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Mitigating the Harmful Effect of Irrigation Salinity on Poinsettia Plants by Using of Koalin Antitranspirant

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Abstract: Nowadays, particle film technology is one of the major ways for the modern production systems, especially under abiotic stress. So, this investigation was performed at the nursery of Hort. Res. Inst., ARC, Giza Egypt during 2020 and 2021 seasons under plastic house conditions to find out the role of spraying with kaolin emulsion at 0, 3 and 5 % concentrations, three times at month's intervals on the foliage of poinsettia (*Euphorbia pulcherrima* Wild. Ex. Klotzsch) transplants irrigated with saline water at concentrations of 0, 1000, 3000 and 5000 ppm in reducing the deleterious effect of this saline water. The effect of interactions between koalin levels and salinity ones was also studied in a factorial experiment based on a complete randomized design, replicated thrice. Results of this study showed that mean values of most vegetative and root growth parameters were significantly increased over those of control and the other salinity treatments by 1000 ppm saline water treatment, which followed by 3000 ppm level. However, the least means recorded in the two seasons were attained by 5000 ppm salinity treatment. On the other hand, spraying with kaolin emulsion at 3 or 5 % induced a significant increment in the means of various growth traits, with the superiority of 3 % level with few exceptions. The combining between any level of kaolin and any one of salinity significantly improved means of the different growth characters and the combination of 1000 ppm saline water and 3 % kaolin gave the utmost high means recorded in the two seasons. A similar trend was also obtained regarding flowering characteristics and the percentage of salinity resistance index (SRI %), but the opposite was the right concerning chemical composition of the leaves, as the concentrations of chlorophyll a, b, carotenoids, total carbohydrates, N and P were gradually decreased with increasing salinity level, whereas concentrations of K, Na and proline were progressively increased. Moreover, both levels of kaolin increased chlorophyll a, total carbohydrates, N, P, K and proline concentrations, with the dominance of 3 % level, whilst concentrations of chlorophyll b, carotenoids and Na were linearly decreased as a result of the progressive increasing in kaolin level. The interaction treatments however, showed a fluctuated effect on the concentrations of the previous constituents. So, it can be recommended to spray the foliage of potted poinsettia plants irrigated with saline water up to 000 ppm concentration with 3 % kaolin emulsion, three times at monthly intervals during the growing period to obtain the best performance of growth and flowering.

Key words: Poinsettia・Saline water・Kaolin anti-transpirant・Growth・Flowering・SRI %

INTRODUCTION

Salinity of either soil or water is still one of the major restrictions for agricultural development all over the world, as it causes reductions in productivity, quality and substantial economic loss [1]. The plants, especially ornamental ones differ greatly in their tolerance to salinity stress, for example *Viburnum tinus* is sensitive species, whereas *Murraya paniculata* and *Polygala myrtifolia* are moderately tolerants and *Raphiolepis umbellata* is tolerant species [2]. Among sensitive ornamental shrubs to salinity may be poinsettia (*Euphorbia pulcherrima* Wild. Ex. Klotzsch), which also known as Christmas flower, belongs to Fam. Euphorbiaceae, grows to 3-4 m high when planting as a garden shrub, but also it is used as flowering potted plant, especially during Christmas

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celebrations as it flowers in winter giving showy, vermilion bracts. Many cultivars are now developed with larger bracts in white, pink and different shades of red colours [3].

Regarding salinity effects on poinsettia, Mostafa [4] found that increasing salinity of water from 900 up to either 1800 or 2700 ppm progressively decreased rooting %, root length and dry weight of poinsettia cuttings, as well as leaf number, leaf area and dry weight of the new transplants. The percentages of N and relative water content (RWC) were also reduced. On the same line were those results revealed by Valdes *et al*., [5]; Gent *et al*., [6] and Gent *et al*., [7].

The adverse effects of salinity, however can be counteracted by several ways, among which using osmolytes, such as glycine betaine and proline, activation of the antioxidant machinery and application of antitranspirants (antidesiccants), which are found in two main types: first of all: the metabolic antitranspirants, which chemically close stomatal pores, such as succinic acids, atrazine, sodium azide ….etc., the second: film-type antitranspirants, which form films on leaves, thereby blocking stomatal pores, or coating the cells inside the leaf with water-proof film, such as waxes, silicons, kaolin …. etc.[8-10].

Kaolin is a white soft and non-abrasive plastic clay, mainly composed of fine-grained plate-like particles and has a low conductivity of heat and electricity. It is formed from altering the anhydrous aluminum silicates (found in feldspar-rich rocks, like granite) by weathering or hydrothermal processes. It is commonly known as China clay and used for many purposes; as an inert filler, extender, ceramic raw material, pigment (for paint), for production paper, rubber, plastics, refractories, fiberglass, cosmetics and pharmaceuticals, it is also used for pest control, prevents fruit drop and improves fruit colour [11, 12]. Kaolin conserves irrigation water helping the plants to survive under dry and salt conditions with better growth performance and good health. These benefits of kaolin particle films were documented by Noor El-Deen *et al*., [13] on *Zinnia elegans*, Abd-Elmoneim *et al*., [14] on *Cyperus alternifolius*, Aly *et al*., [15] on Anna apple, Javan *et al*., [16] on soybean, Alvarez *et al*., [17] on apple, Maletsika and Nanos [18] on olive, Dinis *et al*., [19, 20] on grapevine, [21] Glenn (2016) on apple and Abdallah *et al*., [22] on tomato.

However, the goal of the current work is to evaluate the role of kaolin particle films at different concentrations in reducing the deleterious effects of water salinity on growth, flowering and chemical composition of poinsettia plants.

MATERIALS AND METHODS

A pot experiment was conducted under plastic house conditions at the nursery of Hort. Res. Inst., Giza, Egypt during 2020 and 2021 seasons to examine the effect of various concentrations of kaolin as a film-type antitranspirant on growth, flowering and chemical constituents of poinsettia plants subjected to irrigation with saline water at different levels.

Thus, 6-month-old transplants of poinsettia (*Euphorbia pulcherrima* Wild. Ex. Klotzsch) at a length of about 18.0 cm were planted on August, 20th for every season in 20-cm-diameter plastic pots (one transplant/pot) filled with about 3.5 kg of sandy clay soil. The physical and chemical properties of the soil used in the two seasons were determined and averaged in Table (1).

The temperature and relative humidity inside the plastic house during the course of the study ranged between 23.9-39.8°C and 45.5-85.6 %, respectively, whereas light intensity ranged between 531 and 620 lux. Immediately after transplanting, the plants were watered with fresh water till first of September then the following treatments were applied:

Saline Water Treatments: Pure salts of both NaCl and $CaCl_2$ were mixed together at equal weight parts to prepare artful saline water at the levels of 0, 1000, 3000 and 5000 ppm to irrigate the plants twice per week till the end of experiment (on 30th of December).

Kaolin Treatments: Kaolin aluminum silicate ($Al_4Si_4O_{10}$ (OH)8 $Al_4Si_4O_{10}$ [OH]$_8$) produced by Loba Chemie Co., India was purchased from the local market with the following composition: SiO_2 (46.5 %), Al_2O_3 (39.50 %), Fe_2O_3 (0.57 %), FeO (0.18 %), MgO (0.14 %), CaO (0.41 %), K_2O (0.03 %), H_2O+ (13.15 %) and H_2O- (0.17 %). Kaolin emulsion was prepared by distributing its particles well in tap water at concentrations of 0, 3 and 5 % and sprayed on the foliage three times at months intervals, till the emulsion was run-off. The first spraying was done after 40 days from transplanting (on October, 1st).

Interaction Treatments: Each level of saline water was combined factorially with each concentration of kaolin emulsion to formalize twelve interaction treatments.

A factorial experiment based on a complete randomized design was accomplished in the two seasons, replicated thrice with three transplants in each replicate [23]. All plants under the different treatments received the usual agricultural practices required for such plantation.

Table 1: The physical and chemical properties of the soil used in the two experimental seasons.

Soil texture	Particle size distribution (%)							Cations (meq/L)			
	Coarse sand	Fine sand	Silt	Clay	S.P.	E.C. (dS/m)	pH	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
Sandy clay	39.50	30.40	18.90	11.20	26.30	3.60	7.53	18.90	14.50	32.00	0.90
	Anions (meq/L)				Macro - and micro elements (ppm)						
	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K	Fe	Zn	Mn	Cu
	-	2.70	38.50	25.10	173.30	13.96	356.96	17.53	5.33	8.10	7.36

At the end of each season, data were recorded as follows: plant height (cm), stem diameter at the base (cm), number of branches/plant, number of leaves/plant, leaf area (cm^2), the longest root length (cm), as well as fresh and dry weights of leaves, stem and roots (g). During flowering stage, number of inflorescences/plant and number of bracts/inflorescence were counted and the largest bract area (cm^2) was measured. Besides, salinity resistance index as a percentage (SRI %) was calculated from the following equation suggested by Wilkins [24].

SRI (%) = Mean root length of the salinized plant / mean root length of control plant x 100

Moreover, the photosynthetic pigments (chlorophyll a, b, carotenoids, mg/g f.w.) and the percent of total carbohydrates were determined in fresh leaf samples taken from the middle parts of the plants according to the methods of Sumanta *et al*., [25] and Herbert *et al*., [26], respectively, while in dry leaf ones, the percentages of nitrogen, phosphorus and potassium was measured according to Chapman and Pratt, [27]; sodium as mg/g d. w. according to Jackson, [28] and the free amino acid proline as mg/100 g d. w. according to Bates *et al*., [29].

Data were then tabulated and those of morphological and floral traits were subjected to analysis of variance using the software program explained by Silva and Azevedo [30], followed by Duncan`s New Multiple Range Test according to Steel and Torrie, [31] for means comparison.

RESULTS AND DISCUSSION

Effect of Salinity Levels, Kaolin Concentrations and Their Interactions On:

Vegetative and Root Growth Parameters: It is obvious from data presented in Tables (2-7) that mean values of most vegetative and root growth traits, especially plant height (cm), No. of branches and leaves/plant, leaf area (cm^2), root length (cm), as well as fresh and dry weights of leaves, stem and roots (g) were significantly increased by 1000 ppm saline water treatment, which gave the highest means over those of control and the other saline water treatments in the two seasons. The second rank however was occupied by irrigation with saline water at 3000 ppm with significant differences in most cases of both seasons. Few exceptions were noticed in the matter of growth traits, such as stem diameter means, which were closely near together to control, 1000 and 3000 ppm treatments in the first season and to control and 1000 ppm ones in the second season with non-significant differences among themselves (Table, 2). Likewise, leaf area mean values (Table, 4) which was significantly declined by 3000 ppm salinity treatment to 28.87 cm^2 against for (42.7 /cm^2) 1000 ppm salinity one and even that of control (33.52 cm^2) in the first season, but in the second one it was greatly near to the value of the control treatment with non-significant differences in between them. Also, means of leaves and stem fresh and dry weights recorded by 3000 ppm saline water treatment were almost at par with those achieved by the control treatment in most instances of the two seasons (Tables, 5 and 6). The least records, however were acquired by irrigation with the highest salinity level (5000 ppm) which gave the shortest plants, thinnest stem, least No. branches and leaves, smallest leaf area, shortest roots and lightest fresh and dry weights of leaves, stem and roots in the two seasons.

On the other hand, foliar spraying with kaolin emulsion at either 3 or 5 % concentrations caused significant increments in the means of different growth traits mentioned above compared to the means of control in both seasons, with the superiority of 3 % level which gave the utmost high values in the two seasons, except for the mean values of stem diameter and leaves dry weight, as they were statistically at par with each for the two kaolin levels (Tables, 2 and 5). Similarly, were the means of roots dry weight obtained by 0 and 5 % kaolin levels (Table, 7).

The effect of interaction treatments, Tables (2-7) exhibited that using kaolin at all levels combined with any level of salinity significantly improved the means of various vegetative and root growth attributes measured in the study as compared to irrigation with the same level

Table 2: Effect of irrigation salinity, kaolin and their interactions on plant height and stem diameter of *Euphorbia pulcherrima* Wild. Ex. Klotzsch transplants during 2020 and 2021 seasons

	Kaolin levels							
	0%	3%	5%		0%	3%	5%	
Salinity (ppm)	Plant height (cm)			Mean	Stem diameter (cm)			Mean
				First season; 2020				
0.00 ppm	23.00e	23.80d	23.00e	23.27C	0.50b	0.58a	0.55ab	0.54A
1000 ppm	22.40e	25.60a	24.40c	24.13A	0.48b	0.63a	0.55ab	0.55A
3000 ppm	21.30f	25.30ab	24.60b	23.73B	0.46b	0.60a	0.56ab	0.54A
5000 ppm	21.00f	24.40c	22.36e	22.59D	0.46b	0.50b	0.46b	0.47B
Mean	21.93C	24.78A	23.59B		0.48B	0.58A	0.53AB	
				Second season; 2021				
0.00 ppm	23.50g	24.70de	23.56g	23.92C	0.63bc	0.65ab	0.65ab	0.64A
1000 ppm	24.70de	27.10a	25.80bc	25.87A	0.62b-d	0.70a	0.65ab	0.66A
3000 ppm	22.40gh	26.50ab	25.31cd	24.74B	0.55e-g	0.65ab	0.60b-e	0.60B
5000 ppm	21.67h	24.33ef	22.48gh	22.83D	0.50g	0.60b-e	0.55e-g	0.55C
Mean	23.07C	25.66A	24.29B		0.58B	0.65A	0.61AB	

There is no significant difference among means have the same letter either in the same column or in the same raw (DNMRT).

Table 3: Effect of irrigation salinity, kaolin and their interactions on number of branches and leaves of *Euphorbia pulcherrima* Wild. Ex. Klotzsch transplants during 2020 and 2021 seasons

	Kaolin levels							
	0%	3%	5%		0%	3%	5%	
Salinity (ppm)	Number of branches/plant			Mean	Number of leaves/plant			Mean
				First season; 2020				
0.00 ppm	3.13ef	4.00c	4.00c	3.71C	21.00g	23.50e	22.21f	22.24C
1000 ppm	3.60d	5.00a	4.43b	4.34A	23.80e	32.40a	29.00c	28.40A
3000 ppm	3.40de	4.80ab	4.20bc	4.13B	18.50i	30.00b	26.33d	24.94B
5000 ppm	3.00f	4.40b	3.60d	3.67D	15.31j	21.50g	20.40h	19.07D
Mean	3.28C	4.55A	4.06B		19.65C	26.85A	24.49B	
				Second season; 2021				
0.00 ppm	4.00de	5.00b	4.50c	4.50C	22.50f	24.30de	23.65e	23.48C
1000 ppm	4.30cd	5.50a	4.80b	4.87A	23.90e	33.15a	31.40b	29.48A
3000 ppm	3.90e	5.40a	4.25cd	4.52B	19.50h	30.70b	24.90d	25.03B
5000 ppm	3.75e	5.00b	4.00de	4.25D	16.67i	26.63c	21.50g	21.60D
Mean	3.99C	5.20A	4.39B		20.64C	28.70A	25.36B	

There is no significant difference among means have the same letter either in the same column or in the same raw (DNMRT).

Table 4: Effect of irrigation salinity, kaolin and their interactions on leaf area and root length of *Euphorbia pulcherrima* Wild. Ex. Klotzsch transplants during 2020 and 2021 seasons

	Kaolin levels							
	0%	3%	5%		0%	3%	5%	
Salinity (ppm)	Leaf area (cm2)			Mean	Root length (cm)			Mean
				First season; 2020				
0.00 ppm	30.22g	35.92e	34.43f	33.52B	30.00i	39.50e	35.50g	35.00C
1000 ppm	36.50e	47.30a	44.33b	42.71A	36.50f	45.00a	45.00a	42.17A
3000 ppm	19.93j	39.03c	37.65d	28.87C	31.67h	44.00b	42.31c	39.33B
5000 ppm	18.86j	28.50h	21.85i	23.07D	25.73j	41.10d	32.00h	32.94D
Mean	26.38C	37.69A	34.57B		30.98C	42.40A	38.70B	
				Second season; 2021				
0.00 ppm	30.45g	35.96e	34.50f	33.64B	31.25h	35.50f	35.00f	33.92C
1000 ppm	36.10e	47.62a	45.03b	42.92A	40.20d	46.73a	46.41a	44.45A
3000 ppm	21.33j	38.15d	39.50c	32.99B	32.00h	43.33b	41.63c	38.99B
5000 ppm	20.50j	29.10h	23.00i	24.20C	26.83i	37.00e	33.10g	32.31D
Mean	27.10C	37.71A	35.51B		32.57C	40.64A	39.04B	

There is no significant difference among means have the same letter either in the same column or in the same raw (DNMRT).

Table 5: Effect of irrigation salinity, kaolin and their interactions on leaves fresh and dry weights of *Euphorbia pulcherrima* Wild. Ex. Klotzsch transplants during 2020 and 2021 seasons

	Kaolin levels							
	0%	3%	5%		0%	3%	5%	
Salinity (ppm)	------------Leaves fresh weight (g)------------			Mean	-----------Leaves dry weight (g)-----------			Mean
				First season; 2020				
0.00 ppm	7.40f	8.35e	7.76f	7.84C	0.94f	1.76cd	1.65d	1.45B
1000 ppm	8.33e	15.10a	13.74b	12.39A	1.63d	2.33a	2.15b	2.04A
3000 ppm	6.10g	10.86c	9.98d	8.98B	0.81g	2.10b	1.86c	1.59B
5000 ppm	5.61h	7.63f	6.05g	6.43D	0.57h	1.07e	0.97f	0.87C
Mean	6.86C	10.49A	9.38B		0.99B	1.82A	1.66A	
				Second season; 2021				
0.00 ppm	7.80f	8.76d	8.50d	8.35B	1.08f	2.03cd	1.91d	1.67B
1000 ppm	8.73d	15.60a	14.10b	12.81A	1.88d	2.67a	2.48b	2.34A
3000 ppm	6.46g	10.35c	8.78d	8.53B	0.93g	2.34bc	2.15c	1.81B
5000 ppm	6.07h	8.20e	6.50g	6.92C	0.68h	1.23e	1.07f	0.99C
Mean	7.27C	10.73A	9.47B		1.14B	2.07A	1.90A	

There is no significant difference among means have the same letter either in the same column or in the same raw (DNMRT).

Table 6: Effect of irrigation salinity, kaolin and their interactions on stem fresh and dry weights of Euphorbia pulcherrima Wild. Ex. Klotzsch transplants during 2020 and 2021 seasons

	Kaolin levels							
	0%	3%	5%		0%	3%	5%	
Salinity (ppm)	------------Stem fresh weight (g)-------------			Mean	-----------Stem dry weight (g)-------------			Mean
				First season; 2020				
0.00 ppm	10.74g	12.81c	11.50e	11.68B	2.30c	3.20b	3.06b	2.85A
1000 ppm	11.46e	17.47a	14.55b	14.50A	2.27c	3.34a	3.17b	2.93A
3000 ppm	9.33i	14.45b	12.20d	11.99B	1.93e	3.30a	2.25c	2.49B
5000 ppm	8.79j	11.04f	10.33h	10.05C	1.28g	2.13d	1.67f	1.69C
Mean	10.08C	13.94A	12.15B		1.95C	2.99A	2.54B	
				Second season; 2021				
0.00 ppm	11.05g	13.15c	12.10e	12.10B	2.74d	3.80b	3.64c	3.39A
1000 ppm	12.23e	17.71a	15.20b	15.05A	2.76d	3.97a	3.77bc	3.50A
3000 ppm	9.76i	15.13b	12.60d	12.50B	1.73h	2.78d	2.34f	2.28B
5000 ppm	8.91j	11.42f	10.78h	10.37C	1.42i	2.53e	1.98g	1.98C
Mean	10.49C	14.35A	12.67B		2.16C	3.27A	2.93B	

There is no significant difference among means have the same letter either in the same column or in the same raw (DNMRT).

Table 7: Effect of irrigation salinity, kaolin and their interactions on roots fresh and dry weights of *Euphorbia pulcherrima* Wild. Ex. Klotzsch transplants during 2020 and 2021 seasons.

	Kaolin levels							
	0%	3%	5%		0%	3%	5%	
Salinity (ppm)	------------Roots fresh weight (g)------------			Mean	-----------Roots dry weight (g)------------			Mean
				First season; 2020				
0.00 ppm	5.36f	5.39f	5.15g	5.30C	0.76d	0.79d	0.77d	0.77C
1000 ppm	7.50c	8.89a	8.05b	8.15A	1.10b	1.38a	1.30a	1.26A
3000 ppm	6.25e	8.80a	7.30d	7.45B	0.88cd	1.29a	0.85cd	1.01B
5000 ppm	4.63h	7.21d	4.61h	5.48C	0.50e	1.09b	0.51e	0.70C
Mean	5.94C	7.57A	6.28B		0.81B	1.14A	0.86B	
				Second season; 2021				
0.00 ppm	5.50h	6.00f	5.77g	5.76D	0.93d	0.97d	0.95d	0.95C
1000 ppm	8.36c	9.96a	9.03b	9.12A	1.30bc	1.57a	1.60a	1.49A
3000 ppm	7.10e	9.87a	8.12d	8.36B	1.10d	1.48ab	1.10d	1.23B
5000 ppm	5.31i	8.10d	5.16i	6.19C	0.73e	1.31bc	0.75e	0.93C
Mean	6.57C	8.48A	7.02B		1.02B	1.33A	1.10B	

There is no significant difference among means have the same letter either in the same column or in the same raw (DNMRT).

Table 8: Effect of irrigation salinity, kaolin and their interactions on number of inflorescences and bracts in *Euphorbia pulcherrima* Wild. Ex. Klotzsch transplants during 2020 and 2021 seasons.

	Kaolin levels							
	0%	3%	5%		0%	3%	5%	
Salinity (ppm)	----------No. inflorescences/plant-----------			Mean	----------No. bracts/inflorescence----------			Mean
				First season; 2020				
0.00 ppm	3.00g	3.20f	3.00g	3.07D	6.50de	6.80c	6.50de	6.60C
1000 ppm	4.00c	5.00a	4.20b	4.40A	6.80c	7.80b	8.50a	7.70A
3000 ppm	3.80d	3.60e	4.00c	3.80B	6.50de	7.70b	6.70cd	6.97B
5000 ppm	3.20f	3.20f	3.60e	3.33C	6.38ef	6.40ef	6.50de	6.43C
Mean	3.50B	3.75A	3.70A		6.55B	7.18A	7.05A	
				Second season; 2021				
0.00 ppm	3.50g	3.70ef	3.60fg	3.60C	7.22de	7.56c	7.25de	7.34C
1000 ppm	4.70b	5.20a	4.60b	4.83A	7.50c	8.55b	9.45a	8.50A
3000 ppm	4.10c	3.85d	4.60b	4.18B	7.22de	8.67b	7.50c	7.80B
5000 ppm	3.60fg	3.60fg	4.05c	3.75C	7.10ef	6.88f	7.23de	7.07C
Mean	3.98B	4.09A	4.21A		7.26B	7.92A	7.86A	

There is no significant difference among means have the same letter either in the same column or in the same raw (DNMRT).

Table 9: Effect of irrigation salinity, kaolin and their interactions on bract area and salinity resistance index of *Euphorbia pulcherrima* Wild. Ex. Klotzsch transplants during 2020 and 2021 seasons

	Kaolin levels							
	0%	3%	5%		0%	3%	5%	
Salinity (ppm)	----------------Bract area (cm^2)-----------------			Mean	------Salinity resistance index (SRI %)-------			Mean
				First season; 2020				
0.00 ppm	13.80h	14.20g	13.85h	13.95D	100.00g	100.00g	100.00g	100.00C
1000 ppm	28.60a	25.50b	24.80bc	26.30A	121.67b	113.93d	126.76a	120.79A
3000 ppm	22.10e	23.86cd	22.83de	22.93B	105.57f	111.39e	119.18c	112.05B
5000 ppm	13.56h	21.15f	22.43e	19.05C	85.77i	104.05f	90.14h	93.32D
Mean	19.52B	21.18A	20.98A		103.25B	107.34A	109.02A	
				Second season; 2021				
0.00 ppm	14.46h	15.25h	14.50h	14.74D	100.00g	100.00g	100.00g	100.00C
1000 ppm	23.70b	24.67a	24.25a	24.21A	128.64b	131.63a	132.60a	130.96A
3000 ppm	20.68d	23.45b	20.83d	21.65B	102.40f	122.06c	118.94d	114.47B
5000 ppm	16.75g	22.75c	19.26f	19.59C	85.86i	104.23e	94.57h	94.89D
Mean	18.90B	21.53A	19.71A		104.23B	114.48A	111.53A	

There is no significant difference among means have the same letter either in the same column or in the same raw (DNMRT).

of salinity without kaolin emulsion application. In general, the combinations between salinity at any level and 3 % kaolin level gave better results than with kaolin at 5 %. However, the highest records of different growth parameters were obtained in the two seasons by a combination of 1000 ppm saline water and 3 % kaolin concentration, as this combined treatment gave the utmost high mean values at all relative to all the other combinations in the 1st and 2nd seasons. Furthermore, combining between 3000 ppm saline water level and 3 % one, as well between 1000 ppm saline water treatment and 5 % kaolin level improved some growth traits in the two seasons giving the second rank after the superior combination mentioned before.

Flowering Parameters: It can be seen from data averaged in Tables (8 and 9) that mean values of No. inflorescences/plant, No. bracts/inflorescence and bract area (cm^2) were significantly increased in response to 1000 and 3000 ppm saline water treatments to be higher than those scored by either the control or 5000 ppm salinity treatment in the two seasons. However, the dominance was for 1000 ppm salinity treatment which elevated the values of these flowering characteristics to the maximum in both seasons, followed by 3000 ppm salinity treatment that come into the second position. It was also noticed that irrigating plants with 5000 ppm saline water attained higher means of No. inflorescences/plant and bract area than the control treatment with mostly significant differences in the two seasons, but insignificantly decreased the No. bracts/inflorescence compared to the control in both seasons.

The opposite was the right concerning kaolin application, where the two levels of kaolin (3 and 5 %) induced significant increases in the mean values of the aforenamed flowering traits with excellence of 3 % kaolin level which slightly improved the means of such traits over 5 % that of kaolin level with non-significant differences between them in the two seasons. The interaction treatments exerted also a marked effect on flowering traits giving an additional improvement in the means of such traits by combining between saline water irrigation and kaolin foliar spraying which fulfilled higher mean values in the two seasons compared to the irrigation with only saline water, with the prevalence of both 1000 ppm saline water + 3 % kaolin and 5 % kaolin combined treatments, giving the highest averages in both seasons.

The Salinity Resistance Index (SRI %): A similar response to that of growth and flowering traits was occurred as well in respect of SRI %, where saline water level of 1000 ppm increased the percent of this index to the maximal values (120.7 and 130.9 %) in both seasons, respectively followed by 3000 ppm salinity level. The least percentages of such index were obtained in plants with saline water at 5000 ppm level. Nevertheless, these percentages were decreased only to 93.32 % in the 1st season and to 94.89 % in the 2nd one pointing the improvement in the ability of poinsettia plants to withstand salinity under the conditions of this study, the kaolin application increased the means of such index to the utmost high values by either 3 % or 5 % levels. The combining between irrigation with 1000 ppm saline water and spraying with 5 % kaolin emulsion gave the highest percentage of SR index in the first season, but in the second one, it was true with the combined treatments of 1000 ppm saline water and 3 or 5 % kaolin concentrations.

Chemical Composition of the Leaves: The concentrations of chlorophyll a, b and carotenoids (mg/g f.w.) and the percentages of total carbohydrates, N and P were linearly decreased with increasing salinity level Tables (10 and 11), with the exception of 1000 ppm level which increased chlorophyll a and N % over the control, as well as both 1000 and 3000 ppm levels that raised chlorophyll b to higher concentrations than that of control treatment. On the other side, the gradual increment in salinity level was accompanied by a progressive increase in the contents of K, Na and proline in leaves.

As for the effects of kaolin treatments, it was found that both levels of kaolin (3 and 5 %) increased chlorophyll a, total carbohydrates, N, P, K and proline concentrations and 3 % level was the most effective. The opposite was the right regarding chlorophyll b, carotenoids and Na concentrations, which were gradually decreased with the gradual increase in kaolin level. The interaction treatments however showed fluctuant the effect on concentrations of the previous constituents without a specific trend.

Table 10: Effect of irrigation salinity, kaolin and their interactions on concentrations of some constituents in the leaves of *Euphorbia pulcherrima* Wild. Ex. Klotzsch transplants during 2021 season

	Kaolin levels											
	0%	3%	5%		0%	3%	5%		0%	3%	5%	
Salinity (ppm)	---Chlorophyll a (mg/g f.w.)---			Mean	---Chlorophyll a (mg/g f.w.)----			Mean	-----Carotenoids (mg/g f.w.)----			Mean
0.00 ppm	0.767	1.183	0.956	0.969	0.578	0.381	0.267	0.409	0.393	0.371	0.223	0.329
1000 ppm	0.935	1.191	1.033	1.053	0.786	0.769	0.693	0.749	0.321	0.289	0.268	0.293
3000 ppm	0.904	0.82	0.738	0.821	0.611	0.907	0.439	0.652	0.265	0.220	0.196	0.227
5000 ppm	0.765	0.67	0.668	0.701	0.445	0.355	0.263	0.354	0.228	0.199	0.195	0.207
Mean	0.843	0.966	0.849		0.605	0.603	0.416		0.302	0.27	0.221	
	Total carbohydrates (%)				N (%)				P (%)			
0.00 ppm	43.81	57.76	45.43	49.00	1.990	2.660	2.210	2.290	0.563	0.771	0.701	0.678
1000 ppm	46.18	50.10	46.55	47.61	1.670	2.880	2.430	2.330	0.548	0.728	0.507	0.594
3000 ppm	41.75	53.46	46.21	47.14	1.560	2.630	2.100	2.100	0.396	0.536	0.51	0.481
5000 ppm	40.33	51.83	45.86	46.01	1.430	1.790	1.530	1.580	0.298	0.387	0.336	0.34
Mean	43.02	53.29	46.01		1.660	2.490	2.070		0.451	0.606	0.514	

Table 11: Effect of irrigation salinity, kaolin and their interactions on potassium, sodium and proline concentrations in the leaves of *Euphorbia pulcherrima* Wild. Ex. Klotzsch transplants during 2021 season

	Kaolin levels											
	0%	3%	5%		0%	3%	5%		0%	3%	5%	
Salinity (ppm)	--------Potassium (%)-------			Mean	------Sodium (mg/g d.w.)------			Mean	----Proline (mg/100 g d.w.)----			Mean
0.00 ppm	1.7	1.85	1.73	1.76	0.679	0.51	0.493	0.559	25.33	40.51	28.85	31.56
1000 ppm	1.85	2.1	1.98	1.98	1.282	1.119	1.011	1.137	43.1	47.56	45.61	45.42
3000 ppm	1.96	2.23	2.13	2.11	1.459	1.288	1.063	1.27	45.86	64.39	50.7	53.65
5000 ppm	2.37	2.76	2.5	2.54	1.936	1.686	1.315	1.646	63	68.1	64.51	65.2
Mean	1.97	2.24	2.09		1.338	1.151	0.971		44.32	55.14	47.42	

In conclusion, it is preferable to spray the foliage of poinsettia plants grown under saline water irrigation up to 3000 ppm with the kaolin emulsion at 3 %, three times at monthly interval during the growth period to get the best performance of growth and flowering.

DISCUSSION

Results of the current work showed that saline water irrigation at 3000 or 5000 ppm caused a deleterious effect on both growth and flowering of poinsettia plants. This may be due to that saline water is not readily available to plants causing physiological water stress, the excess of some ions, mainly Na^{+} and Cl^{-} leads not only to ion imbalance in cells of plants, but also to ion toxicity, lowers cell turgor and cell expansion and causes tissue necrosis, yellowing, drying and falling of the leaves [9]. They added that salinity could affect water relations and photosynthetic capacity in plants by stomatal closure or through the direct effect of the salts on the photosynthetic apparatus. Salts also affect photosynthetic enzymes, formation of chlorophylls and other pigments, stomatal density, reactive oxygen species (Ras) accumulation and the activity of antioxidant enzymes [2]. In this concern, Valdes *et al*., [5] found that damage to poinsettia plants, (decreasing bract area, leaf number and aerial parts dry weight) was noticed in plants irrigated with saline water, which gradually increased with increasing salts level from 1000, 1300 and 1600 ppm up to 3000 ppm. Likewise, Gent *et al*., [6] reported that exposing *Euphorbia pulcherrima* cv. “Prestige Red” to potting medium salinity (2750-5000 ppm) gave lower height, decreased the total laminar area and dry biomass and the Na % in stem was the highest. Also, Gent *et al*., [7] revealed that addition of 500 ppm NaCl to a standard fertilizer solution under partial-saturation irrigation caused higher reduction in growth and fresh weight of two poinsettia cultivars than under full-saturation regime. Na concentrations in bract leaf and stem tissues were higher in plants exposed to salinity, but K in stems and P in bracts were less.

In this study, low the saline water level (1000 ppm) hastened some growth characters, especially in plants sprayed kaolin emulsion at 3 %, which ascribed to the effect of kaolin antitranspirant in reducing some physiological troubles of low salinity and creating better circumstances more suitable for good and healthy plant growth. In this respect, Mostafa [4] claimed that addition of IBA at 1250-1500 ppm combined with low salinity level (up to 900 ppm) greatly improved rooting %, length and dry weight of roots, leaf area, number and dry biomass of the new transplants at poinsettia.

On the other side, the foliar spraying with kaolin emulsion especially at 3 % level improved growth, flowering and chemical composition of poinsettia plants. This may be attributed to the role of such antitranspirant in improving plant water potential, nutrition and photosynthesis process, activating hormones and enzymatic systems with reducing degradation and transpiration processes [16]. Coating the plant leaves with kaolin particle film reduces the heat stress; solar injury makes a barrier between the pests and their host plant and conserves irrigation water helping the plants to survive well under abiotic stress, e.g. drought and salinity [18]. Such benefits were demonstrated by Noor El-Deen *et al*., [13] who recommended irrigating *Zinnia elegans* plant with only 80 % of F.C. and spraying with kaolin at 3 % concentration to improve growth, flowering and chemical constituents in the leaves. Similarly, Abd-Elmoneim *et al*., [14] mentioned that irrigating *Cyperus alternifolius* plants with only 75 % of WHC and spraying their foliage with either 200 ppm $CaCO_3$ or 3 % kaolin improved the different growth and chemical measurements without declining their quality or aesthetic value.

On the other crops, Javan *et al*., [16] cited that application of kaolin at a concentration of 6% to soybean grown under limited irrigation significantly increased stem length, node number, stem diameter, No. pods and seeds, seed weight and yield and harvest index. Alvarez *et al*., [17] noticed that spraying of either kaolin or calcium carbonate at 2.5 % concentration for each on apple fruits showed a thermic protective effect compared to control, but kaolin was significantly more effective than $CaCO_3$. Maletsika and Nanos [18] found that repeated spraying of kaolin resulted a highly reflective white coat on olive leaf surfaces which significantly reduce the available photosynthetically active radiation on leaf surface underneath the coat. Leaves sprayed with kaolin-treated seemed to manage better their water status and had more stable physiological characters and less negative midday stem water potential during the period of experiment. On grapevine cv. Touriga Nacional subjected to summer stress, Dinis *et al*., [19] reported that kaolin application increased amounts of total phenols, flavonoids, anthocyanins and vit. C in mature grape berries than fruits of control vines and important changes were also found in the leaves. Kaolin application improved the antoxidant capacity in berries due to regulating secondary metabolism at the transcriptional level through the increase in the transcript abundance of genes encoding phenylalanine ammonia lyase and chalcone synthase. Moreover, Dinis *et al*., [20] added that the kaolin-treated grapevines showed after 2 months from application, during the hottest midday a significant higher quantum yield of PSII photochemistry, flux ratios, maximum trapped excitation flux of PSI, absorption flux, electron transport flux, maximum trapped energy flux per cross section and performance index than plants under control conditions in the wormer year. These results support the hypothesis that the accumulation of active PSII reaction centers was associated with decreased susceptibility to photo inhibition in the kaolin-treated plants and with more efficient photochemical quenching.

The gains of this trial are in accordance with that of Glenn [21] who observed that fruit mass of apple was increased by spraying with calcined kaolin-based particle films (PKPF) at either 3 or 12 %. Red fruit colour was increased over the control and photosynthetically active radiation (PAR) was the least by 12 % PKPF treatment and intermediate by 3 % PKPF one relative to control. Temperature of the whole canopy was significantly decreased from 26°C for the control to 24°C for PKPF treatments (either 3 or 12 %). Calcined kaolin acts as an effective catalyst for ozone degradation and organic materials, such as alfalfa due to the direct reaction with carbon molecules. Combing between 2.7 % PKPF and 0.3 % alfalfa dust consistently had higher photosynthesis than control and than the individual using of either 0.3 % alfalfa or 3 % PKPF treatments. Thus, chronic ozone damage can be reduced to a significant degree by the use of calcined Koalin which catalyze ozone degradation in its particle film and the use of such material may be one of tools to mitigate not only increased ozone stress, but also heat stress from increased temperatures of the growing season in the future. On tomato, Abdallah *et al*., [22] found that spraying kaolin at 3 and 5 % concentrations increased the relative water content (RWC) and reduced the canopy temperature. Kaolin significantly reduced water requirement by about 21 % of that applied to control plants without significant reduction in yield or fruit quality.

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