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Influence of Brassinosteroids on Wheat Plant (*Triticum aestivum* L.) Production under Salinity Stress Conditions II- Chemical Constituent and Nutritional Status

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Abstract: A pot experiment was carried out to study the effect of irrigating saline water at levels (0. 2000, 4000 and 6000 ppm NaCl solution and rates of BRs "28-homBL" (0, 50, 100 and 200 mg/L) on chemical components and nutrients status in grains and straw of grains and straw of wheat plant (*Triticum aestivum* L). Salinity reduced sugar (reducing and non reducing), total carbohydrate and protein percentage of wheat grains while foliar application with BRs significantly increase gradually all the chemical constituents under study as compared with control. In addition foliar application with BRs also significantly increased the concentration and total uptake of macro and micronutrients (N, P, K, Fe, Mn, Zn and Cu) in straw and grains of wheat plants at harvest date.

Key words: Brassinosteroids, salinity stress, total carbohydrates, protein, macro nutrients, micronutrients.

INTRODUCTION

Salinity is one of the oldest enemies of agriculture. Excess amount of salts in the soil or irrigation water adversely affect plant growth and development. Nearly 20% of the world's cultivated areas are affected by salinity (Zhu, 2001). Seedling growth, flowering and fruit set are affected by high salt concentration, leading to diminished economic yield (Sairam and Tyagi, 2004).

Desert cultivation needs more information on crop performance and tolerance under salinity stress conditions, which have a depressing effect on growth, yield of many crops. The same tendency was observed regarding chlorophyll a, b and carotenoids content as well as the chemical constituents and nutrients status in plants. Such depressive effect was increased significently by increasing salinity levels (Abdel Aziz *et al*., 2006 and Mazher, *et al.*, 2008).

Wheat (*Triticum aestivum* L.) is the major and most important cereal crop grown in Egypt., the total cultivated area by wheat in Egypt is about 2.8 million feddan during 2006/2007 season, produced about 8 million tons (Anonymous, 2007). Because of the restricted resources of fresh water from River Nile, the use of saline water becomes important, so it is necessary to improve the salinity tolerance of wheat to increase its yield under stress conditions.

Therefore, it is better to understand different ways that plants can tolerate salinity of lands being washed under the conditions of an increasing need for economic food crop with the increasing population. In this respect, many papers have been published dealing with the role of brassinosteroids (BRs) in plant metabolism and the positive effects of their exogenous application on the plant growth under salinity conditions (Bajguz and Hayat, 2009).

Some investigators reported the increase in different carbohydrate fractions of various plants due to BRs treatments (Talaat and Youssef 1998). It is noteworthy to mention that Nafie and El-Khallal (2000) and Vardhini and Rao (2002) observed that application of BRs as foliar spraying significantly increases contents of reducing sugar, sucrose and polysaccharides in tomato plant. In addition Peng, *et al*., (2004) reported that BRs significantly increased insoluble sugar and starch contents of litchi pericarp. Mohamed (2005) showed that total carbohydrate contents in shoots of *Nigella sativa* plants was highly significantly increased in response to foliar treatment throughout the experimental period.

As regard the effect of brassinosteroids on nitrogenous compounds, Sairam (1993), reported that foliar spraying of BRs on two wheat varieties resulted in an increase of soluble protein content compared with control. Moreover Nilovskaya, *et al*., (2001) noted that epibrassinolide increased protein content in barley plants

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while Hayat and Ahmed (2003) and Hayat, *et al*., (2003) reported that homobrassinolide induced changes in proteins of *Lens culinaris* and wheat plants respectively.

With regard the effect of BRs on the mineral contents, Hathout (1996) reported that spraying wheat plants with BRs enhanced the accumulation of K^+ and Ca^+. While Kerrit (2005) found that spraying maize shoots with BRs increased total N, P, K, Ca and Mg concentration as compared to untreated control.

The objectives of this study is to evaluate the beneficial role for the effect of 28-homobrassinolide foliar application on carbohydrates, protein content and nutrient status of wheat plants grown under different salinity concentrations of the irrigation water.

MATERIAL AND METHODS

A greenhouse experiment was carried out at the National Research Center (Dokki, Cairo, Egypt) to evaluate the response of wheat plant (*Triticum aestivum* L. Cultivar Giza 164) for irrigation with saline water (0.2000, 4000, and 6000 ppm NaCl) and the importance of using the growth regulator Brassinasteroids (28-homobrassinoloide) as a foliar application at different concentrations (0, 50, 100, and 200 mg/L).

Twenty kilograms of sandy soil was placed each in 64 plastic pot (33 cm height and 24 cm wide diameter), phosphorus as superphosphate (8 gm P_2 O_5/pot) was added to each pot thoroughly mixed with the soil during seed bed preparation, the amount applied of nitrogen as $(NH_4)_2SO_4$ and potassium as K_2SO_4 were 10 and 4 gm for each pot respectively applied as three equal doses after 15, 30 and 75 days from sowing. Ten seeds of wheat variety Giza 164, were sown in each pot in randomized application and then irrigated with tap water to keep wet enough to sustain a satisfactory seed germination. Then two weeks after sowing, seedlings were thinned out to five per pot. The saline water was used at seedling emergence.

The pot experiment was carried out in split-plot design with a randomized complete blocks design.

The 64 pots represented the experimental treatments, which were irrigated with different concentrations of NaCl solution (0, 2000, 4000 and 6000 ppm), and were foliarly sprayed with different concentrations of brassinosteroid (28-homobrassinolide) at 0, 50, 100 and 200 mg/L. The combined 16 treatments with both BRs and NaCl solution, each treated pot with saline water (NaCl) after seedling emergence was foliarly sprayed with different concentrations of BRs, four replicates were considered for all treated pots, taking in consideration the control treatment using tap water. Tepole as surfactant was added to the spray solution of BRs at rate of 1ml/L, the volume of the spraying solution was maintained just to cover completely the plants foliage till drip, after 25, 40,and 65 days from sowing date, tap water was sprayed on plants as control treatments.

Samples of wheat plants were collected from each treatment at the harvest time, after 120 days from sowing to determine the reducing and non reducing sugar, total sugar, total carbohydrate and crude protein as percentage were estimated in wheat grains at harvest using the standard methods of A.O.A.C. (1990) and page *et al* (1984).

The concentration and total uptake of macro (N, P and K) and micronutrients (Fe, Mn, Zn and Cu) in straw and grains were determined using standard method described by Cottenie *et al.*, (1982) and Lindsay and Norvell (1978). All the attained data were subjected to conventional methods of statistical analysis according to Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

I- Chemical Constituents of Wheat Grains:

A- Effect of Salinity (S):

Data presented in Table (1) show that the salinity levels of the irrigation water exerted significant reduction on all studied chemical constituents of wheat grains (reducing and non reducing sugars, total sugar, total carbohydrate, and protein %) as compared with control treatment which irrigated with tap water. The highest values of the chemical constituents of wheat grains were obtained under the control treatment, while the lowest attained by using the highest concentration of NaCl in the irrigation water (6000 ppm).

The depressing effect of salinity on plant metabolic contents has been reported by many researchers. Through reducing water absorption and reducing metabolic activities due to salt toxicity and nutrient deficiencies caused by ionic interferences (Yeo, *et al.*, 1999 and Irshad, *et al*., 2002). The obtained results explained as a nutritional unbalance due to salinity levels influence. Moreover, such depression affect on chemical constituents attributed to the effect of water shortage under salinity conditions on enzymatic process retardation, particularly those related to photosynthetic process of wheat plants (Abdel Gawad *et al*., 1993).

B- Effect of Brassinosteroids (BRs):

Data presented in Table (1) show that increasing the concentration of foliar application with BRs, gradually significantly increased wheat grains constituents as compared with control plants.

In this concern Wu *et al*., (2008) stated that increased BRs levels favor sucrose accumulation in the leaf and starch in the seed and regulate the effects of sugar metabolism in leaves and seeds. Sakamoto *et al.*, (2005) stated that increasing BRs levels in rice plant leaves to maximize photosynthetic efficiency and sugar conversion to glucose and sucrose together with decreases in BRs levels at the leaf joint to maximize planting density, they added that seed filling depends on the flow of sucrose and other sugar from the stems and leaves to the embryo and endosperm. This flow is determined by the amount of CO_2 assimilation in the leaves, the loading of the phloem with sucrose and others sugars that can be transported, and by the activities of the enzymes that convert the sugars to starch in the seed. The loading of the phloem is determined by the activities of stem and leaf cell sugar transporters, which themselves are controlled by the levels of free sucrose and other sugars in the cytoplasm (Scofield *et al*., 2007).

Results are in agreement with those obtained by Hathout, 1996; Nafie and El-khallal, 2000; Mohamed, 2005; Kerrit, 2005 and Balbaa, 2007, who revealed that application of BRs as foliar spraying significantly increases contents of soluble and insoluble carbohydrates, reducing sugar, crude protein, sucrose, polysaccharides, soluble sugars and total carbohydrate in wheat, tomato, *Nigella sativa* and maize plants respectively. They added that these increment might substantiate the assumption that BRs may by rather engaged in photosynthetic processes. While Vardhini and Rao (2000) observed that application of brassinosteroid (24 and 28 homobrassinolide) increased levels of nucleic acid in tomato seedlings. It was found out that BRs application significantly increased the contents of protein in rice seedlings (Cao and Zhao, 2008).

In this concern Kuppusamy *et al*., (2009), presented strong evidence that brassinosteroids are required to maintain position-dependant fate specification in roots, so play an essential role in directing cell fate metabolism. Phytohormones have essential roles in coordinately regulating a large array of developmental processes, BRs and absicic acid interact to regulate hundreds of expression in genes, governing many biological processes (Zhang *et al,* 2009). Also Hansen *et al* (2009) proved that brassinoxsteroid acts post-transcriptionally by increasing the protein stability.

C- Effect of Interactions Between (S) × (BRs):

Effect of foliar application with BRs on salinity of irrigation water as presented in Table (1) indicated that all differences between treatments were significant in the studied of components parameters except the reducing sugar. Results were in descending order with increasing salinity and could be counteracted through ascending BRs levels.

In this concern Vardhini and Rao (2003) investigated that osmotic stress caused a considerable reduction in protein contents and BRs enhanced the activity of catalase and reduced the activity of peroxidase and ascorbic acid oxidase in three varieties of sorghum seedlings leading to significant stimulatory effect.

However, the role of BRs in the plant response to oxidative stress, it was shown that exogenous application of BRs modified antioxidant enzymes in rice seedlings under different stress conditions (Nunez, *et al*., 2003). Moreover Özdemir *et al*., (2004) found that 24-epiBL spraying maintained higher activity of ascorbate peroxidase enzyme in salt- sensitive rice seedlings leading to improve it's tolerance.

II- Nutrients Status in Straw and Grains of Wheat Plants:

A- Effect of Salinity (S):

The concentration and total uptake of N, P, K, Fe, Mn, Zn and Cu in wheat plants organs (grains and straw) as affected by different salinity levels of irrigation water are presented in Tables 2, 3, 4 and 5. It is clear from the obtained results that increasing the salinity levels from 0 to 6000ppm NaCl, significantly decreased nutrients uptake (mg/plant) of wheat plants. The highest for all the nutrients under study were obtained at control which irrigated with tap water, while the lowest values were attained by using the highest concentration of NaCl in the irrigation water (6000 ppm). This may be due to the effect of the high salt concentration in rooting media on growth, which might be due to an osmotic inhibition of water absorption, and specific ion concentration in the saline media, or a combination of both (Mazher *et al*., 2008).

The reduction of nutrients concentration as well as total uptake under saline conditions could be attributed to the decrease in dry matter accumulation and to the disturbance in membrane cell injury of root system which may operate for increasing Na^+ influx, accompanied with low Ca^{++} transport. Therefore, a critical interaction between Na^+/Ca^{++} ratio and/or Ca^{++} activity has been postulated to explain the salt tolerance concept

Table 1: Chemical constituents % of wheat grains at harvest as affected by saline irrigation water and BRs foliar application.

Treatments	Reducing	Non reducing	Total sugar	Total carbohydrate	Crude protein

		sugar	sugar			
Saline irrigation water (ppm)						
0		1.2	1.39	2.2	57.13	14.92
2000		1.11	1.26	1.98	55.3	13.78
4000		1.03	1.12	1.8	52.99	13.24
6000		0.9	1	1.63	51.44	11.46
LSD at 5%		0.07	0.07	0.1	1.45	0.89
BRs foliar application (mg/L)						
0		0.86	0.82	1.68	45.96	11.54
50		0.94	1.21	1.65	54.07	12.85
100		1.05	1.34	1.96	57.39	13.99
200		1.38	1.41	2.33	59.44	15.03
LSD at 5%		0.05	0.04	0.07	0.98	0.7
Saline water × BRs						
0	0	0.95	0.9	1.79	47.3	12.35
	50	1.1	1.44	1.9	58.11	14.88
	100	1.2	1.58	2.4	61.4	15.5
	200	1.56	1.62	2.72	61.7	16.94
2000	0	0.9	0.86	1.8	47.43	11.31
	50	0.97	1.29	1.7	55.98	13.69
	100	1.1	1.39	2	57.77	14.5
	200	1.54	1.5	2.41	60.01	15.63
4000	0	0.82	0.8	1.7	45.1	12.69
	50	0.9	1.11	1.59	52.19	12.35
	100	1	1.28	1.73	55.66	13.59
	200	1.39	1.3	2.16	59.01	14.35
6000	0	0.77	0.7	1.41	44.01	9.81
	50	0.8	1	1.4	50.02	10.5
	100	0.9	1.1	1.69	54.71	12.35
	200	1.12	1.2	2.01	57.03	13.19
LSD at 5%		NS	0.08	0.13	1.97	NS

(D'Amico *et al.*, 2004). Furthermore, Tester and Derenport (2003) reported that metabolic toxicity of Na^+ is largely a result of its salinity to compete with K^+ for binding sites essential for cellular function. More than 50 enzymes are activated by K^+ and Na^+ can not substitute in its role. Those high levels of Na^+, K^+ ratios can disrupt various enzymatic processes in the cytoplasm.

Moreover, protein synthesis requires high concentration of K^+, owing to the K^+ requirement for binding of RNA to ribosomes. On the other hand Grattan and Grieve (1999) stated that salinity can directly affect nutrients uptake, such as Na^+ reducing K^+ uptake or by Cl^- reducing NO^-_3 uptake. They added that salinity reduces phosphate uptake and accumulation in crops grown in soils primarily by reducing phosphate availability. They attributed the reduction to the excessive accumulation of Cl^- and Na^+ in leaves of plants, causing a nutritional imbalance through the reducing of Ca^{++}, Mg^{++} and K^+ concentration, also salinity can alter nutrient uptake through antagonistic effect with essential nutrients. The obtained results in this work are in good harmony with those obtained by Abou-El-Nour, (2002), who stated that salinity treatments caused marked depression in root Fe, Mn, Zn and Cu contents by 60, 45, 30 and 20% respectively. While these treatments decreased the aforementioned nutrients by 36, 39, 49 and 20% in plant shoot content respectively. They found that high salt concentration (1000, 2000, and 5000 ppm NaCl) in the root growth medium of wheat plants was found to limit the uptake of nutrients in different organs.

The obtained results showed that the nutrients concentration and uptake by straw and grains of wheat plants were negatively affected by increasing the salt concentration in irrigation water.

B- Effect of Brassinosteroids (BRs):

The concentration and uptake of N, P, K, Fe, Mn, Zn and Cu in grains and straw of wheat plants as affected by foliar application with BRs at the rates of 50, 100 and 200mg/L significantly increased as the foliar application with BRs increased (Tables 2,3,4 and 5). In all cases, the higher nutrients concentration and uptake by grains and straw of wheat plants were associated with the highest concentration of BRs foliar spray (200 mg/L.) as compared with control treatment sprayed with tap water, which had the lowest values.

The positive effect of the studied BRs treatments on increasing uptake of such nutrients is a true reflection of these treatments, which induced nutrients availability and made it accessible to plants for better growth and nutrients uptake.

The good effect of BRs on growth, nutrients concentration and uptake was explained by Morillon *et al.*,

(2001) who stated that the process of cell expansion involves cell wall relaxation followed by the osmotic transport of water and elements into cell to maintain turger pressure and cell wall synthesis to maintain wall thickness. Each of these steps in likely to be modulated by BRs. Thus, BRs are thought to affect the uptake of water and elements through aquaporins and the activity of the vacuolar H^-_+ ATpase. Cuo, *et al.,* (2009), mentioned that cell elongation in plants is controlled by internal growth regulators including plant steroid hormones BRs which are required for normal root elongation. Indeed one of the prominent and early recognized characteristic of BRs is to promote both cell elongation and cell proliferation.

Confirm our obtained results of nutrients status in wheat straw and grains as affected by BRs foliar application, Kerrit (2005) on maize and Abdel Hamid (2008) on wheat, stated that concentration as well as total uptake of N, P, K, Ca and Mg significantly increased over the corresponding control when plants sprayed with BRs concentrations throughout stages of growth.

C- Effect of Interactions Between (S) × (BRs):

The interaction of salinity and BRs application demonstrated that in presence of BRs, the concentrations as well as total uptake of all nutrients under study in straw and grains of wheat plants (N, P, K, Fe, Mn, Zn and Cu) were declined as the salinity of irrigation water increased, but the reductions were more steeper at the highest salt concentration (6000ppm NaCl). At all salinity levels, BRs addition improved the content and uptake of the previous nutrients (Tables 2, 3, 4 and 5) as compared with BRs untreated plants (control). However, such variations were clearly manifested at the lower salt exposure rather than the higher salt treatments. It is worthy to point out that the great plant performance across the salinity levels in the presence of BRs application might be correlated to the reduction in plant Na^+ content (Daoud, 2005). In this concern Yeo *et al*., (1999) explained the mode of action of BRs on reducing Na^+ transport by formation of Na-complex materials which inhibit Na^+ transportation into the salt stressed plants and they stated that this complex may cause partial blockage of the transpiration pass flow.

Table 2: Concentration of macro and micronutrients in wheat straw at harvest as affected by saline irrigation water and BRs foliar application.

Treatment		Concentration (%)			Concentration (ppm)			
		N	P	K	Fe	Mn	Zn	Cu
Saline irrigation water (ppm)								
0		1.73	0.35	1.56	74.96	21.83	11.6	5.18
2000		1.6	0.31	1.34	79.91	19.9	10.05	4.1
4000		1.48	0.27	1.17	76.18	16.73	8.96	3.48
6000		1.4	0.25	1.04	69.39	13.4	7.6	2.88
LSD at 5%		0.1	0.03	0.09	2.59	0.45	0.32	0.31
BRs foliar application (mg/L)								
0		1.28	0.24	1.07	36.6	10.25	2.93	2.76
50		1.51	0.27	1.22	60.48	17.15	7.98	2.96
100		1.67	0.31	1.32	90.38	19.33	12	4.78
200		1.75	0.35	1.52	112.98	25.13	15.3	5.14
LSD at 5%		0.06	0.02	0.07	2.46	0.24	0.25	0.19
Saline water × Brs								
0	0	1.42	0.28	1.33	40.1	12.8	3.7	3.74
	50	1.72	0.31	1.49	43.33	20.4	9.9	3.93
	100	1.85	0.37	1.65	99.1	22.72	14.8	6.3
	200	1.94	0.42	1.76	117.3	31.4	18	6.76
2000	0	1.32	0.25	1.14	39	11.2	3.1	2.8
	50	1.54	0.29	1.28	70.17	18.8	8.2	3
	100	1.73	0.32	1.38	96.27	21	12.7	5.2
	200	1.8	0.37	1.57	114.2	28.6	16.2	5.4
4000	0	1.23	0.23	0.98	36.1	9.8	2.93	2.4
	50	1.4	0.24	1.1	66.2	16.3	7.7	2.6
	100	1.6	0.29	1.21	92.3	18.4	10.3	4.2
	200	1.68	0.31	1.4	110.1	22.4	14.9	4.7
6000	0	1.16	0.21	0.82	31.2	7.2	2	2.1
	50	1.38	0.24	0.99	62.2	13.1	6.1	2.3
	100	1.48	0.27	1.02	73.87	15.2	10.2	3.4
	200	1.57	0.29	1.34	110.3	18.1	12.1	3.7
LSD at 5%		NS	0.01	NS	4.91	0.48	0.51	0.38

Table 3: Total uptake of macro and micronutrients (mg/pot) by wheat straw at harvest as affected by saline irrigation water and BRs

foliar application.

Treatment		Total uptake			Total uptake			
		N	P	K	Fe	Mn	Zn	Cu
Saline irrigation water (ppm)								
0		73.59	14.77	66.03	3.384	0.964	0.53	0.226
2000		53.01	10.26	44.55	2.794	0.69	0.361	0.14
4000		47.17	8.54	37.52	2.58	0.553	0.312	0.115
6000		42.06	7.63	31.9	2.256	0.424	0.255	0.09
LSD at 5%		5.26	1	4.85	0.229	0.067	0.042	0.015
BRs foliar application (mg/L)								
0		28.75	5.49	24.3	0.82	0.234	0.067	0.064
50		45.96	8.25	37.46	1.763	0.529	0.247	0.092
100		63.32	11.91	50.46	3.426	0.737	0.459	0.184
200		77.8	15.56	67.77	5.005	1.13	0.685	0.232
LSD at 5%		3.02	0.57	3.23	0.125	0.027	0.027	0.002
Saline water × Brs								
0	0	40.18	8.02	37.71	1.135	0.362	0.105	0.106
	50	67.63	12.17	58.57	1.704	0.803	0.39	0.154
	100	84.38	16.82	75.29	4.52	1.035	0.675	0.287
	200	102.16	22.08	92.55	6.177	1.654	0.949	0.356
2000	0	28.42	5.37	24.53	0.841	0.241	0.067	0.06
	50	46.81	8.82	38.91	2.133	0.571	0.249	0.091
	100	61.08	11.3	48.78	3.401	0.743	0.448	0.184
	200	75.71	15.56	65.97	4.801	1.203	0.681	0.227
4000	0	24.75	4.64	19.71	0.726	0.197	0.059	0.049
	50	37.46	6.43	29.42	1.774	0.437	0.206	0.07
	100	56.55	10.19	42.52	3.236	0.645	0.361	0.147
	200	69.92	12.9	58.41	4.585	0.933	0.62	0.196
6000	0	21.64	3.92	15.24	0.58	0.134	0.037	0.039
	50	31.93	5.56	22.96	1.443	0.304	0.141	0.053
	100	51.25	9.33	35.27	2.546	0.526	0.353	0.118
	200	63.4	11.71	54.13	4.456	0.731	0.489	0.149
LSD at 5%		6.05	1.13	6.46	0.25	0.053	0.053	0.005

Table 4: Concentration of macro and micronutrients in wheat grains at harvest as affected by saline irrigation water and BRs foliar application.

Treatment		Concentration (%)			Concentration (ppm)			
		N	P	K	Fe	Mn	Zn	Cu
Saline irrigation water (ppm)								
0		2.38	0.44	1.22	88.83	26.53	14.41	7.27
2000		2.21	0.39	0.98	85.48	24.55	12.89	6.67
4000		2.04	0.37	0.78	82	21.33	11.4	5.48
6000		1.84	0.34	0.69	73.65	18.7	9.65	4.78
LSD at 5%		0.12	0.03	0.07	1.3	1	0.47	0.24
BRs foliar application (mg/L)								
0		1.76	0.33	0.71	38.2	12.98	5.27	3.43
50		2.06	0.37	0.88	77.2	21.9	9.82	5.1
100		2.24	0.4	0.98	96.08	25.43	15.48	7.39
200		2.41	0.44	1.1	118.48	30.8	17.78	8.27
LSD at 5%		0.05	0.03	0.05	1	0.56	0.18	0.12
Saline water × Brs								
0	0	1.96	0.37	0.99	45.2	15.5	6.6	4.33
	50	2.37	0.41	1.16	81.6	25.4	11.27	6.42
	100	2.48	0.46	1.28	104.7	29.4	18.63	8.88
	200	2.71	0.52	1.46	123.8	35.8	21.13	9.45
2000	0	1.81	0.35	0.82	40.1	14.1	5.87	3.8
	50	2.19	0.38	0.91	80	23.3	10.6	5.97
	100	2.32	0.41	1.02	100.1	27.2	16.4	7.97
	200	2.5	0.43	1.18	121.7	33.6	18.7	8.93
4000	0	1.71	0.32	0.56	36.3	12.2	4.7	3
	50	1.98	0.36	0.79	77.2	20.6	9.4	4.2
	100	2.16	0.39	0.87	96.2	24.3	14.6	6.9
	200	2.3	0.41	0.9	118.3	28.2	16.9	7.8
6000	0	1.57	0.29	0.47	31.2	10.1	3.9	2.6
	50	1.68	0.32	0.67	70	18.3	8	3.8
	100	1.98	0.35	0.76	83.3	20.8	12.3	5.8
	200	2.11	0.39	0.84	110.1	25.6	14.4	6.9
LSD at 5%		0.11	NS	NS	1.99	1.12	0.37	0.25

Table 5: Total uptake of macro and micronutrients (mg/pot) by wheat grains at harvest as affected by saline irrigation water and BRs foliar application.

Treatment		Total uptake			Total uptake			
		N	P	K	Fe	Mn	Zn	Cu
Saline irrigation water (ppm)								
0		46.26	8.58	23.91	1.82	0.54	0.3	0.15
2000		34.21	6.03	15.32	1.41	0.4	0.21	0.11
4000		30.01	5.43	11.66	1.29	0.33	0.18	0.09
6000		24.29	4.46	9.33	1.06	0.26	0.14	0.07
LSD at 5%		2.23	0.41	1.39	0.04	0.01	0.01	0.005
BRs foliar application (mg/L)								
0		16.58	3.13	6.96	0.36	0.12	0.05	0.04
50		28.46	5.07	12.38	1.06	0.3	0.14	0.07
100		38.47	6.94	17.17	1.65	0.44	0.27	0.13
200		51.27	9.36	23.71	2.51	0.66	0.38	0.18
LSD at 5%		1.06	0.23	0.97	0.05	0.007	0.004	0.002
Saline water × Brs								
0	0	23.92	4.52	12.08	0.55	0.19	0.08	0.05
	50	40.22	6.96	19.68	1.38	0.43	0.19	0.11
	100	51.59	9.57	26.62	2.18	0.61	0.3.9	0.18
	200	69.31	13.3	37.26	3.17	0.92	0.54	0.24
2000	0	17.2	3.33	7.78	0.38	0.13	0.06	0.04
	50	30.22	5.25	12.51	1.1	0.32	0.15	0.08
	100	38.08	6.72	16.73	1.64	0.45	0.27	0.13
	200	51.36	8.82	24.25	2.5	0.69	0.38	0.19
4000	0	15.56	2.91	5.09	0.33	0.11	0.04	0.03
	50	24.75	4.5	9.88	0.97	0.26	0.12	0.05
	100	34.12	6.16	13.79	1.52	0.38	0.23	0.11
	200	45.62	8.13	17.86	2.34	0.56	0.33	0.15
6000	0	9.63	1.78	2.88	0.19	0.06	0.02	0.02
	50	18.65	3.55	7.44	0.78	0.2	0.09	0.04
	100	30.1	5.32	11.55	1.26	0.32	0.19	0.09
	200	38.79	7.17	15.45	2.03	0.47	0.26	0.13
LSD at 5%		2.12	0.46	1.95	0.09	0.01	0.005	0.002

The combination between salinity levels of irrigation water and BRs foliar application with different rates of (0, 50, 100 and 200mg/L) were almost positive for nutrients status of wheat plants. Therefore it can be postulated that BRs treatments might protect plant against salt stress by an exogenous supply of nitrogen which believed to be caused indirectly as a result of its effect on K^+ uptake which plays an essential role in many metabolic processes such as photosynthesis process and hence the formation of starch. On the other hand, the interaction between salinity levels and BRs treatment decreased Na^+ % in different plant organs compared with untreated plants. Hence it could be recommended to spray plants which grown in regions irrigated by saline water with BRs (28-homoBL) to overcome the destructive effect of salinity.

Conclusion:

Brassinosteroids can act efficiently in plants as immunomodulators when applied at the appropriate concentration at the correct stage of plant development. BR (28-HomoBL) regulated stress response as a result of complex sequence of biochemical reaction such as activation or suppression of key enzymatic reactions, induction of protein synthesis, and the production of various chemical defense compounds. In view of this experimental data, attentions is being directly to the fact that BRs application to salt stressed plants is evidently essential not only for increasing the salt tolerance of wheat but also for improving yield potential and mineral plant composition. Base on these promising results, further experiments are still needed to be conducted under field conditions to define sources and optimal rates of BRs under different saline environmental for semi-tolerant crops. BRs open up new approaches for plant resistance against hazardous environmental conditions.

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