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Minimizing Salt Stress Negative Effects by Benzyladenine Foliar-Spray Application on Morpho-Physiological and Chemical Characteristics of *Hibiscus rosa-sinensis* Plant

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ABSTRACT

The current study was carried out during the two successive seasons of 2020 and 2021 at Beni-Suef governorate, Egypt, to examine how to mitigate the negative effects of soil salinity (4, 8 and 12 dS/m) on vegetative, root and flowering parameters as well as chemical constituents of *Hibiscus rosa-sinensis* plants through the use of benzyladenine (25, 50 and 100 ppm). Plant height, leaf area, number of branches/plant, root length, roots fresh and dry weights, flower diameter and fresh and dry weights, photosynthetic pigments and NPK percentages, as well as relative water content were significantly and gradually reduced with the rise in soil salinity concentration, due to the highest salinity level (12 dS/m) the lowest values are presented. In contrast, as the three concentrations of benzyladenine increased, all of studied characteristics were improved. Maximum reduction was seen at 12 dS/m soil salinity which found higher increase of the free proline content, sodium and chloride percentages. The most effective foliar application of benzyladenine was at 100 ppm. It was evident that salinity and benzyladenine work in opposition to each other for traits under the study in both seasons. The outcomes of the combined treatment with high salinization and high benzyladenine were comparable to those of the un-salinized/un-benzyladenine treatment. These findings imply that benzyladenine treatments had a beneficial impact on morpho-physiological, chemical characteristics and diminished the negative effects of salinity on *Hibiscus rosa-sinensis* plants.

KEYWORDS: Benzyladenine, *Hibiscus rosa-sinensis*, Relative water content, Soil salinity, Flowering parameters

1. INTRODUCTION

Hibiscus rosa-sinensis L., also known as the Chinese hibiscus, is a large, attractive evergreen shrub that can reach heights of 5-7 m. it is a member of the Malvaceae family. Its leaves are typically simple, ovate in shape and 8–10 cm long, not lobed but toothed or nearly entire, and they are primarily grown as ornamental in subtropical and tropical climates for their profusion of large, showy flowers (Bailey, 1976) or utilized as shrubs in landscaping as noted by Ozmen (2010). It is a readily available plant for some of this plant's pharmacological uses in natural treatments (Sukirti and Prashant, 2011; Anil and Ashatha, 2012 and Shabana et al., 2013). Medicinal benefits are associated with the leaves and flowers (Nadkarni, 1954; Ali and Ansari, 1997 and Kurup et al., 1979). It has been discovered that flowers have a powerful anti-fertility effect (Singh et al., 1982 and Sethi et al., 1986), also to help in the management of arterial hypertension (Dwivedi et al., 1977).

Salt stress is a detrimental element that inhibits growth and crop yield. Worldwide, 37% of agricultural areas are sodic and 23% are subject to salinity regulations (Khan and Duke, 2001). The presence of excessive amounts of soluble salts in the root zone, which affect soil moisture, is referred to as soil salinity. As a result, the osmotic pressure rises, which has an impact on plant growth and restricts root water uptake (Jouyban, 2012). Additionally, it prevents the uptake of critical nutritive ions (Tester and Bacic, 2005). Because of little or erratic rainfall, shoddy water used for irrigation, surrounding farmers' water leaks and surface drainage from high to low places, salinity can start to form in the upper soil layer (30 cm), which will impede crop growth and development and eventually cause physiological drought (Kadamanda and Natarajan, 2017).

Plant hormones are active participants in the signaling chain that induces plant response to stress (Pedranzani et al., 2003). Abiotic stresses influence phytohormone content and reduce plant growth (Morgan, 1990). As a result, exogenous application of plant growth regulators may be a different approach to reduce salt stress. They are in small doses, alter the physiological functions of plants, which, in turn, affects both yield and quality. One of the most active cytokinins is benzyladenine (BA) according to Nair et al. (2002), raising the concentration of BA in crops may be able to counteract the effects of salt stress. It helps preserve or improve the quality of diverse ornamental plants (Han, 2001). The use of benzyl adenine has been demonstrated to have effects on a wide range of physiological and developmental processes such as, leaf senescence and chlorosis, improve the shelf life, preventing the synthesis of ethylene to postpone the senescence of cut carnations (Cook et al., 1985), apical dominance, promoting floral growth, mobilization of nutrients and protecting plants from drought stress (Waterland et al., 2010). The purpose of the current study is to determine whether using various levels of benzyladenine can mitigate the negative effects of soil salinity levels on the growth and flowering parameters and chemical composition of *Hibiscus rosa-sinensis* plants.

2. MATERIALS AND METHODS

A pot experiment was carried out during the two consecutive seasons of 2020 and 2021 at the experimental farm, Faculty of Agriculture, Beni-Suef University to find out the role of benzyladenine foliar-spray application on reducing the negative impact of soil salinity on growth, flowering characters and chemical constituents of *Hibiscus rosa-sinensis* L. plants.

2.1. Layout of the experiment:

A split-plot system based on a randomized complete block design with 3 replicates was used. The main plots included four levels of salinity while four benzyladenine concentration treatments occupied the sup-plots, therefore, the interaction were 16 treatments.

2.2. Experimental Procedure:

Three-months old of Chinese hibiscus transplants of a uniform height 20-22 cm in length and 8-10 leaves were planted on the first week of April for each season in plastic pots (25 cm) filled beforehand with a 6.5 kg of clay loamy soil per pot, mixed with the designated amounts of pure salts NaCl plus $CaCl_2$ (1:1), by weight at the rates of 0, 4, 8 and 12 dS/m as salinity treatments. Before the addition of NaCl + $CaCl_2$ at the beginning of the experiment, physical and chemical characteristics of soil samples have been identified, according to Jackson (1973), as shown in Table a, then the soil was air dried, sieved to a thickness of 2.0 mm, and the moisture availability was adjusted with deionized water to 65% of the soil field capacity. Each pot of plants, including the control plants, received 5 g of N: P: K; 19:19:19 granular fertilizer when the plants were well-established (one month after transplanting), two doses were added 30 days interval. The 6-Benzylaminopurine, also known benzyladenine (BA; BAP) was procured from El-Gomhorya Company, Egypt. The BA was dissolved by adding a few drops of diluted NaOH solution. BA was sprayed three times with three-week intervals onto the leaves until the run-off point at concentrations of 0, 25, 50 and 100 ppm starting after one month from transplanting in the two growing seasons with Triton B as a wetting agent at 0.1% to increase the spray's adhesion to plant foliage and the plants' ability to absorb it.

Table a. Physical and chemical properties of used soil recorded as average of both seasons at the beginning of the experiment.

O.M. %	$CaCO_3$%	Sand%	Silt %	Clay%	Texture class	pH	ECe, dS/m (at 25^0 C)
1.65	2.08	29.30	32.80	37.90	Clay loamy	7.8	1.28
(mg/100 g soil)		**DTPA Ext. ppm**					
Exch. Ca^{++}	31.52	**Fe**	8.20		Total N% 0.09		
Exch. K^+	2.83	**Zn**	2.84				
Exch. Na^+	2.49	**Cu**	2.03				
		Mn	8.19		Available P 15.10%		

Plants used as a control sprayed with tab water only. Additionally, the various agricultural practices required for such a plantation were carried out.

2.3. Data recorded

2.3.1. Vegetative, flowering and root growth parameters:

At the end of each experimental season (on October, 1^{st}), the following data were recorded, plant height (cm), leaf area (cm^2), number of branches/plant, root length (cm), roots fresh and dry weights (g), flower diameter (cm) and fresh and dry weights of flowers (g).

2.3.2. Physiological and Chemical determinations:

The three photosynthetic pigments in Chinese hibiscus fresh leaf including chlorophyll a, b and carotenoids (mg/g F.W.) were assessed in accordance with Moran (1982), whereas for dry leaves, NPK percentages and sodium as well as chloride were evaluated in accordance with Wilde et al. (1985), Chapman and Pratt (1975), Cottenie et al. (1982) and Brown and Jackson (1955) consecutively. Free proline content in dry leaves was detected by an acid-ninhydrin method as outlined by Bates et al. (1973).

2.3.3. Relative water content (RWC %)

A high RWC has been suggested as a simple agricultural feature to use when choosing plants for their salinity tolerance (Saeed et al., 2019). A pair of leaves were cut from each shoot for the RWC calculation, and their fresh weight (FW) was simultaneously recorded. After they were floating in distilled water (at 4 °C) overnight, the re-saturated weight (RW) was calculated. They were then dried overnight in an oven set at 70 °C before being weighed again to determine the dry weight (DW). The RWC was calculated using the following formula, which was provided by

Teulat et al. (2003).

RWC [%] = [(FW - DW) / (RW - DW)] × 100

2.4. Statistical analysis

The collected data were statistically analyzed using variance analysis (ANOVA) according to MSTAT-C (1986), using the least significant difference (LSD) at 5% level of probability to compare between means (Mead et al., 1993).

3. RESULTS AND DISCUSSION

3.1.Vegetative characteristics

Vegetative growth characteristics, namely, plant height, leaf area and number of branches/plant were greatly reduced in both seasons due to salinity levels in compared to un-treated control plants, (Table 1). The reduction in these vegetative characteristics were gradual and parallel to the gradual increase in salinity level with the least values being obtained due to the high salinity level (12 dS/m). This treatment 12 dS/m gave, significantly, the lowest values than control. The numerical reduction due to this treatment compared to untreated treatment reached 15.05, 23.03 and 19.17% for plant height, leaf area and number of branches/plant, respectively, in first season. The corresponding reductions in second season came to 14.09, 22.22 and 19.97% respectively. Additionally, the present experiment findings that salinity has detrimental impacts on vegetative growth which confirmed by El-Naggar and El-Kouny (2011) on roselle, Abdel-Fattah (2014) on jacaranda, Ahmed (2017) and Nofel et al. (2021) on *Hibiscus rosa-sinensis.* The reduction in vegetative growth parameters

Table 1. Influence of soil salinity and benzyladenine foliar-spray application on plant height (cm), leaf area (cm^2) and number of branches/plant of *Hibiscus rosa-sinensis* L. during 2020 and 2021 seasons.

Salinity Treatments (A)	Benzyladenine (B) ppm									
	Control (water)	BA25	BA50	BA100	Mean (A)	Control (water)	BA25	BA50	BA100	Mean (A)
	First season (2020)					Second season (2021)				
Plant height (cm)										
Control(water)	60.80	61.20	62.50	63.80	62.07	64.50	64.80	66.30	67.50	65.77
4 dS/m	53.60	57.10	60.90	62.50	58.52	57.50	61.00	64.80	66.70	62.50
8 dS/m	51.60	54.70	56.30	59.60	55.55	55.30	58.40	60.20	63.50	59.35
12 dS/m	48.30	51.50	57.30	55.30	52.73	52.00	55.30	57.60	61.10	56.50
Mean (B)	53.57	56.12	60.80	60.30		57.32	59.87	62.22	64.70	
L.S.D. at 5%	A: 3.12		B: 2.23		AB: 4.46	A: 3.22		B: 2.13		AB: 4.26
Leaf area (cm^2)										
Control(water)	16.23	17.88	17.92	19.90	17.98	15.12	16.66	17.09	18.10	16.74
4 dS/m	14.67	15.03	16.52	17.30	15.88	13.83	14.02	16.33	17.75	15.48
8 dS/m	12.18	13.27	15.19	16.75	14.35	12.85	14.00	14.86	16.65	14.59
12 dS/m	11.15	12.95	14.62	16.65	13.84	10.56	12.96	13.77	14.79	13.02
Mean (B)	13.56	14.78	16.06	17.65		13.09	14.41	15.51	16.82	
L.S.D. at 5%	A: 1.20		B: 1.72		AB: 3.44	A: 1.01		B: 1.30		AB: 2.60
Number of branches /plant										
Control(water)	5.10	7.71	9.33	10.61	8.19	4.40	5.61	7.21	9.03	6.56
4 dS/m	5.00	7.20	8.91	9.73	7.71	4.51	5.25	6.61	7.68	6.01
8 dS/m	4.73	6.83	7.50	8.81	6.97	3.82	5.33	6.93	7.81	5.97
12 dS/m	5.41	5.72	7.41	7.95	6.62	3.31	5.13	6.00	6.54	5.25
Mean (B)	5.06	6.86	8.29	9.28		4.01	5.33	6.69	7.77	
L.S.D. at 5%	A: 1.20		B: 1.72		AB: 3.44	A: 1.01		B: 1.30		AB: 2.60

caused by salinity might be due to salt accumulation in the soil, which raised the osmotic pressure of tissue cells and reduced water absorption and/or mineral redistribution and utilization (Mazher et al., 2006). Similarly, Pessarakli and Touchane (2006) demonstrated that the salt mechanism can impede cell division, lowering the rate of plant growth. However, according to Jou et al. (2006), ATPase is involved in the protein sorting machinery regulated by the endoplasmic reticulum Golgi for both housekeeping function and compartmentalization of excess Na^+ in high salinity level, which may be a significant restriction and clarify the obtained findings herewith.

Tabulated data in Table (1) showed that benzyladenine treatments caused considerable and significant augmentation in all vegetative characteristics in two experimental seasons, in comparison with control treatment. The most beneficial treatment which result in the highest values of plant height, leaf area and number of branches/plant was BA at high concentration. This treatment augmented the three above mentioned traits over those control plants by 13.50, 30.16 and 83.40% in the first season and by 12.88, 28.50 and 93.77% in the second one, respectively. Many researchers have emphasized the usefulness of BA in promoting the vegetative growth of various plant species, such as, Matter (2016) on *Hibiscus sabdariffa*, Sorour and El-Shanhorey (2016) on *Dracaena marginata*, Tandel et al. (2018) on *Adhatoda zeylanica*, Abou El-Ghait et al. (2020) on *Jasminum sambac* and Abdel Latef et al. (2021) on *Vicia faba*. The observed results may be attributed to the function of benzyladenine in helping to promote protein synthesis, enhancing cell division and elongation (Cheema and Sharma, 1982).

For the three studied vegetative growth characters, the interaction between salinity levels and BA concentrations was significant in both seasons. When hibiscus plants were grown at salinity levels up to 12 dS/m and were sprayed with BA at 100, these traits were statistically equivalent to those of the control plant, as is obvious in Table (1).

3.2.Root parameters

Data from Table (2) showed that increasing salinity level led to a reduction in all studied root characteristics (root length, fresh and dry weights). Therefore, the most significant values were found in un-salinized plants, as recorded 41.17 and 38.45 cm for root length, 31.01and 26.83 g for roots fresh weight and 9.29 and 9.29 g for roots dry weight for the first and second seasons, respectively. The high salinity level, 12 dS/m gave significantly the lowest values for the three parameters, in comparison with the control in the two growing seasons. Numerically, the reduction in root length, roots fresh and dry weights due to the high salinity level, in comparison with untreated treatment recorded 19.97, 21.51 and 25.83% in the first season and 21.12, 40.33 and 25.73% in the second one. These results were closely supported by the findings of Abdel-Fattah (2014) on jacaranda, Ahmed (2017) and Nofel et al. (2021) *Hibiscus rosa-sinensis.* The decrease in root characteristics caused by increasing salinity may be attributable to interaction of the ion activities of chloride and sodium and osmotic pressure (Taffouo et al., 2010). The plants' ability to absorb water may have been hampered by root damage and mortality brought on by ionic toxicity which might have decreased shoot growth. Osmotic stress is exacerbated by salinity increases which, prevents water from being transported and absorbed. This inhibition causes in hormone-induced sequential reactions that decrease the rate of photosynthetic activity, stomatal opening and CO_2 assimilation (Odjegba and Chukwunwike, 2012; Menezes et al., 2017 and Sarker and Oba, 2020). The other reason for the decline in growth may be due to a drop in carbon gains and the redistribution of energy from growth to the homeostasis of salt stress (Atkin and Macherel, 2009; Sarker and Oba, 2020).

It is worth to mention that the three studied root characteristics were significantly affected by benzyladenine concentrations in both seasons. The BA treatment (100 ppm) caused higher increasing of root length by 46.31 and 36.52%, roots fresh weight by 83.22 and 84.80% and roots dry weight by 45.09% and 37.68% comparison with control in the both growing seasons, respectively. These findings are consistent with those found by Abd El-Aziz (2007) on *Codiaeum variegatum,* Abou El-Ghait et al. (2020) on *Jasminum sambac.* The results showed that BA greatly improved plant growth under a variety of salinity stress conditions. Salinity stress may limit cytokinin synthesis and/or transfer from root to shoot, resulting in reduced cytokinin concentration in the shoot and stomatal closure (Ghanem et al., 2011). As a result, foliar spray of BA might substitute the roots absence of cytokinin availability, contributing to plant growth and physiological activities.

The interaction between salinity levels and BA concentration was significant for root length, fresh and dry weights in both seasons as listed in Table (2). It was intriguing to discover that the results of the high salinity treatment (12 dS/m) combined with high BA treatment (100 ppm) for the three root parameters did not significantly differ from the results of the control treatment (un-salinize/un-benzyladenine) in the two growing seasons, as shown in Table (2).

3.3.Flowering parameters

Data in Table 3, showed that flower diameter, fresh and dry weights of *Hibiscus rosa-sinensis* were significantly decreased due to the three soil salinity concentrations in both growing seasons. In both seasons, the high salt concentration (12 dS/m) led to the greatest reductions in flower diameter (8.17 and 8.23 cm), flower fresh weight (1.21 and 1.29g), and flower dry weight (0.176 and 0.180 g) in comparison with untreated plants in the two experimental seasons. Numerous researchers reached comparable conclusions, including, Ahmed (2017) on *Hibiscus rosa-sinensis,* Abdel-Mola and Ayyat (2020) on *Calendula officinalis.* The decreased cell division and cell elongation may be the cause of the decreased plant growth. This could be explained by the increase in water loss by leaves, which has an impact on the development of reproduction (Fricke and Peters, 2002). Additionally, according to Greenway and Munns (1980), a decrease in flowering criteria may result from a plant's inability to adjust osmotically, toxic counteractions or other similar disruptive

Table 2. Influence of soil salinity and benzyladenine foliar-spray application on root length (cm), roots fresh and dry weights (g) of *Hibiscus rosa-sinensis* L. during 2020 and 2021 seasons.

Salinity Treatments (A)	Benzyladenine (B) ppm									
	Control (water)	BA25	BA50	BA100	Mean (A)	Control (water)	BA25	BA50	BA100	Mean (A)
	First season (2020)					Second season (2021)				
	Root length (cm)									
Control(water)	33.18	36.43	43.46	51.61	41.17	31.40	35.22	39.00	48.16	38.45
4 dS/m	30.09	33.73	39.21	44.40	36.86	28.82	33.16	36.72	47.51	36.55
8 dS/m	29.22	34.04	37.60	43.22	36.02	38.02	35.44	31.21	38.09	35.69
12 dS/m	27.81	32.32	34.83	36.82	32.95	25.33	30.21	30.88	34.90	30.33
Mean (B)	30.08	34.13	38.78	44.01		30.89	33.51	34.45	42.17	
L.S.D. at 5%	A: 4.20	B: 2.23		AB: 4.46		A: 1.88		B: 2.10	AB: 4.20	
	Roots fresh weight (g)									
Control(water)	21.21	28.18	35.15	39.50	31.01	18.05	25.65	29.36	34.24	26.83
4 dS/m	20.11	25.31	29.28	33.47	27.04	16.82	19.73	23.91	28.15	22.15
8 dS/m	18.15	25.15	30.27	34.22	26.95	13.35	14.76	20.54	25.11	18.44
12 dS/m	16.08	22.95	27.09	31.25	24.34	11.48	13.65	16.06	22.84	16.01
Mean (B)	18.89	25.40	30.45	34.61		14.93	17.70	22.47	27.59	
L.S.D. at 5%	A: 3.82	B: 6.22		AB: 12.44		A: 4.32		B: 2.55	AB: 5.10	
	Roots dry weight (g)									
Control(water)	7.23	8.37	10.35	11.21	9.29	7.18	8.41	9.93	11.63	9.29
4 dS/m	7.06	7.25	8.36	10.43	8.28	7.10	7.32	8.40	9.52	8.09
8 dS/m	6.34	7.03	8.33	9.86	7.89	7.00	6.49	8.31	9.23	7.76
12 dS/m	6.25	6.33	7.47	7.50	6.89	6.32	6.40	7.29	7.60	6.90
Mean (B)	6.72	7.25	8.63	9.75		6.90	7.16	8.48	9.50	
L.S.D. at 5%	A: 1.01	B: 0.50		AB: 1.00		A: 1.19		B: 0.23	AB: 0.46	

phenomena, an excessive energy demand placed on the metabolic machinery needed by such homeostatic systems, or any of these factors. Additionally, Abdalla (2011) showed that water stress causes an increase in abscisic acid levels in the roots, which are then transferred to the shoots, where they act as cytokinin and auxin antagonists and play crucial roles in cell growth and division, respectively. Additionally, it prevents the synthesis of DNA.

Regarding the response of flower diameter, fresh and dry weights to different concentrations of BA. Data presented in Table 3, demonstrated that in the two experimental seasons, all flowering characters were significantly improved as a result of the aforementioned treatments when compared to the control treatment. The only exception was BA at 25 ppm had no positive effects on the flowering parameters because the means of these parameters were very similar to those of the control, with no significant difference between the two growing seasons. The gradual increase in BA concentration treatments led to a gradual enhancement of flowering characters, the highest values being obtained at BA concentrations of 100 ppm. The increase percentage were 60.64, 101.69 and 60.49% to flower diameter, fresh and dry weights in the first season and 65.76, 78.46 and 59.21% in the second season, respectively, compared to control treatment. Similar results were obtained by Farag et al. (2018) on chrysanthemum, Hasan (2019) on *Calendula officinalis* and Abou El-Ghait et al. (2020) on *Jasminum sambac*. Improvements in the flowering characteristics of *Hibiscus rosa-sinensis* plants following benzyladenine treatment as compared to control treatment may be attributable to the crucial function of cytokinin in controlling many developmental processes, including the regulation of the plant cell cycle, additionally, it motivates nutrient translocation,

Table 3. Influence of soil salinity and benzyladenine foliar-spray application on flower diameter (cm), flowers fresh and dry weights (g) on *Hibiscus rosa-sinensis* L. during 2020 and 2021 seasons.

Salinity Treatments (A)	Benzyladenine (B) ppm									
	Control (water)	BA25	BA50	BA100	Mean (A)	Control (water)	BA25	BA50	BA100	Mean (A)
	First season (2020)					Second season (2021)				
	Flower diameter (cm)									
Control(water)	8.18	9.41	11.13	13.62	10.59	9.32	10.82	11.69	14.23	11.52
4 dS/m	7.23	9.56	9.74	11.40	9.48	8.52	9.26	10.52	12.11	10.10
8 dS/m	7.12	8.24	9.20	11.02	8.90	6.57	7.34	8.33	11.53	8.44
12 dS/m	6.01	8.00	8.83	9.82	8.17	5.03	7.82	9.15	10.92	8.23
Mean (B)	7.14	8.80	9.73	11.47		7.36	8.81	9.92	12.20	
L.S.D. at 5%	A: 1.02		B: 1.69	AB: 3.38		A: 1.22		B: 1.47	AB: 2.94	
	Flowers fresh weight (g)									
Control(water)	1.52	1.89	2.16	3.42	2.25	1.73	1.97	2.47	3.33	2.38
4 dS/m	1.23	1.31	1.74	2.21	1.62	1.34	1.74	1.77	2.42	1.82
8 dS/m	1.08	1.16	1.27	2.08	1.40	1.11	1.55	1.61	1.90	1.54
12 dS/m	0.88	1.00	1.18	1.79	1.21	1.03	1.18	1.33	1.62	1.29
Mean (B)	1.18	1.34	1.59	2.38		1.30	1.61	1.80	2.32	
L.S.D. at 5%	A: 0.75		B: 0.52	AB: 1.04		A: 0.51		B: 0.54	AB: 1.08	
	Flowers dry weight (g)									
Control(water)	0.193	0.235	0.258	0.296	0.246	0.181	0.220	0.265	0.299	0.241
4 dS/m	0.167	0.202	0.249	0.287	0.226	0.155	0.177	0.223	0.237	0.198
8 dS/m	0.154	0.171	0.211	0.247	0.196	0.150	0.189	0.219	0.230	0.197
12 dS/m	0.132	0.164	0.198	0.210	0.176	0.121	0.183	0.215	0.200	0.180
Mean (B)	0.162	0.193	0.229	0.260		0.152	0.192	0.231	0.242	
L.S.D. at 5%	A: 0.004		B: 0.041	AB: 0.082		A: 0.009		B: 0.048	AB: 0.096	

chlorophyll retention, and the growth and development of plant organs (Pandey and Sinha, 1984). Regarding the interaction between salt stress and BA concentrations, data showed that the highest mean values of flower diameter, fresh and dry weights were obtained in un-salinized plants and receiving high BA concentration (13.62 and 14.23 cm for flower diameter, 3.42 and 3.33 g for flower fresh weight, 0.296 and 0.299 g for flower dry weight) in the two seasons, respectively. However, the plants that received high salinization and no BA treatment had the lowest levels of flower diameter, fresh and dry weights (6.01 and 5.03 cm for flower diameter, 0.88 and 1.03 flower fresh weight, 0.132 and 0.121 for flower dry weight, respectively).

3.4. Physiological and Chemical determinations:

3.4.1. Photosynthetic pigments

Photosynthetic pigments were gradually reduced as salinity levels increased, with significant differences between the three salinity levels and the control treatment in the two growing seasons. Furthermore, the high salinity level (12 dS/m) resulted in the lowest photosynthetic pigments which reached (2.602 and 2.589 for chlorophyll a), (0.831 and 0853 for chlorophyll b) and (1.157 and 1.180 for carotenoids) in comparison to the medium salinity which reached (2.606 and 2.588 for chlorophyll a), (0.847 and 0.856 for chlorophyll b) and (1.182 and 1.203 for carotenoids) and low salinity levels (2.614 and 2.602 for chlorophyll a), (0.863 and 0.870 for chlorophyll b) and (1.244 and 1.249 for carotenoids) for first and second seasons, respectively, as shown in Table (4). Such findings are consistent with those obtained by various studies that reported a decrease in the three photosynthetic pigments, such as, Khafagy et al. (2013), Ahmed (2017) and Nofel et al. (2021) on *Hibiscus rosa-sinensis*, Abdel-Fattah (2014) on jacaranda and Ahmed et al. (2016) on *Acalypha wilkesiana*. Chlorophyll levels in salt-treated plants were reduced due to

Table 4. Influence of soil salinity and benzyladenine foliar-spray application on Chlorophyll a, b and Carotenoids content of *Hibiscus rosa-sinensis* L. during 2020 and 2021 seasons.

Salinity Treatments (A)	Benzyladenine (B) ppm									
	Control (water)	BA25	BA50	BA100	Mean (A)	Control (water)	BA25	BA50	BA100	Mean (A)
	First season (2020)					Second season (2021)				
	Chlorophyll a									
Control(water)	2.671	2.682	2.688	2.696	2.684	2.611	2.620	2.659	2.731	2.655
4 dS/m	2.520	2.620	2.632	2.683	2.614	2.580	2.593	2.610	2.625	2.602
8 dS/m	2.505	2.613	2.625	2.680	2.606	2.457	2.647	2.628	2.620	2.588
12 dS/m	2.501	2.610	2.618	2.679	2.602	2.423	2.655	2.630	2.648	2.589
Mean (B)	2.549	2.631	2.641	2.685		2.518	2.629	2.632	2.656	
L.S.D. at 5%	A: 0.063		B: 0.079		AB: 0.158	A: 0.052		B: 0.019		AB: 0.038
	Chlorophyll b									
Control(water)	0.820	0.881	0.944	0.955	0.900	0.867	0.872	0.883	0.915	0.884
4 dS/m	0.765	0.852	0.902	0.933	0.863	0.852	0.850	0.866	0.911	0.870
8 dS/m	0.752	0.821	0.901	0.913	0.847	0.791	0.863	0.871	0.900	0.856
12 dS/m	0.746	0.811	0.866	0.900	0.831	0.783	0.842	0.905	0.883	0.853
Mean (B)	0.771	0.841	0.903	0.925		0.823	0.857	0.881	0.902	
L.S.D. at 5%	A: 0.035		B: 0.068		AB: 0.136	A: 0.012		B: 0.031		AB: 0.062
	Carotenoids									
Control(water)	1.212	1.237	1.311	1.426	1.297	1.218	1.229	1.293	1.313	1.263
4 dS/m	1.145	1.211	1.288	1.332	1.244	1.206	1.212	1.278	1.301	1.249
8 dS/m	1.127	1.129	1.256	1.216	1.182	1.159	1.175	1.203	1.274	1.203
12 dS/m	1.076	1.112	1.232	1.209	1.157	1.132	1.164	1.190	1.233	1.180
Mean (B)	1.140	1.172	1.272	1.296		1.179	1.195	1.241	1.280	
L.S.D. at 5%	A: 0.032		B: 0.031		AB: 0.060	A: 0.012		B: 0.014		AB: 0.028

inhibition of chlorophyll synthesis and activation of its degradation by the enzyme chlorophyllase (Santos, 2004). Salt inhibits key photosynthesis-related enzymes like Rubisco and PEP carboxylase as well, which is another explanation for why photosynthesis is reduced in the presence of salt (Soussi et al., 1998).

It is clear from the data in (Table, 4) that the three BA treatments applied during the two growing seasons significantly increased the levels of chlorophyll a, b and carotenoids in the leaves of hibiscus plants. The following three treatments, in descending order, produced the three photosynthetic pigments with the highest content, BA at 100 ppm followed by BA at 50 ppm then BA at 25 ppm which increased the chlorophyll a, b and carotenoids over those of the check treatment by 5.34, 3.61 and 3.22 % in the first season, and by 5.48, 4.53 and 4.41 % in the second season, respectively, for chlorophyll a and by 19.97, 17.12 and 9.08 % in the first season and by 9.60, 7.05 and 4.13 % in the second one, successively, for chlorophyll b, while those of carotenoids were 13.68, 11.58 and 2.81 % in the first season and 8.57, 5.26 and 1.36 % in the second one, respectively. Additionally, benzyladenine treatments on photosynthetic pigments were shown to be effective by Abd El-Aziz (2007) on *Codiaeum variegatum,* Gupta et al. (2012) on *Triticum aestivum*, Matter (2016) on roselle and Sorour and El-Shanhorey (2016) on *Dracaena marginata.* The expanding effects of benzyladenine on the photosynthetic pigments observed in this study may be attributed to its ability to protect chlorophylls from photo-oxidation (Petrenko and Biryukova, 1977), chlorophyll retention and prevents its deterioration (Van Staden and Joughin, 1988), delaying theaging process (Xu et al., 2011), promoting the production of one or more proteins that chlorophyll binds to and stabilizes (Salisbury and Ross, 1990), preventing the enzyme (chlorophyllase enzyme) that is responsible for the degradation of chlorophyll from being synthesised from scratch (Beyer, 1981). It suspends the starts of increasing respiration linked to leaf senescence (Thimann, 1980); it keeps the protein content high by slowing the rate of breakdown rather than speeding up the rate of synthesis (Sacher, 1973).

For the photosynthetic pigments, the interaction between the two factors was significant in both seasons. The combination treatment of high salinity and BA could produce results similar to those produced by the check treatment, Table (4). Application of BA at 100 ppm to the high salinized plants (12 dS/m) increased the three photosynthetic pigments by 7.12, 20.64, and 12.36%, respectively, in the first season and 9.29, 12.77 and 8.92%, respectively, in the second season.

3.4.2. Proline, Sodium and Chloride

The data in Table 5, declared that, increasing the salt concentration from 25 to 100 ppm resulted in a significantly higher free proline content than the control treatment. The plants that received the highest salt concentration (100 ppm) had the highest mean values of free proline (0.332 and 0.335 mg) in the two seasons, respectively. In contrast, untreated plants had the lowest mean values (0.234 and 0.255 mg) of free proline content. All salt concentration treatments caused significant augmentation in the leaf contents of sodium and chloride. The increase was parallel to the increase of salinity levels. Therefore, the application of high level of salinity gave the highest values of sodium and chloride percentages in leaves which reached 1.36 and 1.30 % for sodium and 1.55 and 1.43 % for chloride in two growing seasons, respectively. Such results are consistent with those attained by various studies that reported increases in free proline, sodium and chloride content such as, Ahmed et al. (2016) on *Acalypha wilkesiana*, Ahmed (2017) and Nofel et al. (2021) on *Hibiscus rosa-sinensis*. A defense mechanism used by hibiscus plants to combat salinity stress is an increase in proline content. Proline can be thought of as a stabilizer of intracellular osmotic pressure and can aid in cytoplasmic osmotic adjustment, according to Greenway and Munns (1980). The functions attributed to proline accumulation, according to AzevedoNeto and Silva (2015), include increased activity of enzymes, complexes, and protein membranes, protein stabilization, cell redox homeostasis maintenance, the stocks of carbon and nitrogen, regulating cytosolic pH, and the elimination of free radicals. Due to an excessive buildup of toxic Na+ in the cells and a significant decrease in beneficial ions, namely K^+ contents, the poor growth performance of salinized plants was closely correlated with ionic toxicity (Wu et al., 2009). These changes may have been brought on by cell membrane damage, ion leakage, and disruption in essential ion uptakes (Liu, et al. 2020).

Data in Table (5) showed that the free proline content was significantly reduced by BA treatments in the both seasons, compared to check control treatment. The following treatments, in descending order, produced the lowest values of free proline content, high BA concentration followed moderate then low BA concentration over check treatment by 26.79, 25.00 and 20.54% in the first season and by 17.59, 13.89 and 7.10 % in the second one. It should be noted that treating hibiscus plants with three BA treatments resulted in a favorable and significant decrease of sodium and chloride percentages compared to control plants in the two growing seasons. The only exception was the treatment of BA at 25 ppm for chloride percentage in the second season. The foliar application of high concentration of BA (100 ppm) gave the lowest values of sodium and chloride in leaves which reached 1.08 and 1.04 % for sodium and 1.28 and 1.22 % for chloride in both seasons, respectively. The same results have been discovered by Gupta et al. (2012) on *Triticum aestivum*, Abdel Latef et al. (2021) on *Vicia faba*. BA supplementation increased K^+ accumulation while lowering Na^+ content in plant, which supported indirect, yet compelling evidence that BA treatments helped the vacuoles to remove Na^+ effectively and the nutrients were abundant, especially K^+, Furthermore improving leaf succulence, morphological aspects of salt-stressed plants, nutritional balance and enhancing plant survival are all possible benefits (Shrivastava and Kumar, 2015 and Guo, 2017).

Regarding the interaction effects of salt stress and benzyladenine concentrations on proline, sodium and chloride, data revealed that

Table 5. Influence of soil salinity and benzyladenine foliar-spray application on free proline (mg/g F.W.), sodium and chloride percentages of *Hibiscus rosa-sinensis* L. during 2020 and 2021 seasons.

Salinity Treatments (A)	Benzyladenine (B) ppm									
	Control (water)	BA25	BA50	BA100	Mean (A)	Control (water)	BA25	BA50	BA100	Mean (A)
	First season (2020)					Second season (2021)				
	Free proline (mg/g f.w.)									
Control(water)	0.252	0.233	0.226	0.223	0.234	0.285	0.263	0.242	0.231	0.255
4 dS/m	0.293	0.245	0.237	0.233	0.252	0.292	0.275	0.262	0.255	0.271
8 dS/m	0.355	0.269	0.254	0.251	0.282	0.343	0.322	0.293	0.281	0.310
12 dS/m	0.442	0.319	0.289	0.277	0.332	0.375	0.344	0.319	0.300	0.335
Mean (B)	0.336	0.267	0.252	0.246		0.324	0.301	0.279	0.267	
L.S.D. at 5%	A:0.016	B: 0.045		AB: 0.090		A:0.014	B: 0.011		AB: 0.022	
	Sodium %									
Control(water)	0.86	0.75	0.72	0.65	0.75	0.96	0.82	0.77	0.70	0.81
4 dS/m	1.33	1.25	1.20	1.13	1.23	1.31	1.22	1.18	1.12	1.21
8 dS/m	1.38	1.30	1.28	1.22	1.30	1.34	1.29	1.22	1.15	1.25
12 dS/m	1.42	1.40	1.32	1.30	1.36	1.42	1.32	1.26	1.18	1.30
Mean (B)	1.25	1.18	1.13	1.08		1.26	1.16	1.11	1.04	
L.S.D. at 5%	A: 0.35	B: 0.06		AB: 0.12		A: 0.38	B: 0.02		AB: 0.04	
	Chloride %									
Control(water)	1.28	1.15	1.11	1.05	1.15	1.20	1.14	1.12	1.01	1.12
4 dS/m	1.38	1.33	1.28	1.24	1.31	1.29	1.24	1.20	1.15	1.22
8 dS/m	1.55	1.48	1.42	1.37	1.46	1.38	1.38	1.34	1.30	1.35
12 dS/m	1.62	1.58	1.55	1.46	1.55	1.46	1.44	1.40	1.40	1.43
Mean (B)	1.46	1.39	1.34	1.28		1.33	1.30	1.27	1.22	
L.S.D. at 5%	A: 0.14	B: 0.06		AB: 0.12		A: 0.11	B: 0.06		AB: 0.12	

the plants received high concentration salinity (12 dS/m) and did not receive BA obtained the highest mean values of proline, sodium and chloride (0.442 and 0.375 mg for proline, 1.42 and 1.42 % for sodium and 1.62 and 1.46 % for chloride) in the first and second seasons, respectively. However, un-salinized plants plus BA at high concentration had the lowest levels of proline, sodium and chloride (0.223 and 0.231 mg for proline, 0.65 and 0.70 % for sodium, and 1.05 and 1.01 % for chloride) in both seasons, respectively.

3.4.3. Relative water content

As shown in Table 6, a gradual increase in salinity concentration led to a progressive decrease in the relative water content in leaves, which reached the lowest values by 12 dS/m level in the two seasons. Numerically, the reduction due to the high salinity level, in comparison with control treatment recorded 14.84 and 12.54% in the both seasons. This is due to the damaging effects of salinity on the root cell wall structure and cell enlargement (Byrt et al., 2018).These results are consistent with the results of numerous studies such as, El-Sayed et al. (2019) on *Enterolobium contortisiliquum*, Abrar et al. (2020) on *Jatropha curcas*, El-Shanhorey and Hassan (2021) on *Gazania rigens*, Sadat-Hosseini et al. (2022) and Abou-Sreea et al. (2022) on roselle. Salinity has been demonstrated to potentially have a negative impact on the internal water state of plants due to ionic imbalance (Ahmad, 2010 and Azooz et al., 2011), which can disrupt leaf relative water content, stomatal conductance and osmotic and turgor potential (Mohamed et al., 2013). This could result in a decrease in plant vigour in many species (Koç et al., 2003), which is explained by the fact that other hibiscus species lose water content in saline conditions.

Table 6. Influence of soil salinity and benzyladenine foliar-spray application on relative water content of *Hibiscus rosa-sinensis* L. during 2020 and 2021 seasons.

Salinity Treatments (A)	Benzyladenine (B) ppm									
	Control (water)	BA25	BA50	BA100	Mean (A)	Control (water)	BA25	BA50	BA100	Mean (A)
	First season (2020)					Second season (2021)				
	Relative water content									
Control(water)	80.93	82.92	84.44	86.10	83.60	82.33	85.11	85.90	87.11	85.11
4 dS/m	74.23	77.74	80.51	82.81	78.82	75.43	82.33	83.52	82.16	80.86
8 dS/m	70.31	74.00	77.63	79.81	75.44	71.13	74.68	79.45	79.89	76.29
12 dS/m	63.66	71.35	69.83	79.93	71.19	68.88	71.14	76.11	81.65	74.45
Mean (B)	72.28	76.50	78.10	82.16		74.44	78.32	81.25	82.70	
L.S.D. at 5%	A: 2.56	B: 1.45		AB: 2.90		A: 3.42	B: 1.32		AB: 2.64	

Data from Table (6) showed that the three BA treatments caused considerable and significant augmentation in relative water content in leaves in the two growing seasons, in comparison with control treatment. The increment was gradual and parallel to the gradual increase in benzyladenine concentration. The BA treatment (100 ppm) led to higher increases in relative water content by 13.67% in the first season and by 11.10 % in the second one, compared to untreated plants, respectively. The findings regarding benzyladenine are consistent with those revealed by El-Malt et al. (2006), Gupta et al. (2012) on *Triticum aestivum,* Sorour and El-Shanhorey (2016) on *Dracaena marginata,* Abou El-Ghait et al. (2020) on *Jasminum sambac* and Gaur et al. (2022) on *Gladiolus grandiflorus.* These findings may be clarified by how benzyladenine promotes the synthesis of proteins, soluble and non-soluble sugars. or could be as a result of the benzyladenine's capacity to cause the treated area to act as a sink into which nutrients are drawn from other areas of the plant (Salisbury and Ross, 1974). It has been hypothesized that this rise in RWC after benzyladenine treatments may be the result of improved water absorption. Exogenous cytokinin enhanced wheat's ability to absorb water, increasing yield, according to Gupta et al. (2000).

The interaction between salinity levels and benzyladenine concentrations was significant, in both seasons, for relative water content. This parameter were statistically equal to those of the (un-salinize/un-BA) plants when hibiscus plants were expose to salinity levels up to 12 dS/m and were sprayed with BA at 100 ppm, as is evident in Table (6).

3.4.5. NPK percentages

Data in Table (7) showed that when *Hibiscus rosa-sinensis* L. plants were exposed to four salinity concentrations, the percentages of the three elements gradually decreased with increasing salinity levels in comparison with the control plants. As a result, the lowest NPK contents in leaves were obtained when a high level of salinity was applied. These values were 1.702 and 1.828% for N, 0.319 and 0.336% for P and 1.553 and 1.577 for K in the two experimental seasons, respectively. Untreated (control) plants produced the highest values. The salinity results are consistent with those that have been reported by El-Naggar and El-Kouny (2011) on roselle, Ahmed et al. (2016) on *Acalypha wilkesiana*, Ahmed (2017) and Nofel et al. (2021) on *Hibiscus rosa-sinensis*. According to Tester and Daveport (2003), high soil sodium levels directly interfere with potassium selective ion channel transporters in the root plasma membrane, preventing nutrients from being taken up by the plant, and restricting root growth due to osmotic effects of sodium ion and negative effects on soil structure. In vacuoles, potassium is the most prevalent inorganic cation, which is essential for preserving potassium homeostasis between

Table 7. Influence of soil salinity and benzyladenine foliar-spray application on NPK percentages of *Hibiscus rosa-sinensis* L. during 2020 and 2021 seasons.

Salinity Treatments (A)	Benzyladenine (B) ppm									
	Control (water)	BA25	BA50	BA100	Mean (A)	Control (water)	BA25	BA50	BA100	Mean (A)
	First season (2020)					Second season (2021)				
					N %					
Control(water)	2.135	2.318	2.396	2.421	2.318	2.065	2.113	2.328	2.393	2.225
4 dS/m	1.881	2.098	2.158	2.011	2.037	1.910	2.082	2.182	2.196	2.093
8 dS/m	1.715	1.865	1.932	1.943	1.864	1.810	1.972	1.985	2.052	1.955
12 dS/m	1.556	1.697	1.711	1.842	1.702	1.655	1.866	1.769	2.023	1.828
Mean (B)	1.822	1.995	2.049	2.054		1.860	2.008	2.066	2.166	
L.S.D. at 5%	A: 0.264		B: 0.164	AB: 0.328		A: 0.118		B: 0.132	AB: 0.264	
					P %					
Control(water)	0.386	0.392	0.398	0.421	0.399	0.363	0.379	0.387	0.399	0.382
4 dS/m	0.362	0.375	0.382	0.407	0.382	0.349	0.362	0.374	0.380	0.366
8 dS/m	0.347	0.353	0.350	0.368	0.355	0.333	0.348	0.360	0.364	0.351
12 dS/m	0.268	0.322	0.320	0.365	0.319	0.315	0.329	0.342	0.358	0.336
Mean (B)	0.341	0.361	0.363	0.390		0.340	0.355	0.366	0.375	
L.S.D. at 5%	A: 0.014		B: 0.016	AB: 0.032		A: 0.013		B: 0.011	AB: 0.022	
					K %					
Control(water)	1.583	1.618	1.637	1.654	1.623	1.582	1.652	1.661	1.681	1.644
4 dS/m	1.577	1.609	1.600	1.632	1.605	1.561	1.619	1.633	1.574	1.597
8 dS/m	1.550	1.579	1.583	1.588	1.575	1.551	1.593	1.584	1.587	1.579
12 dS/m	1.528	1.548	1.563	1.572	1.553	1.532	1.574	1.570	1.630	1.577
Mean (B)	1.560	1.589	1.596	1.612		1.557	1.610	1.612	1.618	
L.S.D. at 5%	A: 0.015		B: 0.019	AB: 0.038		A: 0.032		B: 0.035	AB: 0.070	

the cytoplasm and vacuole and cell turgor pressure (Heelebust, 1976). High ionic balance produced by an excess of Na and Cl, the two main ions found in salty soils, may increase the selectivity of the root membrane (Bohra and Doerffling, 1993). A lot of the time, sodium builds up in the vacuoles, where it can quantitatively and qualitatively replace potassium (Storey et al., 1983). Potassium ion uptake and transport were therefore inhibited (Lynch and Läuchi, 1984). There may be an antagonistic relationship between K and Na, as evidenced by the decrease in K concentration with an increase in Na concentration (Rashid et al., 2004). This antagonistic relationship might be caused by strong competitiveness between potassium and sodium at the plasma lemma's ion absorption site (Epstein and Rains, 1987), where K was to be replaced with Na in order to activate a select few enzymes that require a univalent activity (Jeffrey, 1987). Osmotic adjustment is required for a plant to live in salty surroundings, according to (Flowers et al. 1997). Because of their ability to utilize Na to maintain a sufficient osmotic potential gradient between their tissues and the surrounding fluid, plants exposed to salt may experience an increase in sodium concentration (Glenn, 1987). Data in Table (7) of our findings showed that lowering the phosphorous concentration in leaves was facilitated by a rise in salinity. the decrease in phosphorous and its uptake under salinity stress attributed to a reduction in phosphorous absorption and translocation through the root as a result of the root medium's increased osmotic pressure (Greenway et al., 1969). In terms of plant uptake, Champagnol (1979) came to the conclusion that it is unlikely that chloride and phosphate ions are competitive. Additionally, the fact that Na salts increased the soil's pH and consequently decreased the availability of P to plants should be considered (Sonneveld and Voogt, 1983). The inhibitory influence of salinity on reducing water uptake may be the cause of the decrease in nitrogen under salinity stress (Lea-Cox and Syvertsen, 1993) and/or a rise in chloride uptake and accumulation supported by a fall in plant nitrate concentration because chloride and nitrate compete which led to lowering nitrate content (Khan and Srivastava, 1998).

BA treatments showed a positive impact on improving the accumulation NPK in leaves (Table, 7). The increase of the NPK contents in leaves was gradual due to the gradual raise in the examined BA concentrations. The highest contents of the three elements were obtained from the following benzyladenine concentrations in descending order: BA at 100 ppm followed by 50 ppm then 25 ppm. These three treatments increased the NPK content over those of control plants by 12.73, 12.46 and 9.50% for nitrogen and by 14.37, 6.45 and 5.87 for phosphor and by 3.33, 2.31 and 1.86% for potassium in the first season, respectively, also in the second season, by 16.45, 11.08 and 7.97% for N and by 10.29, 7.65 and 4.41% for P and by 3.92, 3.53 and 3.40% for K, respectively. The results regarding the impact of BA mentioned above on NPK were reported by numerous authors, including, Eid and Abou-Leila (2006) on croton, El-Malt et al. (2006) on *Hippeastrum vittatum*, Ibrahim et al. (2010) on croton, Matter (2016) on roselle and Abou El-Ghait et al. (2020) on *Jasminum sambac.* Cytokinins like BA and zeatin, widen the conducting tissues (xylem and phloem) increasing the absorption and transport of the component necessary for plant growth (Krishnamoorthy, 1981). The influence of cytokinins on membrane permeability may provide an explanation for how they change the mechanism of ions uptake and the speed at which ion cross the membrane or by how quickly they move from the membrane to the shoot (Van-Steveninck, 1976).

The interaction between salinity levels and BA concentration treatments was found to significantly increase N, P and K% in the two growing seasons, according to the data shown in Table (7). It was intriguing to discover that the results of the high salinity treatment combined with high BA treatment for the three elements did not significantly differ from those of the control treatment (un-salinize/un-BA) in the two experimental seasons.

4. CONCLUSION

Finally, this study's findings suggest that *Hibiscus rosa-sinensis* L plants should be given 100 ppm benzyladenine foliar spray in order to minimize the effects of soil salinity stress (12 dS/m) and maximize vegetative, flowering growth, leaf relative water content and chemical constituents.

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الملخص العربى

تقليل التأثيرات السلبية للإجهاد الملحي عن طريق الرش الورقى بالبنزايل ادينين على الخصائص المورفو– فسيولوجية والكيميائية لنبات الهبسكس

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أجريت الدراسة الحالية خلال الموسمين المتعاقبين ٢٠٢٠ و ٢٠٢١ في محافظة بني سويف ، مصر ، لدراسة كيفية التخفيف من الآثار السلبية لملوحة التربة (٤ ، ٨ ، ١٢ ديسيسيمنز/ م) على صفات النمو الخضرى والجذرى والزهرى. لنباتات الهبسكس من خلال استخدام البنزايل ادينين (٢٥ و ٥٠ و ١٠٠ جزء في المليون). أظهرت النتائج ان صفات ارتفاع النبات ، مساحة الورقة ، عدد الفروع / النبات ، طول الجذر ، الوزن الطازج والجاف للجذور ، قطر الزهرة والوزن الطازج والجاف للازهار، صبغات التمثيل الضوئي ، النسبة المئوية للنيتروجين والفوسفور والبوتاسيوم ، وكذلك محتوى الماء النسبي فى الاوراق قد انخفضت بشكل ملحوظ وتدريجي بالتوازي مع ارتفاع ملوحة التربة ،وكانت أقل القيم المتحصل عليها عند أعلى مستوى ملوحة (١٢ ديسيسيمنز/ م). في المقابل تم تحسين جميع هذه الصفات السابقة مع الزيادة التدريجية فى التركيزات الثلاثة للبنزايل أدينين ،كان الحد الأقصى للانخفاض عند (١٢ ديسيسيمنز/ م) ملوحة التربة والتي وجدت عندها أعلى زيادة في محتوى البرولين الحر والنسب المئوية للصوديوم والكلوريد. كان الرش الورقي الأكثر فعالية للبنزايل ادينين عند ١٠٠ جزء في المليون. كان من الواضح أن التضاد بين الملوحة ومعاملات البنزيل أدينين قد أحدث تأثيرات معنويه على الصفات المدروسة في كلا الموسمين. واتضح ان النباتات المعاملة بأعلى نسبة ملوحة مع معاملتها بالبنزايل ادينين باعلى تركيز كانت قادرة على أعطاء نفس النتائج في النباتات الغير معاملة (الكنترول) وبالتالى تشير هذه النتائج إلى أن معاملات البنزايل أدينين كان لها تأثير مفيد على الصفات المورفولوجية والفسيولوجية والكيميائية وتقليل الآثار الضارة للملوحة على نباتات الهبسكس.

الكلمات المفتاحية: البنزايل ادينين – الهبسكس – محتوى الماء النسبى – ملوحة التربة – الصفات الزهرية