The Beneficial Role of Salicylic Acid, Triacontanol and δ-Aminolevulinic Acid on the Growth, Flowering and Chemical Composition of Pansy (*Viola wittrockiana* Gams) under Salt Stress Conditions

Ramy Gaber El-Kinany

Hort. Dept. (Floriculture and Ornamental Plants), Fac. Agric., Damanhour University, Damanhour, El-Beheira, PO Box 59, Egypt

Received: *14/3/2020*

Abstract: Two pot trials were carried out during the two successive Winter seasons of 2015/2016 and 2016/2017 at private commercial nursery, Damanhour city, El-Beheira Governorate, Egypt under greenhouse conditions. The objective of these experiments was to study the effect of foliar application with each of salicylic acid (SA) (50 and 100 mgL^{-1}), triacontanol (TRIA) (25 and 50 mgL^{-1}) and δ-aminolevulinic acid (ALA) (25 and 50 mgL^{-1}) on *Viola wittrockiana* Gams L. (Blue with Blotch cultivar) grown under different concentrations of salinity (0, 20, 40 and 60 mM of NaCl). Generally, the tested materials were varied in their significant effects on studying characters. The obtained results of the two seasons indicated that increasing salinity levels from 20 to 60 mM significantly reduced all studied parameter levels, *i.e.*, plant height, branches number per plant, shoot dry weight per plant, leaf area, root length and root dry weight, nitrogen, phosphorus, potassium, calcium, magnesium, and chlorophyll contents. While Na^+ and Cl^- were increased relative to control. Also, the results indicated that the salicylic acid, δ-aminolevulinic acid, and triacontanol significantly increased plant growth and chemical traits, as well as reduced the contents of Na^+ and Cl^- compared to the control (distilled water only) treatment. Application of triacontanol (25 mgL^{-1}) or salicylic acid (50 mgL^{-1}); improved vegetative, flowering, root growth and leaves chemical composition under salt stress during both seasons. Triacontanol enhanced salinity tolerance in both seasons by increasing proline accumulation. Under each salinity level, triacontanol (25 mgL^{-1}) was the most effective treatment for mitigating the deleterious effect of salt stress in pansy plants.

Keywords: pansy, violet, triacontanol, salicylic acid, aminolevulinic acid, salt stress

INTRODUCTION

Salinity of soil and irrigation water is considered one of the most important problems that facing the agriculture development, especially in arid and semi-arid regions. Mohamed *et al*. (2007) showed that 33% of the Egyptian cultivated lands are already salinized due to irrigation with low water quality and poor drainage systems. In saline soils, the presence of Na^+ in excessive levels; led to a reduction in the availability of essential nutrients such as K^+ and Ca^{2+} (Khan *et al*., 2010; Iqbal and Ashraf, 2013). Higher concentrations of Na^+ and Cl^- in plant tissues caused by salinity; cause a reduction in the plant growth and yield as well as alternating the biochemical and physiological processes within the plant (Khan *et al*., 2010). Salt stress, like many abiotic stress factors; at cellular level it can stimulate cellular accumulation of damaging reactive oxygen species (ROS) which can damage membrane lipids, proteins and nucleic acids that called oxidative stress (Azevedo-Neto *et al*., 2006). Many floriculture species are sensitive to salt accumulation in the root zone especially, to sodium chloride. However, using saline water in irrigation of floriculture production may be inevitable in the long run since the fresh water supply is decreasing over time (Niu and Rodriguez, 2006).

The Pansy (*Viola wittrockiana* Gams.) is one of the most important commercially cool season garden crops for landscape, and one of the five best-selling bedding plants in both developed and undeveloped countries (Runkle *et al*., 2003). It belongs to family "Violaceae". The pansy (*Viola wittrockiana* Gams.) result from extensive hybridizing and selection involving the species of *Viola tricolor* L., *Viola lutea* Huds. and *Viola altaica* Gawl and others (Vukics *et al*., 2008). Breeders have chosen these three species due to their large flowers and unusual combinations of colors. Pansies are ideal plants for autumn and winter landscapes because they can tolerate cool temperatures and will provide color when few other plants are flowering (Hamlin and Mills, 2001). Pansy is very suitable for cultivation in gardens, parks and other green areas. Many studies showed that pansy is sensitive to salinity (Bailey and Xu, 2005), so, the tolerance of pansy to different saline water must be taken into account before it is introduced into new regions for cultivation.

Salicylic acid (SA) is a phenolic compound that produced in a large number of plants by root cells and plays a lot of roles in the growth and development of plants as a quasi-hormonal substance (Khan *et al*., 2015). Induction of multiple stress tolerance in plants by exogenous application of SA and its derivatives may have a significant practical usage in agriculture (Senaratna *et al*., 2000). Many researchers mentioned SA to be a suitable treatment for ameliorating the effect of salinity on growing plants by increasing vegetative growth traits, photosynthetic pigments, chemical constitution and yield such as faba bean (Orabi *et al*., 2013).

The δ-aminolevulinic acid (ALA) widely found in animals, bacteria, fungi and plants, especially in non-protein amino acids in living cells (Jia *et al*., 2016). The ALA is also implicated in important plant physiological functions, including photosynthesis,

*Corresponding author e-mail: dr_ramy_gaber@yahoo.com

respiration and other metabolic activities (Zhang *et al*., 2015). Production of ALA acid is the step on which the speed of synthesis of chlorophyll is regulated in plants. Some researchers have suggested that plants exposed to stress conditions such as salinity perform better pertaining to growth and development when treated with ALA (Zhang *et al*., 2006). From earlier studies, it was found that the exogenous application of ALA promoted the resistance of plants to salt stress by improving the tissue water status, chlorophyll biosynthesis and aggravates the antioxidant activity, which reduces the production of ROS (Naeem *et al*., 2010).

Triacontanol (TRIA) has been classified as a plant growth regulator that significantly affects plant growth and development (Shahbaz *et al*., 2013). Naturally, it exists in small amounts in cuticular waxes of plant species (Kolattukudy and Walton, 1972). Exogenous application of TRIA has been reported to enhance chlorophyll contents, total soluble sugars, nucleic acids, protein, chlorophyll fluorescence and photosynthetic rate in wheat parameters (Perveen *et al*., 2010). Also, it had a good role in stimulating nitrogen fixation, photosynthesis, nutrient uptake, enzyme activities, membrane stability and productivity of many crops (Ramanarayan *et al*., 2000). Triacontanol not only improves crop growth and yield under non-stress conditions, but also it can up-regulate crop growth under stressful environments. For instance, exogenously applied TRIA improved the growth of soybean plants and increased chlorophyll and proline contents as well as the uptake of calcium and potassium under salinity conditions (Krishnan and Kumari, 2008).

Literature about the interactions between SA, TRIA and ALA as well as salinity levels on Pansy (*Viola wittrockiana* Gams.) is scant, to the best of our knowledge. Accordingly, the current study aimed to investigate the effect of foliar application of SA, TRIA and ALA on growth, flowering and chemical composition of pansy plants grown under different concentrations of salinity.

MATERIALS AND METHODS

Two separated pot experiments were carried out during the two successive seasons of 2015/2016 and 2016/2017 at private commercial nursery, Damanhour city, El-Beheira Governorate, Egypt under greenhouse conditions. The 'Blue with Blotch' pansy specie (*Viola wittrockiana* Gams.) was used in these experiments. Well-developed seeds were obtained from Ontario Seeds Company Ltd. Waterloo, Ont., Canada. Seeds were sown on 15 October in both seasons in 20 cm black plastic pots filled with soil consist of sand, silt, and clay as appeared in Table (A). On November 20 and after 35 days from seed sowing plants were thinned to one plant per pot in both seasons.

Prior to conducting the experiments, soil samples were collected, and the physical and chemical characteristics of the soil were determined according to the methods described by Jackson (1967) in both seasons of cultivation (Table A). The soil characteristic analyses were carried out at the Department of Natural Resources and Agriculture Engineering, Faculty of Agriculture, Damanhour University. Watering was carried out as needed and pests and weed control were undertaken.

Table (A): Chemical and physical properties of the experimental soil during both seasons of 2015/2016 and 2016/2017

Chemical properties						
Season	**pH**	**EC (dSm^{-1})**	**Organic matter (%)**	**N (ppm)**	**P (ppm)**	**K (ppm)**
2016	7.80	0.46	0.08	17.34	12.61	26.27
2017	7.83	0.45	0.08	16.67	12.58	31.34
Physical properties						
Season	**Sand (%)**	**Silt (%)**	**Clay (%)**	**Texture**	**Bulk density ($g\ cm^{-3}$)**	**$CaCO_3$ (%)**
2016	87.73	9.03	3.24	Sandy	1.52	2.43
2017	88.23	8.10	3.67	Sandy	1.53	2.48

The experiments were designed as a split plot design with three replicates (Snedecor and Cochran, 1967), whereas the salinity levels arranged in the main plots and the foliar spraying treatments were randomly placed in the sub-plots. Each treatment was composed of three replicated pots with one plant for each pot. The experiment included 28 treatments representing the combinations of four salinity levels (0, 20, 40 and 60 mM) of NaCl and seven treatments of foliar applications of salicylic acid (SA) as (50 and 100 mg L^{-1}), TRIA (25 and 50 mg L^{-1}), ALA (25 and 50 mg L^{-1}) and distilled water as a control treatment. All chemicals were previously dissolved in absolute ethyl during preparation.

On November 30, forty five-days-old uniform plants of pansy were prepared for treatments. The plants were treated with saline water as a drench soil with 4 days interval. The value drench was 80 ml per plant. The treatments with SA, TRIA and ALA were applied on the same day of irrigation with saline water. Spray application was conducted in the morning. After the spray application, plants were irrigated at the end of the day. The plants were sprayed once a week and continued till the flowering stage. The soil surface was covered with polyethylene before application of SA, TRIA and ALA to avoid the falling of spray drips on the soil. The tested materials treatment concentrations were applied using a hand sprayer (capacity 2 liter) and non-ionic surfactant tween 80 at 0.05% (v/v) was added to all concentrations to reduce the surface tension and increase the content angle of spray droplets. Each plant was individually sprayed, and the foliage of plants was moistened until the point of runoff. The spraying volume was 10 ml. per plant. All treatments received identical doses of N, P and K fertilization as soluble forms to avoid mineral precipitation. Other agricultural practices were adopted whenever it was necessary and as commonly recommended in the commercial production of pansy.

Recorded Data

Plant growth parameters, at the end of the experiment, three plants from each treatment in each replicate were randomly chosen and tagged for collect vegetative growth traits; plant height (cm), number of branches plant^{-1}, leaf area (cm^2) according to Zidan (1962), shoot dry weight plant^{-1} (g) were determined without the flowers and also for roots by the end of the experiment for all plants. Dry weights were determined by drying the plant samples in the oven at 70 °C till obtaining a constant weight, then left to cool inside the oven and weighed in grams. In all cases, the weight measurements were performed using a digital scale with a precision of 0.001 digits. Likewise, root growth parameters were measured such as root length, root dry weight plant^{-1} (g).

Flowering growth parameters, were also measured such as; flower diameter (cm), number of flowers plant^{-1}, flowering date (number of days to flowering) expressed as the mean number of days between the beginning of the experiment" the seedlings were about 45 days old" and the appearance of the first flower for each plant in each treatment per replicate, days to flower senescence from full bloom, flowering duration was calculated as the number of days elapsed between the appearance of the first flower and the last one in each plant of each treatment per replicate, the average of days was determined (day) and flower fresh and dry weight (g) were estimated according to Elkinany (2016).

Leaves chemical analyses

Photosynthetic pigments (mg/g), (chlorophyll a and chlorophyll b and chlorophyll a+b) were measured spectrophotometrically according to Arnon (1949).

Leaf proline content (mg/g), was determined according to Bates *et al*. (1973).

Leaf minerals analysis, the leaves samples of each treatment were taken at the end of the experiment and dried at 70°C for 72 hr. to constant weight, then they were ground in a stainless steel rotary knife and digested with hydrogen peroxide (H_2O_2) and concentrated sulphuric acid (H_2SO_4) according to Lauchli and Wieneka (1979) to determine the sodium (Na^+), chloride (Cl^-), calcium (Ca^{+2}), magnesium (Mg^{+2}), nitrogen (N^+). phosphorus (P^+) and potassium (K^+).

Chloride was determined by Beckman analyzer, while sodium, potassium and magnesium were measured against standard curves using the flame photometer (Fisher Flame Photometer). Phosphorus percentage was calorimetrically determined using the stannous chloride phosphomolibdic-sulforic acid system and measured at 660 nm wavelength according to (Jackson, 1978) and total nitrogen was determined by digestion using the micro-Kjeldhl method (Black *et al*., 1965). Also, K^+/Na^+ ratio was calculated by dividing the concentration of K over the concentration of Na.

The statistical analysis

Data were analyzed by Statistical Analysis Systems (CoStat, 2008) and the means were compared by Tukey multiple comparison test at 0.05 probability

RESULTS AND DISCUSSION

Plant growth characters

Data showing the main effects of the two studied factors (different salinity concentrations and different levels of triacontanol (TRIA), δ-aminolevulinic acid (ALA) and salicylic acid (SA) and their interactions on plant growth of pansy plants during the two growing seasons 2015/2016 and 2016/2017 are presented in Tables (1 and 2).

Regarding the main effect of salt stress on plant growth parameters, data in Table (1) showed clearly that all studied vegetative growth parameters decreased as salinity levels increased from 0 to 60 mM. The reduced rates of vegetative growth varied depending on the level of imposing salt stress. At the highest salinity concentration (60 mM), the estimated percentage reduction in plant growth; expressed as plant height, branch numbers per plant, shoots dry weight, leaf area, root length and root dry weight were (38.12 and 32.94%), (76.27 and 73.62%), (81.06 and 80.12%), (71.71 and 71.31%), (75.77 and 74.52%) and (81.36 and 81.75%) compared to the control treatment for the first and second seasons, respectively. These results could be attributed to the negative effect of salinity on enzymatic systems, stomatal conductance, photosynthetic capacity, plant cell membrane stability, ionic balance and many other physiological processes which lead to decreasing the morphological characters of plants grown under salinity stress (Abdul Qados, 2011). The obtained results are in harmony with those reported by Roshdy and Berengi (2016) on *Phaseolus vulgaris* and Darwish *et al*. (2017) on *Tecoma capensis*.

Table (1): The main effect of different salinity concentrations and different levels of triacontanol (TRIA), aminolevulinic acid (ALA) and salicylic acid (SA) on plant growth parameters of pansy plants during both 2015/2016 and 2016/2017 seasons

NaCl (mM)	Plant height (cm)		No. of branches/ plant		Shoots dry weight/ plant (g)		leaf area (cm^2)		Root length (cm)		Root dry weight/ plant (g)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Salinity												
0	12.88 A	13.6 A	8.05 A	7.77 A	6.39 A	6.44 A	19.76 A	19.62 A	17.91 A	17.27 A	6.01 A	6.19 A
20	11.91B	12.62 B	5.33 B	5.29 B	3.93 B	4.19 B	15.8 B	14.91 B	13.19 B	12.79 B	3.72 B	3.95 B
40	10.67 C	11.75 C	3.33 C	3.67 C	2.61 C	2.56 C	11.09 C	10.35 C	9.06 C	9.07 C	2.31 C	2.11 C
60	7.97 D	9.12 D	1.91D	2.05 D	D 1.21	1.28 D	5.59 D	5.63 D	4.34 D	4.4 D	1.12 D	1.13 D
TRIA, ALA and SA												
Control	10.34 G	11.12 G	3.92 F	3.92 D	3.03 G	2.86 G	11.03 G	10.72 G	9.68 G	9.26 G	2.66 G	2.86 G
TRIA 25	11.34 A	12.46 A	5.42 A	5.33 A	4.09 A	4.44 A	15.23 A	14.91 A	12.81 A	12.53 A	3.86 A	3.77 A
50	10.58 E	11.42 E	4.42 DE	4.58 C	3.31 E	3.34 E	12.32 E	11.86 E	10.48 E	10.6 E	3.22 E	3.27 E
ALA 25	11.08 C	11.99 C	4.92 BC	5.08 AB	3.7 C	3.79 C	13.74 C	13.19 C	11.72 C	11.31C	3.49 C	3.47 C
50	10.93 D	11.88 D	4.67 CD	4.75 BC	3.55 D	3.577 D	13.04 D	12.55 D	11.03 D	10.85 D	3.38 D	3.37 D
SA 50	11.26 B	12.34 B	5.17 AB	5.08 AB	3.9 B	4.21 B	14.41 B	13.96 B	12.09 B	11.85 B	3.6 B	3.63 B
100	10.49 F	11.22 F	4.08 EF	4.08 D	3.17 F	3.08 F	11.67 F	11.20 F	10.05 F	9.77 F	2.82 F	3.04 F

1st and 2nd; first season and second seasons. Means were compared using Tukey's Honest Significant Difference test ($P \leq 0.05$); n = 3; Means with the same capital letters are not significant different between different salinity concentrations or between different levels of triacontanol, aminolevulinic acid and salicylic acid

Concerning the main effect of foliar application of different rates of TRIA, ALA and SA on the various vegetative growth parameters, data in Table (1) clarified that spraying pansy plants with any of the tested of TRIA, ALA and SA levels, significantly stimulated plant height, branches number per plant, shoots dry weight, leaf area, root length and root dry weight compared to the control treatment during both seasons. Moreover, the treatment with low concentration (25 mgL^{-1}) of TRIA exhibited the highest mean values for the previously mentioned growth parameters followed by SA at 50 mg L^{-1}. At 25 mgL^{-1} TRIA. The estimated percentage of increases for plant height, branches number per plant, shoots dry weight, leaf area, root length and root dry weight were (9.67 and 12.05%), (38.27 and 35.97%), (34.98 and 55.25%), (38.08 and 39.09%), (32.34 and 35.31%) and (44.89 and 31.82%) for the first and second seasons, respectively.

Plants are sensitive to extremely low doses of TRIA; thus, low concentrations of TRIA may be biologically active (Ries and Houtz, 1983). Under salinity conditions, foliar application of TRIA has been reported to up-regulate genes involved in the photosynthetic process, enhancing water and mineral nutrient uptake, enhancing the antioxidant enzyme activities, and stimulating the synthesis of various organic compounds through increased nitrogen metabolism (Perveen *et al*., 2011). Also, TRIA can interact with other growth hormones like cytokinins and gibberellic acid to regulate growth, yield, and metabolic processes in plants (Aftab *et al*., 2010). Moreover, TRIA plays an important role in water uptake, increasing cell division, cell elongation, and permeability of membranes (Hangarter *et al*., 1978). The aforementioned results are in good accordance with those postulated in *Ocimum bacillicum* (Borowski and Blamowski, 2009) and *Helianthus annuus* (Aziz *et al*., 2013).

The promotive effect of SA could be led to its bio regulator effects on physiological and biochemical processes in plants such as ion uptake by the stressed plant, cell differentiation, cell division, cell elongation, enzymatic activities and increase of CO_2 assimilation and photosynthetic rate (Raskin, 1992). Also, SA had an important role in ameliorating the salinity stress effects by increasing the cellular membrane stability and modulating the antioxidant enzyme activity (Mimouni *et al*., 2016). These results are in harmony with in faba bean (Orabi *et al*., 2013).

Exogenous application of ALA with low concentration was found to stimulate growth and yield of several crops and vegetables (Hotta *et al*., 1997). The effect of exogenous application of ALA in alleviating salt stress may be due to its role in improving the tissue water status, stimulating the biosynthesis of photosynthetic pigments and exacerbates the antioxidant activity, which lowers the production of ROS (Naeem *et al*., 2010), and resulting in decreasing oxidative stress due to more stable biological membranes (Balestrasse *et al*., 2010). Similar results were reported in *Brassica napus* (Naeem *et al*., 2010) and *Leymus chinensis* (Ahmad Anjum *et al*., 2016).

The interaction effects between salinity levels and foliar applications of TRIA, ALA and SA on the plant growth parameters of pansy plants are presented in Table (2). The combined treatment of tap water and TRIA at 25 mgL^{-1} recorded the highest mean values of plant height, branches number per plant, shoots dry weight, leaf area, root length and root dry weight of pansy plants in both seasons.

Flowering parameters:

Pertaining to the main effect of salt stress on flowering parameters the gained results presented in Table (3) showed that there was a negative relationship between flowering parameters and salinity concentrations. As salinity concentrations increased, flower diameter, the number of flowers per plant, the number of days to flowering, days to flower senescence from full bloom, flowering duration, flower fresh and dry weights were decreased. So, the high salinity concentration gave the lowest mean values of flowers, but the lowest salinity concentration gave the highest mean values of flowers, in both seasons. The estimated percentages decrease in flower diameter, the number of flowers per plant, the number of days to flowering, days to flower senescence from full bloom, flowering duration, flower fresh weight and flower dry weight were (47.6 and 51.86%), (84.47 and 77.02%), (31.59 and 33.83%), (43.34 and 42.25%), (81.94 and 82.21%), (58.27 and 57.03%) and (83.33 and 76.15%) compared to the control treatment for the first and second seasons, respectively.

Flowers are very sensitive to salt stress, the inhibition of flower growth characters under salinity treatments would almost certainly be due to the inhibition of photosynthesis of plants via the changes in chlorophyll contents and components and damage the photochemical apparatus (Lyengar and Reddy, 1996), which lead to a reduction in carbohydrates amount (source of energy) necessary for cell division and elongation, which might be the reason for the observed decrease in flower diameter, flower fresh and dry weights and flower longevity. Also, the reduction of photosynthesis under salt stress conditions causing a reduction in growth period of plants and accelerated the flowering (Torbaghan and Ahmadi, 2011) as a mechanism of escape from stress condition or adaptation to salinity stress in the most plant. Under salinity conditions the concentration of the assimilate conducting pathway of flowers formation is reduced (Aldesuquy and Ibrahim, 2001), and leaves start behaving as sinks rather than sources (Arbona *et al*., 2005). This causes inhibition of assimilate movement towards the developing reproductive organs, which might be the reason for decreasing flowers number. The reduction of flowering duration may be resulted from inhibition of water and minerals absorption and utilization of them under salinity stress (Mazher *et al*., 2006), also, the reduction of number of flowers and flower longevity causing a reduction in flowering duration too. The mentioned results of inhibition of flower growth characters under salinity treatments are in accordance with those were reported in *Solidago canadensis* L. (Kumari, 2017).

Table (2): The interaction effect between different salinity concentrations and different levels of triacontanol (TRIA), aminolevulinic acid (ALA) and salicylic acid (SA) on plant growth parameters of pansy plants during the 2015/2016 and 2016/2017 seasons

NaCl (mM)	Trts	Plant height (cm)		No. of branches/ plant		Shoots dry weight/ plant (g)		Leaf area (cm^2)		Root length (cm)		Root dry weight (g)/ plant	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	Control	12.41f	13.45e	7.33d	7.33b	5.78e	5.3 g	17.90g	17.58g	16.43e	15.83 f	4.89g	5.70e
	TRIA 25	13.53a	13.78a	9.00a	8.33 a	6.95a	7.71 a	22.58a	22.42 a	19.97a	19.23 a	6.90a	6.71a
	50	12.58e	13.52 de	7.67 cd	7.67 ab	6.06d	5.99 e	18.84e	18.74e	17.47d	16.9 d	5.95e	6.03d
	ALA 25	13.00c	13.66 bc	8.33abc	8 ab	6.67bc	6.68c	19.99c	20.07c	18.23c	17.57 c	6.45c	6.31c
	50	12.84d	13.58cd	8.00bcd	7.67 ab	6.64c	6.23 d	19.38d	19.34d	17.53d	16.9 d	6.29d	6.20c
	SA 50	13.38b	13.72ab	8.67ab	8 ab	6.75b	7.52b	21.17b	21.08b	18.97b	18.23 b	6.62b	6.57b
	100	12.45f	13.48 de	7.33d	7.33b	5.86e	5.58 f	18.47f	18.08f	16.77e	16.23 e	5.00f	5.81e
20	Control	11.73k	12.37 k	4.33ij	4.67 e-g	3.42k	3.28 n	13.97n	12.95 n	12.23 i	11.63 j	3.14m	3.39j
	TRIA 25	12.07g	13.00 f	6.33e	6 c	4.427f	5.03 h	17.20h	17.13h	14.60f	13.87 g	4.34h	4.32f
	50	11.87ij	12.51ij	5.00ghi	5 d-f	3.81i	3.83 l	15.27l	14.19 l	12.60hi	12.57 i	3.65k	4.00 h
	ALA 25	11.95h	12.66h	5.67 e-g	5.67 cd	4.05h	4.51 j	16.49j	15.57 j	13.60g	13.2 h	3.83j	4.07gh
	50	11.92hi	12.6 hi	5.33f-h	5.33 c-e	3.88i	4.3 k	16.07k	14.67k	12.92h	12.7 i	3.78j	4.01h
	SA 50	12.02g	12.78g	6.00ef	5.67 cd	4.22g	4.79 i	16.80i	16.26 i	13.77g	13.7 g	3.95i	4.17g
	100	11.81j	12.42 jk	4.67hi	4.67 e-g	3.68j	3.59 m	14.79m	13.61 m	12.60hi	11.83 j	3.37l	3.66i
40	Control	10.17q	11.24 p	3.00k-m	3 ij	2.11q	2.04 u	8.18u	8.32 u	7.47n	7.1 o	1.87t	1.69o
	TRIA 25	11.06l	12.09 l	3.67jk	4.33 f-h	3.21l	3.12 o	13.52o	12.36 o	10.63 j	10.66 k	2.66n	2.56k
	50	10.57o	11.67 n	3.33kl	3.67 hi	2.36p	2.42 s	10.18s	9.48s	8.47m	9.1 m	2.28r	2.01mn
	ALA 25	10.800n	11.89 m	3.33kl	4 gh	2.75n	2.68 q	12.61q	11.08 q	9.80k	9.36 m	2.463p	2.21 l
	50	10.59o	11.84 m	3.33kl	3.67 hi	2.56o	2.57 r	11.13r	10.54 r	9.38l	9.1 m	2.35q	2.06 m
	SA 50	10.99m	12.00 l	3.67jk	4 gh	2.99m	2.87 p	12.98p	11.97p	9.84k	10.06 l	2.55o	2.32 l
	100	10.49p	11.53 o	3.00k-m	3 ij	2.28p	2.19 t	9.02t	8.71 t	7.80n	8.1 n	2.00s	1.90 n
60	Control	7.05x	7.37 v	1.00q	0.67 m	0.79w	0.79 A	4.07B	4.03 B	2.58s	2.49 u	0.75A	0.67 t
	TRIA 25	8.71r	10.96 q	2.67 l-n	2.67 jk	1.76r	1.91 v	7.63v	7.72 v	6.04o	6.36 p	1.53u	1.50p
	50	7.29v	7.97 u	1.67o-q	2 k	1.02v	1.13 y	4.96z	5.01z	3.38r	3.83 s	1.00y	1.03 r
	ALA 25	8.58t	9.76 s	2.33 m-o	2.67 jk	1.32t	1.31x	5.85x	6.05 x	5.24p	5.1 q	1.22w	1.30q
	50	8.34u	9.48 t	2.00 n-p	2.33jk	1.12u	1.2 y	5.56y	5.67 y	4.30q	4.68 r	1.110x	1.20q
	SA 50	8.65s	10.85 r	2.33 m-o	2.67 jk	1.62s	1.66 w	6.67w	6.53 w	5.79o	5.42 q	1.29v	1.43p
	100	7.18w	7.44 v	1.33 pq	1.33 l	0.87w	0.96 z	4.41A	4.41 A	3.05r	2.89 t	0.90z	0.80s

1st and 2nd; first season and second seasons. Means were compared using Tukey's Honest Significant Difference test ($P \leq 0.05$); n = 3; Means with the same small letter show no significant interaction between different salinity concentrations and between different levels of triacontanol, aminolevulinic acid and salicylic acid

Table (3): The main effect of different salinity concentrations and different levels of triacontanol (TRIA), aminolevulinic acid (ALA) and salicylic acid (SA) on flowering growth parameters of pansy plants during the 2015/2016 and 2016/2017 seasons

NaCl (mM)	Flower diameter(cm)		No. of flowers per plant		No. of days to flowering		Days to flower senescence from full bloom (days)		Flowering duration (days)		Flower fresh weight (g)		Flower dry weight (g)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Salinity														
0	7.31 A	7.25 A	10.43 A	10.14 A	118.76 A	120.33 A	6.46 A	6.39 A	51.43 A	A٥١.١٤	2.54 A	2.42 A	1.26 A	1.3 A
20	5.96 B	5.85 B	6.43 B	7.38 B	104.43 B	104.38 B	5.47 B	5.54 B	31.05 B	B٣٠.٤٨	B ١.٨٧	1.81 B	0.67 B	0.78 B
40	4.75 C	4.28 C	3.76 C	4.33 C	90.86 C	91.143 C	4.53 C	4.66 C	19.62 C	C١٩.١٩	1.23 C	1.18 C	0.38 C	0.49 C
60	3.83 D	3.49 D	1.62 D	2.33 D	81.24 D	79.619 D	3.66 D	3.69 D	9.29 D	9.1 D	1.06 D	1.04 D	0.21 D	0.31 D
TRIA, ALA and SA														
Control	5.05 G	4.78 G	4.67 E	4.92E	91.83 G	91.50 G	4.55 G	4.60 G	22.75 G	22.00G	1.35 G	1.35 G	0.53 G	0.60 G
TRIA 25	5.83 A	5.71 A	6.50 A	6.92 A	104.29 A	105.58 A	5.50 A	5.50 A	32.83 A	32.33 A	2.03 A	1.89 A	0.76 A	0.83 A
50	5.33 E	5.06 E	5.17 D	5.92 C	97.92 E	97.00 E	4.88 E	4.93 E	26.08 E	25.83 E	1.57 E	1.52 E	0.59 E	0.68 E
ALA 25	5.64 C	5.32 C	5.92 BC	6.42 B	100.54 C	101.13 C	5.18 C	5.20 C	29.58 C	29.25 C	1.76 C	1.68 C	0.68 C	0.75 C
50	5.47 D	5.16 D	5.58 C	6.08 C	99.25 D	99.46 D	4.98 D	5.08 D	28.00 D	28.08 D	1.66 D	1.59 D	0.63 D	0.71 D
SA 50	5.74 B	5.56 B	6.25 AB	6.58 B	102.50 B	103.08 B	5.34 B	5.37 B	31.33 B	31.00 B	1.88 B	1.80 B	0.72 B	0.80 B
100	5.18 F	4.94 F	4.83 DE	5.50 D	95.42 F	94.33 F	4.76 F	4.82 F	24.33 F	23.83 F	1.46 F	1.46 F	0.56 F	0.65 F

1st and 2nd; first season and second seasons. Means were compared using Tukey's Honest Significant Difference test ($P \leq 0.05$); n = 3; Means with the same capital letters are no significantly different between different salinity concentrations or between different levels of triacontanol, aminolevulinic acid and salicylic acid

Concerning the main effect of foliar application of different rates of TRIA, ALA and SA on the various flowering parameters, data in Table (3) indicated that foliar spray pansy plants with any of the tested of TRIA, ALA and SA levels, significantly stimulated flower diameter, the number of flowers per plant, the number of days to flowering, days to flower senescence from full bloom, flowering duration, flower fresh and dry weights compared to control treatment during both seasons. Moreover, the treatment with 25 mgL^{-1} TRIA recorded the highest mean values for the previously mentioned flowering parameters followed by SA at 50 mgL^{-1}. At 25 mgL^{-1} TRIA the estimated percentage of increase for flower diameter, the number of flowers per plant, the number of days to flowering, days to flower senescence from full bloom, flowering duration, flower fresh weight and flower dry weight were (47.6 and 51.86%), (84.47 and 77.02%), (31.59 and 33.83%), (43.34 and 42.25%), (81.94 and 82.21%), (58.27 and 57.03%) and (83.33 and 76.15%) for the first and second seasons, respectively.

Our two-year study demonstrated that TRIA treatment has stimulatory effects on flowering plants. Beneficial effects of TRIA at flowering in pansy plants might be attributed to the role of TRIA in enhancing water uptake, cell division, cell elongation, and the permeability of plant cell membranes (Hangarter *et al*., 1978) which led to produces vigorous plants as reflected on improving vegetative growth and followed by active translocation of the photosynthesis products from source to flowering organs which lead to narrowing C/N ratio, then induction of more flowers (Rajamani *et al*., 1990) and increasing flower diameter and flower fresh and dry weight. Also, TRIA application inhibits cellulase and pectinase enzyme activity thereby delaying flower abscission and reducing flower drop, then increasing flower longevity (Hua *et al*., 1985). The increment on flowering duration may be attributed to the increment of flower longevity and flowers number. These results agreed with the findings of Vijayakumar *et al*. (2017) on China aster.

Beneficial effects of SA on flowering can be related to increasing photosynthetic efficiency by stabilization of chlorophyll, higher production and translocation of photosynthetic reserves for enhanced flowering (Hayat *et al*., 2010). Also, application of SA produces vigorous plants as reflected in improving vegetative growth and followed by active translocation of the photosynthetic products from source to flower production. Moreover, foliar application of SA may have interfered with the biosynthesis/action of ethylene, which in turn reduced flower/fruitlet abscission (Nunez-Elisea and Davenport, 1986). The obtained results are in consonance with the findings of Mahroof *et al*. (2017) on *Zinnia elegans*.

Presumably, ALA alleviated the inhibitions of photosynthesis and stimulated chlorophyll synthesis, and by that way impact on the photosynthetic CO_2 absorption (Hotta *et al*., 1997). These might explain our results that the flower size of pansy plants was improved after ALA treatments. Similarly, the high chlorophyll content could result higher assimilating capacity, which led to the earlier flower formation. The obtained results are in harmony with Denisow *et al*. (2016) on Hosta Tratt.

The interaction effects between salinity levels and foliar applications of SA, TRIA and ALA on the flower characteristics of pansy plants are presented in Tables (4). The combined treatment of tap water and TRIA at 25 mgL^{-1} recorded the highest mean values of flower diameter, the number of flowers per plant, the number of days to flowering, days to flower senescence from full bloom, flowering duration, flower fresh weight and flower dry weight of pansy plants in both seasons.

Leaves chemical analysis

Photosynthetic pigments and proline concentrations

Regarding the main effect of different salinity levels on chlorophyll a, chlorophyll b, chlorophyll a+b, and proline content, data in Table (5) indicated that Chl. a, Chl. b and Chl. a+b of pansy plants were significantly decreased with increasing levels of salinity to the highest one in both seasons. But proline content significantly increased with increasing levels of salinity in both seasons. The greatest reduction of Chl. a, Chl. b and Chl. a+b and the greatest increment of proline content were obtained under severe salt stress, in both seasons. The estimated percentages decrease in Chl. a, Chl. b and Chl. a+b were (70.47 and 69.14%), (62.63 and 63.96%) and (68.36 and 67.51%) and the estimated percentage increase of proline content was (294.86% and 299.65) in compared to the control treatment for the first and second seasons, respectively.

Originally, the photosynthetic pigments are considered as one of the most important indicators for salinity stress effect (Mimouni *et al*., 2016). Many researches explained the reasons beyond the reduction of photosynthesis because of salinity stress, which could be mainly due to the reduction of photosynthetic enzyme activity (Brugnoli and Lauteri, 1991) and depletion of stomatal conductance that leads to CO_2 deficiency (Gama *et al*., 2007). The obtained results are in harmony with those were reported by Karimi and Zadeh (2013) on *Vitis vinifera*. An increase in proline content was reported with increasing salinity as one of the defense mechanisms in which stressed plants used to reduce cell osmotic potential, which led to increasing cell water uptake with concomitant increases in both cell turgidity and its activity (Khalil and El-Noemani, 2012). The obtained results are in harmony with those were reported by Heidari and Akbari (2012) on two marigold genotypes.

Concerning the main effect of different rates of TRIA, ALA and SA on the photosynthesis pigments and proline content, data in Table (5) reported that foliar spray pansy plants with any of the tested of TRIA, ALA and SA levels, significantly stimulated the given photosynthesis pigments parameters i.e. Chl. a, Chl. b and Chl. a+b and proline content compared to the control treatment, in both seasons. Furthermore, the treatment with 25 mgL^{-1} TRIA recorded the highest mean values of Chl. a for both seasons and the highest mean values of Chl. b and Chl. a+b for the second season, but the treatment with SA at 50 mgL^{-1} recorded the highest mean values of Chl. b and Chl. a+b for the first season.

Table (4): The interaction effect between different salinity concentrations and different levels of triacontanol (TRIA), aminolevulinic acid (ALA) and salicylic acid (SA) on flowering growth parameters of pansy plants during the 2015/2016 and 2016/2017 seasons

NaCl (mM)	Trts	Flower diameter(cm)		No. of flowers per plant		No. of days to flowering		Days to flower senescence from full bloom (days)		Flowering duration (days)		Flower fresh weight (g)		Flower dry weight (g)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	Control	6.93g	6.80 f	9.00e	8.33 d	110.33g	111.00 g	5.93f	5.97 e	46.00g	45.67 f	2.26f	2.22 f	1.13g	1.19 g
	TRIA 25	7.77a	7.90 a	11.67a	11.00 a	126.83a	131.83 a	7.23a	6.90 a	55.33a	55.00 a	2.90a	2.70 a	1.43a	1.44 a
	50	7.14e	6.97 e	10.00cd	10.00 bc	117.00e	117.00 e	6.30d	6.20 d	50.00e	49.67 d	2.41e	2.27 e	1.20e	1.22 e
	ALA 25	7.45c	7.40 c	11.00ab	10.67 a	120.83c	123.00 c	6.57c	6.43 c	53.67c	53.33 b	2.61c	2.50 c	1.29c	1.34 c
	50	7.28d	7.10 d	10.67bc	10.33 ab	118.67d	119.83 d	6.33d	6.37 c	51.67d	52.00 c	2.53d	2.37d	1.23d	1.27 d
	SA 50	7.57b	7.70 b	11.33ab	11.00 a	124.33b	126.33 b	6.83b	6.73 b	54.67b	54.33 a	2.69b	2.63 b	1.36b	1.41 b
	100	7.04f	6.87 ef	9.33de	9.67 c	113.33f	113.33 f	6.03e	6.13 d	48.67f	48.00 e	2.37e	2.250 ef	1.18f	1.21 f
20	Control	5.41n	5.07 l	5.67h	6.67 g	97.33m	97.667 n	5.03k	5.17 k	26.00m	25.00 m	1.45m	1.43 k	0.52n	0.6 m
	TRIA 25	6.37h	6.50 g	7.33f	8.00 de	109.33h	109.33 h	5.80g	5.90 ef	37.33h	36.67 g	2.24f	2.06 g	0.87h	0.91 h
	50	5.82l	5.68 j	6.00gh	7.33 e-g	104.00k	103.33 l	5.30j	5.37 i	28.33l	27.67 k	1.76j	1.76 i	0.59l	0.76 k
	ALA 25	6.20j	5.97 h	6.67fg	7.67 d-f	106.33i	106.33 j	5.63h	5.70 g	32.33j	32.00 i	2.03h	1.85 h	0.74j	0.80 i
	50	6.03k	5.83 i	6.33gh	7.33 e-g	105.33j	105.00 k	5.40i	5.57 h	31.00k	30.33 j	1.89i	1.82 h	0.68k	0.78 j
	SA 50	6.28i	6.43 g	7.33f	7.67 d-f	107.00i	108.00 i	5.80g	5.83 f	36.00i	35.67 h	2.12g	2.04 g	0.79i	0.9 h
	100	5.60m	5.47 k	5.67h	7.00 fg	101.67l	101.00m	5.30j	5.27 j	26.33m	26.00 l	1.57l	1.69 j	0.53m	0.72 l
40	Control	4.40u	4.02 r	3.00lm	3.67 jk	87.00t	85.00 t	4.20q	4.27 r	15.67t	14.33 s	0.94s	0.95 p	0.31st	0.43 r
	TRIA 25	5.10 o	4.68 m	4.67i	5.67 h	95.67n	96.50 o	4.83l	5.07 l	25.00n	24.33 m	1.65k	1.47 k	0.46o	0.58 n
	50	4.60s	4.15 pq	3.33kl	4.00 ij	89.33r	88.33 r	4.43o	4.50 p	17.67r	17.67 q	1.11q	1.11 n	0.35r	0.45 r
	ALA 25	4.93q	4.33 o	4.00 i-k	4.67 i	91.33p	93.50 q	4.67m	4.80 n	20.67p	20.67 o	1.26o	1.22 m	0.43p	0.50 p
	50	4.70r	4.24 op	3.67j-l	4.00 ij	90.33q	92.67 q	4.53n	4.67 o	19.00q	19.33 p	1.19p	1.15 n	0.37q	0.47 q
	SA 50	5.03p	4.450 n	4.33ij	4.67 i	94.33o	95.00 p	4.70m	4.93 m	22.67o	22.00 n	1.46m	1.33 l	0.44p	0.53 o
	100	4.47t	4.1 qr	3.33kl	3.67 jk	88.00s	87.00 s	4.33p	4.40 q	16.67s	16.00 r	0.99r	0.99 o	0.32s	0.44 r
60	Control	3.43A	3.22 x	1.00p	1.00 n	72.67z	72.33 y	3.03w	3.00 y	3.33z	3.00 y	0.75t	0.79 r	0.17y	0.19 x
	TRIA 25	4.10v	3.77 s	2.33mn	3.00 kl	85.33u	84.67 t	4.13q	4.13 s	13.67u	13.33 t	1.33n	1.33 l	0.30t	0.38 s
	50	3.77y	3.43 vw	1.33 op	2.33 l	81.33x	79.33 w	3.50u	3.66 w	8.33x	8.33 w	0.99r	0.94 p	0.23w	0.30 v
	ALA 25	3.96w	3.57 tu	2.00 no	2.67 l	83.67v	81.67 v	3.87s	3.87 u	11.67v	11.00 v	1.14pq	1.13 n	0.25v	0.35 t
	50	3.87x	3.47 uv	1.67 n-p	2.67 l	82.67w	80.33 w	3.67t	3.73 v	10.33w	10.67 v	1.03r	1.02 o	0.23w	0.33 u
	SA 50	4.07v	3.67 st	2.00 no	3.00 kl	84.33v	83.00 u	4.03r	3.97 t	12.00v	12.00 u	1.26o	1.22 m	0.28u	0.36 t
	100	3.60z	3.33 w	1.00p	1.67 m	78.67y	76.00 x	3.37v	3.48 x	5.67y	5.33 x	0.91s	0.89 q	0.21x	0.25 w

1st and 2nd; first season and second seasons. Means were compared using Tukey's Honest Significant Difference test ($P \leq 0.05$); n = 3; Means with the same small letter show no significant interaction between different salinity concentrations and between different levels of "triacontanol, aminolevulinic acid and salicylic acid"

Table (5): The main effect of different salinity concentrations and different levels of triacontanol (TRIA), aminolevulinic acid (ALA) and salicylic acid (SA) on photosynthetic pigments and proline content of pansy plants during the 2015/2016 and 2016/2017 seasons

NaCl (mM)	Chl. a (mg/g)		Chl. b (mg/g)		Chl. a+b		Proline (mg/g)	
	1st	2nd	1st	2st	1nd	2nd	1st	2nd
Salinity								
0	2.54 A	2.43 A	0.99 A	1.11 A	3.54 A	3.54 A	2.92 D	2.82 D
20	1.88 B	1.83 B	0.74 B	0.89 B	2.62 B	2.72 B	5.35 C	5.10 C
40	1.20 C	1.21 C	0.42 C	0.64 C	1.62 C	1.85 C	6.93 B	7.47 B
60	0.75 C	0.75 D	0.37 D	0.40 D	1.12 D	1.15 D	11.53 A	11.27 A
TRIA, ALA and SA								
Control	1.30 G	1.28 G	0.54 BC	0.69 B	1.84 D	1.98 E	5.60 G	5.66 G
TRIA 25	1.89 A	1.88 A	0.65 BC	0.86 A	2.54 AB	2.73 A	6.27 E	5.93 F
50	1.48 E	1.45 E	0.74 AB	0.71 B	2.22 C	2.16 D	7.50 B	7.38 B
ALA 25	1.71 C	1.61 C	0.63 BC	0.78 AB	2.34 BC	2.39 C	5.90 F	6.26 E
50	1.58 D	1.55 D	0.56 BC	0.78 AB	2.14 C	2.33 C	7.21 C	7.02 C
SA 50	1.8 B	1.75 B	0.87 A	0.77 AB	2.67 A	2.52 B	6.63 D	6.66 D
100	1.39 F	1.35 F	0.45 C	0.74 B	1.84 D	2.09 D	7.65 A	7.74 A

1st and 2nd; first season and second seasons. Means were compared using Tukey's Honest Significant Difference test ($P \leq 0.05$); n = 3; Means with the same capital letters are no significantly different between different salinity concentrations or between different levels of salicylic acid, triacontanol and aminolevulinic acid

On the other hand, foliar application of SA at 100 mg L^{-1} followed by TRIA at 50 mg L^{-1} recorded the highest mean values of proline in both seasons. The estimated percentage of increases for Chl. a, Chl. b and Chl. a+b and proline content were (45.39 and 46.88%), 61.11 and 24.64%), (45.11 and 37.88%) and (36.61 and 36.75%) for the first and second season, respectively.

Generally, the superior influence of TRIA treatments on stimulating plant photosynthesis pigments may be due to the role of TRIA application in increasing water and mineral nutrients uptake (Krishnan and Kumari, 2008; Perveen *et al*., 2011, 2012), increasing stomatal conductance which affects the photosynthetic rate by regulating CO_2 fixation in the leaf mesophyll tissue and is positively correlated with photosynthesis (Ivanov and Angelov, 1997; Muthuchelian *et al*., 2003).

Also, TRIA affected photosynthesis by increasing the level and activity of ribulose-1, 5-bisphosphate carboxylase oxygenase (RuBisCO) and by improving the status of the photosystems (Eriksen *et al*., 1981). The obtained results are in harmony with Borowski and Blamowski (2009) on *Ocimum basilicum*.

The superior effect of SA treatments in enhancing net photosynthetic rate may be due to the enhancement of the enzymatic status of treated plants or increment of cell membrane stability especially chloroplast membrane that affecting the ionic balance and photosynthetic pigments formation (Khan *et al*., 2010). Moreover, foliar application of SA may participate in the regulation of many physiological processes in plants, like stomatal closure induced by drought stress, ion uptake and transport (Gunes *et al*., 2005). The obtained results are in good accordance with those postulated by Yildirim *et al*. (2008) on cucumber.

Aminolevulinic acid, possibly improves net photosynthetic rate of pansy plants under NaCl stress, and this role is likely related to enhanced stomatal conductance and increased intercellular CO_2 concentration (Jia *et al*., 2016). Also, expression of many plastidic genes seems to be induced by both light and cytokinins (Cohen *et al*., 1988), and the cytokinin activity has also been specifically related to the synthesis of δ-aminolevulinic acid (ALA) (Fletcher *et al*., 1973; Dei, 1985). The obtained results are in harmony with Naeem *et al.* (2010) on *Brassica napus* L.

Proline plays a vital role in a wide range of protective responses, including osmotic adjustment, stabilizer for cellular structure and decreasing damage to photosynthetic apparatus (Nounjan *et al*., 2012). The foliar-applied TRIA markedly enhanced the osmolytes

such as the free proline in pansy plants under saline and non-saline regime conditions (Perveen *et al*., 2012). The accumulation of free proline was enhanced under TRIA treatments such as in soybean (Krishnan and Kumari, 2008). The exogenous application of SA provided protection against salinity in plants, probably due to the accumulation of osmolytes, such as sugar, sugar alcohol or proline (Szepesi *et al*., 2005). The obtained results of SA on proline content are in good accordance with those were postulated by Alyemeni *et al*. (2014) on leguminous plant. Also, foliar application of ALA may increase cellular fluid concentration under salt stress, reduce cellular water potential, and enhance water absorption in cells by increasing proline content (Nunkaew *et al*., 2014). Current results of ALA are in good accordance with those were postulated by Ahmad Anjum *et al*. (2016) on *Leymus chinensis*.

The interaction effects between salinity levels and foliar applications with TRIA, ALA and SA on the photosynthesis pigments and proline content of pansy plants is presented in Table (6). The combined treatment of tap water and TRIA at 25 mgL^{-1} recorded the highest mean values of Chl. a and Chl. a+b in both seasons and Chl. b in the second season. Also, the combined treatment of 20 Mm NaCl and SA at 50 mgL^{-1} recorded the highest mean values of Chl. b in the first season. But, the lowest mean values of Chl. a, Chl. b and Chl. a+b were observed at 60 mM NaCl and control treatment for Chl. a and Chl. a+b in both seasons and Chl. b in the second season, and at 40 mM NaCl and 25 mgL^{-1} TRIA treatment for Chl. b in the first season. On the other hand, the combined treatment of 60 mM NaCl and SA at 100 mgL^{-1} recorded the highest mean values of proline content in both seasons, but the lowest mean values recorded for control treatment.

Table (6): The interaction effect between different salinity concentrations and different levels of triacontanol (TRIA), aminolevulinic acid (ALA) and salicylic acid (SA) on photosynthetic pigments and proline content of pansy plants during the 2015/2016 and 2016/2017 seasons

NaCl (mM)	Trts	Chl. a (mg/g)		Chl. b (mg/g)		Chl. a+b		Proline (mg/g)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	Control	2.24f	2.18 ef	0.97 a-d	1.07 a-d	3.21 cd	3.24 c	2.29 u	2.26 u
	TRIA 25	3.03a	3.05 a	1.26 ab	1.23 a	4.28 a	4.28 a	2.79 s	2.54 t
	50	2.3e	2.24 de	1.06 a-d	1.03 a-d	3.36 cd	3.28 c	3.25 q	3.12 pq
	ALA 25	2.69c	2.33 c	0.7 c-i	1.06 a-d	3.39 c	3.39 c	2.54 t	2.69 st
	50	2.38d	2.29 cd	1.10 a-c	1.144 a-c	3.49 bc	3.43 c	3.22 qr	3.01 qr
	SA 50	2.88b	2.69 b	0.99 a-d	1.17ab	3.88 ab	3.86 b	2.97 rs	2.86 rs
	100	2.26ef	2.20 ef	0.90 b-f	1.08 a-d	3.16 cd	3.28 c	3.36 q	3.25 p
20	Control	1.49m	1.44 k	0.48 e-j	0.73 f-h	1.96 g-i	2.17 f	5.02 p	4.43 o
	TRIA 25	2.18g	2.15 f	0.73 c-h	1.06 a-d	2.93 de	3.22 c	5.29 no	4.55 o
	50	1.83k	1.71 i	0.87 b-g	0.934 c-f	2.7 ef	2.65 e	5.53 mn	5.44 m
	ALA 25	2.00i	1.96 g	0.92 b-e	0.89 d-f	2.93 de	2.85 d	5.13 op	5.09 n
	50	1.92j	1.88 h	0.41g-j	1.01 b-e	2.33 fg	2.9 d	5.47 mn	5.39 m
	SA 50	2.09h	2.12 f	1.40a	0.78 fg	3.49 bc	2.9 d	5.38 m-o	5.31 m
	100	1.62l	1.54 j	0.39 g-j	0.83 e-g	2.02 gh	2.36 f	5.62 m	5.52 m
40	Control	0.98s	1.02 o	0.45 e-j	0.72 f-h	1.43 j-m	1.75 gh	5.95 l	6.55 l
	TRIA 25	1.43m	1.38 kl	0.20 j	0.81 e-g	1.64 h-l	2.19 f	6.36 k	6.64 kl
	50	1.14q	1.18 n	0.61 d-j	0.47 i-k	1.75 h-k	1.65 h	7.98 h	8.37 h
	ALA 25	1.27o	1.27 m	0.63 d-j	0.63 g-i	1.9 g-j	1.9 g	6.13 kl	6.83 k
	50	1.21p	1.23 mn	0.29 h-j	0.5 i-k	1.5 i-m	1.72 gh	7.42 I	7.93 i
	SA 50	1.33n	1.30 lm	0.46 e-j	0.63 g-i	1.8 h-k	1.93 g	6.66 j	7.48 j
	100	1.06r	1.08 o	0.29 h-j	0.74 f-h	1.35 k-m	1.82 gh	8.02 h	8.48 h
60	Control	0.51y	0.48 s	0.25 h-j	0.26 l	0.76 o	0.74 l	9.16 g	9.38 g
	TRIA 25	0.93st	0.94 p	0.39 g-j	0.31 kl	1.32 k-m	1.25 ij	10.62 e	10.00 f
	50	0.67w	0.67 r	0.41 g-j	0.41 j-l	1.08 m-o	1.08 jk	13.24 b	12.6 b
	ALA 25	0.85uv	0.87 pq	0.27 h-j	0.56 h-j	1.12 m-o	1.43 i	9.79 f	10.42 e
	50	0.82v	0.81 q	0.44 f-j	0.46 i-l	1.24 l-n	1.27 ij	12.72 c	11.76 c
	SA 50	0.9tu	0.90 p	0.62 d-j	0.51 i-k	1.52 i-m	1.41 i	11.53 d	11.00 d
	100	0.59x	0.59 r	0.22 ij	0.30 kl	0.81 no	0.9 kl	13.61 a	13.70a

1st and 2nd; first season and second seasons. Means were compared using Tukey's Honest Significant Difference test ($P \leq 0.05$); n = 3; Means with the same small letter show no significant interaction between different salinity concentrations and between different levels of salicylic acid, triacontanol and aminolevulinic acid.

Leaves mineral percentages

Regarding the main effect of salt stress on leaves mineral %, data in Table (7) showed that leaves mineral composition of pansy plants treated with salinity levels displayed different attitudes. Firstly, for leaf N, P, K, Ca^{2+}, Mg and K/Na ratio, the treated plans with salinity gave negative significant effects on their concentrations, especially under 60 mML^{-1} with mean reduction percentages (36.22 and 37.22%), (48.83 and 50%), (36.74 and 35.86%), (31.01 and 35.19%), (56.37 and 56.74%), and (96.2 and 96.6%) compared to the control treatment for the first and second seasons, respectively. On the contrary, the results detected that each of Na^+ and Cl^- leaves % showed increasing manner coupling with increasing in salinity level with increment percentages of 1525 and 1620.51% and 740 and 740 % compared to the control treatment for the first and second seasons, respectively.

Generally, the superior influence of salt stress on leaves mineral % may be due to the deleterious roles of Na^+ and Cl^- on the ionic balance of nutrients that could be due to the competition of Na^+ and Cl^- with nutrients like K^+, Ca^{2+}, and NO^{3-} (Iqbal and Ashraf, 2013), which negatively affected many of physiological processes in plants suffering from salt stress. Many researchers stated an antagonistic relationship between Na^+ and Cl^- and N, P and K^+ (Abdelhamid *et al*., 2009) on *vicia faba*. In salinity studies, it was clear that there is a negative correlation between Na^+ and K^+ due to their uptake competition (Tester and Davenport, 2003) through Na^+ and K^+ co- transporters and may also block the K^+ specific transporters of root cells under salinity conditions. The high concentrations of Na^+ or low values of K/Na ratio can disrupt various enzymatic processes in the cytoplasm (Tester and Davenport, 2003). The present results are in parallel with those were reported by Kumar *et al*. (2017) on *Nerium oleander* L.

Concerning the main effect of different rates of TRIA, ALA and SA on the leaves mineral %, data in Table (7) indicated that foliar applications of TRIA, ALA and SA significantly increased the K^+, Ca^{2+} % and K/Na ratio progressively which enhances the nutritional status of pansy and in the same time reducing the negative impacts of both Na^+ and Cl^- compared to control (spraying with tap water) in both seasons. The foliar application of 25 mg L^{-1} TRIA was more effective in increasing the % of nitrogen by (8.52 and 8.53%), phosphorus by (22.8 and 23.96%), potassium by (12.75 and 12.46%), calcium by (10.97 and 8.17%), magnesium by (22.95 and 22.8%) and K/Na ratio by (94.27 and 157.5%) compared to the control treatment for the first and second seasons, respectively. In addition, the highest level reductions of sodium in pansy tissues were observed with 25 mgL^{-1} TRIA treatments; reduced the contents of sodium by (28.69 and 29.37%) in the first and second seasons, respectively, relative to control plants. However, the foliar application of 25 mgL^{-1} TRIA and 25 mgL^{-1} ALA treatments achieved the highest reduction of chlorine %, by (39.39, 42.42 and 50, 50%) compared to the control treatment and for the first and second seasons, respectively.

Exogenous application of TRIA promotes the influx of Ca^{2+} into the cytoplasm (Ries *et al*., 1993), which could bind to receptor proteins such as calmodulin (Evans *et al*., 1991), while the increment of K^+ uptake could be due to increase the competition in the plasma membrane sites (Epstein, 1966) that regulate growth processes in the face of certain external stimuli (Ries *et al*., 1993).

Also, the possible mechanism of TRIA-induced alteration is a TRIA-mediated increase in membrane bound enzyme activities, such as, Ca^{2+}/Mg^{2+} ATPase (Lesniak *et al*., 1986); fluidity of membranes to several solutes by the generation of an electrochemical gradient across plasma membranes; and increased the uptake of essential nutrients such as Ca^{2+}, Mg^{2+}, and K^+ (Ries *et al*., 1993). Moreover, foliar application of TRIA also reduced the accumulation of Na^+ and Cl^- under saline conditions. The aforementioned results are in accordance with those were postulated by Krishnan and Kumari (2008) on soybean.

It has already been observed that foliar application of ALA significantly increased nitrogen, phosphorus, potassium and calcium concentrations in different plants under stress conditions (Xu *et al.*, 2010). This was evidence for the role of ALA in reclaiming the cell membrane integrity and reducing root permeability (Essa, 2002). The definite effects of ALA on improving mineral nutrients absorption and increasing plant growth may be a result of enhancement of plant photosynthetic capacity (Hotta *et al*., 1997). Our results are in agreement with Naeem *et al*. (2010) on *Brassica napus* L.

Exogenous application of SA has the ability to counterbalance the ionic content in pansy leaves, and this may be attributed to the role of SA in enhancing the plasma membrane integrity (Mimouni *et al*., 2016). The present results are in parallel with those were reported by Roshdy and Brengi (2016) on bean.

The interaction effects between salinity levels and foliar applications of TRIA, ALA and SA on the leaves chemical composition of pansy plants is presented in Table (8). The combined treatment of tap water and TRIA at 25 mgL^{-1} recorded the highest mean values of nitrogen, phosphorus, potassium, calcium and magnesium in both seasons. Also, the combined treatment of tap water and the rest of treatments recorded the highest mean values of nitrogen in the first season. On the other hand, the lowest mean values of sodium % were observed at the combination of tab water and TRIA at 25 mgL^{-1} or ALA at 25 mgL^{-1} in the first season and at the combination of tab water and all treatments in the second season. Also, the lowest mean values of chlorine were recorded at 25 and 50 mgL^{-1} TRIA, 25 mgL^{-1} ALA and 50 mgL^{-1} SA in the first season and at 25 mgL^{-1} ALA in the second season.

Table (7): The main effect of different salinity concentrations and different levels of triacontanol (TRIA), aminolevulinic acid (ALA) and salicylic acid (SA) on leaves minerals content of pansy plants during the 2015/2016 and 2016/2017 seasons

NaCl (mM)	N%		P%		K%		Ca%		Mg%		Na%		Cl%		K/Na ratio	
	1st	2nd	1st	1st	2nd	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Salinity																
0	3.744 A	3.829 A	0.471 A	0.470 A	2.812 A	2.872 A	1.709 A	1.722 A	0.761 A	0.742 A	0.080 D	0.078 D	0.005 D	0.005 D	36.35 A	40.87 A
20	3.348 B	3.413 B	0.422 B	0.386 B	2.548 B	2.610 B	1.519 B	1.559 B	0.578 B	0.577 B	0.341C	0.336 C	0.021C	0.016 C	8.08 B	8.43 B
40	3.067 C	2.965 C	0.330 C	0.309 C	2.170 C	2.232 C	1.341 C	1.347 C	0.432 C	0.432 C	0.984 B	1.022 B	0.029 B	0.023 B	2.23 C	2.21 C
60	2.388 D	2.404 D	0.241 D	0.235 D	1.779 D	1.842 D	1.179 D	1.116 D	0.332 D	0.321 D	1.300 A	1.342 A	0.042 A	0.042 A	1.38 D	1.39 D
TRIA, ALA and SA																
Control	2.993 C	3.025 G	0.329 G	0.313 G	2.189 G	2.248 G	1.358 G	1.384 G	0.475 G	0.465 G	0.833 A	0.858 A	0.033 A	0.034 A	8.37 E	6.73 F
TRIA 25	3.248 A	3.283 A	0.404 A	0.388 A	2.468 A	2.528 A	1.507 A	1.497 A	0.584 A	0.571A	0.594 F	0.606 G	0.020 E	0.017 E	16.26 A	17.33 A
50	3.163 AB	3.233 B	0.389 B	0.371 B	2.408 B	2.471 B	1.493 B	1.474 B	0.564 B	0.554 B	0.654 D	0.680 D	0.022 D	0.019CD	11.20 D	12.13 D
ALA 25	3.174 AB	3.198 C	0.373 C	0.360 C	2.371 C	2.429 C	1.467 C	1.449 C	0.539 C	0.539 C	0.613 E	0.630 F	0.019 E	0.017 E	12.46 C	15.3 B
50	3.210 AB	3.156 D	0.366 D	0.349 D	2.328 D	2.350 E	1.410 E	1.432 D	0.522 D	0.516 D	0.671 C	0.699 C	0.025 C	0.021C	11.48 CD	13.56 C
SA 50	3.130 B	3.108 E	0.358 E	0.341 E	2.289 E	2.392 D	1.440 D	1.415 E	0.505 E	0.498 E	0.643 D	0.659 E	0.021 D	0.018DE	13.77 B	16.78 A
100	3.038 C	3.067 F	0.345 F	0.329 F	2.238 F	2.307 F	1.384 F	1.400 F	0.491 F	0.483 F	0.725 B	0.729 B	0.029 B	0.025 B	10.54 D	10.74 E

1st and 2nd; first season and second seasons. Means were compared using Tukey's Honest Significant Difference test ($P \leq 0.05$); n = 3; Means with the same capital letters are no significantly different between different salinity concentrations or between different levels of triacontanol, aminolevulinic acid and salicylic acid

Table (8): The interaction effect between different salinity concentrations and different levels of triacontanol (TRIA), aminolevulinic acid (ALA) and salicylic acid (SA) on leaves minerals content of pansy plants during the 2015/2016 and 2016/2017 seasons

NaCl (mM)	Trts	N%		P%		K%		Ca%		Mg%		Na%		Cl%		K/Na	
		1st	2nd	1st	2nd	1st	2nd	1st	1st	2nd	2nd	1st	2nd	1st	2nd	1st	2nd
0	Control	3.68a	3.76 g	0.45 ef	0.44 e	2.717g	2.79 g	1.66 f	1.69 d	0.71 f	0.68 g	0.10 o	0.14 n	0.0146 p	0.0134 j	26.58 e	19.91 g
	TRIA 25	3.82a	3.91 a	0.51 a	0.52 a	2.907a	2.96 a	1.75 a	1.76 a	0.79 a	0.79 a	0.06 p	0.05 o	0.0006 s	0.0012 kl	50.693a	54.64 a
	50	3.72a	3.88 b	0.49 b	0.49 b	2.87b	2.93 b	1.73 ab	1.75 a	0.78 ab	0.78 b	0.08op	0.07 o	0.0014 s	0.0046 kl	33.01 d	36.48 e
	ALA 25	3.77a	3.86 c	0.47 c	0.48 c	2.83c	2. 9 c	1.73 bc	1.73 b	0.78 b	0.77 c	0.07p	0.06 o	0.0006 s	0.0007 l	36.99 c	48.09 c
	50	3.79a	3.82d	0.46 cd	0.46 d	2.82d	2.84 e	1.70 d	1.73 b	0.77 c	0.75d	0.09 op	0.08 o	0.0051 r	0.0049 kl	33.67 d	41.75 d
	SA 50	3.74a	3.8 e	0.46d	0.45 de	2.79e	2.88 d	1.72 c	1.71c	0.76 d	0.722 e	0.08 op	0.06 o	0.0011 s	0.0036 kl	41.55 b	53.31 b
	100	3.70a	3.78 f	0.46 de	0.44 e	2.76 f	2.81 f	1.68 e	1. 7 d	0.73e	0.70 f	0.09 op	0.09 o	0.0099 q	0.0057 k	31.99 d	31.91 f
25	Control	3.24c-f	3.31 m	0.40 k	0.35 l	2.43 n	2.49 n	1.41 m	1.50 j	0.50 l	0.511 m	0.60 k	0.61 k	0.0247 kl	0.0170 g-j	4.05 h	4.12 k
	TRIA 25	3.46b	3.53 h	0.44 fg	0.43 f	2.66 h	2.72 h	1.62 g	1.63 e	0.69 g	0.65 h	0.27 n	0.27 m	0.0188 o	0.0147 ij	9.98 f	10.28 h
	50	3.31b-d	3.5 i	0.44 g	0.41 g	2.62 i	2.68 i	1.60 h	1.6 f	0.65 h	0.61 i	0.29 mn	0.29 lm	0.0213 mn	0.0153 h-j	8.33fg	8.67 ij
	ALA 25	3.39bc	3.46 j	0.43 h	0.4 h	2.59 j	2.65 j	1.57 i	1.57 g	0.58 i	0.60 i	0.28 mn	0.27m	0.0182 o	0.0142 j	9.07 fg	9.34 hi
	50	3.43bc	3.42 k	0.42 hi	0.38 i	2.54 k	2.58 l	1.47 k	1.56 g	0.56 j	0.58 j	0.302 m	0.3 lm	0.0229 lm	0.0161 h-j	8.64 fg	8.97 ij
	SA 50	3.340bc	3.36 l	0.41 ij	0.37 j	2.52 l	2.61 k	1.53 j	1.54 h	0.54 k	0.56 k	0.29 mn	0.28 m	0.0195 no	0.0150 ij	9.43 f	9.81 hi
	100	3.27b-e	3.32 m	0.41 j	0.36 k	2.48 m	2.54 m	1.45 l	1.52 i	0.53 k	0.54 l	0.36 l	0.33 l	0.0240 l	0.0162 h-j	7.02 g	7.82 j
50	Control	2.90 h	2.85 t	0.28 q	0.28 q	2.02 u	2.08 u	1.29 r	1.31 p	0.39 q	0.37 t	1.12 g	1.14 f	0.0310 f-h	0.0312 d	1.8 hi	1.82 lm
	TRIA 25	3.11d-g	3.08 n	0.39 l	0.33 m	2.35 o	2.42 o	1.39 n	1.40 k	0.47 m	0.49 n	0.87 j	0.88 j	0.0275 ij	0.0198 f-h	2.71 hi	2.76 l
	50	3.32bc	3.04 o	0.36 m	0.33 m	2.25 p	2.33 p	1.38 o	1.38 l	0.47 m	0.48 o	0.98 i	1.05 g	0.0292 g-j	0.0221 ef	2.14 hi	2.04 lm
	ALA 25	3.06f-h	3.01 p	0.34 n	0.32 n	2.22 q	2.27 q	1.36 p	1.37 m	0.45 n	0.45 p	0.88 j	0.95 i	0.0268 jk	0.0193f-i	2.29 hi	2.29 lm
	50	3.09e-h	2.97 q	0.33 n	0.31 o	2.16 r	2.17 s	1.32 q	1.33 n	0.43 o	0.42 q	0.99 i	1.07 g	0.0293 g-j	0.0229 ef	2.20 hi	2.11 lm
	SA 50	3.03 gh	2.93 r	0.32 o	0.30 o	2.12 s	2.22 r	1.35 p	1.32 op	0.42 o	0.41 r	0.97 i	0.99 h	0.0289 h-j	0.0213 fg	2.55 hi	2.44 lm
	100	2.96 gh	2.88 s	0.3 p	0.29 p	2.07 t	2.13 t	1.30 r	1.32 o	0.40 p	0.4 s	1.07 h	1.07 g	0.0297f-i	0.0262 e	1.93 hi	1.99 lm
75	Control	2.16 k	2.17A	0.18 v	0.18 v	1.6 B	1.63 B	1.07 x	1.04 w	0.3 u	0.29 x	1.50 a	1.54 a	0.063 a	0.073 a	1.06 i	1.06 m
	TRIA 25	2.61 i	2.61 u	0.28 q	0.27 r	1.95 v	2.00 v	1.27 s	1.20 q	0.38 q	0.38 u	1.18 f	1.23 e	0.032 ef	0.032 d	1.65 hi	1.63 lm
	50	2.30 jk	2.52 v	0.26 r	0.26 s	1.89 w	1.95 w	1.27 s	1.17 r	0.36 r	0.35 u	1.26 d	1.31 d	0.036 d	0.035 d	1.33 i	1.33 m
	ALA 25	2.48 ij	2.47 w	0.26 s	0.25 st	1.84 x	1.89 x	1.21 t	1.13 s	0.35 s	0.34 v	1.22 e	1.24e	0.032 e-g	0.032 d	1.48 i	1.46 lm
	50	2.54 i	2.42 x	0.25 st	0.24 t	1.79 y	1.81z	1.15 v	1.11 t	0.33 t	0.31 w	1.30c	1.36 c	0.041c	0.040 c	1.43 i	1.42 lm
	SA 50	2.41 ij	2.35 y	0.24 t	0.24 t	1.73 z	1.86 y	1.17 u	1.09 u	0.31 u	0.30 w	1.25 de	1.3 d	0.034 de	0.033 d	1.55 i	1.57 lm
	100	2.22 k	2.29 z	0.22 u	0.22 u	1.65 A	1.75A	1.11 w	1.07 v	0.31 u	0.3 x	1.38 b	1.43 b	0.0534 b	0.050 b	1.19 i	1.23 m

1st and 2nd; first season and second seasons. Means were compared using Tukey's Honest Significant Difference test ($P \leq 0.05$); n = 3; Means with the same small letter show no significant interaction between different salinity concentrations and between different levels of triacontanol, aminolevulinic acid and salicylic acid.

CONCLUSION

It could be concluded that salt stress significantly affected pansy plant growth, flowering characterizations and its chemical composition. Furthermore, foliar applications of TRIA, ALA and SA enhanced the salt stress response of pansy plants. Application of TRIA at 25 mgL^{-1} provided the highest plant growth, flowering characterizations and chemical composition followed by SA at 50 mgL^{-1} for stressed and non-stressed pansy plants. Therefore, it might be preferable to use TRIA for pansy production under saline and non-saline conditions.

REFERENCES

Abdelhamid, M. T., M. B. Shokr and M. A. Bekheta (2009). Effects of induced salinity on four *vicia faba* cultivars differing in their broomrape tolerance. In sustainable management of saline waters and salt-affected soils for agriculture: Proceedings of the Second Bridging Workshop Aleppo, Syria 15-18 Nov 2009, p. 58, ICARDA.

Abdul Qados, A. M. A (2011). Effect of salt stress on plant growth and metabolism of bean plant (*Vicia faba* L.). J. Saudi Soc. Agric. Sci., 10(1): 7-15.

Aftab, T., M. M. A. Khan, M. Idrees, M. Naeem, M. Singh and M. Ram (2010). Stimulation of crop productivity, photosynthesis and artemisinin production in *Artemisia annua* L. by triacontanol and gibberellic acid application. J. Plant Interact, 5(4): 273–281.

Ahmad Anjum, S., J. H. Li; J. Lv; X. F. Zong, L. Wang; A. J. Yang, R. Yan, Z. Ali, J. X. Song and S. G. Wang (2016). Regulation mechanism of exogenous ALA on growth and physiology of *Leymus chinensis* (Trin.) under salt stress. Chilean J. Agric Res, 76(3): 314-320.

Aldesuquy. H. S and A. H. Ibrahim (2001). Water relations, abscisic acid and yield of wheat plants in relation to the interactive effect of seawater and growth bioregulators. J. Agron and Crop Sci., 187: 97-104.

Alyemeni, M. N., Q. Hayat, L. Wijaya and S. Hayat (2014). Effect of salicylic acid on the growth, photosynthetic efficiency and enzyme activities of leguminous plant under cadmium stress. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 42(2): 440-445.

Arbona. V., A. J. Marco, D. J. Ijlesias, M. F. Lopez-Climent, M. Talon and A. Gómez-Coudenas (2005). Carbohydrate depletion in roots and leavers of salt stressed potted *Citrus clemtina* L. Plant Growth Regul., 46(2): 153-160.

Arnon, D. I. (1949). Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris. Plant physiology, 24(1): 1-15.

Azevedo-Neto, D., J. Prisco, J. Eneas, C. De Abreu and E. Gomes (2006). Effect of salt stress on antioxidative enzymes and lipid peroxidation in leaves and roots of salt-tolerant and salt sensitive maize varieties. Environ. Exp. Bot., 56(1): 87-94.

Aziz, R., Shahbaz, M. and M. Ashraf (2013). Influence of foliar application of triacontanol on growth attributes, gas exchange and chlorophyll fluorescence in sunflower (*Helianthus annuus* L.) under saline stress. Pak. J. Bot, 45(6): 1913-1918.

Bailey, D. A. and Y. Xu (2005). "The commercialized production of pansy," China Flowers & Horticulture, 4(1):20-25. (In Chinese).

Balestrasse, K. B., M. L. Tomaro, A. Batlle, and G. O. Noriega (2010). The role of 5-aminolevulinic acid in the response to cold stress in soybean plants. Phytochemistry, 71(17): 2038-2045.

Bates, N. S., R. D. Waldren and I. D. Teare (1973). Rapid determination of free proline for water-stress studies. Plant Soil, 39(1): 205 - 207.

Black, C. A., D. D. Evans and L. E. Ensminger (1965). Methods of soil analysis. Agronomy J. Amer. Soc. Agron. Inc. Publ., Madison, Wisconsin, U.S.A.

Borowski, E. and Z. K. Blamowski (2009). The effect of triacontanol 'TRIA' and Asahi-SL on the development and metabolic activity of sweet basil (*Ocimum basilicum* L.) plants treated with chilling. Folia Hortic., 21(1): 39-48.

Brugnoli, E. and M. Lauteri (1991). Effects of salinity on stomatal conductance, photosynthetic capacity, and carbon isotope discrimination of salt-tolerant (*Gossypium hirsutum* L.) and salt-sensitive (*Phaseolus vulgaris* L.) C_3 non-halophytes. Plant physol., 95 (2): 628-635.

Cohen, L., T. Arzee and A. Zilberstein (1988). Mimicry by cytokinins of phytochrome regulated inhibition of chloroplast development in etiolated cucumber cotyledons. Physiol Plant, 72(1): 57–64.

CoStat (2008). CoStat program, version 6.4. CoHort Software, Monterey, CA., USA.

Darwish, M. A., R. M. Nassar, N. G. Abdel-Aziz and A. S. Abdel-Aal (2017). Riboflavin minimizes the deleterious effects of salinity stress on growth, chloroplast pigments, free proline, activity of antioxidant enzyme catalase and leaf anatomy of *Tecoma capensis* (Thumb.) Lindl. Middle East J, 6(3): 757-765.

Dei, M. (1985). Benzyladenine-induced stimulation of 5-aminolevulinic acid accumulation under various light intensities in levulinic acid-treated cotyledons of etiolated cucumber. Physiol Plant, 64(2): 153-160.

Denisow, B., M. Strzałkowska-Abramek, E. Pogroszewska and H. Laskowska (2016). The effect of Pentakeep–V application on flower traits and nectar production in *Hosta Tratt*.'Krossa Regal'. Acta Scientarum Polonorum Hortorum Cultus, 15(1): 27-39.

Elkinany, R. G. (2016). Possibility of enhancing commercial characteristics of zinnia (*Zinnia elegans* L.) by using cycocel. J. Agric. & Env. Sci. Damanhour University, 15(2): 85-98.

Epstein, E. (1966). Dual pattern of ion absorption by plant cells and by plants. Nature, 212: 1324-1327.

Eriksen, A. B., G. Selld´en, D. Skogen and S. Nilsen (1981). "Comparative analyses of the effect of triacontanol on photosynthesis, photorespiration and growth of tomato (C3-plant) and maize (C4-plant)," Planta, 152(1): 44-49.

Essa, T. A. (2002). Effect of salinity stress on growth and nutrient composition of three soybean (*Glycine max* L. Merrill) cultivars. J. Agron. Crop Sci, 188(2): 86-93.

Evans, D. E., S. A. Briars and L. E. Williams (1991). Active calcium transport by plant cell membranes. J Exp Bot, 42(3): 285-303.

Fletcher, R. A., C. Tao and A. Ali (1973). Stimulation of chlorophyll synthesis in cucumber cotyledons by benzyladenine. Can. J. Bot, 51(5): 937-939.

Gama, P. B. S., S. Inanaga, K. Tanaka and R. Nakazawa (2007). Physiological response of common bean (*Phaseolus vulgaris* L.) seedlings to salinity stress. Afr. J. Biot., 6(2): 79-88.

Gunes, A., A. Inal and M. Alpaslan (2005). Effects of exogenously applied salicylic acid on the induction of multiple stress tolerance and mineral nutrition in maize (*Zea mays* L.). Arch Agron. Soil Sci., 51(6): 687-95.

Hamlin, R. L. and H. A. Mills (2001). Pansy floral development and nutrient absorption as influenced by temperature, nitrogen form, and stage of plant development. Journal of plant nutrition, 24(12): 1975-1985.

Hangarter, R., S. K. Ries, and P. Carlson (1978). "Effect of triacontanol on plant cell cultures in vitro," Plant Physiol, 61(5): 855-857.

Hayat, Q., H. Hayat, M. Irfan and A. Ahmad (2010). Effect of exogenous salicylic acid under changing environment: A review. Environmental and Experimental Botany, 68(1): 14-25.

Heidari, M. and T. Akbari (2012). Effect of salinity stress on photosynthesis pigments and osmotic components of two marigold (*Tagetes patula* L.) genotypes. In UMT 11th International Annual Symposium on Sustainability Science and Management, Terengganu, Malaysia, 204-209.

Hotta, Y. Y., T. Tanaka, H. Takaoka, Y. Takeuchi and M. Konnai (1997). New physiological effects of 5-Aminolevulinic acid in plants: The increase of photosynthesis, chlorophyll content, and plant growth. Biosci. Biotechnol. Biochem., 61(12): 2025-2028.

Hua, I. B., D. Rend and J. Chen (1985). Abscission of citrus fruit. The effect of triacontanol on cellulase and pectinase activities in the abscission of young faint explants of Bendizao mandarin. Acta Hort., 12(2): 77-82.

Iqbal, M. and M. Ashraf (2013). Gibberellic acid mediated induction of salt tolerance in wheat plants: growth, ionic partitioning, photosynthesis, yield and hormonal homeostasis. Environ. Exp. Bot., 86(1): 76-85.

Ivanov, A. G. and M. N. Angelov (1997). "Photosynthesis response to triacontanol correlates with increased dynamics of mesophyll protoplast and chloroplast membranes," Plant Growth Regul, 21(2): 145-152.

Jackson, M. L. (1967). Soil Chemical Analysis Prentice Hall of India Pvt. Ltd., New Delhi, p. 205.

Jackson, M. L. (1978). Soil Chemical Analysis. Fall Indian Private. Ltd. New Delhi.

Jia, B. Y., Q. W. Chen, T. T. Tao, G. Wang and F. Xu (2016). Promotive effects of 5-aminolevulinic acid on growth, photosynthetic gas exchange, chlorophyll, and antioxidative enzymes under salinity stress in *Prunnus persica* (L.) Batseh seedling. Emirates J. Food and Agric., 28(11): 786-795.

Karimi, H. and H. Y. Zadeh (2013). The effect of salinity level on the morphological and physiological traits of two grapes (*Vitis vinifera* L.) Cultivars. International journal of Agronomy and Plant Production, 4(5): 1108-1117.

Khalil, S. E. and A. A. El-Noemani (2012). Effect of irrigation intervals and exogenous proline application in improving tolerance of garden cress plant (*Lepidium sativum* L.) to water stress. Journal of Applied Sciences Research, 8(1): 157-167.

Khan, N., S. Syeed; A. Masood, R. Nazar and N. Iqbal (2010). Application of salicylic acid increases contents of nutrients and antioxidative metabolism in mung bean and alleviates adverse effects of salinity stress. Inter. J. Plant Biol., 1(1): 1-8.

Khan, M. I. R., M. Fatma, T. S. Per, N. A. Anjum and N. A. Khan (2015). Salicylic acid-induced abiotic stress tolerance and underlying mechanisms in plants. Frontiers in Plant Science, 6: 462.

Kolattukudy, P. E. and T. J. A. Walton (1972). The biochemistry of plant cuticular lipids. Prog. Chem., 13(3): 119-175.

Krishnan, R. R. and B. D. R. Kumari (2008). Effect of triacontanol on the growth of salt stressed soybean plants. J. BioSci., 19(2): 53-62.

Kumar, D., M. Al Hassan, M. A. Naranjo, V. Agrawal, M. Boscaiu and O. Vicente (2017). Effects of salinity and drought on growth, ionic relations, compatible solutes and activation of antioxidant systems in oleander (*Nerium oleander* L.). Plos one, 12(9): 1-22.

Kumari, J. (2017). Effect of Saline Water and GA3 on Flowering Parameters and Yield of Goldenrod (*Solidago canadensis* L.). IJCS, 5(5): 1892-1895.

Lauchli, A. and J. Wieneka (1979). Studies on growth and distribution of Na+, K+ and Cl- in Soybean varieties differing in salt tolerance. Z. Phanzenernaehr. Bodenkd. 142(1): 3-13.

Lesniak, A. P., A. Haug and S. K. Ries (1986). Stimulation of ATPase activity in barley (*Hordeum vulgare*) root plasma membranes after treatment of intact tissues and cell free extracts with triacontanol. Physiol Plant, 68(1): 20-26.

Lyengar. E. R. and M. P. Reddy (1996). Photosynthesis in highly salt tolerant plants. In:Pesserkali, M.(Ed), Handbook of photosynthesis. Marshal Dekar, Baten Rose, USA, 897-909.

Mahroof, S., U. S. Qureshi, S. Chughtai, M. Shah, S. John and A. Qureshi (2017). Effect of different growth stimulants on growth and flower quality of zinnia (*Zinnia elegans*) var. Benery's giant. IJB., 11(2): 25-34.

Mazher, A. A. M., R. A. Eid and N. G. A. Abd El-Aziz (2006). Effect of Microbien under salt stress on modulation, growth and chemical constituents of *Sesbania egyptiac* in sandy soil. Bull NRC, Egypt, 31(3): 247-268.

Mimouni, H., S. Wasti, A. Manaa, E. Gharbi, A. Chalh, B. Vandoorne, S. Lutts and H. Ben Ahmed (2016). Does salicylic acid (SA) improve tolerance to salt stress in plants? A study of SA effects on tomato plant growth, water dynamics, photosynthesis, and biochemical parameters. Omics: a J. Integrative biol., 20(3): 180-190.

Mohamed, A. A., B. Eichler-Löbermann and E. Schnug (2007). Response of crops to salinity under Egyptian conditions: a review. Landbauforschung Völkenrode, 2(57): 119-125.

Muthuchelian, K., M. Velayutham and N. Nedunchezhian (2003). "Ameliorating effect of triacontanol on acidic mist-treated *Erythrina variegata* seedlings changes in growth and photosynthetic activities," Plant Science, 165(6): 1253-1259.

Naeem, M. S., Z. L. Jin, G. L. Wan, D. Liu, H. B. Liu; K. Yoneyama and W. J. Zhou (2010). 5-Aminolevulinic acid improves photosynthetic gas exchange capacity and ion uptake under salinity stress in oilseed rape (*Brassica napus* L.). Plant Soil, 332(1): 405-415.

Niu, G. and D. Rodriguez (2006). Relative salt tolerance of five herbaceous perennials. HortScience, 41(6):1493- 1497.

Nounjan, N., P. T. Nghia and P. Theerakulpisut (2012). Exogenous proline and trehalose promote recovery of rice seedlings from salt-stress and differentially modulate antioxidant enzymes and expression of related genes. J Plant Physiol, 169(6): 596-604.

Nunez-Elisea, R. and T. L. Davenport (1986). Abscission of mango fruitlets as influenced by enhanced ethylene biosynthesis. Plant Physiology, 82(4): 991-994.

Nunkaew, T., D. Kantachote, H. Kanzaki, T. Nitoda and R. J. Ritchie (2014). Effects of 5-aminolevulinic acid (ALA)-containing supernatants from selected *Rhodopseudomonas palustris* strains on rice growth under NaCl stress, with mediating effects on chlorophyll, photosynthetic electron transport and antioxidative enzymes. Electron. J. Biotechnol, 17(1): 19-26.

Orabi, S. A., B. B. Mekki and F. A. Sharara (2013). Alleviation of Adverse Effects of Salt Stress on Faba Bean (*Vicia faba* L.) Plants by Exogenous Application of Salicylic Acid. World Appl. Sci. J., 27(4): 418-427.

Perveen, S., M. Shahbaz and M. Ashraf (2010). Regulation in gas exchange and quantum yield of photosystem II (PSII) in saltstressed and non-stressed wheat plants raised from seed treated with triacontanol. Pak. J. Bot., 42(5): 3073-3081.

Perveen, S., M. Shahbaz and A. Ashraf (2011). Modulation in activities of antioxidant enzymes in salt stressed and non-stressed wheat (*Triticum aestivum* L.) plants raised from seed treated with triacontanol. Pak. J. Bot., 43(5): 2463–2468.

Perveen, S., M. Shahbaz and M. Ashraf (2012). Is pre-sowing seed treatment with triacontanol effective in improving some physiological and biochemical attributes of wheat (*Triticum aestivum* L.) under salt stress? J. Appl. Bot. Food Qual., 85(1): 41-48.

Rajamani, K., S. Sundararajan and D. Veeraragavathatham (1990). Effect of triacontanol, 2,4-D and boron on yield of certain chilli(*Capsicum annuum* L.) culture. South Indian Hort., 38(5): 253- 257.

Ramanarayan, K., A. Bhut, V. Shripathi, G. S. Swamy and K. S. Rao (2000). Triacontanol inhibits both enzymatic and nonenzymatic lipid peroxidation. Phytochemistry, 55(1): 59-66.

Raskin, I. (1992). Role of salicylic acid in plants. Ann. Rev. Plant Physiol. Plant Mol. Biol., 43(1): 439-463.

Ries, S. and R. Houtz (1983). "Triacontanol as a plant growth regulator," Horticultural Science, 18(5): 654-662.

Ries, S., S. Savithiry, V. Wert and I. Widders (1993). Rapid induction of ion pulses in tomato, cucumber, and maize plants following a foliar application of L (+)-adenosine. Plant Physiol, 101(1): 49–55.

Roshdy, A. E. H and S. H. M. Berengi (2016). Possibility of overcoming salt stress of bean (*Phaseolus vulgaris* l.) plants using some safety materials. J. Agric. & Env. Sci. Damanhour University, 15(3): 52-81.

Runkle, E. S and R. H. Heins (2003). Photocontrol of flowering and extension growth in the long day plant pansy. J. Amer. Soc. Hort. Sci., 128(4): 479-485.

Senaratna, T., D. Touchell, E. Bunn and K. Dixon (2000). Acetyl salicylic acid (Aspirin) and salicylic acid induce multiple stress tolerance in bean and tomato plants. Pl. Grow. Regul., 30(2): 157-161.

Shahbaz, M., N. Noreen and S. Perveen (2013). Triacontanol modulates photosynthesis and

osmoprotectants in canola (*Brassica napus* L.) under saline stress. J. Plant Interactions, 8(4): 350-359.

Snedecor, G. W. and W. G. Corchan (1967). Statistical Methods. 6th Edition. Iowa State Univ. Press, Ames, Iowa, U.S.A.

Szepesi, A., J. Csiszar, S. Bajkan, K. Gemes, F. Horvath, L. Erdei, A. K. Deer; M. L. Simon and I. Tari (2005). Role of salicylic acid pre-treatment on the acclimation of tomato plants to salt- and osmotic stress. Acta Biologica Szegediensis, 49(1): 123-125.

Tester, M. and R. Davenport (2003). Na^+ tolerance and Na^+ transport in higher plants. Ann. Bot., 91(5): 503-527.

Torbaghan, M. E. and M. M. Ahmadi (2011). The effect of salt stress on flower yield and growth parameters of saffron (*Crocus sativus* L.) in greenhouse condition. International Research Journal of Agricultural Science and Soil Science, 1(10): 421-427.

Vijayakumar, S., K. R. Rajadurai and P. Pandiyaraj (2017). Effect of plant growth regulators on flower quality, yield and postharvest shelf life of china aster (*Callistephus chinensis* L. nees.) cv. local. Int. J. Agric. Sci. and Res., (IJASR), 7(2): 297-304.

Vukics, V., A. Kery and A. Guttman (2008). "Analysis of polar antioxidants in heartsease (*Viola tricolor* L.) and garden pansy (*Viola x wittrockiana* Gams.)." J. Chromatographic sci., 46(9): 823-827.

Xu, F., J. Zhu, S. Cheng, W. Zhang and Y. Wang (2010). Effect of 5-aminolevulinic acid on photosynthesis, yield, nutrition and medicinal values of kudzu (*Pueraria phaseoloides*). Tropical Grasslands, 44: 260-265.

Yildirim, E., M. Turan and I. Guvenc (2008). Effect of foliar salicylic acid applications on growth, chlorophyll and mineral content of cucumber (*Cucumis sativus* L.) grown under salt stress. J. Plant Nutri., 31(3): 593-612.

Zhang, Z. J., H. Z. Li, W. J. Zhou, Y. Takeuchi and Y. Yoneyama (2006). Effect of 5-aminolevulinic acid on development and salt tolerance of potato (*Solanum tuberosum* L.) microtubers in vitro. Plant Growth Regul., 49(1): 27-34.

Zhang, Z. P., M. M. Miao and C. L. Wang (2015). Effects of ALA on photosynthesis, antioxidant enzyme activity, and gene expression, and regulation of proline accumulation in tomato seedlings under NaCl stress. J. Plant Growth Regul., 34(3): 637-650.

Zidan, E. (1962). Evaluation of some Tomato lines in regard to leaf area efficiency and relation of partial defoliation to early and total yield fruit size, soluble solids, leaf rolling and blossom and rot. Ph. D. Thesis, Cornell Univ. Ithaca. New York, U.S.A.

الدور الإيجابى لإستخدام حمض السالسيليك والترياكونتانول وحمض أمينوليفولينيك على النمو والإزهار والمحتوى الكيميائى لنبات البانسيه تحت ظروف الإجهاد الملحى

رامي جابر الكناني

قسم البساتين (شعبة الزهور ونباتات الزينة) - كلية الزراعة - جامعة دمنهور - دمنهور - محافظة البحيرة - جمهورية مصر العربية

تم إجراء تجربتي أصص خلال موسمي ٢٠١٥/٢٠١٦ و ٢٠١٦/ ٢٠١٧ داخل إحدى الصوب في مشتل خاص - بمحافظة البحيرة - جمهورية مصر العربية. وكان الهدف من البحث هو دراسة تأثير الرش بواسطة كل من حمض الساليسيليك بتركيزات (٥٠ و ١٠٠ ملجم/لتر) والترياكونتانول بتركيزات (٢٥ و ٥٠ ملجم/لتر) وحمض أمينوليفولينيك بتركيزات (٢٥ و ٥٠ ملجم/لتر) على نباتات البانسيه صنف (Blue with Blotch) المنماة تحت تركيزات مختلفة من الملوحة (٠ ، ٢٠ ، ٤٠ ، ٦٠ ملي مول/لتر من كلوريد الصوديوم). وقد أوضحت النتائج تباين استجابة نباتات البانسيه للمواد موضع الدراسة في تأثيرها على الصفات المختلفة التي تم قياسها. حيث أشارت النتائج التي تم الحصول عليها بعد الموسمين إلى أن مستويات الملوحة المتزايدة من ٢٠ إلى ٦٠ ملي مول/لتر تقلل بشكل كبير قيم جميع الصفات المدروسة، مثل ارتفاع النبات وعدد الفروع لكل نبات والوزن الجاف للنبات ومساحة سطح الورقة وطول الجذر والوزن الجاف للجذور ومحتوى الأوراق من النتروجين والفوسفور والبوتاسيوم والكالسيوم والماغنسيوم وكذلك محتواها من الكلورفيل. في حين قد أدت إلي زيادة محتوى الأوراق من الصوديوم والكلور. وقد أشارت النتائج أيضًا إلى أن حمض الساليسيليك وحمض الأمينيوليفينول وترياكونتانول قد زاد بشكل كبير من نمو النبات والصفات الكيميائية المذكورة سابقا، وكذلك تقليل محتوى الأوراق من الصوديوم والكلور مقارنة بالكونترول. وقد أظهرت نتائج النباتات المعاملة بواسطة الترياكونتانول بتركيز (٢٥ ملجم/لتر) أو حمض الساليسيليك بتركيز (٥٠ ملجم/لتر) حدوث تحسين في صفات النمو الخضري والزهري والجذري وكذلك المحتوى الكيميائي للأوراق تحت ظروف الإجهاد الملحي في كلا الموسمين. وقد عزز الترياكونتانول تحمل نباتات البانسيه للملوحة في كلا الموسمين وقد ظهر ذلك من خلال زيادة تراكم البرولين. وقد وجد من النتائج السابقة أنه تحت كل مستوى من مستويات الملوحة أن المعاملة بواسطة مركب الترياكونتانول (٢٥ ملجم / لتر) قد يكون العلاج الأكثر فاعلية للتخفيف من التأثيرات الضارة للملوحة على نبات البانسيه.