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Bhanwar Lal
Department of Plant Physiology, S.K.N. College of Agriculture, Jobner, Rajasthan, India

DL Bagdi
Department of Plant Physiology, S.K.N. College of Agriculture, Jobner, Rajasthan, India

BK Dadarwal
Department of Plant Physiology, S.K.N. College of Agriculture, Jobner, Rajasthan, India

\Corresponding Author:
Bhanwar Lal
Department of Plant Physiology, S.K.N. College of Agriculture, Jobner, Rajasthan, India

Role of brassinolide in amelioration of salinity induced adverse effects on growth, yield attributes and yield of wheat

Bhanwar Lal, DL Bagdi and BK Dadarwal

Abstract
The study entitled "Role of brassinolide in amelioration of salinity induced adverse effects on growth, yield attributes and yield of wheat'' was conducted in the cage house at Department of Plant Physiology, S.K.N. College of Agriculture Jobner during *rabi* season of 2015-2016 under pot culture experiments. Two wheat cultivars namely Raj-1482 (salinity susceptible) and Raj-3077 (Salinity tolerant) were grown in cemented pots under salinity (0, 5 and 10 dSm^{-1}). Different concentrations of brassinolide (0.0, 1.0 and 1.5 ppm) were sprayed at 45 and 75 days after sowing. Control plants were provided normal water. A significant decrease were recorded in Plant height, Leaf area, number of spikes/plant, number of seeds/spike, length of spike/plant, test weight, grain yield with increase in salt stress up to EC 10 dSm^{-1},Whereas the foliar spray treatment with brassinolide up to 1.5 ppm significantly increased Plant height, Leaf area, number of spikes/plant, number of seeds/spike, length of spike/plant, test weight, grain yield in both the cultivars under salt stress as well as non stress conditions. The 1.5 ppm concentration of brassinolide was found most effective under salt stress and non stress conditions. Raj-3077 observed superior over Raj 1482 on the basis of physio-biochemical analysis.

Keywords: Wheat, salinity, brassinolide, growth, yield attributes, yield, Raj-1482 and Raj-3077

Introduction
Wheat 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 temperate, sub-tropical and tropical regions and ranks only next to rice in area and production.

Scarcity of food and water deficit are the greatest problem discussed nowadays, 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 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 (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]. 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 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 were conducted at cage house located in the Department of Plant Physiology, S.K.N. College of Agriculture, Jobner during *Rabi* season 2015-15, to investigate "Role of brassinolide in amelioration of salinity induced adverse effects on growth, yield attributes and yield of wheat". The pots were filled with 15kg of loamy sandy soil having a bulk density of 1.5 g cm^{-3}, electric conductivity (EC) 0.4 dSm^{-1}, P^H 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.54 pots for both cultivar Raj-3077 (salinity tolerant) and Raj-1482 (salinity susceptible) was 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 5 and 10 dSm^{-1}; Chloride and sulphate 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), 1.0 ppm and 1.5 ppm were sprayed at tillering stage (45 DAS), anthesis stage (75 DAS), at haresting and after harvesting. The observations were recorded 10 days after spray of brassinolides using Completely Randomized Design. The height of three randomly selected plants was measured from base to the top of the plant with the help of meter scale, Leaf area was measured with the help of leaf area meter (LICOR 3000 USA), The total number of spike per plant and number of seeds per spike 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, 1000-grains were counted and their average weight was recorded and After harvest, plants were air dried and the grain yield (g) was taken and calculated as per plant basis.

Results and Discussion

Varietal response

It is evident from the data in Table 1 that the increase in Plant height, Leaf area, number of spikes/plant, number of seeds/spike, length of spike/plant, test weight, grain yield of Raj-3077 was found significantly more than Raj-1482 under saline conditions. The per cent increase in Plant height of Raj-3077 was recorded 13.06 and 14.04; Leaf area was recorded 11.22 and 12.60 per cent; number of spikes/plant 16.08 per cent; number of seeds/spike was recorded 14.93 per cent; length of spike/plant was recorded 9.03 per cent; and in grain yield was 22.51 per cent than Raj-1482 respectively.

Effect of brassinolide

A study of the data in the above table 1 indicated that spray treatment with brassinolide up to 1.5 ppm concentration significantly increased Plant height, Leaf area, number of spikes/plant, number of seeds/spike, length of spike/plant, and grain yield over its preceding levels at 52 and 82 DAS. The increase in Plant height due to application of 1.0 and 1.50 ppm concentration of brassinolide was 14.92, 27.15 and 7.73, 15.97 per cent at 52 and 82 DAS, respectively over that of control under saline conditions.

A further study of the data in the above table 1 indicated that brassinolide significantly increased Leaf area over its preceding levels. The increase in relative water content percent content was 15.37, 25.96 and 12.44, 22.01 per cent at 52 and 82 DAS, respectively over that of control under saline conditions.

A further study of the data in the above table1 indicated that brassinolide significantly increased number of spikes/plant. The maximum number of spikes per plant was recorded due to the application of 1.50 ppm concentration of brassinolide which was higher by 15.13 per cent followed by 1.0 ppm (29.35 per cent) concentration over control, respectively.

The maximum increase in number of seeds per spike was obtained at 1.50 ppm concentration of brassinolide than its preceding levels. Number of seeds per spike was recorded 9.29 and 27.35 per cent higher over control due to the application of 1.0 and 1.50 ppm concentration of brassinolide, respectively.

The maximum increase in spike length per plant was obtained due to the use of 1.50 ppm concentration of brassinolide than the others under both non stress and salt stress conditions. The increase in spike length was recorded 4.47 and 7.95 per cent at 1.0 and 1.50 ppm concentration of brassinolide over control.

The maximum increase in grain yield was recorded due to use of 1.50 ppm concentration of brassinolide which was higher by 21.75 per cent, followed by 1.0 ppm (10.34 per cent) concentration over control, respectively.

The significantly higher values for number of spikes per plant, length of spike and number of seeds per spike were obtained with spray treatment of brassinolide is because, 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 [8].

Brassinolide (1.0 ppm) was applide on wheat, barley, maize and rice, these cereal crops showed yield increased of 6-9% [9]. Homobrassinolide application caused significant increase in grain yield and related parameters such as 100 grain weight and harvest index under irrigated and stressed plants in green gram as observed by [10]. The findings of [11] also support the present investigation they observed that treatment with exogenous brassinolide at appropriate stage of their development results in increase of crop yield and quality. Use of brassinolide up to 1.50 ppm was observed to increase significantly grain yield, biological yield and harvest index of clusterbean as reported by [12]. Increases in grain yield due to brassinosteroids application have also been reported by various workers [13].

Effect of salinity

Data from above table 1 further revealed that salt stress was found to decrease the plant height significantly up to EC 10.0 dSm^{-1}. The decrease in plant height at EC 5.0 and EC 10.0 dSm^{-1} was recorded 14.55, 28.75 and 10.68, 20.64 per cent; leaf area was 10.30 and 9.77 per cent; number of spikes per plant was 14.93 and 24.65 per cent.

A referance to data given in the Table 1 further revealed that saline irrigation water was found to decrease the number of seeds per spike significantly up to EC 10.0 dSm^{-1}. The per cent decrease in number of seeds per spike was 12.58 at EC 5.0 and at EC10.0 dSm^{-1}, it was observed 27.85 over control. The per cent decrease in spike length per plant was found 7.73 at EC 5.0 dSm^{-1} and at EC 10.0 dSm^{-1}, it was recorded 16.00 over control, respectively.

The decrease in grain yield was recorded due to use of saline irrigation water of EC 5.0 dSm^{-1} was 11.79 per cent and at EC 10.0 dSm^{-1}, it was recorded 33.89 per cent over control, respectively.

The results of [14] also showed that the yield per plant, fertility percentage, and number of productive tillers, panicle length and number of primary braches per panicle were reduced by salinity. Reduction of spikelet and kernel number per spike under the influence of root zone salinity was observed by [15, 16]. also found a reduction in tillering capacity, spike length, number of spikelets and kernels per spike of moderately salt-stressed wheat. Reduction in grain yield was significantly higher in KRL-19 than more tolerant Kharchia-65 in salinity stress as reported by [17].

Interactive effect

The interactive effect of variety and salinity; and variety and brassinolide on sodium content was found to be non significant.

Conclusion

Raj-3077 was found to performed better in comparison to Raj-1482 with respect to growth, yield and yield attributes under salt stress. The adverse effects of salinity on growth, yield and yield attributes of wheat varieties were observed to reduce by the use of brassinolide up to 1.5ppm concentration as foliar spray. It may be concluded from this investigation that the 1.5ppm concentration of brassinolide may be recommended to farmers for the cultivation of wheat under salt stress up to EC 10 dSm^{-1}.

Table 2: Effect of brassinolide on growth, yield tributes and yield of wheat under salinity.

Treatments	Plant height		Leaf area		Number of spikes/ plant	Number of seeds/ spike	Length of spike/ plant	Test weight (g)	Grain yield (g/plant)
	52 DAS	82 DAS	52 DAS	82 DAS	After harvesting	After harvesting	After harvesting	After harvesting	After harvesting
Varieties									
Raj-3077	36.95	54.56	81.82	100.26	2.68	46.63	8.74	39.35	4.71
Raj-1482	32.68	47.84	72.64	87.63	2.32	39.67	7.95	36.47	3.65
S.Em ±	0.30	0.51	0.66	0.81	0.03	0.42	0.07	0.36	0.03
CD(P=0.05)	0.87	1.45	1.88	2.33	0.09	1.20	0.20	1.03	0.10
Salinity levels									
Control	40.69	57.17	86.91	105.40	2.88	49.90	9.06	40.68	4.92
4.0 dSm^{-1}	34.77	51.06	77.96	95.10	2.45	43.57	8.36	37.97	4.34
8.0 dSm^{-1}	28.99	45.37	66.83	81.34	2.17	35.98	7.61	35.07	3.27
S.Em ±	0.37	0.62	0.81	1.00	0.04	0.51	0.09	0.44	0.04
CD(P=0.05)	1.06	1.78	2.31	2.85	0.11	1.47	0.24	1.26	0.12
Brassinolide									
0	30.69	47.44	67.31	84.19	2.18	38.39	8.05	35.46	3.77
1.0	35.27	51.11	77.66	94.22	2.51	41.96	8.41	37.57	4.16
1.5	38.41	55.02	84.79	103.54	2.82	48.89	8.69	40.71	4.59
S.Em ±	0.37	0.62	0.81	1.00	0.04	0.51	0.09	0.44	0.04
CD(P=0.05)	1.06	1.78	2.31	2.85	0.11	1.47	0.24	1.26	0.12

DAS=Days after Sowing

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