g)/plant:

Table (6) shows that, flower heads fresh weight (g) per plant was increased with increasing ascorbic acid concentrations. Also, ascorbic acid at300 ppm gave the highest value compared to the other concentration and control in the first and second seasons.

Data reported in Table (6) indicate that, the flower heads fresh weight (g) per zinnia plant was increased with increasing salicylic acid concentrations. Also, the heaviest significant flower heads fresh weight resulted from spraying with 300 ppm of salicylic acid when compared with other treatments and control, during both seasons. Similarly, the effect of salicylic acid on flower heads fresh weight was studied by Kohanmoo *et al.* (2016) who found that spraying with salicylic acid at 50 mg/l on chamomile (*Matricaria chamomilla* L. cv: Bona) was significant. Also, Al-Qubaie (2013) stated that, foliar application of salicylic acid at 50 to 400 ppm on *Jasminum sambac* Ait plants caused a material promotion on fresh weight of flowers per plant.

Data recorded in Table (7) indicate that, under all ascorbic acid concentrations, all levels of salicylic acid increased flower heads fresh weight (g)/plant compared to control. The highest and significant fresh weight obtained from the interaction treatment of 300 ppm ascorbic acid + 300 ppm salicylic acid, with no significant difference with 300 ppm ascorbic acid + 150 ppm salicylic acid during the two seasons.

Table 6: Effect of foliar application with ascorbic and salicylic acids on flowering characters of zinnia during 2017 and 2018 seasons.

Treatments	Flowering characters/plant							
	No. of flower heads/plant		Flower head diameter (cm)		Flower heads fresh weight (g/plant)		Flower heads dry weight (g/plant)	
Ascorbic acid	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Untreated	14.00	13.83	6.7	6.6	107.0	96.4	16.0	14.2
150 ppm	25.42	23.92	7.4	7.1	160.2	154.3	26.5	24.3
300 ppm	28.33	31.42	7.5	7.2	173.6	176.3	36.9	37.7
LSD at 0.05	3.64	4.45	0.30	0.27	10.42	8.18	2.30	4.75
Salicylic acid								
Untreated	15.3	15.0	6.6	6.5	119.5	113.7	18.4	18.0
75 ppm	19.8	18.3	7.0	6.8	136.8	134.4	23.2	21.9
150 ppm	24.3	26.7	7.3	7.2	156.6	150.4	29.3	26.1
300 ppm	30.8	32.2	7.8	7.4	174.7	170.8	34.9	35.4
LSD at 0.05	2.86	3.78	0.28	0.53	8.57	10.61	3.15	3.11

2.4. Flower heads dry weight (g)/plant:

Data reported in Table (6) point out that, the flower heads dry weight (g)/plant was increased with increasing ascorbic acid concentrations. Also, the heaviest dry weight resulted from using ascorbic acid at 300 ppm with significant increase compared to control

It is evident from the obtained data in Table (6) that, there was an increase in flower heads dry weight (g)/plant of zinnia plants with increasing salicylic acid levels. Furthermore, the treatment of 300 ppm gave significant increases compared to the other treatments and control, during 1st and 2nd seasons. These results are in good line with those of Al-Abbasi *et al.* (2015) on *Zinnia elegans* L.

Data recorded in Table (7) state that, under ascorbic acid concentrations, the different levels of salicylic acid gave significant increases in flower heads dry weight (g)/plant compared to control. In addition, the interaction treatment (300 ppm ascorbic acid + 300 ppm salicylic acid) recorded the heaviest dry weight of flower heads in the two seasons.

Table 7: Effect of interaction between foliar application with ascorbic and salicylic acids on flowering characters of zinnia during 2017 and 2018 seasons.

Treatments		Flowering characters/plant							
		No. of flower heads		Flower head diameter (cm)		Flower heads fresh weight (g/plant)		Flower heads dry weight (g/plant)	
Ascorbic acid	Salicylic acid	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Untreated	Untreated	8.7	8.0	6.1	6.5	69.9	60.1	11.1	8.6
	75 ppm	10.3	11.3	6.8	6.7	91.2	82.7	14.7	13.0
	150 ppm	13.7	14.7	6.7	6.8	117.1	108.4	16.6	15.3
	300 ppm	23.3	21.3	7.2	6.6	149.7	134.2	21.7	19.8
150 ppm	Untreated	16.7	16.3	6.7	6.4	138.8	128.6	15.9	16.7
	75 ppm	21.7	18.7	7.0	6.5	149.6	150.7	20.5	19.1
	150 ppm	28.3	27.0	7.7	7.4	166.8	159.1	31.5	24.6
	300 ppm	35.0	33.7	8.0	8.0	185.7	178.8	38.0	36.7
300 ppm	Untreated	20.7	21.7	7.0	6.7	149.9	152.3	28.3	28.7
	75 ppm	27.3	25.0	7.2	7.2	169.7	169.7	34.3	33.7
	150 ppm	31.0	38.3	7.6	7.4	186.0	183.7	39.7	38.3
	300 ppm	34.3	41.7	8.1	7.6	188.7	199.3	45.1	49.7
LSD at 0.05		4.95	6.54	0.49	0.92	14.85	18.4	5.45	5.38

3. Chemical constitutes:

Data recorded in Table (8) revealed that, increasing ascorbic acid concentrations gradually decreased total indoles content in the leaves with non-significant differences between treatment and control. Moreover, the untreated plant showed the highest percentage compared to the other treatment.

In contrary, data reported in the same Table revealed that, total indoles content gradually increased with increasing of salicylic acid with non-significant differences between treatment and control. However, salicylic acid with the concentration of 300 ppm gave the highest percentage compared to control. The role of salicylic acid was emphasized by El-Yazeid (2011) who demonstrated that, all treatments (50 and 100 ppm) increased auxin level in sweet pepper (*Capsicum annuum* L.) shoots, and Fang and YunWei (2009) of lily (*Liliuma siatic* hybrids) varieties Prato and Elite, detected that, salicylic acid at concentrations of 0.05, 0.5, and 5 mmol/liter increased the contents of endogenous IAA in bulbs, and the ratio of IAA to GA.

As shown in Table (9) there was non-significant between all the interaction treatments on total indoles content in fresh zinnia leaves. All treatments of salicylic acid alone gave the highest content comparing with the interaction treatments between the two concentrations of ascorbic acid in addition to all concentrations of salicylic acid. The highest total indoles content obtained from the treatment of 300 ppm salicylic acid only, while the least content recorded with the interaction treatment of (300 ppm ascorbic acid + 150 ppm salicylic acid).

3.2. Phenols percentage:

It is quite clear from the data in Table (8) that, phenols percentage in zinnia leaves decreased by increasing ascorbic acid concentration. In addition, the highest value in this concern was obtained from untreated plants.

From the data described in Table (8), it is clear that, the highest percentage of phenols in zinnia leaves was obtained from the plants sprayed with 300 ppm of salicylic acid. Such results were in harmony with the findings of Latif *et al.* (2016) on *Zea mays* L. plants, and also Khandaker *et al.* (2011) showed that, the highest total polyphenol occurred in 10^{-5} M salicylic acid treatment in red amaranth (*Amaranthus tricolor* L.).

It is evident from the obtained data in Table (9) that, the treatment of 300 ppm from salicylic acid only gave the highest percentage of phenols in zinnia leaves comparing with the other interaction treatments.

3.3. Total carbohydrates percentage:

Data in Table (8) point out that, total carbohydrates percentage of zinnia leaves was increased to the highest value by foliar application with ascorbic acid at 150 ppm when compared with both untreated plants and ascorbic acid at 300 ppm.

The data illustrated in Table (8) show that, the highest and significant carbohydrates percentage in zinnia leaves was obtained from the treatment of salicylic acid at 75 ppm comparing with 150 and 300 ppm. These results are in combatable with those mentioned by El-Shamy and Gendy (2013) on German chamomile (*Matricaria chamomilla* L.) who revealed that, total carbohydrates percentage was achieved by spraying the plants with the highest concentrations of salicylic acid at 200 ppm.

The data given in Table (9) suggest that, the different interaction treatments between ascorbic and salicylic acids concentrations gave significant increases of carbohydrates percentage in most cases. Generally, the treatment of ascorbic acid at 150 ppm + salicylic acid at 75 ppm resulted in the highest percentage comparing with all interaction treatments. Similar results were obtained by AbdelKader and Hamad (2014) on roselle plant.

Table 8: Effect of foliar application with ascorbic and salicylic acids on chemical constitutes of zinnia during 2018 season

Treatments	Chemical constitutes					
Ascorbic acid	Indoles (mg/100 g d.w.)	Phenols (%)	Carbohydrates (%)	Chlorophyll a (mg/g f.w.)	Chlorophyll b (mg/g f.w.)	Anthocyanin (mg/g d.w.)
Untreated	1.68	0.670	12.02	0.60	0.19	245.6
150 ppm	1.32	0.578	17.01	0.71	0.25	252.3
300 ppm	1.23	0.545	12.52	0.83	0.27	257.9
LSD at 0.05	N.S	0.32	1.73	0.03	0.03	0.61
Salicylic acid						
Untreated	1.27	0.583	12.14	0.65	0.20	246.6
75 ppm	1.17	0.448	16.98	0.70	0.23	250.2
150 ppm	1.57	0.534	13.99	0.74	0.25	253.9
300 ppm	1.62	0.825	12.29	0.78	0.27	257.2
LSD at 0.05	N.S	0.44	1.11	0.03	0.02	1.12

Table 9: Effect of interaction between foliar application with ascorbic acid and salicylic acids on chemical constitutes of zinnia during 2018 season.

Treatments		Chemical constitutes					
Ascorbic acid	Salicylic acid	Indoles (mg/100 g d.w.)	Phenols (%)	Carbohydrates (%)	Chlorophyll a (mg/g f.w.)	Chlorophyll b (mg/g f.w.)	Anthocyanin (mg/g d.w.)
Untreated	**Untreated**	1.42	0.559	12.30	0.52	0.15	238.3
	75 ppm	1.31	0.441	16.27	0.58	0.19	244.4
	150 ppm	1.85	0.476	12.24	0.63	0.20	248.6
	300 ppm	2.12	1.204	7.26	0.69	0.22	251.3
150 ppm	**Untreated**	1.16	0.672	14.60	0.66	0.21	247.5
	75 ppm	1.10	0.448	24.78	0.69	0.24	250.6
	150 ppm	1.63	0.660	17.84	0.72	0.26	254.5
	300 ppm	1.40	0.530	10.80	0.76	0.27	256.7
300 ppm	**Untreated**	1.24	0.517	9.51	0.76	0.23	253.7
	75 ppm	1.11	0.456	9.89	0.82	0.27	255.8
	150 ppm	1.22	0.465	11.88	0.87	0.28	258.8
	300 ppm	1.33	0.741	8.80	0.88	0.31	263.5
LSD at 0.05		N.S	0.76	1.92	0.05	0.03	1.93

3.4. Chlorophyll a (mg/g f.w.):

Data in Table (8) show that, Chlorophyll a (mg/g) of zinnia leaves increased by increasing ascorbic acid concentration. Likewise, all ascorbic acid concentrations gave significant differences compared to control. Also, the highest value obtained from 300 ppm.

The data illustrated in Table (8) show that, increasing salicylic acid concentration gradually increased chlorophyll a content of zinnia leaves. Moreover, the different concentrations gave significant differences compared to control. In addition, the maximum concentration (300 ppm) gave the highest value. Similar results, in general, were obtained by Fan *et al.* (2017) who pointed out that, the content of chlorophyll increased when spraying tomato seedlings with salicylic acid for 6 days at 350 mg/liter, and Keshavarz *et al.* (2012) on canola (*Brassica napus* L.).

The data given in Table (9) suggest that, the different interaction treatments between ascorbic and salicylic acid concentrations gave significant increases compared to control. Generally, interaction treatment of (300 ppm of ascorbic acid + 300 ppm salicylic acid) gave the highest value of chlorophyll a compared all interaction treatments and control.

3.5. Chlorophyll b (mg/g f.w.):

Data tabulated in Table (8) indicate that, all ascorbic acid concentrations gradually increased chlorophyll B content and recorded significant differences compared to control. Also, the highest value obtained from the treatment of 300 ppm with non-significant with the treatment of 150 ppm.

Data reported in Table (8) reveal that, increasing salicylic acid concentrations increased chlorophyll b content in zinnia leaves. Furthermore, all concentrations gave significant increases compared to control. Also, the highest chlorophyll b content in leaves obtained from the maximum concentration (300 ppm) treatment. The obtained results are in harmony with Al-Qubaie (2013) who stated that, foliar application of salicylic acid at 50 to 400 ppm on *Jasminum sambac* Ait plants caused a material promotion on some plant pigments (chlorophyll a and b), and El-Shamy and Gendy (2013) on *Matricaria chamomilla* L.

Results under discussion in Table (9) state that, all interaction treatments between ascorbic and salicylic acid concentrations gave significant increases of chlorophyll b content compared to control. Furthermore, interaction treatment (300 ppm of ascorbic acid + 300 ppm salicylic acid) gave the highest content in leaves compared to the other interaction treatments and control. The results are harmonious with a previous report from AbdelKader and Hamad (2014) who found that, total chlorophyll content (a + b) in leaves of roselle plant could be obtained by spraying ascorbic acid at 300 ppm in combined with salicylic acid at 200 ppm.

3.6. Anthocyanin (mg/g d.w.):

The data given in Table (8) clear that, the content of anthocyanin in zinnia flowers gradually increased with increasing concentrations of ascorbic acid. Moreover, all treatments gave significant differences compared to control. Furthermore, full concentration of ascorbic acid (300 ppm) recorded the highest content compared to the other treatment.

The obtained data in Table (8) demonstrate that, all salicylic acid concentrations gave significant increases in anthocyanin content in dry flowers of zinnia plant compared to control. Generally, the content of anthocyanin gradually was increased by increasing salicylic acid concentration. Since, the concentration of 300 ppm gave the highest value. Such results were in harmony with the findings of Keshavarz *et al.* (2012) who concluded that, salicylic acid spray with the concentrations of (0, 100, 200 and 400 micro M) significantly increased anthocyanin content in canola (*Brassica napus* L.).

It is evident from the results in Table (9) that, different interaction treatments between ascorbic and salicylic acid concentrations gave significant increases of anthocyanin content in dry flowers of zinnia plant compared to control. Also, the interaction treatment between ascorbic at 300 ppm + full concentration of salicylic acid (300 ppm) gave the highest anthocyanin content with significant increases compared to the other interaction treatments and control. These results are in agreement with those reported by AbdelKader and Hamad (2014) on roselle plant.

According to this study and to get high quality of zinnia plants grown in sandy soil under drip irrigation system it is recommended to spray the plants with a combination treatment with ascorbic acid at 300 ppm + salicylic acids at 300 ppm.

References

AbdelKader, M.A.I. and E.H.A. Hamad, 2014. Response of growth, yield and chemical constituents of roselle plant to foliar application of ascorbic acid and salicylic acid. Global Journal of Agriculture and Food Safety Sciences, 1(2):126-136.

Al-Abbasi, A.M.A.S., J.A. Abbas and M.T.H. Al-Zurfi, 2015. Effect of spraying thiamin and salicylic acid on growth and flowering of *Zinnia elegans* L. AAB Bioflux, 7(1):44-50.

Al-Qubaie, A.I., 2013. Response *Jasminum sambac* Ait plants to spraying salicylic acid. Journal of King Abdulaziz University - Meteorology, Environment and Arid Land Agriculture Sciences, 24(1):67-73.

A.O.A.C., 1980. Official Methods of Analysis, The Association of Official Agricultural Chemists, 11th Ed. P. O. Box 540, Washington D. C., USA.

Bayat, H., M. Alirezaie and H. Neamati, 2012. Impact of exogenous salicylic acid on growth and ornamental characteristics of calendula (*Calendula officinalis* L.) under salinity stress. Journal of Stress Physiology & Biochemistry, 8(1):258-267.

Brickell, C., 1997. The American Horticultural Society A-Z Encyclopedia of Garden Plants. DK Publishing, Inc., New York, USA, 1092 p.

Choudhary, A., A. Mishra, P.K. Bola, S.K. Moond and M. Dhayal, 2016. Effect of foliar application of zinc and salicylic acid on growth, flowering and chemical constitute of African marigold cv. Pusa Narangi Gainda (*Targets erecta* L.). Journal of Applied and Natural Science, 8(3):1467-1470.

Du, C.T. and F.J. Francis, 1973. Anthocyanin of Roselle. J. Food Sci., 38 (5): 810 – 812.

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers and F. Smith, 1956. Colorimetric method for determination of sugars and related substances. Analytical chemistry, 28(3): 350-356.

El-Shamy, H.A. and A.S.H. Gendy, 2013. Improved productivity of German chamomile by foliar application of complete fertilizer and salicylic acid. Bulletin of Faculty of Agriculture, Cairo University, 64(1):67-77.

El-Yazeid, A.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. Research Journal of Agriculture and Biological Sciences, 7(6):423-433.

Fan, Z., L. JingFu, J. JingBin, Z. He, C. XiuLing and X. XiangYang, 2017. Effect of exogenous salicylic acid on the cold resistance of tomato seedlings. Jiangsu Agricultural Sciences, 45(3):91-94.

Fang, L. and Z. YunWei, 2009. Effects of salicylic acid on bulb development and its relation to endogenous hormone contents in two species of lily. Plant Physiology Communications, 45(11):1085-1088.

Faraji-Mehmany, A., B. Esmaielpour, F. Sefidkon and S. Khorramdel, 2016. Effects of foliar spraying with salicylic acid and putrescine on growth characteristics and yield of summer savory (*Satureja hortensis* L.). Iranian Journal of Field Crops Research, 14(1): 73-85.

Ferrante, A., A. Spinardi, T. Maggiore, A. Testoni and P.M. Gallina, 2008. Effect of nitrogen fertilization levels on melon fruit quality at the harvest time and during storage. J. Sci. Food Agric., 88: 707–713.

Fuleki, T. and F.J. Francis, 1968. Quantitative methods of anthocyanin. 1. Extraction and determination of anthocyanin in cranberries. J. Food Sci., 33 (1): 72.

Hayat Q., S. Hayat, M. Irfan and A. Ahmad, 2010. Effect of exogenous salicylic acid under changing environment: A review. Environ. Exp. Bot., 68: 14–25.

Ibrahim, O.M., A.A. Gaafar, B.A. Bakry and M.F. El-Kramany, 2016. Alleviating the adverse effect of salinity on maize by the ameliorative effect of salicylic acid. Egyptian Journal of Agronomy, 38(3):569-577.

Keshavarz, H., S.A. M. Sanavi, F. Zarin-kamar, A. Dolatabadian, M. Panahi and K. Sadat-Asilan, 2012. Study of foliar application of salicylic acid on some biochemical properties of two canola cultivars (*Brassica napus* L.) under cold stress condition. Iranian Journal of Field Crop Science, 42(4):723-734.

Khandaker, L., A.M. Akond and O.B.A. Shinya, 2011. Foliar application of salicylic acid improved the growth, yield and leaf's bioactive compounds in red amaranth (*Amaranthus tricolor* L.). Vegetable Crops Research Bulletin, 74:77-86.

Kohanmoo, M.A., M. Modaresi and Z.B. Kahkesh, 2016. Effects of spraying salicylic acid and jasmonicacide on the morphological and biochemical characteristics of chamomile (*Matricaria chamomilla* L.) under bushehr climate conditions. Iranian Journal of Medicinal and Aromatic Plants, 32(3): 428-434.

Kolomazník, K., J. Pecha, V. Friebrová, D. Janáčová and V. Vašek, 2012. Diffusion of biostimulators in plant tissues. Heat and Mass Transfer, 48: 1505. https://doi.org/10.1007/s00231-012-0998-6.

Larsen, P., A. Harbo, S. Klungsour and T. Asheim, 1962. On the biogenesis of some indole compounds in *Acetobacter xylinum*. Physiologia Plantarum, 15(3):552-565.

Latif, F., F. Ullah, S. Mehmood, A. Khattak, A.U. Khan, S. Khan and I. Husain, 2016. Effects of salicylic acid on growth and accumulation of phenolics in *Zea mays* L. under drought stress. Acta Agriculturae Scandinavica, Section B - Soil & Plant Science, 66(4):325-332.

Mazid, M., T.A. Khan, Z.H. Khan, S. Quddusi and F. Mohammad, 2011. Occurrence, biosynthesis and potentialities of ascorbic acid in plants. International Journal of Plant, Animal and Environmental Sciences, 1(2): 167-148.

Merwad, A.R.M., 2016. Efficiency of potassium fertilization and salicylic acid on yield and nutrient accumulation of sugar beet grown on saline soil. Communications in Soil Science and Plant Analysis, 47(9):1184-1192.

Mills-Hicks, J., 2007. Botanica's Pocket: Gardening Encyclopedia. H.F. Ullman, Germany, 1008 p.

Popova L., T. Pancheva and A. Uzunova, 1997. Salicylic acid: properties, biosynthesis and physiological role. Bulg. J. Plant Physiol., 23: 85-93.

Ramtin, A., S. Kalatejari, R. Naderi and M. Matinizadeh, 2015. Effect of pre-harvest foliar application of benzyl adenine and salicylic acid on carnation cv. Spray and Standard. Biological Forum, 7(2):955-958.

Snedecor, G.W. and W.G. Cochran, 1980. Statistical methods. 7th Ed., Iowa State Univ., Press, Amer., Iowa, USA.