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Influence of Foliar Spraying by Antioxidants on Growth, Flowering and Chemical Composition of Chrysanthemum (*Dendranthema grandiflorum*) Plant

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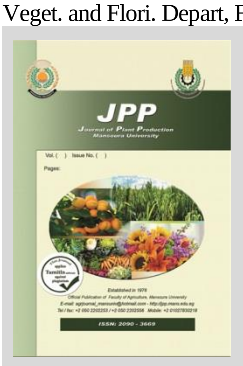

ABSTRACT

In this study, investigate the influence of foliar spraying by antioxidants (salicylic, ascorbic, oxalic, boric and nicothinic acid) at rate of 150/300/450 ppm on growth, flowering, chemical and quality composition of chrysanthemum (*Dendranthema grandiflorum*Ram) plant during winter seasons of 2018-2019 and 2019-2020. Salicylic acid at 450 ppm was more successful than most of the other treatments for increasing plant height, number of branches/plant, fresh and dry weight as well as flowering traits as number of flower/plant, also, pigments content of leaves (total chlorophyll and carotenoids) , N, P and K (%), total carbohydrates (%), phenol(mg/100g DW), but decreased proline content. While, the lowest values of all parameters were observed with the control treatment (sprayed with water) except proline content recorded the highest value during both seasons of the experiment.

Keywords: Chrysanthemum, antioxidants, salicylic, ascorbic, oxalic, boric, nicothinic acid .

INTRODUCTION

Chrysanthemum (*Dendranthema grandiflora*ram) is a main commercial crop grown for cut flowers and pot plant (Navale *et al*. 2010). Chrysanthemum is one of the more famous flowers grown in our country for its diversified beauty of shapes, colours, shades and keeping quality. Flowers of standard varities are created on long, strong stems and have a decent keeping quality. These characters make it exceptionally appropriate for flower arrangements. Its bloom last over a brief time of 1 to 2 months. Thus, they order and give gainful cost in the market. By virtue of its great keeping quality, chrysanthemum flowers can be shipped to a far off market easily (Aashutosh *et al.* 2019).

Improvement of plant development by growth regulators such as salcylic acid, ascorbic acid,oxalic acid, boric acid and Nicotinic acid, have critical consideration lately (Abdul Kareem and Saeed, 2020).

Salicylic acid (SA) is a phenolic compound of hormonal nature delivered by plants and play a significant part in responses to several pathogen attack and abiotic stresses. The effect of salicylic acid foliar spray was studied to stimulate flowering herbaceous plants without the different stresses. (Hegazi and El-Shrayi, 2007), incitement of stomatal closure, root growth and decreased transpiration (Singh and Usha, 2003), reversal of the effects of abscisic acid and regulation of gravitropism (Hussein *et al*., 2007). The impact of SA as an endogenous regulator of flowering was shown in a several of all plants. As to the roles of salicylic acid in improvement some flowers were mentioned by Aashutosh *et al*. (2019) on chrysanthemum plant.

Ascorbic Acid (AsA) is a little antioxidant molecule also namely (vitamin C) fulfills fundamental metabolic functions in the life of plants and animals. Vitamin C serves as a cofactor for some enzymes (Arrigoni and Tullio, 2000). Ascorbic acid functions as a fital redox support and as a cofactor for enzymes involved in hormone biosynthesis, regulating photosynthesis and regenerating other antioxidants. AsA regulates cell division and development and is involved in signal transduction (Ashihara *et al*. 2013). The role of ascorbic acid (vit. C) in improving flowers were mentioned by Khalil (2015) on gladiolus.

Oxalic acid (OA) is viewed as antioxidant substance, which acting a important part in regulating a number of physiological processes i.e. transpiration, ions uptake and transport, photosynthesis, plant metabolism and growth (Singh *et al*. 2010). Additionally, adding has gotten a lot of attention in comparable to, induced disease systemic resistance and its antioxidant capability (Malencic *et al.*, 2004).

Boric acid (B(OH)3 or H_3BO_3) is another compound which defers senescence of some flowers Like carnation (Serrano *et al*., 2001). It’s considered wellspring of boron which plays a significant role in enhancing cell division, flowers fertilization and pollination, biosynthesis of proteins and carbohydrates. Additionally, nicotinic acid provides stress resistance in plants by protecting the cells against oxidative damage (Berglund *et al.*, 2017).

Nicotinic acid provides stress resistance in plants by protecting the cells against oxidative damage (Berglund *et al*., 2017). Dehydroascorbic acid plays an important role in plant adaptation to environmental stresses and by means of the dehydroascorbatereductase (DHAR) reaction (Smirnoff and Wheeler, 2000), can be reduced to ascorbic acid, one of the most important antioxidants in plants, the nicotinic acid-induced stimulation of flowering.

The optimum temperature for growth of chrysanthemum is between 18-20°C. (Spaargaren, 2002). As a result, it's critical to study the possibility of breeding chrysanthemum cultivars that can be cultivated at lower

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temperatures while still producing the same amount of flowers. Low temperatures are one of the most damaging abiotic stresses affecting that temperate plants. Adams *et al.* (1998) studied the impact of temperature on the time of floral initiation in chrysanthemum (*Chrysanthemum grandiflorum*) and found that flowering occurred most rapidly in plants grown at a mean temperature of 20.4 ◦C, while the time of floral initiation was significantly delayed at 9.6 ◦C. Also, Rezazadeh *et al.* (2018) also studied the effect of temperature on flower development in red firespike and found the optimum temperature for floral induction to visible bud was 25 ◦C.

The objective was to research the effect of foliar spraying with different plant regulators as salicylic acid, ascorbic acid, oxalic acid, boric acid and nicotinic acid as foliar application on growth, flowering and chemical content of chrysanthemum flower.

MATERIALS AND METHODS

The present study was conducted during the two successive winter seasons of 2018/2019 and 2019/2020, to investigate the influence of foliar spraying by antioxidants salicylic, ascorbic, oxalic, boric and nicothinic acid on growth, flowering and chemical composition of chrysanthemum (*Dendranthema grandiflorum* Ram*)* cv. Flyer plant. To achieve the mentioned investigation, two field experiments were carried out at the Experimental Station and Laboratory of the Vegetable and Ornamental Plants Dept., Faculty of Agriculture, Mansoura Univ., Egypt.

Plant material: Chrysanthemum cuttings used in this study were purchased from a well-known commercial orchard at El-Kanater El-Khyrea. The plot area was 24 m^2, the terminal cutting bases (15-20 cm) was planted at 30-40 cm between plants and 50 cm between rows apart on 14^{th} November of each season. Fertilizer NPK (20:20:20) as soil application at the rate of 2 g for each cutting was used. All the agricultural practices were kept uniform for all the treatments in the experiment.

Experimental design: The experiment was laid-out with 16 treatments each treatment was replicated three times (6 plants / replicate) the treatments including: Control (water only), 150, 300 and 450 ppm for each; Salicylic acid, Ascorbic acid, oxalic acid, boric acid and nicothinic acid. The plants were foliar sprayed with investigation antioxidants in the morning at different concentrations three times at two week intervals beginning of flower bud formation (28 days after transplanting of seedlings).

The physical and chemical properties of the experimental soil were determined before cultivation according to Jackson (1973) and Black *et al*., (1982), as shown in Table (A)

Table A. The mean values of some physical and chemical properties of the experimental soil before cultivation of chrysanthemum (*Dendranthema grandiflorum)* in the two growing seasons (2019-2020).

Mechanical analysis (%)		Chemical analysis		Soluble cations and anions	
Coarse sand	1.96	Available N (ppm)	42.00	Cations (meq/100 g soil)	
Fine sand	29.33	Available P (ppm)	6.30	Ca^{++}	1.83
Silt	37.03	Available K (ppm)	330.00	Mg^{++}	1.27
Clay	31.68	Organic matter (%)	2.13	Na^{+}	0.97
Texture	Clay loamy	E.C.* %	0.26	K^{+}	0.08
		pH**	8.14	Anions (meq/100 g soil)	
		$CaCO_3$	1.95	$CO_3^{=}$	0.00
				HCO_3^{-}	2.53
				$SO_4^{=}$	0.74
				Cl^{-}	0.88

* 1 : 5 soil : water extraction
** 1:2.5 soil suspension

The monthly average maximum and minimum temperature during the two seasons at the experimental region were shown in Table (B).

Table B. Average maximum and minimum monthly temperature during 2019 and 2020 seasons at the experimental region.

Month	Temperature C°			
	2019		2020	
	Max.	Min.	Max.	Min.
November	30.08	19.61	23.7	16.26
December	20.14	11.93	21.87	13.16
January	18.39	9.98	12.96	9.64
February	20.81	11.19	14.31	8.44
March	24.51	12.94	22.90	13.51

* Source: https://www.weather-atlas.com

Data recorded: At the end of those experiments on 12^{th} February and 24^{th} March for first and second season, respectively, six plants were randomly collected from each treatment and the following characters were recorded:

1.Vegetative and flower parameters: Plant height (cm), number of branches /plant, number of flowers/plant and plant fresh and dry weights (g/plant).

2.Chemical determinations:

- **Pigments content (mg/g f.w.)**: Total chlorophyll and total carotenoids were determined in leaf samples after harvesting (mg / 100g FW) according to Mackinney (1941).
- **Nutrient elements determination: Nitrogen determination:** Nitrogen % was determined by modified micro kjeldahle method as described by Pregl (1945).
- **Phosphorus determination:** Phosphorus % was determined according to Jackson (1967).
- **Potassium determination:** Potassium % was determined according to Black (1965).

3.**Quality parameters: Total carbohydrates (%):** Total carbohydrates in dried plant sample was determined according to Hedge and Hofreiter (1962).

Total phenols (%): Total phenols estimation was carried out with the Folin-ciocalteau reagent according to Malick and Singh (1980).Proline (mg/100g DW):Proline was determined by the modified ninhydrine methods of Troll and Lindsley (1955), omitting phosphoric acid to avoid interference with concentrated sugars (Mang and Larher, 1992).

Statistical analysis

The experiment was laid in simple experiment Randomized Complete Block Design (RCBD) according to Steel and Torrie (1980). Data were subjected to analysis of variance by using the SAS program (1994). Treatments comparing between means were achieved using the least significant difference (LSD) at 0.05 level, as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1.Vegetative and flowering traits:

Data on vegetative growth as plant height, number of branches/plant, fresh and dry weight as well as flowering traits as number of flower/plant are tabulated in Table (1) as affected by various plant growth regulators as salicylic, ascorbic, boric, oxalic and nicothanic acids with different concentration for each one 150, 300 and 450 ppm comparing with the control (water sprayed) during both seasons of 2018-2019 and 2019-2019.

- **Plant height cm:**

Data presented in Table (1) indicated that all the foliar application of plant growth regulators under investigation with different concentration proved significantly superior to the control (water sprayed plants) concerning the plant height. Salicylic acid treated plants showed generally better plant height than other treatments followed by ascorbic acid comparing to the control. The highest concentration 450 ppm of salicylic acid gave the tallest plants (27.17 and 29.15 cm) during both seasons, respectively followed by 450 ppm of ascorbic acid with significant effect comparing to the control plants which recorded the lowest values for both seasons.

- **Number of branches/plant:**

The foliar application of all plant growth regulators under investigation significantly affected in number of branches/plant as shown in Table (1). All foliar application increased number of branches/plant over the control and the plants foliared with salicylic acid at 450 ppm recording the highest values (4.33 and 4.66) during both seasons, respectively followed by ascorbic acid at 450 ppm with no significant effect in both seasons. While the lowest values scored with control plants in both seasons.

Furthermore, the possible involvement of AsA-hormone crosstalk in the regulation of several key physiological and biochemical processes like plant height and number of branches. These results are in the same line with those reported by Rahimi *et al*. (2013). On *Cuminum Cyminum* L.Plant and Gad et al . (2016) on Ixora coccinea

- **Number of flowers/plant:**

Data presented in Table (1) show that spraying chrysanthemum with all antioxidants (salicylic, ascorbic, boric, oxalic and nicothanic acids with different concentration for each one 150, 300 and 450 ppm) increased significantly number of flowers/plant during both seasons. Plants sprayed with salicylic at 450 ppm promoted number of flowers/plant over the control followed by ascorbic acid at 450 ppm with low significant effect.

Table 1. Effect of salyclic, ascorbic, boric, oxalic and nicothinic acids on plant height (cm), number of branches and number of flowers of *Dendranthemagrandiflorum* plants during (2018 / 2019) and (2019 / 2020) seasons.

Treatments		Plant height cm		Number of branches/plant		Number of flower/plant	
		2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020
Control		14.18 l	15.42 m	1.66 d	1.66 f	3.66 g	2.33 e
Salicylic acid	150 ppm	21.20 f	22.90 fg	2.66 a-d	2.33 d~f	9.66 d~f	4.66 ed
	300 ppm	25.70 b	27.31 bc	4.33 a	2.33 d~f	19.00 b	12.66 a~c
	450 ppm	27.17 a	29.15 a	4.33 a	4.66 a	23.66 a	17.00 a
Ascorbic acid	150 ppm	20.18 g	21.96 hg	3.66 a~c	2.66 c-f	10.00 de	5.66 c~e
	300 ppm	24.61 c	26.41 cd	3.00 a~d	3.33 b~d	3.66 g	3.66 e
	450 ppm	26.21 b	28.31 ab	4.33 a	4.33 ab	21.33 ab	13.66 ab
Boric acid	150 ppm	16.72 j	18.25 kl	2.66 a~d	3.00 c~e	14.33 c	12.33a~d
	300 ppm	19.47gh	20.92 hi	3.66 a~c	2.00 ef	4.66 g	3.33e
	450 ppm	23.69 d	25.54 de	2.66 a~d	2.33 d~f	9.33 d~f	8.33 b~e
Oxalic acid	150 ppm	15.89 kj	17.54 l	4.00 ab	2.33 d~f	9.66 d~f	6.00 b~e
	300 ppm	18.70 h	20.08 ij	2.00 cd	2.66 c~f	13.00 cd	6.00 b~e
	450 ppm	22.87 ed	24.73 e	3.33 a-d	2.66 c~f	9.33 d~f	6.00 b~e
Nicothinic acid	150 ppm	15.26 k	16.43 m	2.66 a~d	2.33 d~f	6.66 g~f	4.66 de
	300 ppm	17.72 j	19.19 jk	4.00 ab	2.33 d~f	5.66 fg	6.33 b~e
	450 ppm	22.01ef	23.62 f	2.33 cd	2.33 d~f	12.33 cd	5.00 cde

- **Fresh and dry weight g/plant:**

As illustrated in Fig (1 and 2). Ascorbic acid at 450 ppm significantly increased both fresh and dry weight and scored (114.66 and182.66 g/plant)and(25.24 and 30.05 g/plant) for fresh and dry weight in the two seasons, respectively followed by salicylic acid at the same rate which scored. 102.66 and 107.33 g/ plant and (22.37 and 17.70 g/plant) for fresh and dry weight in the two seasons, respectively. While the control caused the reduction of fresh and dry weight in the two seasons as (36.66 and 37.33 g/ plant).

The recent experiment shown that chrysanthemum plant growth and flowering can be improved. by all antioxidants under investigation especially salicylic and ascorbic acid at 450 ppm. The data revealed that foliar with salicylic had a positive effect on most vegetative growth and number of flowers, this may be attributed to that fact that salicylic acid asses key roles in organization of various developmental and physiological processes of plants (Souri and Tohidloo, 2019). These beneficial impacts might be because of the role of salicylic acid in increasing the plant content of internal hormones such as auxin, gibberellin and cytokinine, consequently increasing cell division and ultimately promoting and elongation plant development and growth (Hayat and Ahmed, 2007). There is proof of a cross-talk between salicylic and auxin signaling pathways during plant vegetative development (Rivas-San Vicente and Plascencia, 2011). Improvement of vegetative growth due to foliar spray with salicylic in this investigation are in concurrence with those obtained byAbd Allah *et al.* (2015) resulted that foliar application with 400 mg/L salicylic acid increased significantly growth characters (plant height, leaves number/plant as well as plant dry weight)

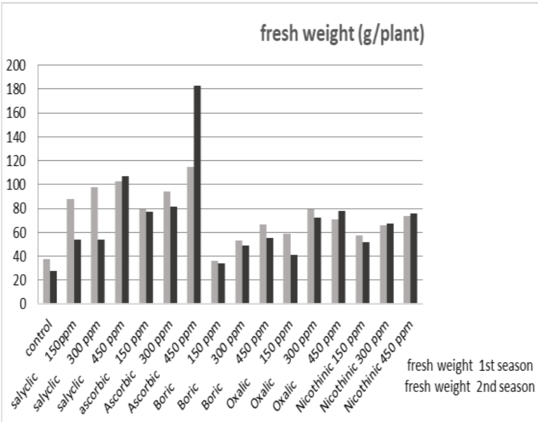

Fig.1. Effect of salyclic, ascorbic, boric, oxalic and nicothinic acids on plant fresh weight (g) of *Dendranthema grandiflorum* plants during the two seasons of (2018/2019) and (2019/2020).

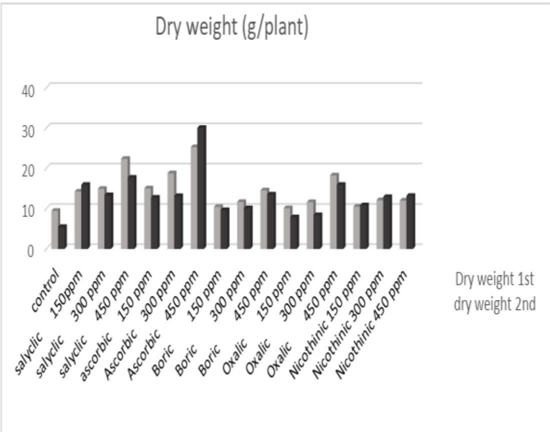

Fig.2. Effect of salyclic, ascorbic, boric, oxalic and nicothinic acids on plant dry weight (g) of *Dendranthema grandiflorum* plants during the two seasons of (2018/2019) and (2019/2020).

The improvement of vegetative growth specially fresh and dry weight which recorded the highest values with sprayed plants by Ascorbic acid as well as other traits might be attributed to its role in various functions. It is a cofactor for the enzymes associated in a variety of with an assortment processes including plant hormone synthesis and flavonoids, xanthophyll cycle (Tullio and Arrigoni, 2004). Likewise this augmentation in vegetative development might be ascribed to the way that this acid co-regulates the cell division. In this regard Smirnoff (1996) detailed that ascorbate has been embroiled in regulation of cell division. In this association, who additionally pointed out that cell wall localized ascorbate oxidase and cell wall ascorbate has been implicated in control of growth; high ascorbate oxidase activity is associated with quickly expanding cells. The results could paint in the same direction ofRashed *et al.* (2017) who reported that foliar application with 400 ppm ascorbic acid significantly increased growth parameters expressed as plant height, number of branches and leaves per plant, fresh and dry weight per plant and leaf area per plant.

2. Chemical constituents:

Regarding the effect of growth regulators substances treatments as (salicylic, ascorbic, boric, oxalic and nicothanic acids with different concentration for each one 150, 300 and 450 ppm) on total chlorophyll, carotene mg/100g FW, N, P and K % of leaves in chrysanthemum plant comparing to the control during both seasons of 2018-2019 and 2019-2020 in tables (2 and 3).

- **Total chlorophyll mg/100g FW:**

With regard to the antioxidants treatments, the listed data in Table (2) declared that all antioxidants with different concentration increased significantly total chlorophyll comparison with the plants sprayed with water. Salicylic acid at high concentration (450 ppm) gave the maximum value of total chlorophyll followed by ascorbic acid at the same concentration over all other treatments. While the lowest value recorded with the control during both seasons of the experiments.

- **Carotene mg/100g FW:**

Data in Table (2) showed that carotene content of chrysanthemum was significantly increased compared to the control in both seasons due to foliar application with various antioxidants with different concentration. It seems that foliar application of higher concentration of salicylic gave the highest value of carotene reached to (13.11 and 12.56 mg/100g) in both seasons, respectively followed by the highest level of ascorbic acid (12.73 and 12.07 mg/100g) in both seasons, respectively. While the lowest value recorded with the control treatments.

Table 2. Effect of salicylic, ascorbic, boric, oxalic and nicothinic acids on total chlorophyll and carotene (mg/100g FW) in leaves of *Dendranthema grandiflorum* plants during the two seasons of (2018 / 2019) and (2019 / 2020).

Treatments		Total chlorophyll (mg \ 100g FW)		Carotene (mg \ 100g FW)	
		2018-2019	2019-2020	2018-2019	2019-2020
Control		32.36 k	32.35k	8.84l	7.22 m
Salicylic acid	150 ppm	38.05e	40.65 f	10.74f	10.44g
	300 ppm	42.48b	47.31c	11.53 c	11.68c
	450 ppm	50.86a	53.57 a	13.11 a	12.56a
Ascorbic acid	150 ppm	37.12f	40.07fg	10.54 g	10.20 h
	300 ppm	41.18c	45.81d	11.47 c	11.34d
	450 ppm	42.75b	50.77b	12.73 b	12.07b
Boric acid	150 ppm	33.92h~j	38.48 h	9.77 j	9.47 j
	300 ppm	35.73g	39.90fg	10.31h	10.10h
	450 ppm	39.54d	45.03 d	11.25d	11.04e
Oxalic acid	150 ppm	33.49ij	37.04 i	9.35k	9.17k
	300 ppm	34.54h	39.57 g	10.14hi	9.87i
	450 ppm	39.37d	42.36 e	11.01e	10.86f
Nicothinic acid	150 ppm	33.09jk	35.41 j	9.17 k	8.86 l
	300 ppm	34.15hi	39.11gh	10.01 i	9.65j
	450 ppm	38.47e	41.84e	10.80 f	10.79f

Foliar application of salicylic acid is involved in stomata regulation thereby can work the controlling to photosynthetic rate, consequently, enhanced photosynthesis, additionally it increased sap production in the leaf lamella which resulted in maintenance of relative water content in leaf and better growth (Hayat et al., 2010). Pacheco et al. (2013)

illustrated that the increase in photosynthesis rate in plants due to the foliar application with salicylic acid can be assigned to metabolic changes at the chloroplasts level (efficiency of photosystem II and Rubisco enzyme activity). The stimulatory impacts of salicylic acid on photosynthetic pigments of chrysanthemum are in agreement with those of Fariduddin et al. (2003) expressed that salicylic acid improved the rate of net photosynthetic, water use efficiency, intercellular CO, transpiration rate and stomatal conductance in Brassica juncea. Furthermore, salicylic acid had a stimulatory impacts on pigment contents and increased CO2 assimilation, increased mineral uptake and photosynthetic rate by the plant (Szepesi et al. 2005). In addition, its antioxidant scavenging impact protected chloroplasts and prevented chlorophyll degradation by the toxic reactive oxygen radicals (Aono et al. 1993).The stimulatory effects of salicylic acid on photosynthetic pigments of chrysanthemum are in agreement with those of Abd Allah et al. (2015) who reported that foliar application with 400 mg/L salicylic acid increased significantly photosynthetic pigments (chlorophyll a, chlorophyll b, carotenoids) of quinea.

As for the effect of ascorbic acid, (Azooz and Al-Fredan, 2009) recommended that, chlorophyll content of plants treated with ascorbic acid was increased because of the protection impact of these vitamin. Azzedine et al. (2011) reported that, ascorbic acid can neutralize and detoxify the reactive oxygen species by prevention of free radicals activity, leading to increase in chlorophyll content of vitamin- treated plants. They also found that, application of ascorbic acid was significant to increased leaf area and improved chlorophyll and carotenoids contents.

- **N, P and K% in leaves:**

The effect of antioxidants under investigation on N, P and K% of chrysanthemum leaves are illustrated in Table (3). All antioxidants increased significantly nutrition values in leaves with increasing all concentration from 150 up to 450 ppm comparing to the control. Data clearly showed that salicylic acid at the highest concentration (450 ppm) was more pronounced N, P and K % in leaves than all treatments and scored (3.47 and 3.61%), (0.58 and 0.60%) and (2.57 and 2.76%) for N, P and K% in both seasons, respectively followed significantly by 450 ppm ascorbic acid comparing to the control which recorded the lowest values during both seasons of the experiments.

Table 3. Effect of salicylic, ascorbic, boric, oxalic and nicothinic acids on N, P and K (%) in leaves of *Dendranthema grandiflorum* plants during (2018 / 2019) and (2019 / 2020) seasons.

Treatments		N%		P%		K%	
		2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020
Control		2.34 p	2.36k	0.47 l	0.50 e	1.70 p	1.93 l
Salicylic acid	150 ppm	2.92 h	3.02 f	0.53 fg	0.57b-e	2.18 h	2.38 ef
	300 ppm	3.35 c	3.47 c	0.57 bc	0.60 b~d	2.46 c	2.69 b
	450 ppm	3.47 a	3.61 a	0.58 a	0.71 a	2.57 a	2.76 a
Ascorbic acid	150 ppm	2.84 i	2.98 f	0.52 g	0.56 bcde	2.10 i	2.34 fg
	300 ppm	3.24 d	3.36 d	0.56 cd	0.60 b~d	2.40 d	2.59 c
	450 ppm	3.41 b	3.56 b	0.57 ab	0.62 b	2.51 b	2.70 b
Boric acid	150 ppm	2.57 m	2.68 i	0.49 j	0.53 c~e	1.89 m	2.08 j
	300 ppm	2.78 j	2.90 g	0.51 h	0.55 bcde	2.03 j	2.29 g
	450 ppm	3.17 e	3.32 d	0.55 d	0.61 bc	2.35 e	2.57 c
Oxalic acid	150 ppm	2.49 n	2.68 i	0.49 jk	0.52 c~e	1.80 n	2.05 j
	300 ppm	2.72 k	2.90 g	0.51 hi	0.54 bcde	1.99 k	2.21 h
	450 ppm	3.09 f	3.32 d	0.54 e	0.58 bcde	2.27 f	2.51 d
Nicothinic acid	150 ppm	2.43 o	2.57 j	0.48 k	0.51 de	1.77 o	2.00 k
	300 ppm	2.62 l	2.82 h	0.50 i	0.53 bcde	1.93 l	2.15 i
	450 ppm	3.00 g	3.23 e	0.53 f	0.57 bcde	2.23 g	2.42 e

Saeidi-Sar et al., (2013) Phosphorus and potassium are critical nutrients that are required for cell division, cell turger, and the formation of DNA and RNA. They also play a crucial role in the production and translocation of carbohydrates. In this concern, Grown (2012) announced such stimulatory impacts of salicylic acid on nutrition elements concentrations components of sunflower plants these findings to the impact of salicylic acid on many physiological and biochemical processes that were reflected on active translocation of photosynthesis products and improving vegetative growth. Additionally, salicylic acid is involved in a wide range of significant functions as leaf development and antioxidant defense which increased photosynthetic rate (Jacquot et al., 2002). In additionally, Farouk et al. (2011) indicated that the positive effect of ascorbic acid on nutrition values of plant may be due to its effect on increasing uptake of nutrient and increase elements content such as nitrogen, phosphorous, and potassium. This positive effect of the utilized treatments led to promoted uptake of nutrient and finally reflexes on the N, P and K concentration.

3. Quality parameters:

Concerning the effect of growth regulators as salicylic, ascorbic, boric, oxalic and nicothanic acids with different concentration for each one 150, 300 and 450 ppm comparing with the control (water sprayed) on total carbohydrates, phenol and proline in chrysanthemum flower during both seasons of 2018-2019 and 2019-2019 are presented in Table (4).

- **Total carbohydrates%:**

As regard to the effect of concentration of various antioxidants on total carbohydrates, data in Table (4) revealed that, the foliar application of all plant growth regulators increased significantly the content of total carbohydrates% during both seasons of the experiments in compare with the control plants. It was found that 450 ppm from salicylic acid as foliar application recorded the highest values followed by 450 ppm from ascorbic acid over all of other treatments. While the lowest value indicated with the control plants.

The significant increase in carbohydrate% might be because rof the stimulatory effects of the used plant growth biostimulators on the photosynthetic process, the photosynthetic machinery is activated. On the one hand, salicylic acid therapy may block polysaccharide-hydrolyzing enzyme system and/or speed up the incorporation of soluble sugars into polysaccharides. (Bakry *et al.* 2012).

- **Phenol content:**

It is obvious from the data presented in Table (4) that spraying with 450 ppm salicylic acid had the highest significant value of phenol content as (27.17 and 29.15 mg/100g) in both seasons, respectively comparing to the control which recorded the lowest values as (14.18 and 15.42 mg/100g) in both seasons, respectively. The next treatment was 450 ppm of ascorbic acid with high significant effect and scored (26.21 and 28.31 mg/100g) in both seasons, respectively, the other treatments recorded medium values.

Phenols content is a suitable pointer for developing plant metabolism (Sharma *et al*., 2019). The results of this investigation showed that this metabolite increased due to foliar application of salicylic acid. The enhancement happened because salicylic acid it's self a plant-produced phenolic compound, additionally it's endogenous growth regulator, which participates in the regulation of physiological processes in plants (Pila *et al*., 2010). Salicylic acid (SA) (o-hydroxybenzoic acid), which has a place to a group of plant phenolics, is broadly disseminated in plants and is now considered as a hormone-like substance, which assumes a significant role in the regulation of plant development and growth (Raskin, 1992; Klessig and Malamy 1994). Khalil *et al.* (2018) reported that an increase in total polyphenol content in *Thymus vulgaris* L. plants under salicylic acid compared to control.

- **Proline content:**

Proline, an amino acid, assumes a highly profoundly role in plants presented to different stress conditions. Other than acting as an excellent osmolyte, proline assumes three significant roles during stress, i.e., as an antioxidative defense molecule, a metal chelator and a signaling molecule. many investigation shows that a stressful environment results in an overproduction of proline in plants which in turn imparts stress tolerance by keeping up osmotic balance or cell turgor; balancing out membranes thereby forestalling electrolyte leakage; and bringing concentrations of reactive oxygen species (ROS) inside normal ranges, consequently preventing oxidative burst in plants (Hayat *et al.*,2012).

Results outline in Table (4) exhibited that, all plant growth regulators significantly affected in proline content in chrysanthemum flower i.e. salicylic, ascorbic, boric, oxalic and nicothanic acids with different concentration for each one 150, 300 and 450 ppm. It is obvious that the chrysanthemum was grown during winter seasons which mean low temperature. So, the highest mean values of proline content was observed with control plants sprayed with water (9.79 and 11.27 mg/100g) during both seasons, respectively, while antioxidants reduce proline content and the lowest mean value was observed with 450 ppm salicylic acid (7.04 and 6.96 mg/100g) during both seasons, respectively.

As an essential mechanism, osmotic change is included in plant adaptations to different stresses. Proline is a significant components of osmoregulation in the expanded leaves of numerous species (Mostajeran and Rahimi-Eichi, 2009). In the current study, observed that the concentrations of proline were decreased because of the salicylic acid treatments. Low temperature enormously expanded the concentrations of proline in chrysanthemum. From this result, we conclude that salicylic acid may not be associated in the up-regulation of proline biosynthesis for its promoting mechanism of drought tolerance in chrysanthemum as mentioned by (Abd El-Mageed *et al*. 2016).

Table 4. Effect of salicylic, ascorbic, boric, oxalic and nicothinic acids on total carbohydrates (%),Phenol(mg/100g DW)and Proline (mg/100g DW)in leaves of *Dendranthema grandiflorum* plants during (2018 / 2019) and (2019 / 2020) seasons.

Treatments		Total carbohydrates(%)		Phenol (mg/100g DW)		Proline (mg/100g DW)	
		2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020
Control		22.96 k	23.67 i	14.18 l	15.42 m	9.79 a	11.27 a
Salicylic acid	150 ppm	31.27 e	32.74 de	21.20 f	22.90 fg	8.35 gh	9.04 f
	300 ppm	36.21 b	38.24 b	25.70 b	27.31 bc	7.44 lm	7.65 i
	450 ppm	38.25 a	40.34 a	27.17 a	29.15 a	7.04 n	6.96 k
Ascorbic acid	150 ppm	30.17 f	31.82 ef	20.18 g	21.96 gh	8.46 fg	9.32 de
	300 ppm	35.06 c	36.90 c	24.61 c	26.41 cd	7.62 lk	7.84 ih
	450 ppm	37.42 a	38.86 b	26.21 b	28.31 ab	7.27 mn	7.33 j
Boric acid	150 ppm	26.10 i	27.41 g	16.72 j	18.25 kl	9.24 cd	10.44 b
	300 ppm	28.92 g	30.50 f	19.47 gh	20.92 hi	8.66 f	9.64 c
	450 ppm	34.19 cd	35.70 c	23.69 d	25.54 de	7.82 kj	8.10 gh
Oxalic acid	150 ppm	25.13 i	25.13 h	15.89 jk	17.54 l	9.46 bc	9.46 cd
	300 ppm	28.19 g	28.19 g	18.70 h	20.08 ij	8.93 e	8.93 f
	450 ppm	33.23 d	33.23 d	22.87 ed	24.73 e	7.96 ij	7.96 gh
Nicothinic acid	150 ppm	24.12 j	24.12 ih	15.26 k	16.43 m	9.55 ab	9.55 cd
	300 ppm	27.19 h	27.19 g	17.72 i	19.19 jk	9.08 de	9.05 ef
	450 ppm	32.13 e	32.12 de	22.01 ef	23.62 f	8.13 hi	8.13

CONCLUSION

Foliar application of different plant growth regulators with different concentration increased vegetative growth traits and flower number as well as chemical and quality content, while decreased proline content. The effect of salicylic followed by ascorbic acids was more pronounced than the other plant growth regulators in increasing most studied parameters. Moreover, 450ppm was the most effective concentration for both acids during both seasons of the experiments.

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تأثير الرش الورقى بمضادات الأكسده على النمو و الإزهار و التركيب الكيميائى للأراولا

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أجريت تجربة لمعرفة تأثير الرش الورقي بمضادات الأكسدة (حمض الساليسيليك ، الأسكوربيك ، الأوكساليك ، البوريكوالنيكوتينيك) بمعدلات ١٥٠/٣٠٠/٤٥٠ جزء في المليون على النمو والتزهير والتركيب الكيميائي و جودة نبات الأراولا صنف فايرخلال الموسمين الشتويين ٢٠١٨-٢٠١٩ و ٢٠١٩-٢٠٢٠. كان حمض الساليسيليك عند ٤٥٠ جزء في المليون أكثر فاعلية من معظم المعاملات الأخرى لزيادة طول النبات ، وعدد الأوراق ، الوزن الطازج ، الجاف للنبات و عدد الأزهار للنبات بالإضافه الى محتوى الصبغات فى الاوراق (الكلوروفيل الكلى و الكاروتين) والتركيب الكيميائي (النسبه المئويه للنيتروجين و الفوسفور و البوتاسيوم) كذلك محتوى الازهار من الكربوهيدرات الكليه و الفينولات و لكن حدث إنخفاض فى محتوى البرولين. بينما أقل القيم لجميع الصفات سجلت مع النباتات التى تم رشها بالماء (كنترول) ما عدا البرولين الذى سجل أعلى القيم خلال موسمى التجربه.