

## Effect of Brassinolide on Physio-Biochemical Traits, Growth and Yield of Barley (*Hordeum vulgare* L.) under Salt Stress

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**Abstract** An experiment was conducted to investigate the role of brassinolide in amelioration of harmful effects of salinity on physio-biochemical traits, growth and yield of barley cv namely RD-2794 (salinity tolerant) and RD-2035 (salinity susceptible) in the laboratory and cage house during *rabi* season of 2014–2015. The seeds were sown in petri plates and in cemented pots containing 15 kg soil in which saline irrigation (tap water, 3, 6, 9 and 12 dSm<sup>-1</sup>) were applied as and when required. Different concentrations of brassinolide (0.0, 0.5, 1.0 and 1.5 ppm) were added in

the saline set of petri-dishes whereas, in the pot experiment, plants were sprayed with brassinolide at 52 and 82 days after sowing. Control plants were provided normal water whenever needed. Seedling growth parameters were recorded at 8 days after treatment in the laboratory and physiological, biochemical observations were recorded at 52 and 82 days after sowing in pot conditions. Yield parameters were recorded at harvest. Analysis of data revealed that a significant decrease were recorded in germination percentage, root length, shoots length, fresh weight, dry weight of root and shoot, plant height, leaf area, number of spikes, length of spike per plant, number of seeds per spike, chlorophyll, relative water content, cell membrane stability, protein content and grain yield with increase in proline and carotenoid content up to 8 dSm<sup>-1</sup> whereas a significant increase were recorded in these parameters by the use of brassinolide up to 1.5 ppm concentration. On the basis of the above findings RD-2794 observed superior over RD-2035 with respect to traits studied under laboratory and pot experiment.

**Keywords** Barley, Brassinolide, Physiology, Growth, Salinity.

### Introduction

*Hordeum vulgare* L. (barley) is an important cereal crop for both malting industry and animal husbandry.

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Barley is an annual cereal grain crop that is consumed as a major feed for the animals. The rest is used as malt in whiskey or sugar as well as health food. It is basically a grass crop that comes from the family of Poaceae and considered to be the fourth most important crop in the world after wheat, maize and rice. The crop resembles white berries and is believed to be excellent for drought-like conditions. Other than playing its part a major food crop, it is also used in beverages and beers. It is available in a variety of forms like whole barley, hulled barley, pearled barley as well as barley flakes. It is a rich source of metals like zinc, copper and phosphorus, as well as other nutrients like calcium and iron.

Salinity affects plant growth, activity of major cytosolic enzymes by disturbing intracellular potassium homeostasis, causing oxidative stress and programmed cell death, reduced nutrient uptake, metabolic toxicity, inhibition of photosynthesis, reduced CO<sub>2</sub> assimilation and reduced root respiration [1]. Salinity has negative impact on water and nutrient uptake because of osmotic and ionic imbalance. This will produce plants with reduced height, less leaves and tillers as well as reduced yield [2]. Since salinity is complicated trait and genetically controlled, plants show different response when they grown under salinity stress according to their genes content [3].

Brassinosteroids (BRs) are a new type of polyhydroxy steroidal phytohormones with significant growth-promoting influence [4] BRs played important roles in monitoring the stress-protective properties in plants against a number of abiotic stresses like low temperature/chilling, freezing, salt, high temperature/heat stress, water/drought/water logging, heavy metals and biotic stresses [5]. BRs confer salt tolerance to plants by mitigating its negative effects on the physiological, biochemical and molecular processes in plants [6]. Brassinolide improved the growth, yield and chemical composition of berseem (*Trifolium alexandrinum* L.) grown in saline soils [7, 8]. Problem of salinity is increasing day by day, one of the best solutions is to use saline soils effectively for improved salt tolerance in crops. For this purpose different approaches, were adopted, among those one is the exogenous application of plant growth regulators. The objective of this study was to observe the

**Table 1.** Composition of salts for preparing different levels of saline irrigation water.

Salinity levels	NaSO <sub>4</sub> (mg/l)	NaCl (mg/l)	MgCl <sub>2</sub> (mg/l)	CaCl (mg/l)
Control	Tap water	Tap water	Tap water	Tap water
EC <sub>3</sub> dSm <sup>-1</sup>	532.65	614.25	457.41	551.31
EC <sub>6</sub> dSm <sup>-1</sup>	1065.3	1228.5	914.82	1102.62
EC <sub>9</sub> dSm <sup>-1</sup>	1597.95	1842.75	1372.23	1653.93
EC <sub>12</sub> dSm <sup>-1</sup>	2136.6	2457	1829.64	2205.24

effect of exogenous application of brassinolide as foliar spray in amelioration of harmful effects of salinity on growth and yield of wheat.

## Materials and Methods

### Plant materials and experimental details

A laboratory and pot experiment were conducted at cage house located in the Department of Plant Physiology, S.K.N. College of Agriculture, Jobner during *rabi* season 2014-15, to investigate effect of brassinolide on physio-biochemical traits, growth and yield of barley (*Hordeum vulgare* L.) under salt stress. The pots were filled with 15 kg of loamy sandy soil having a bulk density of 1.5 g cm<sup>-3</sup>, electric conductivity (EC) 0.4 dSm<sup>-1</sup>, pH 8.2, sodium absorption ratio 12.5 and CaCO<sub>3</sub> 0.14%. The field capacity and permanent wilting point of the soil were 11.8 and 2.8%, respectively. 72 pots for both cultivar RD-2794 (salinity tolerant) and RD-2035 (salinity susceptible) were used for growing of wheat up to harvesting. The recommended doses of manures, fertilizers and other inputs were provided at the appropriate time. Salts used to prepare saline irrigation water of EC 3, 6, 9 and 12 dSm<sup>-1</sup>; (Table 1) chloride and sulfate in 3:1 ratio by using following salts, NaCl, NaSO<sub>4</sub>, CaCl and MgCl<sub>2</sub>. One liter of the saline water was provided to each pot having three plants as and when required. The control plants were irrigated with tap water. The plants were irrigated with saline water as per treatment up to maturity.

**Table 2.** Effect of salinity and brassinolide on germination %, root and shoot length, fresh and dry weight of seedling root and shoot of wheat. DAT=Days After Treatment.

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Fresh weight of root (mg/seedling)	Dry weight of root (mg/seedling) After oven drying	Fresh weight of shoot (mg/seedling)	Dry weight of shoot (mg/seedling) After oven drying
	8 DAT	8 DAT	8 DAT	8 DAT	8 DAT	8 DAT	8 DAT
<b>Varieties</b>							
RD-2794	81.81	6.07	5.21	9.29	2.03	24.88	4.56
RD-2035	73.22	5.12	6.13	7.86	1.75	29.11	6.36
SEm ±	0.62	0.11	0.12	0.20	0.05	0.43	0.09
CD ( <i>p</i> =0.05)	1.75	0.31	0.33	0.56	0.14	1.22	0.25
<b>Salinity levels</b>							
Control	85.28	6.75	7.71	9.43	2.26	30.12	7.00
3.0 dSm <sup>-1</sup>	82.35	6.33	6.39	8.95	2.18	20.00	6.63
6.0 dSm <sup>-1</sup>	78.00	6.05	6.00	8.53	2.01	26.88	6.25
9.0 dSm <sup>-1</sup>	71.88	5.75	5.83	8.15	1.83	25.85	5.93
12.0 dSm <sup>-1</sup>	70.05	5.65	5.51	7.81	1.70	24.12	5.60
SEm ±	0.98	0.13	0.19	0.19	0.05	0.68	0.14
CD ( <i>p</i> =0.05)	2.76	0.36	0.52	0.53	0.14	1.92	0.40
<b>Brassinolide</b>							
0	71.96	4.81	4.90	7.46	1.64	22.95	3.93
0.5	76.62	5.04	5.12	8.51	1.91	25.91	4.95
1.0	79.50	5.6	5.81	9.04	2.12	28.56	6.06
1.5	81.96	6.1	6.34	9.29	2.27	30.56	6.90
SEm ±	0.88	0.08	0.08	0.28	0.07	0.61	0.13
CD ( <i>p</i> =0.05)	2.47	0.22	0.21	0.79	0.19	1.72	0.36

The plants were sprayed with Brassinolides of following concentration for different treatment. The different concentrations of brassinolide 0.0 (control), 0.5 ppm, 1.0 ppm and 1.5 ppm were sprayed at vegetative stage (52 DAS) and pre-anthesis stage (82 DAS). The observations were recorded 10 days after spray of brassinolides using completely randomized design. The data of membrane stability were recorded by using the method of Sullivan [9]; chlorophyll content by Arnon [10]; determination of proline, protein and reducing sugar by the methods earlier [11, 12] determination of seedling growth and yield parameters; seed germination percentage was calculated by counting the number of seeds germinated at 8 DAT. The root length and shoot length were measured with the help of scale at 8 DAT. Five washed seedling from each petridish were separated into root and shoot for the determination of fresh weight (8<sup>th</sup> DAT) and dry weight of seedling root. Dry weight was determined after oven drying the root samples at 70°C until constant weight was obtained. The height of three ran-

domly selected plants were measured from base to the top of the plant with the help of meter scale in cm at 60 and 90 DAS. Leaf area was measured with the help of leaf area meter (LICOR 3000 USA). Three plants were selected randomly and average green leaf area was calculated at 60 and 90 DAS. The total number of spike per plant were counted in each pot and then the average was calculated. Length of the main spike excluding awns was measured with the help of scale. The total number of seeds per spike was counted in each pot and then the average was calculated. After harvest, plants were air dried and the grain yield was taken and calculated as per plant basis.

## Results and Discussion

### Seedling parameters

#### *Varietal response*

Table 2 showed that RD-2794 (salinity tolerant) ex-

**Table 3.** Effect of salinity and brassinolide on germination %, root length and shoot length of wheat. DAT=Days After Treatment.

Treatments	Plant height		Leaf area		Number of spikes/plant After harvesting	Length of spikes/plant After harvesting	Number of seeds/spike After harvesting	Grain yield (g/plant) After harvesting
	60 DAT	90 DAT	60 DAT	90 DAT				
Varieties								
RD-2794	36.28	48.27	80.06	97.82	2.92	8.95	46.48	4.25
RD-2035	32.33	53.72	73.77	87.98	2.43	8.01	38.94	3.58
SEm ±	0.42	0.46	0.76	0.98	0.04	0.11	0.46	0.06
CD ( <i>p</i> =0.05)	1.19	1.30	2.14	2.75	0.11	0.32	1.29	0.18
Salinity levels								
Control	41.22	56.55	87.84	104.22	3.25	9.02	48.88	4.66
3.0 dSm <sup>-1</sup>	36.51	53.05	81.91	96.91	2.91	8.73	45.29	4.16
6.0 dSm <sup>-1</sup>	33.54	50.45	76.22	91.55	2.63	8.45	42.13	3.85
9.0 dSm <sup>-1</sup>	31.22	48.22	71.24	87.81	2.37	8.20	39.22	3.57
12.0 dSm <sup>-1</sup>	29.02	46.71	67.35	84.02	2.21	8.01	38.02	3.33
SEm ±	0.67	0.73	1.20	1.55	0.06	0.09	0.73	0.10
CD ( <i>p</i> =0.05)	1.88	2.05	3.38	4.34	0.17	0.26	2.04	0.29
Brassinolide								
0	28.66	46.08	66.07	81.55	2.24	7.93	38.39	3.24
0.5	33.10	49.75	74.72	90.62	2.60	8.38	41.70	3.81
1.0	36.32	53.03	81.55	97.59	2.87	8.68	44.45	4.16
1.5	39.13	55.13	85.32	101.85	2.99	8.94	46.29	4.44
SEm ±	0.60	0.65	1.08	1.38	0.05	0.15	0.65	0.09
CD ( <i>p</i> =0.05)	1.68	1.83	3.02	3.88	0.35	0.44	1.83	0.26

hibited a significant increase in germination percentage (11.7% more than RD-2035). A significant increase in root length (18% more than RD-2035), fresh weight (18.1% more than RD-2035) and dry weight (16.0% more than RD-2035) of seedling root at 8 DAT, whereas an increase was recorded in shoot length (17.6% more than RD-2035), fresh weight (17.0% more than RD-2035) and dry weight (20.9% more than RD-2035) of seedling shoot at 8 DAT.

#### *Effect of salinity*

Data further revealed that salinity levels (3, 6, 9 and 12 dSm<sup>-1</sup>) significantly reduced the seedling traits as compared to control this includes germination percentage (3.55, 9.33, 18.6 and 21.7% less than control), root length (6.6, 11.5, 17.3 and 19.4% less than control at 8 DAT), shoot length (5.0 and 11.8, 15.0 and 21.7% less than control at 8 DAT), fresh weight of root (5.36, 10.5, 15.7 and 20.7% less than control), dry weight of root (3.66, 12.4, 23.4 and 32.9% less than control), fresh weight of shoot (7.57, 12.0, 16.5 and 24.8% less

than control) and dry weight of shoot (5.58, 12.0, 18.0 and 25.0% less than control) at 3, 6, 9 and 12 dSm<sup>-1</sup>. Higher salt concentration hampers vital processes such as germination percentage and seedling growth [13]. The harmful effect of salt stress includes the reduction in germination rate and seedling growth [13]. A decline in root and shoot length may be due to NaCl toxicity and disproportion in nutrient absorption by the seedlings [14, 15]. As salt concentration increases in the medium, plants absorb lesser water causing physiological desiccation and may be responsible for decrease in fresh and dry weight of seedlings [16].

#### *Effect of Brassinolide*

Table 2 further showed that a significant increase were recorded in seedling parameters; these involves germination percentage (6, 47, 10.4 and 13.89% more than control at 8 DAT); root length (4.78, 16.4 and 26.0% more than control at 8 DAT); shoot length (4.48, 18.5 and 29.0% more than control at 8 DAT); fresh weight

**Table 4.** Effect of salinity and brassinolide on germination %, root length and shoot length of wheat. DAT=Days After Treatment.

Treatments	Chlorophyll 'a'		Chlorophyll 'b'		Carotenoid content		Relative water content (%)		Cell membrane stability (%)		Proline (µg/g f.w.)		Protein (mg/g f.w.)	
	(mg/g f.w.)		(mg/g f.w.)		(µg/ml)		(%)		(%)		(µg/g f.w.)		(mg/g f.w.)	
	52	82	52	82	52	82	52	82	52	82	52	82	52	82
	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT
<b>Varieties</b>														
RD-2794	1.35	1.55	1.19	1.15	1.09	1.13	74.34	74.54	77.91	77.81	29	37	19.85	21.73
RD-2035	1.18	1.28	1.05	1.00	1.49	1.42	64.98	65.46	75.99	75.77	40	54	17.06	19.96
SEm ±	0.03	0.04	0.03	0.03	0.03	0.04	1.14	0.90	0.64	0.64	3.8	3.1	0.26	0.31
CD (p=0.05)	0.10	0.11	0.09	0.08	0.09	0.10	3.21	2.51	1.79	1.81	10.6	8.7	0.73	0.87
<b>Salinity level</b>														
Control	1.42	1.58	1.20	1.38	1.02	1.09	74.55	74.66	82.55	84.11	14	28	20.90	23.01
3.0 dSm <sup>-1</sup>	1.36	1.54	1.17	1.20	1.28	1.33	22.54	72.81	79.55	80.55	28	39	19.25	22.11
6.0 dSm <sup>-1</sup>	1.29	1.44	1.14	1.15	1.39	1.49	70.42	71.00	76.61	77.00	38	48	17.55	21.00
9.0 dSm <sup>-1</sup>	1.19	1.33	1.09	1.08	1.48	1.58	67.22	67.65	74.00	74.58	54	65	16.81	19.89
12.0 dSm <sup>-1</sup>	1.06	1.19	0.98	0.97	1.53	1.63	63.55	63.88	72.02	72.71	79	85	15.74	18.22
SEm ±	0.02	0.014	0.01	0.05	0.05	0.06	0.47	0.70	0.81	1.25	3.2	2.9	0.41	0.24
CD (p=0.05)	0.05	0.04	0.02	0.13	0.15	0.16	1.32	1.97	2.29	3.11	8.9	8.2	1.15	0.68
<b>Brassinolide</b>														
0	1.04	1.24	0.99	0.95	1.07	1.21	64.86	65.13	71.89	73.32	29	32	16.72	19.17
0.5	1.26	1.37	1.09	1.06	1.27	1.41	67.63	68.09	75.63	76.18	31	38	17.99	20.39
1.0	1.34	1.49	1.17	1.13	1.44	1.54	70.72	71.23	78.66	79.41	40	46	19.17	21.48
1.5	1.41	1.57	1.21	1.16	1.57	1.63	75.42	75.56	81.61	82.25	52	56	19.93	22.34
SEm ±	0.05	0.05	0.03	0.03	0.05	0.05	0.91	0.91	1.05	0.76	0.61	2.1	0.37	0.36
CD (p=0.05)	0.13	0.11	0.08	0.09	0.13	0.15	2.54	2.55	2.94	2.14	1.7	5.8	1.03	1.03

of root (14.0, 21.1 and 24.5% more than control at 8 DAT); dry weight of root (16.8, 29.2 and 38.4% more than control); fresh weight of shoot (12.8, 24.4 and 33.1% more than control at 8 DAT) and dry weight of shoot (8.7, 21.1 and 33.3% more than control after oven drying) at 0.5, 1.0 and 1.5 ppm concentration. Vardhini and Rao [17] reported that 28-brassinolide and 14-epibrassinolide are very effective in increasing germination percentage and seedling growth rate of sorghum under osmotic stress. Generally [18] stated that BRs removed the salinity induced inhibition of seed germination and seedling growth of rice (*Oryza sativa*).

#### Growth and yield parameters

##### Varietal response

Table 3 showed that RD-2794 showing significantly higher plant height (12.3 and 11.2% at 60 and 90 DAT), leaf area (8.52 and 11.2% at 60 and 90 DAT), number

of spikes/plant (20.1%), length of spike/plant (11.7%), number of seeds/spike (19.3% more than RD-2035) and grain yield/plant (18.7% more than Raj-1482).

##### Effect of salinity

Data further revealed that the increasing level of salinity up to 12 dSm<sup>-1</sup> significantly reduced the growth and yield traits as compared to control; this includes plant height (12.9, 22.8, 32.0 and 42.1; 6.7, 12.0, 17.2 and 21.0% less than control at 60 and 90 DAT); leaf area (7.23, 15.2, 23.3 and 30.4; 7.54, 13.8, 18.6 and 24.0% more than control at 60 and 90 DAT); number of spikes/plant (11.6, 23.5, 37.1 and 47.0% more than control); length of spike/plant (3.32, 6.74, 10.0 and 12.6% more than control); number of seeds/spike (7.92, 16.0, 24.6 and 28.5% more than control) and grain yield/plant (12.0 and 21.0, 30.0 and 39.9% more than control) at 3, 6, 9 and 12 dSm<sup>-1</sup>. These effects might be due to salinity which inhibits the growth of wheat plant through reduced water absorption and reduced

metabolic activity due to Na and Cl toxicity and nutrient deficiency caused by ionic interference [19]. Since under saline condition root pressure is reduced causing a decrease in water flow, that means less water is taken up by the roots and transported into shoot, consequently, less water is available for normal growth and development [20].

#### *Effect of brassinolide*

Table 3 further showed that a significant increase were recorded in growth and yield traits; this includes plant height (15.4, 26.7 and 36.5; 8.15, 15.2 and 19.8% at 60 and 90 DAT); leaf area (13.0, 23.4 and 29.1; 11.1, 19.6 and 24.8% at 50 and 65 DAT); number of spikes/plant (16.0, 28.1 and 33.4%); length of spike/plant (5.67, 9.45 and 12.7%); number of seeds/spike (8.62, 15.7 and 20.5%) and grain yield/plant (17.5, 28.3 and 37.0%) as compared to control at 0.5, 1.0 and 1.5 ppm concentration. Foliar application of brassinolide increased yield and yield attributes of treated plants and significantly overcome the depressive effect of saline irrigation water at all levels on crop productivity and photosynthetic pigments. The obtained results are in good agreement with those reported by Abdel and Ebitahal [21] on wheat who stated that foliar spray of brassinolide showed a high significant increase in growth parameters as compared with untreated control plants.

#### Physiological parameters

##### *Varietal response*

Table 4 showed that RD-2794 indicating significantly higher chlorophyll a content (14.4 and 21.0% at 52 and 82 DAT), chlorophyll b (13.3 and 15.0% at 52 and 82 DAT), carotenoid control (36.6 and 25.6% at 52 and 82), relative water content (14.4 and 13.8% at 52 and 82), cell membrane stability (2.5 and 2.69%), proline content (39.9 and 31.4%), reducing sugar (15.1 and 16.5%) and protein content (16.3 and 8.86%) more than RD-2035.

##### *Effect of salinity*

Data further revealed that the increasing level of salinity up to 12 dSm<sup>-1</sup> significantly reduced the physi-

ological variables as compared to control; this includes chlorophyll content a (3.6, 10.0, 19.3 and 33.9; 2.59, 9.72, 18.7 and 32.7% at 52 and 82 DAT); chlorophyll content b (1.69, 5.2, 10.0 and 22.4; 15.0, 20.0, 27.7 and 42.2% at 52 and 82 DAT); cell membrane stability (3.77, 7.75, 11.5 and 14.0; 4.41, 9.23, 12.7 and 15.6% at 52 and 82 DAT); relative water content (2.77, 5.86, 10.9 and 17.3; 2.54, 5.15, 10.32 and 16.8% at 52 and 82 DAT); protein content (8.57, 19.0, 24.3 and 32.7; 4.02, 9.52, 15.6 and 26.2% at 52 and 82 DAT) with increase in proline content (16.6, 58.3, 125.0 and 229.0; 39.2, 71.4, 132.0 and 203.0% at 52 and 82 DAT); and carotenoid content (25.4, 36.2, 45.0 and 50.0; 22.0, 36.6, 44.9 and 49.5% at 52 and 82 DAT). Chaves et al. [22] reported that the reduction in crop production in various plant species exposed to salt stress linked to the decline in photosynthesis. The binding between chlorophyll and chloroplast proteins depend upon the ion content of cells under high salinity, such links are loosened and as a result more chlorophyll can be destroyed [23]. Free proline is known to accumulate in response to biotic and abiotic stresses and has been shown to protect plants against free radical induced damage [24], this is because proline accumulation in salt stressed plants is a primary defense response to maintain the osmotic pressure in a cell. The data of protein content are in accordance with the findings of Bera et al. [25]. It could be concluded that salinity adversely affected the photosynthetic pigments. In addition, spraying salinity stressed-wheat plants with brassinolide can reduce the undesirable effect of salinity through improving growth and nutrients status of plants as well.

##### *Effect of brassinolide*

Table 3 revealed that a significant increase were recorded in physiological traits; this includes chlorophyll a content (21.1, 28.8 and 35.5; 10.48, 20.1 and 26.6% at 52 and 82 DAT); chlorophyll b content (10.1, 18.1 and 22.2; 11.5, 18.9 and 22.1% at 52 and 82 DAT); cell membrane stability (5.2, 9.4 and 13.5, 3.9, 8.3 and 12.2% at 52 and 82 DAT); relative water content (4.27, 9.0 and 16.2; 4.4, 9.36 and 16.0% at 52 and 82 DAT); carotenoid content (18.6, 34.5 and 46.7; 16.5, 27.2 and 34.7% at 52 and 82 DAT); proline content (6.8, 37.9 and 79.3; 18.7, 43.7 and 75.0% at 52 and 82 DAT); and protein content (7.59, 14.6 and 19.2; 6.36, 12.0 and

16.5% at 52 and 82 DAT) as compared to control. Brassinolide detoxified the stress generated by Na and Cl significantly improves the values for growth and photosynthetic parameters [8]. Abdel and Ebitahal [21] found that spraying plant with brassinoloide significantly increased photosynthetic pigments in *Oryza sativa* and wheat plants respectively as compared with untreated control plants. These results are in good agreement with those obtained by Cao and Zhao [26] who stated that spraying *Nigella sativa* seeds and rice seedlings with BRs respectively caused highly significant increase in photosynthetic pigment content of plants. The results of cell membrane stability are in accordance with the findings of Gograj et al. [27]. The results of proline content are in accordance with the findings of Gograj et al. [27]. The results of protein content are in accordance with the findings of Bera et al. [25], as compared to control at 0.25, 0.50 and 1.00 ppm concentration over control.

## Conclusion

In this study, salinity induced variations in grain yield and quality were larger among sensitive genotypes than salt tolerant ones. These results suggested that the use of salt-tolerant wheat cultivars might be the most promising strategies for harvesting higher grain yield of best quality under saline conditions. One of the best solutions is to use saline soils effectively for improved salt tolerance in crops. For this purpose different approaches, were adopted, among those one is the exogenous application of plant growth regulators.

## References

- Liu J, Gao H, Wang X, Zheng Q, Wang C, Wang X, Wang Q (2014) Effects of 24-pibrassinolide on plant growth, osmotic regulation and ion homeostasis of salt stressed canola. *Pl Biol* 16 : 440—450.
- Yaycili O, Alikamanoglu S (2012) Induction of salt tolerant potato (*Solanum tuberosum* L.) mutants with gamma irradiation and characterization of genetic variations via RAPD-PCR. *Analysis* 36 : 405—412.
- Gupta B, Huang B (2014) Mechanism of salinity tolerance in plants: Physiological, biochemical and molecular characterization. *J Genomics*, pp 1—18.
- Vardhini BV, Anjum NA (2015) Brassinosteroids make plant life easier under abiotic stresses by modulating major components of antioxidant defense system. *Frontiers in Environ Sci* 2 : 67.
- Vardhini BV (2013) Brassinosteroids, role for amino acids, peptides and amines modulation in stressed plants-A review. In: NA Anjum, SS Gill, Gill, R Cab (eds). *Plant adaptation to environmental change: Significance of amino acids and their derivatives*. Int of Nosworthy Way, Wallingford OX10 8DE, United Kingdom, pp 300—316.
- Ashraf M, Akram NA, Arteca RN, Foolad MR (2010) The physiological, biochemical and molecular roles of brassinosteroids and salicylic acid in plant processes and salt tolerance. *Crit Rev Pl Sci* 29 : 162—190.
- Daur I, Tatar O (2013) Effects of gypsum and brassinolide on soil properties and berseem growth, yield and chemical composition grown on saline soil. *Leg Res* 36 : 306—311.
- Hayat S, Hasan SA, Yusuf M, Hayat Q, Ahmad A (2010) Effect of 28-homobrassinolide on photosynthesis, fluorescence and antioxidant system in the presence or absence of salinity and temperature in *Vigna radiata*. *Environ Expt Bot* 69 : 105—112.
- Sullivan CY (1971) Techniques for measuring plant drought stress. In: KL Larson, JD Easti (eds). *Drought injury and resistance in crops*. Crop Sci Soc Am, Madison, USA, pp 1—18.
- Arnon DI (1949) Copper enzyme in isolated chloroplasts. Polyphenol oxidase in *Beta vulgaris*. *Pl Physiol* 24 : 1—15.
- Bates LS, Waldren RP, Teare ID (1973) Rapid determination of free proline for water stress studies. *Pl and Soils* 34 : 205—207.
- Lowry OH, Rosenbrought NJ, Farr AL, Randall RJ (1951) Protein measurement with folin-phenol reagent. *J Biochem* 19 : 265—275.
- Sairam RK, Tyagi A (2004) Physiology and molecular biology of salinity stress tolerance in plants. *Curr Sci* 86 : 407—421.
- Jamil M, Bashir S, Anwar S, Bibi S, Bangash A, Ullah F, Rha ES (2012) Effect of salinity on physiological and biochemical characteristics of different varieties of rice. *Pak J Bot* 44 : 7—13.
- Bordi A, Tabatabaei J (2009) Effect of salinity stress on germination and seedling properties in Canola cultivars. *Notulae Botanicae Hort Agrobotanici Cluj-Napoca* 37 : 71—76.
- Bagdi DL, Afria BS (2008) Alleviation of deleterious effects of salinity by plant growth regulators in wheat. *Ind J Pl Physiol* 3 : 272—277.
- Vardhini BV, Rao SSR (2003) Amelioration of osmotic stress by brassinosteroids on seed germination and seedling growth of three varieties of sorghum. *Pl Growth Regul* 41 : 25—31.
- Bajguz A, Hayat S (2009) Effect of brassinosteroids on the plant responses to environmental stresses. *Pl Physiol and Biochem* 47 : 1—8.
- Aziz Eman E, Taalab ASM (2004) Dragon head plants (*Dracocephalum mldavica* L.) responses to salt stress and different sources of sulfur. *Egypt J Appl Sci* 19 : 239—257.

20. Mazher Azza AM, Zaghloul M, Sahar, T El-Mesiry (2008) Nitrogen forms affects on the growth and chemical constituents of *Taxodium disticum* grown under salt conditions. *Aust J Basic Appl Sci* 2 : 527—534.
21. Abdel Hamid, Ebitahal M (2008) Physiological effect of some phytohormones on growth productivity and yield of wheat plant cultivated in new reclaimed soil. PhD thesis. Bot Dep Univ College of Women for Arts, Sci and Educ Ain Shams Univ Cairo, Egypt.
22. Chaves MM, Flexas J, Pinheiro C (2009) Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. *Ann Bot* 103 : 551—556.
23. Strogonov BP (1964) Physiological basis of salt tolerance of plants (as affected by various types of salinity). *Israel Prog Sci Transl Jerusalem*, Subraha.
24. Matysik J, Alia Bhalu B, Mohanty P (2002) Molecular mechanisms of quenching reactive species by proline under stress in plants. *Curr Sci* 82 : 525—532.
25. Bera AK, Pati MK, Anita Bera (2006) Brassinolide ameliorates adverse effects of salt stress on germination and seedling growth of rice. *Ind J Pl Physiol* 11 : 182—189.
26. Cao YY, Zhao H (2008) Protective roles of brassinolide on rice seedlings under high temperature stress. *Rice Sci* 15 : 63—68.
27. Gograj Jat, Bagdi DL, Kakralya BL, Jat ML, Shekhawat PS (2012) Mitigation of salinity induced effects using brassinolide in clusterbean. *Crop Res Hisar* 44 : 45—50.