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Effect of Brassinolide on Wheat (*Triticum aestivum* L.) Production under Salt Stress

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Abstract A pot experiment was conducted to know the amelioration of harmful effects of salinity by brassinolide on physiological traits, growth and yield of wheat cv namely HD-2687 (salinity susceptible) and Raj-3777 (salinity tolerant) under salt stress in the laboratory and cage house during *rabi* season of 2013-2014. The seeds were sown in petriplates and in cemented pots containing 15 kg soil in which saline irrigation (tap water, 4 and 8 dSm^{-1}) were applied as and when required. Different concentrations of brassinolide (0.0 0.25, 0.50 and 1.0 ppm) were added in the saline set of petri-dishes whereas, in the pot experiment, plants were sprayed with brassinolide at 45 and 60 days after sowing. Control plants were provided normal water whenever needed. Seedling growth parameters were recorded at 3, 5 and 7 days after treatment in the laboratory and physiological, biochemical observations were recorded at 50 and 65 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 and dry weight of root and shoot lower in Raj-3777 as compared to HD-2687 with increase in salinity levels up to 8 dSm–1 whereas an increased were observed in these traits more in Raj-3777 over HD-2687 with increase in brassinolide levels up to 1.0 ppm. Foliar spray of brassinolide up to 1.0 ppm concentration significantly increased photosynthetic rate, transpiration rate, stomatal conductance, total chlorophyll content, cell membrane stability, proline content, protein content, plant height and leaf area where a significant decrease were recorded in these parameters except proline, which was recorded more in salinity over non saline condition, under salinity up to 8 dSm^{-1}. Number of spikes per plant, length of spike, number of seeds per spike, grain and yield were decreased significantly on account of salt stress up to EC 8 dSm^{-1} whereas a significant increase were seen in these variables by the use of brassinolide up to 1.0 ppm concentration. On the basis of the above findings Raj-3777 observed superior over HD-2687 with respect to parameters studied under laboratory and

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Table 1. Effect of salinity and brassinolide on germination %, root and shoot length of wheat.

Treat-ments	Germi-nation (%) 3 DAT	Root length (cm) 3 DAT	5 DAT	7 DAT	Shoot length (cm) 3 DAT	5 DAT	7 DAT
Varieties							
Raj-3777	84.22	0.90	1.75	3.37	2.42	3.79	6.57
HD-2687	78.00	1.06	2.03	3.78	2.14	3.19	5.25
SEm±	0.68	0.04	0.07	0.13	0.08	0.12	0.17
CD (*p*= 0.05)	1.92	0.10	0.20	0.36	0.24	0.35	0.48
Salinity levels							
Control	87.88	1.23	2.31	4.17	2.67	4.11	6.77
4.0 dSm^{-1}	83.22	0.94	1.83	3.50	2.28	3.46	5.96
8.0 dSm^{-1}	72.22	0.77	1.53	3.04	1.89	2.90	5.00
SEm±	0.83	0.05	0.09	0.15	0.10	0.15	0.21
CD (*p*= 0.05)	2.35	0.13	0.25	0.44	0.29	0.43	0.58
Brassinolide							
Control	75.00	0.72	1.35	2.65	1.64	2.64	4.74
0.25 ppm	78.77	0.89	1.74	3.30	2.10	3.20	5.54
0.50 ppm	83.33	1.07	2.08	3.89	2.50	3.75	6.30
1.00 ppm	87.33	1.24	2.39	4.45	2.88	4.37	7.06
SEm±	0.96	0.05	0.10	0.18	0.12	0.18	0.24
CD (*p*= 0.05)	2.71	0.15	0.29	0.51	0.34	0.50	0.67

Table 2. Effect of salinity and brassinolide on fresh and dry weight of seedling root and shoot of wheat.

Treatments	Fresh weight of root (mg/ seedling) 7 DAT	Dry weight of root (mg/ seedling) After oven drying	Fresh weight of shoot (mg/ seedling) 7 DAT	Dry weight of shoot (mg After oven drying
Varieties				
Raj-3777	8.02	1.84	29.59	5.42
HD-2687	8.72	2.20	26.60	4.80
SEm±	0.20	0.05	0.30	0.08
CD (*p*=0.05)	0.58	0.15	0.86	0.22
Salinity levels				
Control	9.35	2.36	32.62	7.09
4.0 dSm^{-1}	8.42	2.05	27.70	4.30
8.0 dSm^{-1}	7.34	1.66	24.57	3.94
SEm±	0.25	0.06	0.37	0.09
CD (*p*=0.05)	0.71	0.18	1.05	0.27
Brassinolide				
Control	6.81	1.60	24.50	4.10
0.25 ppm	7.84	1.87	26.40	4.69
0.50 ppm	8.93	2.17	29.48	5.47
1.00 ppm	9.90	2.44	32.00	6.18
SEm±	0.29	0.07	0.43	0.11
CD (*p*=0.05)	0.82	0.21	1.22	0.31

pot conditions.

Keywords Wheat, Brassinolide, Physiology, Growth, Salinity.

Introduction

Wheat (*Triticum aestivum* L.) is an important staple cereal crop throughout the world. It is eaten in various forms by more than thousands million human beings in the world. Its straw is used as the feed for large population of animals. In India, it is the second staple food crop following the rice. It contains about 8–15% protein and its gluten is especially important for bakery and bread making. Wheat is an important *rabi* cereal crop which is grown throughout the temperature, sub-tropical and tropical regions and ranks only next to rice in area and production.

Food shortage and water deficit are the greatest problem discussed now a days, and it is linked to both with population growth and water allocation to different sectors, such as domestic, agronomic and industrial uses. According to the FAO Land and Plant Nutrition Management Service, over 6% of the world's land is affected by either salinity or sodicity. Moreover the low water quality and the poor drainage systems are the greatest causes of these stresses and this problem is more acute with higher evaporation, especially in arid and semi arid zones, where saline soils are widespread that induced the decreasing of land productivity in many countries over the world [1]. Furthermore salinity affects soil fertility and due

Table 3. Effect of salinity and brassinolide on germination %, root length and shoot length of wheat.

Treatments	Plant height 50 DAT	Plant height 65 DAT	Leaf area 50 DAT	Leaf area 65 DAT	Number of spikes/plant After harvesting	Length of spike/plant After harvesting	Number of seeds/spike After harvesting	Grain yield (g/plant) After harvesting	Straw yield (g/plant) After harvesting
Varieties									
Raj-3777	38.46	56.50	85.44	103.66	2.83	8.93	48.96	4.95	6.15
HD-2687	33.59	49.90	73.68	89.75	2.48	8.06	41.35	3.81	5.45
SEm±	0.29	0.42	0.63	0.76	0.031	0.07	0.36	0.03	0.013
CD (p=0.05)	0.81	1.19	1.78	2.14	0.088	0.19	1.02	0.09	0.036
Salinity levels									
Control	42.10	59.44	89.53	108.49	3.06	9.24	52.22	5.16	6.53
4.0 dSm^{-1}	35.98	53.17	80.31	97.89	2.60	8.53	45.59	4.55	6.07
8.0 dSm^{-1}	30.00	46.99	68.84	83.73	2.30	7.71	37.65	3.43	4.80
SEm±	0.35	0.51	0.77	0.93	0.038	0.08	0.44	0.04	0.016
CD (p=0.05)	0.99	1.46	2.18	2.63	0.108	0.23	1.24	0.11	0.044
Brassinolide									
Control	30.23	47.00	69.10	85.75	2.23	8.02	39.11	3.67	5.32
0.25 ppm	35.47	51.22	75.90	93.72	2.52	8.33	42.23	4.19	5.50
0.50 ppm	38.33	55.03	84.55	102.00	2.82	8.65	48.77	4.62	5.97
1.00 ppm	40.07	59.55	88.70	105.35	3.05	8.98	50.50	5.04	6.41
SEm±	0.40	0.59	0.89	1.07	0.044	0.09	0.51	0.04	0.018
CD (p=0.05)	1.15	1.68	2.51	3.03	0.125	0.26	1.44	0.13	0.051

to these situations some solutions were taken to reduce this problem through soil reclamation or growing tolerant species; however, soil reclamation is a very expensive process and then the selection of tolerant varieties of crops is still the most practical solutions when salinity is low. 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 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]. 28-homo BL alleviated the negative impact of salt stress on *Vigana radiata* by enhancing the rate of photosynthesis, fluorescence and antioxidant system [8]. Problem of salinity is increasing day by day, one of the best solutions is to use saline soils effectivety 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 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 pot experiment was carried out in the cage house located in the Department of Plant Physiology, S.K.N.

College of Agriculture, Jobner during *rabi* season 2013-14, to investigate effect of brassinolide on wheat production under salinity. The pots were filled with 15 kg of loamy sandy soil having a bulk density of 1.5 g cm^{-1}, electric conductivity (EC) 0.4 dSm^{-1}, pH 8.2, sodium absorption ratio 12.5 and $CaCo_3$ 0.14%. The field capacity and permanent wilting point of the soil were 11.8 and 2.8%, respectively. 72 pots for both cultivar Raj-3777 (salinity tolerant) and HD-2687 (salinity susceptible) were used for the growth of wheat up to harvesting. The recomended doses of manures, fertilizers and other inputs were provided at the appropriate time. Salts used to prepare saline irrigation water of EC 4 and 8 dSm^{-1}; Chloride and sulfate in 3:1 ratio by using following salts; NaCl, $NaSO_4$, CaCl and $MgCl_2$. 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 1. Composition of salts for preparing different levels of saline irrigation water.

Salinity levels	$NaSO_4$ (mg/l)	NaCl (mg/l)	$MgCl_2$ (mg/l)	CaCl (mg/l)
Control	Tap water	Tap water	Tap water	Tap water
EC4 dSm^{-1}	621.14	717	534	643
EC8 dSm^{-1}	1243	1434	1068	1286

The plants were spraid with Brassinolides of following concentration for different treatment. The different concentrations of brassinolide 0.0 (control), 0.25 ppm, 0.50 ppm and 1.00 ppm were sprayed at Vegetative stage (45 DAS) and Pre-anthesis stage (60 DAS). The observations were recorded at 50 and 65 DAS (5 days after spray of brassinolides) using completely randomized design. Gas-exchange parameters; Photosynthesis, transpiration and stomatal conductance were measured by Infra Red Gas Analyzer (CI-301, gas analyzer, USA). All these measirements were taken at 10:00–11:30 h (Indian time) Data of menbrane stability index were recorded by using the method of Sullivan et al. [9]; chlorophyll stability index by Arson [10]; determination of proline and protein by the methods of Bates et al. [11] and Lowry et al. [12]. Determination of seedling growth and yield parameters; seed germination percentage was calculated by counting the number of seeds germinated in each petri-dish at 3 days after treatment. Root length (cm) was measured at 3, 5 and 7 DAT with the help of scale. Seedling shoot length (cm) was measured at 3, 5 and 7 DAT with the help of scale. Five washed seedling from each petri-dish were separated into root and shoot for the determination of fresh weight (7^{th} 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 randomly selected plants was measured from base to the top of the plant with the help of meter scale and recorded as plant height in cm at 50 and 65 DAS. The average was recorded as mean plant height in cm of three randomly selected plants out of plantation in each pot. 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 50 and 65 DAS. The total number of spike per plant was 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. 1000-grains were counted and their average weight was recorded.

Results and Discussion

Seedling parameters

Varietal response

Table (1 and 2) showed that Raj-3777 (salinity tolerant) exhibited significant increase in germination percentage (7.38% more than HD-2687). A significant increase in root length (15.09, 13.70 and 10.84% more than HD-2687 at 3, 5 and 7 DAT), fresh weight (8.02% more than HD-2687) and dry weight (16.36% more than HD-1687) of seedling root in HD-2687 than Raj-3777 whereas an increase was recorded in shoot length (11.57, 15.83 and 20.0% more than HD-2687 at 3, 5 and 7 DAT), fresh weight (10.10% more than HD-2687) and dry weight (11.84% more than HD-2687) of seedling shoot of Raj-3777.

Table 4. Effect of salinity and brassinolide on germination %, root length and shoot length of wheat.

Treatments	Photosynthetic rate (µ mol CO_2 $m^{-2}s^{-1}$)		Transpiration rate (m mol H_2O $m^{-2}s^{-1}$)		Stomatal conductance (m mol $m^{-2}s^{-1}$)		Chlorophyll (mg/g fr.wt.)		CMS (%)		Proline (mg/g fr.wt.)		Protein (mg/g fr.wt.)	
	50 DAT	65 DAT	50 DAT	65 DAT	50 DAT	65 DAT	50 DAT	65 DAT	50 DAT	65 DAT	50 DAT	65 DAT	50 DAT	65 DAT
Varieties														
Raj-3777	33.52	37.28	1.82	2.25	47.11	51.56	2.12	2.63	71.51	77.37	0.36	0.60	19.62	22.73
HD-2687	21.18	24.65	1. 28	1.67	44.25	48.49	1.92	2.40	67.07	73.29	0.21	0.51	18.12	21.69
SEm±	0.39	0.42	0.020	0.024	0.58	0.60	0.026	0.030	0.73	0.89	0.009	0.015	0.22	0.24
CD (*p*=0.05)	1.11	1.20	0.057	0.068	1.64	1.69	0.074	0.086	2.07	2.52	0.026	0.042	0.61	0.68
Salinity levels														
Control	32.38	36.20	1.88	2.34	50.57	54.86	2.30	2.78	75.65	81.99	0.15	0.42	21.03	24.06
4.0 dSm^{-1}	27.73	31.14	1.55	1.95	45.24	49.68	2.06	2.58	71.23	77.30	0.25	0.54	19.08	23.01
8.0 dSm^{-1}	21.94	25.56	1.22	1.60	41.25	45.54	1.70	2.19	60.99	66.70	0.46	0.70	16.49	19.56
SEm±	0.48	0.52	0.025	0.029	0.71	0.73	0.032	0.037	1.09	1.09	0.011	0.018	0.26	0.30
CD (*p*=0.05)	1.36	1.47	0.070	0.083	2.01	0.07	0.091	0.106	2.53	3.08	0.032	0.052	0.75	0.84
Brassinolide														
Control	19.44	23.14	1.14	1.52	37.47	43.90	1.70	2.24	62.88	68.80	0.13	0.35	16.36	19.78
0.25 ppm	25.51	29.10	1.46	1.85	42.44	47.14	1.94	2.40	66.53	72.86	0.24	0.50	17.57	21.10
0.50 ppm	30.71	34.33	1.73	2.15	49.50	53.10	2.14	2.60	71.57	77.65	0.30	0.62	19.54	23.37
1.00 ppm	33.75	37.30	1.87	2.34	53.32	55.87	2.30	2.82	76.18	82.01	0.47	0.75	22.01	24.60
SEm±	0.55	0.60	0.028	0.034	0.82	0.84	0.037	0.043	1.25	1.26	0.013	0.021	0.31	0.34
CD (*p*=0.05)	1.57	1.70	0.080	0.096	2.32	2.39	0.105	0.122	2.92	3.56	0.037	0.060	0.87	0.97

Effect of salinity

Data further revealed that salinity levels (4 and dSm^{-1}) significantly reduced the seedling traits as compared to control this includes germination percentage (5.3 and 17.81% more than control), root length (23.57 and 37.39 at 3 DAT; 20.77 and 33.76 at 5 DAT; 16.60 and 27.09% more than control at 7 DAT), shoot length (14.6 and 29.21 at 3 DAT; 15.81 and 29.44 at 5 DAT; 11.96 and 26.14% more than control at 7 DAT), fresh weight of root (9.94 and 21.49% more than control), dry weight of root (13.13 and 29.66% more than control), fresh weight of shoot (13.49 and 23.26% more than control) and dry weight of shoot (39.35 and 44.42% more than control) at 4 and 8 dSm^{-1}. Higher salt concentration hampers vital processes such as germination percentage and seedling growth [13]. The harmful effects of salt stress includes the reduction in germination rate and seedling growth [14]. A decline in root and shoot length may be due to NaCl toxicity and disproportion in nutrient absorption by the seedlings [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

Data of Table (1 and 2) further showed that a significant increase were recorded in seedling parameters; this involves germination percentage (4.78, 10.0 and 14.11% more than control); root length (19.10, 32.71 and 41.93 at 3 DAT; 22.41, 35.09 and 43.51 at 5 DAT; 19.69, 31.87 and 40.44% more than control at 7 DAT); shoot length (21.09, 34.4 and 43.05 at 3 DAT; 17.5, 29.6 and 39.58 at 5DAT; 14.44, 24.76 and 32.86% more than control at 7 DAT), fresh weight of root (13.13, 23.74 and 31.21% more than control at 7 DAT), dry weight of root (14.43, 26.26 and 34.42% more than control), fresh weight of shoot (7.19, 16.89 and 23.43% more than control at 7 DAT) and dry weight of shhot (12.57, 25.04 and 33.65% more than control) at 0.25.0.50 and 1.00 ppm concentration over control. Vardhini and Rao [17] reported that 28-brassinolide and 24-epibrassinolde 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*).

Effect of interaction

The effect of interaction was found non-significant.

Growth and yield parameters

Varietal response

Table 3 showed that Raj-3777 showing significantly higher plant height (12.66 and 11.68% at 50 and 65 DAT), leaf area (13.76 and 13.41% at 50 and 65 DAT), number of spikes/plant (12.36%), length of spike plant (9.74%), number of seeds/spike (15.54% more than HD-2687), grain yield/plant (23%) and straw yield/plant (11.38) more than HD-2687.

Effect of salinity

Data further revealed that the increasing level of salinity up to 8 dSm^{-1} significantly reduced the growth and yield traits as compared to control; this includes plant height (14.53 and 28.74; 10.54 and 20.49% more than control at 50 and 65 DAT); leaf area (10.29 and 23.1; 9.77 and 22.82% more than control at 50 and 65 DAT); number of spikes/plant (15.03 and 24.83% more than control); length of spike/plant (7.68 and 16.55% more than control); number of seeds/spike (12.69 and 27.9% more than control); grain yield/plant (11.82 and 33.52% more than control) and straw yield (7.05 and 26.49% more than control) at 4 and 8 dSm^{-1}. 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 saine 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 (14.77, 21.13 and 24.55; 823, 14.59 and 21.07% at 50 and 65 DAT); leaf area (895, 18.27 and 22.09, 8.57, 15.93 and 18.6% at 50 and 65 DAT); number of spikes/plant (11.5, 20.92 and 26.88%); length of spike/plant (3.72, 7.28 and 10.69%); number of seeds/spike (7.39, 19.8 and 22.55%); grain yield/plant (12.41, 2056 and 27.18%) and straw yield (3.27, 10.88 and 17.0%) as compared to control at 0.25.0.50 and 1.00 ppm concentration over control. 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 [21] on wheat who stated that foliar spray of brassinolide showed a high significant increase in growth parameters as compared with un treaded control plants.

Effect of interaction:

The effect of interaction was found non-significant.

Physiological parameters

Varietal response:

Table 4 showed that Raj-3777 indicating significantly higher photosynthetic rate (36.81 and 33.87% at 50 and 65 DAT), transpiration rate (29.67 and 25.77% at 50 and 65 DAT), stomatal conductance (6.70 and 5.95%), total chlorophyll content (9.43 and 8.74%), cell membrane stability (6.21 and 5.27%), proline content (41.66 and 15.0%) and protein content (7.64 and 4.57%) more than HD-2687.

Effect of salinity

Data further revealed that the increasing level of salinity 4 and 8 dSm^{-1} significantly reduced the physiological variables as compared to control; this includes photosynthetic rate (14.36 and 32.24; 13.97 and 29.39% at 50 and 65 DAT); transpiration rate (17.55 and 35.1; 16.66 and 31.62% at 50 and 65 DAT); sto-

Table 5. Interactive effect of varieties and salinity; variety and brassinolide on photosynthetic and transpiration rate of wheat.

Variety × Salinity	Photosynthetic rate				Transpiration rate			
	50 DAS		65 DAS		50 DAS		65 DAS	
	Raj-3777	HD-2687	Raj 3777	HD-2687	Raj-3777	HD-2687	Raj-3777	HD-2687
S_0	38.78	25.98	42.90	29.50	2.21	1.55	2.68	2.00
S_1	34.65	20.81	38.20	24.08	1.82	1.28	2.23	1.67
S_2	27.14	16.74	30.75	20.37	1.44	1.00	1.85	1.34
SEm ±		0.68		0.74		0.03		0.04
CD (p=0.05)		1.92		2.08		0.10		0.12
Variety × Brassinolide	50 DAS		65 DAS		50 DAS		65 DAS	
	Raj-3777	HD-2687	Raj-3777	HD-2687	Raj-3777	HD-2687	Raj-3777	HD-2687
BR_0	24.27	14.60	28.10	18.17	1.34	0.94	1.72	1.31
BR_1	31.54	19.48	35.26	22.95	1.72	1.20	2.12	1.58
BR_2	37.53	23.89	41.28	27.37	2.04	1.42	2.47	1.82
BR_3	40.76	26.74	44.49	30.11	2.20	1.54	2.70	1.97
SEm ±		0.78		0.85		0.04		0.05
CD (p=0.05)		2.22		2.41		0.11		0.14

matal conductance (10.53 and 18.42; 9.44 and 16.98% at 50 and 65 DAT); total chlorophyll content (10.43 and 26.08; 7.19 and 21.22% at 50 and 65 DAT); cell membrane stability (5.84 and 19.37; 5.72 and 18.64% at 50 and 65 DAT); proline content (40.0 and 67.39; 22.22 and 40.0 at 50 and 65 DAT) and protein content (9.27 and 21.58; 4.36 and 18.7% at 50 and 65 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 decrease in photosynthesis is due to the direct effect of salt on stomatal conductance via a reduction in guard cell turgor and intercellular CO_2 to inhibit photosynthesis [23]. Transpiration rate tends to decline with increasing salinity due to the fact that lower water potential in the root can trigger a signal from root to shoot. Salt accumulation in mesophyll cells may inhibit carbon assimilation resulting in an increase in internal CO_2 concentration, with eventual reduction in stomatal conductance [16]. 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 [24]. 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 [25], 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. [26]. 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 4 revealed that a significant increase were recorded in physiological traits; this includes photosynthetic rate (23.79, 36.69 and 42.4; 20.48, 32.59 and 37.97% at 50 and 65 DAT); transpiration rate (21.91, 34.1 and 39.0; 17.83, 29.3 and 35.04% at 50 and 65 DAT); stomatal conductance (11.71, 24.3 and 29.72; 6.87, 17.32 and 21.42% at 50 and 65 DAT); total chlorophyll content (12.37, 20.56 and 26.08; 6.66, 13.84 and 20.56% at 50 and 65 DAT); cell membrane stability (5.49, 12.14 and 17.45; 5.57, 11.39 and 16.1% at 50 and 65 DAT); proline content (45.8, 56.6 and 72.34; 30.0, 43.54 and 53.33% at 50 and 65 DAT) and protein content (6.94, 16.32 and 25.71; 6.25, 15.36 and 19.59% at 50 and 65 DAT) as compared to control. Bajguz and

Hayat [18] stated that it has been shown BRs can regulate the initial carboxylation activity of ribulose 1,5-bisphosphate by influence photosynthetic CO_2 assimilation which is determined by electron transport efficiency in photosynthesis. Brassinolide detoxified the stress generated by Na and Cl significantly improves the values for growth and photosynthetic parameters [8]. The results of stomatal conductance are in accordance with the earlier findings [16]. 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 [27], 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. [28]. The results of proline content are in accordance with the findings of Gograj et al. [28]. The results of protein content are in accordance with the findings of Bera et al. [26], as compared to control at 0.25, 0.50 and 1.00 ppm concentration over control.

Effect of interaction (V × S; V × b)

Table 5 indicated that the interactive effect of V × S was found significant on photosynthetic rate. All the treatment combinations differed significantly among them. The highest photosynthetic rate was obtained by Raj-3777 under salinity up to 8 dSm^{-1} at 50 and 65 DAS. The interactive effect of V × B was also found significant on photosynthetic rate. The spray of brassinolide up to 1 ppm significantly increased the photosynthetic rate at 50 and 65 DAS. The maximum photosynthetic rate was recorded under the application of 1 ppm brassinoide with variety Raj-3777 over HD-2687. All the treatment combinations differed significantly among them. The interactive effect of V × S was found signficant on transpiration rate. All the treatment combinations differed significantly among them. The highest transpiration rate was obtained by Raj-3777 under non salinity condition and lowest with HD-2787 under application of EC 8 dSm^{-1} saline water at 50 and 65 DAS. The interactive effect of V × B was also found significant on photosynthetic rate. The spray of brassinolide up to 1 ppm significantly increased the transpiration rate. The maximum transpiration rate was recorded under the application of 1 ppm brassinoide with variety Raj-3777 and lowest was recorded by brassinolide zero with HD-2687 at 50 and 65 DAS. All the treatment combinations also differed significantly among them.

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 and 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.

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