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EFFECT OF SOME BIOSTIMULATING SUBSTANCES ON ZONAL GERANIUM GROWTH AND FLOWERING UNDER IRRIGATION WATER SALINITY

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ABSTRACT: This pots investigation was carried out during the two successive growing seasons of 2019 and 2020 at the Nursery of Ornamental plants, Horticulture Department, Faculty of Agriculture, Minia University, to examine the response of pink zonal geranium (*Pelargonium* × *hortorum* L.H. Bailey) plants, grown in sandy calcareous soil, to four levels of salinity and three treatments of biostimulants (seaweed extract, amino acid and control) as well as their interaction in terms of different vegetative growth parameters, root characters, flowering aspects and some chemical composition. The results pointed out that vegetative growth traits (plant height, number of branches and number of leaves/plant), root growth parameters (root fresh and dry weights), flowering aspects (number of inflorescences/plant and diameter of inflorescence) as well as photosynthetic pigments, N, P and K % were significantly decreased as a result to irrigation with saline water with the highest reductions were obtained with 0.75%. At the same time, salinity treatments increased Na, Ca and Cl % and proline content (mg/g f.w.). In addition, application of plants with any of the biostimulants (seaweed extract or amino acid, each at 200 ppm) led to a significant increase in all previous characteristics of vegetative growth, root growth, flowering aspects and some chemical composition (N, P, K and Ca %) compared to control. Therefore, biostimulant treatments decreased both Na and Cl % as well as proline content (mg/g f.w.). The combination treatments of tap water with amino acid (200 ppm) were superior than other interaction treatments for all studied parameters except in K %.

Key words: *Pelargonium* × *hortorum*, salinity, seaweed extract, amino acids, vegetative growth, chemical composition

INTRODUCTION

The zonal (cutting) geranium perennially ranks among the top five greenhouse flowering potted plants in total production units and whole value in the United States (Tayama and Carver, 1990). *Pelargonium* × *hortorum* L.H. Bailey, zonal geranium, belonging to the Family Geraniaceae are among the most economically important bedding and pot plants. Currently, North America and Europe are the major producers and distributors of zonal pelargonium with global annual sales amounting to $700 million (Mithila *et al*., 2001).

About one-third of nearly 160 million hectares of cultured land under irrigation universally, is already salt-affected soils (Singh and Chatrath, 2001). Salinity stress seriously affected more than a third of the world's cultivated lands (Bayat *et al*., 2012), caused many harmful effects on plants, a sharp decrease in the yield of many plants and biomass, leads to growth reduction as well as metabolic changes (Abdelaal, 2015 and El-Banna and Abdelaal, 2018).

Seaweed extracts are an important source of plant growth regulators, containing amino acids, mineral nutrients, organic osmolites, vitamins, and vitamin precursors. In recent years, the use of natural seaweed extract as plant growth stimulation has allowed for its replacement in place of traditional synthetic fertilizers (Sahoo, 2000 and Khan *et al*., 2009).

Amino acids are a well-known biostimulating material that has positive effects on plant growth, flowering, yield and significantly mitigates the adverse effects caused by abiotic stresses (Kowalczyk and Zielony, 2008).

Therefore, the aim of the present study was to evaluate the role of some biostimulants (seaweed extract and amino acid, each at 200 ppm) in reducing the harmful effects of irrigation water salinity on zonal geranium (*Pelargonium × hortorum* L.H. Bailey) plants under Minia city conditions.

MATERIALS AND METHODS

A pot investigation was carried out during the two successive growing seasons of 2019 and 2020 at the Nursery of Ornamental plants, Horticulture Department, Faculty of Agriculture, Minia University, Egypt. Cutting of *pelargonium zonal* (*Pelargonium × hortorum* L.H. Bailey) were obtained from the Nursery. Average cut length was 12.0 cm and the cutting diameter was 0.6 cm, having 3 leaves. The experimental was arranged in a randomized complete block design (RBCD) in a split plot design with three replicates, each replicate containing 6 cuttings. The main plot (A) includes four levels of irrigation water salinity (0.25, 0.50 and 0.75%, equal 2.5, 5.0 and 7.5 g/l of both NaCl + $CaCl_2$ w/w)), while three treatments of biostimulants (seaweed extract, amino acid, each at 200 ppm, and control) occupy the sub plot. Therefore, the experiment consists of 12 treatments. The physical and chemical analyses of the used soil were presented in Table (a).

Algeser product contains seaweed extract, which was released from Shoura Chemical Company, Cairo-Alexandria Desert Road, Giza Governorate, Egypt. The chemical properties of the seaweed extract used in the experiment in both seasons were presented in Table (b). Also, Aminoactal product contains a blend of three amino acids (methionine, treptophan and cysteine), also, was obtained from Shoura Chemical Company.

Table a. Physical and chemical analysis of the used soil during the two seasons of 2018/2019 and 2019/2020.

Soil characters	Values		Soil characters	Values	
	2018/2019	2019/2020		2018/2019	2019/2020
Physical properties:			**Exchangeable nutrients (mg/100 g soil):**		
Sand (%)	90.0	91.0	**Ca^{++}**	8.21	8.43
Silt (%)	7.30	6.40	**Mg^{++}**	1.53	1.59
Clay (%)	2.70	2.60	**Na^{+}**	0.99	1.05
Soil type	Sandy	Sandy	**K^{+}**	0.92	1.03
Chemical properties:			**DTPA-Extractable nutrients:**		
pH (1:2.5 paste)	8.15	8.25	**Fe (ppm)**	1.12	1.28
E.C. (dS/m)	1.07	1.10	**Cu (ppm)**	0.40	0.44
O.M. (%)	0.05	0.04	**Zn (ppm)**	0.35	0.29
$CaCO_3$ (%)	14.88	14.90	**Mn (ppm)**	0.55	0.66

Table b. Chemical properties of seaweeds extract used in both seasons of 2019 and 2020.

Character	Values	Character	Values
Moisture (%)	6.0	**S (%)**	3 – 9
O.M. (%)	45 – 60	**Mg (%)**	0.5 – 0.9
Inorganic matter (%)	45 – 60	**Cu (ppm)**	1.0 – 6.0
Protein (%)	6 – 8	**Fe (ppm)**	50 – 200
Carbohydrate (%)	35 – 50	**Mn (ppm)**	5 – 12
Aliginic acid (%)	10 – 20	**Zn (ppm)**	10 – 100
Mannitol (%)	4 – 7	**B (ppm)**	20 – 100
Total N (%)	1.0 – 1.5	**Mo (ppm)**	1 – 5
P (%)	0.02-0.09	**Cytokinins (%)**	0.02
K (%)	1.0 – 1.2	**IAA (%)**	0.03
Ca (%)	0.2 – 1.5	**ABA (%)**	0.01

Cuttings were planted in the last week of February 2019 and 2020 in plastic pots (20 cm diameter). Each was filled with 4.0 kg sandy calcareous soil in the Nursery of Ornamental plants, each contained 3 cuttings and seedlings were thinned to one seedling/pot after one month from planting date (last week of March). The irrigation water salinity started on the first day of April and was repeated every two days with 300 ml/pot tap water or saline solution and continued until the end of the experiment (last week of September). Both seaweed extract and amino acid were applied 5 times at one-month intervals, starting from 7th April.

Data recorded:

Vegetative growth traits (plant height, number of branches and number of leaves/plant), root growth parameters (root fresh and dry weights), flowering aspects (number of inflorescences/plant and diameter of inflorescence) as well as some chemical composition [photosynthetic pigments and proline content (mg/g f.w), N, P, K, Ca, Na and Cl (%)].

N, P, K, Ca, Na and Cl content of leaves were done as described by ICARDA (2013). Chlorophyll content in fresh leaves samples (mg/g. f.w.) according to Fadl and Sari El–Deen (1978). Proline content was determined according to Bates *et al.* (1973) method.

The obtained results were tabulated and statistically analyzed according to MSTAT–C (1986), and LSD test at 5% was followed to compare the means of treatments.

RESULTS

1. Vegetative growth traits:

Data presented in Table (1) showed that all vegetative growth parameters of zonal pelargonium (plant height, number of branches and number of leaves/plant) were significantly decreased by using the **s**alinity treatments (0.25, 0.50 and 0.75%) as compared to the control in both seasons. It could be noticed that the greatest vegetative growth was obtained with control, while the lowest vegetative growth was recorded with the high irrigation water salinity level (0.75%).

These results were in agreement with those recorded by Valdés *et al*. (2015) and Breś *et al*. (2017) on *Pelargonium* × *hortorum*; Fornes *et al*. (2007) on *Petunia hybrid*, Cassaniti *et al*. (2009) on *Grevillea juniperina*, Khalid *et al*. (2014) on *Nigella sativa*; Rehman *et al*. (2014) on Kardinal (Rose), García-Caparrós *et al*. (2016) on *Aloe vera*, Ahir *et al*. (2017) on Tuberose, Francisco *et al*. (2017) on *Catharanthus roseus*, Shahmoradi and Naderi (2018) on winter jasmine, and Gadallah *et al*. (2020) and Singh *et al*. (2021) on *Pelargonium graveolens*.

Regarding the impact of biostimulants treatments on vegetative growth traits, the two used treatments of biostimulants (seaweed extract and amino acid, each at 200

Table 1. Effect of irrigation water salinity and some biostimulants treatments on plant height, number of branches and number of leaves/plant of zonal geranium plants during the first and second seasons.

Biostimulants treatments (B)	Irrigation water salinity levels (%) (A)									
	0.0	0.25	0.50	0.75	Mean (B)	0.0	0.25	0.50	0.75	Mean (B)
	The 1st season (2019)					The 2nd season (2020)				
	Plant height (cm)									
Control	23.00	21.00	13.00	11.00	17.00	23.46	21.42	13.26	11.22	17.34
Seaweed extract (200 ppm)	25.30	24.79	23.83	22.81	24.18	25.81	25.29	24.31	23.27	24.67
Amino acid (200 ppm)	26.56	26.01	24.99	23.74	25.33	27.09	26.53	25.49	24.21	25.83
Mean (A)	24.85	23.93	20.61	19.18		25.45	24.41	21.02	19.57	
L.S.D. at 5%	A: 0.93		B: 0.28		AB: 0.56	A: 1.02		B: 0.29		AB: 0.58
	Number of branches/plant									
Control	4.00	2.67	2.60	2.23	2.88	4.08	2.72	2.65	2.28	2.93
Seaweed extract (200 ppm)	4.67	3.33	3.00	2.33	3.33	4.76	3.40	3.06	2.38	3.40
Amino acid (200 ppm)	6.00	4.66	3.33	2.67	4.17	6.12	4.75	3.40	2.72	4.25
Mean (A)	4.89	3.55	2.98	2.41		4.99	3.62	3.04	2.46	
L.S.D. at 5%	A: 1.34		B: 0.70		AB: 1.40	A: 1.39		B: 0.71		AB: 1.48
	Number of leaves/plant									
Control	14.33	12.00	9.33	7.00	10.67	14.41	12.20	9.53	7.68	10.96
Seaweed extract (200 ppm)	15.00	14.30	12.20	9.10	12.65	14.86	14.00	12.00	9.00	12.49
Amino acid (200 ppm)	16.80	16.00	13.00	11.33	14.28	17.00	16.11	13.31	11.46	14.47
Mean (A)	15.80	14.10	11.51	9.14		15.46	14.10	11.62	9.38	
L.S.D at 5%	A: 1.20		B: 0.40		AB: 0.80	A: 1.30		B: 0.34		AB: 0.68

ppm) significantly increased all studied vegetative growth parameters in both seasons compared to the control. The treatment of amino acid was more effective than seaweed extract in both seasons.

Many researchers proved the enhancement effect of biostimulants on vegetative growth characters, such as Krajnc *et al*. (2012) on zonal pelargonium. Youssef (1997) on *Delphinium ajacis*, Thirumaran *et al*. (2009a), on *Abelmoschus esculentus*, Thirumaran *et al*. (2009b) on cluster bean, Akila and Jeyadoss (2010) on *Helianthus annus*, Sridhar and Rengasamy (2010) and Nofal *et al*. (2021) on *Tagetes erecta*, Abd El-Aziz *et al.* (2011) and Kumareswari and Rani (2015) on *Amaranthus*, De Luncia and Vecchietti (2012), on *Lilium*, Talib *et al.* (2012) and Nofal *et al.* (2015) on *Calendula officinalis*, Hassan (2016) and Khalil (2021) on *Gladiolus grandiflorus*, and Roshani and Asadi-Gharneh (2019) on *Pelargonium graveolens*, concerning the important role of seaweed extract.

In addition, Hassn *et al*. (2015) on *Pelargonium × hortorum*, Abd El-Aziz *et al.* (2009), Hassan (2016) and Khalil (2021) on gladiolus, De lunica and Vecchietti (2012) and El-Naggar *et al.* (2013) on *lilium*, Nazmy and Arafa (2017) on *Calendula officinalis*, Nosir and El-Kinany (2019) on *Rosa hybrida*, Roshani and Asadi-Gharneh (2019) on *Pelargonium graveolens*, and El-Kinany (2020) on pansy plants, concerning the effect of amino acids.

The interaction between main and sub-plots treatments was significant for plant height, number of branches and number of leaves/plant in both seasons. Irrigated plants with tap water or low salinity level (0.25 %) in combination with amino acid led to produce the greatest values.

2. Root growth parameters:

Data presented in Table (2) clarified that irrigation water salinity treatments (0.25, 0.50 and 0.75%) had negative effects on fresh and dry weights of roots in both seasons compared with the control. The reduction in the root fresh weight due to 0.75% was 11.31% in both seasons compared with the control. While 0.75% salinity level declined root dry weight by

Table 2. Effect of irrigation water salinity and some biostimulants treatments on root growth and flowering parameters of zonal geranium plants during the first and second seasons.

Biostimulants treatments (B)	Irrigation water salinity levels (%) (A)									
	0.0	0.25	0.50	0.75	Mean (B)	0.0	0.25	0.50	0.75	Mean (B)
	The 1st season (2019)					The 2nd season (2020)				
	Root fresh weight (g)									
Control	18.24	16.80	16.44	15.60	18.24	20.06	18.48	18.08	17.16	18.45
Seaweed extract (200 ppm)	20.28	19.80	19.32	18.24	20.28	22.31	21.78	21.25	20.06	21.35
Amino acid (200 ppm)	21.96	21.48	21.00	19.80	21.96	24.16	23.63	23.10	21.78	23.17
Mean (A)	20.16	19.36	18.92	17.88	20.16	22.18	21.30	20.81	19.67	
L.S.D. at 5%	A: 0.82		B: 0.25		AB: 0.50	A: 0.90		B: 0.27		AB: 0.54
	Root dry weight (g)									
Control	5.47	5.04	4.93	4.68	5.03	6.02	5.54	5.42	5.15	5.53
Seaweed extract (200 ppm)	6.08	5.94	5.80	5.47	5.82	6.69	6.53	6.38	6.02	6.41
Amino acid (200 ppm)	6.59	6.44	6.30	5.94	6.32	7.25	7.09	6.93	6.53	6.95
Mean (A)	6.05	5.81	5.68	5.36		6.65	6.39	6.24	5.91	
L.S.D. at 5%	A: 0.26		B: 0.10		AB: 0.20	A: 0.30		B: 0.15		AB: 0.30
	Number of inflorescences/plant									
Control	6.00	4.00	3.00	1.00	3.50	6.03	4.20	3.15	1.05	3.61
Seaweed extract (200 ppm)	6.10	5.93	5.70	5.47	5.80	6.41	6.23	5.99	5.74	6.09
Amino acid (200 ppm)	7.32	7.17	7.03	6.75	7.07	7.69	7.53	7.38	7.09	7.42
Mean (A)	6.47	5.70	5.24	4.41		6.71	5.99	5.51	4.63	
L.S.D at 5%	A: 0.78		B: 0.09		AB: 0.18	A: 0.74		B: 0.11		AB: 0.22
	Diameter of inflorescence (cm)									
Control	7.40	7.00	6.00	4.00	6.10	7.70	7.28	6.24	4.16	6.35
Seaweed extract (200 ppm)	7.77	7.35	6.30	4.20	6.41	8.09	7.64	6.55	4.37	6.66
Amino acid (200 ppm)	7.84	7.69	7.53	7.22	7.57	8.15	7.99	7.83	7.51	7.87
Mean (A)	7.67	7.35	6.61	5.14		7.98	7.64	6.78	5.35	
L.S.D at 5%	A: 0.34		B: 0.08		AB: 0.16	A: 0.36		B: 0.09		AB: 0.18

11.41 in the first season, and by 11.13% in the second one comparing to the control (16.80) in the first season, and 17.75, 17.34 and 16.39 cm in the second season compared with the control (18.48), respectively. The other two salinity treatments (0.25 and 0.50%) gave an intermediate values.

Similar results were recorded by Bahadoran and Salehi (2015) on *Polianthes tuberosa* and Ahmed (2017) on Rose China and Raslan.

Regarding the impact of the biostimulants treatments, data listed in Table (2) indicated that using either seaweed extract or amino acid, each at 200 ppm, significantly improved root fresh and dry weights compared with control in both seasons. Amino acid treatment was superior to seaweed extract in this concern in both seasons. Such superior treatment increased root dry weight by 8.59% in the first season and 8.42% in the second season compared to seaweed extract, respectively.

The enhancement influence of seaweed extract on root fresh and dry weights were reported by Krajnc *et al*. (2012) on zonal geranium Thirumaran *et al*. (2009a) on *Abelmoschus esculentus*, Thirumaran *et al*. (2009b) cluster bean and Osman and Salem (2011) on sunflower, concerning the effect of seaweed extract. Whereas, Shehata *et al*. (2011) on celeriac plants and Roshani and Asadi-Gharneh (2019) on *Pelargonium graveolens*, regard to the impact of amino acid.

The interaction between the main and sub-plots treatments (A × B) was significant for root fresh and dry weights in both seasons. Planting pelargonium zonal in sandy calcareous soil, irrigated with unsalinized water or low salinity water (0.25%) and sprayed with amino acid (200 ppm) produced the heaviest root fresh and dry weights as clearly shown in Table (2).

3. Flowering parameters:

Data in Table (2) indicated that number of inflorescence/plant and diameter of inflorescence were reduced by increasing salinity level, till 0.50 and 0.75% salinity levels significantly decreased both characters in two growing seasons compared to the control.

Similarly, the same trends were obtained by Grieve and Poss (2010) on ornamental sunflower, Ahmad *et al*. (2013) on *Rosa hybrid*, Chauhan and Ambast (2014) on marigold, Bahadoran and Salehi (2015) on *Polianthes tuberosa* and Ahmed (2017) *Hibiscus rosa-sinensis*.

Data presented in Table (2) showed that number of inflorescence/plant and diameter of zonal geranium inflorescence was significantly increased by using seaweed extract or amino acid, each at 200 ppm, compared to the control in both seasons. Moreover, amino acid treatment was more effective than seaweed extract in this concern.

Many authors proved the augmented effects of seaweed extract on diameter of inflorescence such as Abd El-Aziz *et al.* (2011) on *Amaranthus tricolor* and Talib *et al*. (2012) on *Calendula officinalis*. Also, the improvement roles of amino acid on diameter of inflorescence were recorded by Afifipour and Kosh-Khui (2015) on *Polianthes tuberose* and Mahdi and Saeed (2019) on gerbera plants.

The interaction between the two experimental factors (A × B) was significant for number of inflorescence/plant and diameter of inflorescence in both seasons. The best interaction treatments were to plants irrigated with tap water or a low level of salinity (0.25%) and plants sprayed with amino acid at 200 ppm.

4. Chemical composition:

a. Photosynthetic pigments:

Data presented in Tables (3) indicated that all used salinity treatments (0.25, 0.50 and 0.75%) significantly decreased chlorophyll a, b and carotenoids as compared to control in both seasons. The treatment of 0.75% saline water resulted the greatest reduction in chlorophyll a (2.467 and 2.491 mg/g f.w.), chlorophyll b (0.782 and 0.788 mg/g f.w.) and carotenoids (0.813 and 0.829 mg/g f.w.) in the first season. While the low level of salinity (0.25%) slightly decreased photosynthetic pigments. The same trend was obtained in the second season.

Similar results were obtained by Valdés *et al*. (2015), Breś *et al*. (2016) and Breś *et al*. (2017) on *Pelargonium × hortorum*, Garnett *et al*. (2002), Khetsha and Sedibe (2015) and Singh *et al*. (2021) on *Pelargonium graveolens*, Khalid *et al*. (2010), Al-Khafajy *et al*. (2020) and El-Shawa *et al*. (2020) on *Calendula officinalis*, Bahadoran and Salehi (2015) and Ahir *et al*. (2017) on *Polianthes tuberosa*, Ahmed (2017) on Rose China and Shahmoradi and Naderi (2018) on winter jasmine.

Regarding the effect of biostimulants (seaweed extract and amino acid, each at 200 ppm), using each of them significantly increased chlorophyll a, b and carotenoids as compared with control (Table, 3). Moreover, amino acid treatment was more effective in this concern.

Several researchers demonstrated the positive impact of seaweed extract on photosynthetic pigments such as Krajnc *et al*. (2012) on *Pelargonium × hortorum*, Blunden *et al*. (1997), on some plant species, Thirumaran *et al*. (2009a) on *Abelmoschus esculentus*, Thirumaran *et al*. (2009b) on cluster bean, Sridhar and Rengasamy (2010) on *Tagetes erecta*, and Akila and Jeyadoss (2010), on *Helianthus annus*, Abd El-Aziz *et al.* (2011) and Kumareswari and Rani (2015)

Table 3. Effect of irrigation water salinity and some biostimulants treatments on photosynthetic pigments (mg/g f.w.) of zonal geranium plants during the first and second seasons.

Biostimulants treatments (B)	Irrigation water salinity levels (%) (A)									
	0.0	0.25	0.50	0.75	Mean (B)	0.0	0.25	0.50	0.75	Mean (B)
	The 1st season (2019)					The 2nd season (2020)				
	Chlorophyll a (mg/g f.w.)									
Control	2.358	2.003	1.946	1.947	1.989	2.382	2.023	1.966	1.663	2.009
Seaweed extract (200 ppm)	3.655	2.494	2.428	2.414	2.748	3.692	2.519	2.452	2.438	2.775
Amino acid (200 ppm)	3.983	3.807	3.558	3.340	3.672	4.023	3.845	3.593	3.373	3.709
Mean (A)	3.332	2.768	2.644	2.467		3.366	2.796	2.670	2.491	
L.S.D. at 5%	A: 0.088		B: 0.005		AB: N.S.	A: 0.083		B: 0.007		AB: N.S.
	Chlorophyll b (mg/g f.w.)									
Control	0.766	0.648	0.629	0.529	0.643	0.774	0.654	0.635	0.534	0.649
Seaweed extract (200 ppm)	1.201	0.811	0.779	0.785	0.894	1.213	0.819	0.787	0.793	0.903
Amino acid (200 ppm)	1.307	1.249	1.166	1.033	1.189	1.320	1.261	1.178	1.043	1.201
Mean (A)	1.091	0.903	0.858	0.782		1.102	0.911	0.869	0.788	
L.S.D. at 5%	A: 0.062		B: 0.011		AB: N.S.	A: 0.066		B: 0.013		AB: N.S.
	Carotenoids (mg/g f.w.)									
Control	0.806	0.688	0.668	0.569	0.683	0.822	0.702	0.681	0.580	0.696
Seaweed extract (200 ppm)	1.252	0.851	0.829	0.826	0.939	1.276	0.868	0.846	0.843	0.958
Amino acid (200 ppm)	1.346	1.289	1.206	1.043	1.222	1.375	1.315	1.230	1.064	1.246
Mean (A)	1.135	0.943	0.901	0.813		1.158	0.962	0.919	0.829	
L.S.D at 5%	A: 0.092		B: 0.041		AB: N.S.	A: 0.081		B: 0.043		AB: N.S.

on *Amaranthus*, Osman and Salem (2011) on sunflower, De Luncia and Vecchietti (2012), on *Lilium*, Talib *et al*. (2012) on *Calendula officinalis* and Hassan (2016) and Khalil (2021) on *Gladiolus grandiflorus*.

Furthermore, the enhancement effects of amino acid on augmented photosynthetic pigments were reported by Abd El-Aziz *et al.* (2009), Sewedan *et al*. (2012), Hassan (2016) and Khalil (2021) on gladiolus, Ibrahim *et al*. (2010) on *Helichrysum bracteatum*, Mahgoub *et al.* (2011) on *Dahila pinnata*, Rahmatzadeh *et al*. (2012) on *Catharanthus roseus*, Ali and Hassan (2013) on *Tagetes erecta*, Aly *et al*. (2014) on Kapok, Rafiee *et al.* (2013) and Nazmy and Arafa (2017) on *Calendula officinalis* and Roshani and Asadi-Gharneh (2019) on *Pelargonium graveolens*.

The interaction between the main and sub-plots (A x B) was not significant for chlorophyll a, b and carotenoids in both seasons as clearly shown in Table (3).

b. N, P, K and Ca (%):

Data presented in Tables (4) showed that all levels of salinity treatments (0.25, 0.50 and 0.75%) significantly decreased N, P and K percentages in pelargonium leaves, however, they increased Ca (%) as compared to control in both seasons. The highest percentages of N, P and K in the first season reached 2.80, 0.42 and 1.98%, facing the lowest percentages, 2.02, 0.31 and 1.44%, respectively. Similarly, in the second season, the highest values were 2.94, 2.08 and 2.12%, while, the lowest values, 2.12, 0.33 and 1.51%, respectively. For N, P and K%, the highest values were recorded with control treatments in both seasons, while the lowest values were produced with the highest level of saline irrigation water (0.75%). Contrarily, the highest values of Ca % were obtained with the highest level of saline irrigation water as it gave 1.64% and 1.72% in the first and second seasons, respectively.

Table 4. Effect of irrigation water salinity and some biostimulants treatments on N, P, K and Ca (%) of zonal geranium plants during the first and second seasons.

Biostimulants treatments (B)	Irrigation water salinity levels (%) (A)									
	0.0	0.25	0.50	0.75	Mean (B)	0.0	0.25	0.50	0.75	Mean (B)
	The 1st season (2019)					The 2nd season (2020)				
	Nitrogen (%)									
Control	2.34	2.11	1.86	1.67	2.00	2.46	2.22	1.95	1.75	2.10
Seaweed extract (200 ppm)	2.89	2.63	2.33	2.09	2.49	3.03	2.76	2.45	2.19	2.61
Amino acid (200 ppm)	3.18	2.89	2.56	2.30	2.73	3.34	3.03	2.69	2.42	2.87
Mean (A)	2.80	2.54	2.25	2.02		2.94	2.67	2.36	2.12	
L.S.D. at 5%	A: 0.20		B: 0.15		AB: 0.30	A: 0.22		B: 0.18		AB: 0.36
	Phosphorus (%)									
Control	0.37	0.35	0.32	0.27	0.33	0.40	0.37	0.34	0.28	0.35
Seaweed extract (200 ppm)	0.43	0.41	0.37	0.31	0.38	0.45	0.43	0.39	0.33	0.40
Amino acid (200 ppm)	0.47	0.45	0.41	0.35	0.42	0.49	0.47	0.43	0.37	0.44
Mean (A)	0.42	0.40	0.37	0.31		0.44	0.42	0.39	0.33	
L.S.D. at 5%	A: 0.01		B: 0.02		AB: 0.04	A: 0.01		B: 0.02		AB: 0.04
	Potassium (%)									
Control	1.83	1.74	1.57	1.33	1.62	1.92	1.84	1.65	1.40	1.70
Seaweed extract (200 ppm)	2.01	2.00	1.80	1.53	1.84	2.21	2.12	1.89	1.61	1.96
Amino acid (200 ppm)	1.20	1.91	1.72	1.46	1.57	2.11	2.02	1.81	1.53	1.87
Mean (A)	1.98	1.88	1.70	1.44		2.08	1.99	1.78	1.51	
L.S.D at 5%	A: 0.03		B: 0.05		AB: 0.10	A: 0.04		B: 0.06		AB: 0.12
	Calcium (%)									
Control	1.13	1.19	1.31	1.51	1.29	1.19	1.25	1.38	1.59	1.35
Seaweed extract (200 ppm)	1.24	1.31	1.44	1.66	1.41	1.30	1.38	1.52	1.74	1.48
Amino acid (200 ppm)	1.30	1.38	1.51	1.74	1.48	1.37	1.45	1.59	1.83	1.56
Mean (A)	1.22	1.29	1.42	1.64		1.28	1.36	1.49	1.72	
L.S.D at 5%	A: 0.06		B: 0.04		AB: 0.08	A: 0.08		B: 0.05		AB: 0.10

The adverse effects of salinity on NPK were obtained by Cassaniti *et al*. (2009) on *Grevillea juniperina*, Leithy *et al*. (2009) and Khetsha and Sedibe (2015) and Singh *et al*. (2021) on *Pelargonium graveolens*, and Ahmed (2017) on Rose China.

Concerning the impact of biostimulants, data listed in Table (4) clarified that the two treatments of seaweed extract and amino acid, each at 200 ppm, significantly increased NPK and Ca % in both seasons as compared with control. Moreover, amino acid treatment was superior than seaweed extract in increasing the N, P and Ca percentages. On the other hand, seaweed extract was more effective in increasing potassium percentage in pelargonium leaves.

Several researchers pointed out the improvement role of biostimulants on N, P, K and Ca percentages such as Abd El-Aziz *et al.* (2011) on *Amaranthus*, Hassan (2016) and Khalil (2021) on *Gladiolus grandiflorus*, regard to seaweed extract.

Furthermore, the enhancement effects of amino acid on augmented N, P and K percentages were reported by Abd El-Aziz *et al.* (2009), Sewedan *et al*. (2012), Hassan (2016) and Khalil (2021) on gladiolus, Nofal *et al*. (2021) on African marigold.

The interaction between the main and sub-plots (A × B) was significant for N, P, K and Ca percentages in both seasons as clearly shown in Table (4). The highest values of N, P and K percentages were recorded with tap water in combination with amino acid or seaweed extract, each at 200 ppm or irrigated plants with low level of salinity (0.25%) plus amino acid. However, the highest value of Ca percentage was obtained with the highest level of salinity (0.75%) in combination with amino acid at 200 ppm.

c. Na, Cl and proline content:

Data presented in Table (5) proved that unlike the trend of N, P and K%, sodium, chloride and proline contents were significant increase by using any of the three levels of irrigation water salinity (0.25, 0.50 and 0.75%) in pelargonium leaves as compared to control in both seasons.

Similar results were recorded by Valdés *et al*. (2015), Breś *et al*. (2016) and Breś *et al*. (2017) on zonal geranium, Prasad *et al*. (2006) and Leithy *et al*. (2009) on *Pelargonium graveolens*, Fornes *et al*. (2007) on *Petunia hybrida*, Cassaniti *et al*. (2009) on *Grevillea juniperina*, Bahadoran and Salehi (2015) on tuberose Ahmed (2017) on Rose China and García-Caparrós and Lao (2018) on some ornamental plants.

Data presented in Table (5) indicated that spraying plants with biostimulants (seaweed extract and amino acid, each at 200 ppm) significantly decreased both of Na, Cl and proline content as compared to control in both seasons.

The interaction between the main and sub-plots (A × B) was significant for Na, Cl and proline content in both seasons as clearly shown in Table (5). The highest values in the first season (2.13, 1.78%) and 0.497 mg/g f.w., respectively) were recorded with the highest level of salinity (0.75%) without the addition of either amino acid or seaweed extract. Although, the lowest values of Na, Cl and proline in the first season (1.49%, 1.27%) and 0.363 mg/g f.w. were obtained with the lowest level of salinity (0.25 %) in combination with amino acid at 200 ppm. The same trend was observed in the second season.

DISCUSSION

Treated plants with saline irrigation water (0.25, 0.50 and 0.75 %) led to a decrease in all vegetative growth traits, root growth parameters, flowering aspects and photosynthetic pigments as well as NPK %. On the other hand, Na, Ca, Cl and proline contents were increased. These results reflected the negative role of salinity which were explained by many authors as follows:

- Reclaimed wastewater may contain toxic

Table 5. Effect of irrigation water salinity and some biostimulants treatments on sodium, chloride, and proline content of zonal geranium leaves during the first and second seasons.

Biostimulants treatments (B)	Irrigation water salinity levels (%) (A)									
	0.0	0.25	0.50	0.75	Mean (B)	0.0	0.25	0.50	0.75	Mean (B)
	The 1st season (2019)					The 2nd season (2020)				
	Sodium (%)									
Control	1.64	1.73	1.92	2.13	1.86	1.72	1.82	2.02	2.24	1.95
Seaweed extract (200 ppm)	1.56	1.64	1.82	2.02	1.76	1.65	1.72	1.91	2.12	1.85
Amino acid (200 ppm)	1.49	1.57	1.75	1.94	1.69	1.57	1.65	1.83	2.03	1.77
Mean (A)	1.57	1.65	1.83	2.03		1.65	1.73	1.92	2.13	
L.S.D. at 5%	A: 0.07		B: 0.04		AB: 0.08	A: 0.06		B: 0.05		AB: 0.10
	Chloride (%)									
Control	1.39	1.50	1.62	1.78	1.57	1.45	1.56	1.68	1.85	1.64
Seaweed extract (200 ppm)	1.32	1.43	1.54	1.69	1.50	1.37	1.49	1.60	1.76	1.56
Amino acid (200 ppm)	1.27	1.37	1.48	1.63	1.55	1.32	1.42	1.54	1.70	1.50
Mean (A)	1.33	1.43	1.55	1.70		1.38	1.49	1.61	1.77	
L.S.D. at 5%	A: 0.09		B: 0.04		AB: 0.08	A: 0.07		B: 0.03		AB: 0.06
	Proline content (mg/g f.w.)									
Control	0.382	0.402	0.447	0.497	0.432	0.397	0.418	0.465	0.517	0.449
Seaweed extract (200 ppm)	0.374	0.393	0.438	0.487	0.423	0.389	0.409	0.456	0.506	0.440
Amino acid (200 ppm)	0.363	0.381	0.425	0.472	0.410	0.378	0.396	0.442	0.491	0.427
Mean (A)	0.373	0.392	0.437	0.485		0.388	0.408	0.454	0.505	
L.S.D at 5%	A: 0.015		B: 0.08		AB: 0.016	A: 0.018		B: 0.08		AB: 0.016

ions and high concentrations of salt, a problem whose magnitude will depend on the location of any wastewater treatment plant (Bañón *et al*., 2011).

- Salinity caused a disturbance in water relationship resulting in a loss of turgor, inhibition of cell elongation, stomatal closure and a decrease in the intensity of photosynthesis (Munns and Tester 2008; Cassaniti *et al*., 2012).
- One of the first responses of plants to salinity is a decreased rate of leaf growth (Blum, 1986) primarily due to the osmotic effect of salt around the roots, which leads to a reduction in water supply to leaf cells. High external salt concentrations can also inhibit root growth (Wild, 1988), with a reduction in length and mass of roots (Shannon and Grieve, 1999) and of function.

Effect of seaweed extract:

The observed enhancement effect of seaweed extract in this study reflected physiological and biological roles and function of this stimulant material, which were explained by many researchers, that these extracts involved macro and microelements, amino acids and growth regulators (cytokinins, auxin and gibberellins), fatty acids and vitamins (Chapman and Chapman, 1980; Kingman and Moore, 1982).

Effect of amino acid:

The improvement impact of amino acid reflected the physiological role and functional of amino acid which was noted by many authors. Some amino acids can affect plant growth and development through their influence on IAA and GA biosynthesis, and it play an important role in plant metabolism and protein assimilation which are necessary for cell formation, and consequently increase plant weights (Phillips, 1971; Russel, 1982 and Walter and Nawacki, 1987). Also, they buffering the biosynthesis of other organic compounds like, pigments, vitamins, alkaloids, enzymes, co-enzymes, tryptophan, purine and pyrimidine bases (Goss, 1973; Kamar and Omar, 1987).

From the previous physiological and biological studies, it might be concluded that salt stress had negative effects on vegetative growth, root growth, flowering aspects and photosynthetic pigments as well as NPK %, and application plants with stimulant substances (seaweed extract and amino acid) which were responsible for enhancing different physiological processes and alleviate the adverse effects of salinity stress. Which reflected on stimulant various vegetative growth traits, root growth, flowering aspects and some chemical composition, i.e. photosynthetic pigments, N, P, K, Na, Ca and Cl and proline content of zonal geranium (*Pelargonium* x hortorum L.H. Bailey) plants.

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تأثير بعض المواد المنشطة علي نمو وتزهير نبات الجارونيا تحت ظروف ماء الري المالح

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تجارب أُصص تم إجرائها خلال موسمي نمو متعاقبين ٢٠١٩ و٢٠٢٠ بمشتل نباتات الزينة، قسم البساتين، كلية الزراعة، جامعة المنيا، مصر لدراسة استجابة نبات الجارونيا الوردي (*Pelargonium x hortorum* L.H. Bailey) النامي في التربة الرملية الجيرية لأربعة مستويات من الملوحة وثلاث معاملات للمنشطات الحيوية (مستخلص الأعشاب البحرية ، والأحماض الأمينية والكنترول) بالإضافة إلى التفاعل بينهما من حيث صفات النمو الخضري، وخصائص النمو الجذري، والصفات الزهرية وبعض المكونات الكيميائية. أشارت النتائج إلى أن صفات النمو الخضري (ارتفاع النبات، عدد الأفرع وعدد الأوراق/نبات)، معاملات نمو الجذور (وزن الجذر الطازج والجاف)، الصفات الزهرية (عدد النورات/نبات وقطر النورة)، وصبغات التمثيل الضوئي والنسبة المئوية لكلٍ من النيتروجين والفوسفور والبوتاسيوم قد انخفضت معنوياً نتيجة للري بالمياه المالحة، وكانت أكبر الانخفاضات مع الري بماء مالح (٠,٧٥٪). في الوقت نفسه، أدت معاملات الملوحة إلي زيادة كل من النسبة المئوية للصوديوم والكالسيوم والكلوريد ومحتوي البرولين (مليجرام/جرام وزن طازج). بالإضافة إلى ذلك، أدي رش النباتات بأيٍ من المنشطات الحيوية (مستخلص الأعشاب البحرية أو الأحماض الأمينية، بتركيز ٢٠٠ جزء في المليون لكلٍ منهما) إلى زيادة معنوية في جميع الصفات السابقة للنمو الخضري ونمو الجذور والصفات الزهرية وبعض المكونات الكيميائية (النسبة المئوية لكل من النيتروجين و الفوسفور و البوتاسيوم والكالسيوم) مقارنة بالكنترول. وبالتالي، قللت معاملات المنشطات الحيوية كل من النسبة المئوية لكل من الصوديوم والكلوريد وكذلك محتوى البرولين (مليجرام/جرام وزن طازج). تفوقت معاملات التداخل بين الري بماء الصنبور مع الحمض الأميني (٢٠٠ جزء في المليون) على معاملات التداخل الأخرى في كل الصفات المدروسة ماعدا النسبة المئوية للبوتاسيوم.