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Alleviation of adverse effects of salt stress on growth, yield and yield attributes in wheat by foliar treatment with ascobin

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Abstract
A pot experiment was conducted during rabi season, 2018 in the cage house at Department of Plant Physiology, S.K.N. College of Agriculture, Jobner, Rajasthan to study the effect of ascobin in alleviating the adverse effects of salinity on growth, yield and yield attributes of wheat. Wheat cultivars namely Raj-4037 and Raj-3077 were grown in ceramic pots under salinity conditions (0, 4 and 8 dSm^{-1}). Different concentrations of ascobin (0, 500, 750 and 1000 ppm) were sprayed at 45 and 65 days after sowing. Control plants were provided normal water. Yield parameters were recorded at harvest. Result revealed a significant decrease were recorded in plant height, leaf area, number of effective tillers per plant, plant height, leaf area, number of effective tillers per plant, number of spikes per plant, length of spike, number of seeds per spike, grain yield, biological yield per plant, harvest index and test weight in both the cultivars at 55 and 75 DAS. Parameters were recorded at harvest and anthesis, reduction in plant height, leaf area, number of effective tillers per plant, number of spikes per plant contributing parameters on account of salt stress was more in cultivar Raj-4037. The foliar spray treatment with ascobin up to 1000 ppm significantly increased growth and yield. Reduction in growth, yield and yield contributing parameters on account of salt stress was more in cultivar Raj-4037. On the basis of the above findings genotype Raj-3077 observed most salt tolerant and the tolerance was mediated by growth, yield and yield characteristics.

Keywords: Salinity, ascobin, growth, yield, harvest index, wheat

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important staple food crop of the world as well as India. It is believed to be native of South Western Asia. It is an annual herb belonging to the family Gramineae. It is cultivated under diverse growing conditions of soil and climate. In India, it is the second most important food crop after rice. It is cultivated mainly in the states of Uttar Pradesh, Madhya Pradesh, Punjab, Rajasthan, Haryana, Bihar, Gujarat and Maharashtra. The lower productivity in most of the cases is attributed to various abiotic stresses. Salt affecting soil is a worldwide problem. Salt stress is a serious problem in crop production in India. While high concentrations of salt have detrimental effect on plant growth (Mer *et al.,* 2000) [16], excessive amounts cause death of growing plants. Such soil is poor in fertility with low available nutrients, high osmotic pressure, poor air and water movement and low microbial activity. There are certain chemicals which have potential to induce salt tolerance in crop plants. They are associated with several cellular and physiological processes and may be useful for protecting crop plants against abiotic stresses like salinity (Gupta *et al.*, 2001) [11].

Plant height, number of tillers, leaf area index, dry matter, grain number, grain weight and harvest index are the yield contributing characters of wheat and the salinity has found to affect the yield by adversely affecting one or more of these parameters (Munns *et al.*, 1995) [22]. Salinity reduced leaf area and number of tillers and increase sodium (Na^+) and chloride (Cl^-) concentration of leaves (Munns and Termaat, 1986) [21]. Plant height, number of tillers, leaf area index, dry matter, grain number, grain weight and harvest index are the yield contributing characters of wheat and the salinity has found to affect the yield by adversely affecting one or more of these parameters (Munns *et al.*, 1995) [22]. Salinity reduced leaf area and number of tillers and increase sodium (Na^+) and chloride (Cl^-) concentration of leaves (Munns and Termaat, 1986) [21]. Ghane *et al.* (2009) [9] revealed that the increase of salinity of irrigation water from EC 4 to 12 dSm^{-1} decreased grain yield and productivity of wheat.

The detrimental effects of salinity can be attributed to the decrease in osmotic potential and disturbances in mineral nutrition of wheat plant (Sharma, 1996) [27]. Salt stress affects the various physiological processes of plants which reduces the yield and quality of produce. Mittova and Loganberbien (2000) [19] reported the influence of salt stress on respiration metabolism in higher plants and found that activity of glycolysis decreases significantly with increasing salinity. The salt stress developed at various phenological stages affects the yield and yield attributes differentially by manipulating various plant processes (Chongo and Vetty, 2001) [7]. These effects can result in turgor reduction, inhibition of membrane functions or enzyme activity, inhibition of photosynthesis (Walker *et al.*,1981) [31], induction of ion deficiency due to inadequate transport/selectivity mechanism or increased use of metabolic energy for growth processes involved in the maintenance of tolerance (Yeo, 1983) [33]. In many part of the world, soil salinization is continuously reducing the arable land for conventional agriculture. Salt stress is a major yield reducing factor in coastal areas.

Salt stress is known to affect the seed germination, growth, water deficit, ion imbalance and cause several biochemical lesions in various plants (Dash and Panda, 2001) [8]. Uddin *et al*. (2017) [30] experiment performed in a three-factor experiment comprising wheat genotypes, five doses of salinity (control, 4, 8, 12, 16 dS/m) and three growth stages. Control was the most appropriate environment in attaining higher yield followed by 4 and 8 dS/m salinity level. Grain yields were greatly decreased with salinity increase and the decreases differed depending upon the tolerance of genotype.

Ascobin (ascorbic acid and citric acid with ratio of 2:1) have auxinic and also synergistic effect on plant. Ascorbic acid has also synergistic effect on plant. Ascorbic acid is an important primary metabolite in plants that functions as antioxidant, an enzyme cofactor and a cell signaling modulator in a wide array of crucial physiological processes, including biosynthesis of the cell wall, secondary metabolites and phytohormones, stress tolerance, photoprotection, cell division and growth (Wolucka *et al*., 2005) [32]. Antioxidant (such as ascorbic acid and citric acid) are designing chemicals when added in small quantities to plant, react rapidly with radical intermediates of an auto-oxidation chain and stop it from progressing (Khan *et al*., 2006) [12, 13].

2. Materials and Methods

Investigate the effect of salt stress on yield and yield attributes of wheat cultivars namely Raj-3077 salinity tolerant and Raj-4037 salinity susceptible will be screened out in pot conditions. Seeds were raised in seventy two cemented pots filled with about 15 Kg of well mixed FYM soil in each pot. The crop will be irrigated with saline irrigation water one liter to each pot of EC 0 (Tap water), 4 and 8 dS m^{-1} prepared by mixing of NaSO4, NaCl, $CaCl_2$, and $MgCl_2$ salts in 3:1 ratio of chloride and sulphate up to maturity. Plant height at harvest; 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 (cm), at harvest. 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). After harvest, length of the main spike excluding awns was measured and plant height with the help of scale in cm, plants were air dried and the grain was taken as number of effective tillers per plant, number of spikes per plant, length of spike, number of seeds per spike, grain yield, biological yield per plant, harvest index and test weight were counted and their average was recorded. The experiment was laid out in factorial based on Completely Randomized Design with three replicationAll the data were statistically analysed using Completely Randomized Design (CRD) with three replications.

3. Results

Data in Table 1 depicted that Raj-3077 significantly performing better than Raj-4037 under both non stress and salt stress conditions. The increase in plant height of Raj-3077 was found 13.92 per cent over Raj-4037 at harvest, respectively. That application of ascobin enhanced plant height significantly up to 1000 ppm concentration over its preceding levels. The plant height increase due to use of 500, 750 and 1000 ppm concentration of ascobin were recorded 10.76,19.73 and 32.39 per cent higher over that of control at harvest.

Table 1: Effect of salinity and ascobin on Plant height (cm) at harvest, Number of effective tillers/plant at harvest and Leaf area (cm^2 / plant) at anthesis stage of wheat

Treatments	Plant height (cm) at harvest	Number of effective tillers / plant at harvest	Leaf area (cm^2 / plant) at anthesis stage
Varieties			
Raj-3077	58.32	2.32	96.51
Raj-4037	51.19	2.02	85.45
S.Em.±	0.48	0.02	0.70
C.D.(P=0.05)	1.33	0.07	1.97
Salinity levels (dSm^{-1})			
0	60.80	2.91	105.15
4 4	55.65	2.65	95.38
8 8	50.43	2.23	83.42
S.Em.±	0.59	0.04	0.88
C.D. (P=0.05)	1.62	0.11	2.30
Ascobin (ppm)			
0	49.15	2.04	83.15
500	54.44	2.42	90.65
750	58.85	2.57	101.25
1000	65.07	3.02	114.20
S.Em.±	0.68	0.03	1.02
C.D. (P=0.05)	1.87	0.08	2.85

The highest plant height was recorded by application of 1000 ppm concentration of ascobin under non stress and salt stress conditions. A critical examination of data given in Table 1 revealed that a higher number of effective tillers per plant at harvest was recorded by variety Raj-3077 (14.85 per cent more than Raj-4037). Raj-3077 significantly performing better than Raj-4037 under both non stress and salt stress conditions. That application of ascobin enhanced significantly the number of effective tillers per plant at harvest up to 1000 ppm concentration under both non stress and salt stress conditions. The maximum number of effective tillers per plant at harvest was recorded due to the application of 1000 ppm concentration of ascobin which was higher by 48.03 per cent followed by 750 ppm (25.98 per cent), 500 ppm (18.62 per cent) concentration over control, respectively. It is evident from the data in Table 1 revealed that at anthesis stage a significantly higher leaf area per plant was recorded by cultivar Raj-3077 which was higher by 12.94 per cent over Raj-4037 under both non stress and salt stress conditions. A further study of the data in above table revealed that the leaf area per plant increased significantly up to the 1000 ppm level of ascobin at anthesis. The leaf area increase due to use of 500, 750 and 1000 ppm concentration of ascobin were recorded 9.01,21.76and 37.34 per cent higher over that of control at anthesis stage. The highest leaf area per plant was recorded by application of 1000 ppm concentration of ascobin under non stress and salt stress conditions.

A critical examination of data given in Table 2 revealed that a higher number of spikes per plant was recorded by variety Raj-3077 (11.55 per cent more than Raj-4037). Raj-3077 significantly performing better than Raj-4037 under both non stress and salt stress conditions. A further study of the data in above table revealed that the leaf area per plant increased significantly up to the 1000 ppm level of ascobin at anthesis. The leaf area increase due to use of 500, 750 and 1000 ppm concentration of ascobin were recorded 9.01,21.76 and 37.34 per cent higher over that of control at anthesis stage. The highest leaf area per plant was recorded by application of 1000 ppm concentration of ascobin under non stress and salt stress conditions. A critical examination data presented in Table 2 revealed that a higher number of seeds per spike was recorded by variety Raj-3077 (16.18 per cent more than Raj-4037). Raj-3077 significantly performing better than Raj-4037 under both non stress and salt stress conditions. Further reference to data in the above table showed that a significant increase in number of seeds per spike was recorded up to 1000 ppm concentration of ascobin over control under non stress and salt stress conditions.

Table 2: Effect of salinity and ascobin on number of seeds/spike, number of spikes/plant, length of spike /plant, test weight, grain yield, biological yield and harvest index of wheat.

Treatments / Varieties	Number of Seeds /spike	Number of spikes /plant	Length of spike /plant	Test weight	Grain yield	Biological yield	Harvest index
Raj-3077	46.30	2.71	8.82	40.10	4.94	10.50	46.10
Raj-4037	39.85	2.43	8.04	37.56	3.83	9.05	42.34
S.Em.±	0.36	0.03	0.06	0.30	0.03	0.07	0.60
C.D.(P=0.05)	1.07	0.08	0.17	0.85	0.08	0.20	1.70
Salinity levels (dSm^{-1})							
0	52.37	3.02	9.18	42.32	5.10	11.20	48.14
4	44.94	2.49	8.54	39.80	4.41	10.45	44.20
4 8	37.55	2.18	7.85	37.48	3.88	8.10	40.25
8 S.Em.±	0.43	0.05	0.08	0.45	0.04	0.13	0.80
C.D. (P=0.05)	1.28	0.12	0.22	1.10	0.12	0.32	2.35
Ascobin (ppm)							
0	37.42	2.24	7.50	35.20	3.72	7.90	41.05
500	40.85	2.52	7.96	36.72	4.27	8.10	43.34
750	47.27	2.80	8.65	39.42	4.45	9.60	47.13
1000	50.15	3.05	9.10	40.54	5.10	10.25	48.92
S.Em.±	0.52	0.04	0.13	0.41	0.05	0.11	0.80
C.D. (P=0.05)	1.50	0.11	0.35	1.21	0.13	0.30	2.38

The maximum increase in number of seeds per spike was obtained at 1000 ppm concentration of ascobin than its preceding levels. Number of seeds per spike was recorded 9.16, 26.32 and 34.01 per cent higher over control due to the application of 500,750 and 1000 ppm concentration of ascobin, respectively. Examination of data given in Table 2 revealed that a higher length of spike per plant was recorded by variety Raj-3077 (9.70 per cent more than Raj-4037). Raj-3077 significantly performing better than Raj-4037 under both non stress and salt stress conditions. Further reference to data from the above table showed that a significant increase in spike length per plant was recorded up to 1000 ppm concentration of ascobin over control. The maximum increase in spike length per plant was obtained due to the use of 1000 ppm concentration of ascobin than the others under both non stress and salt stress conditions. The increase in spike length was recorded 6.13, 15.33 and 21.33 per cent at 500,750 and 1000 ppm concentration of ascobin over control. A perusal of data given in Table 2 revealed that a higher test weight was recorded by variety Raj-3077 (6.76 per cent more than Raj-4037). Raj-3077 significantly performing better over Raj-4037 in salt stress as well as non-stress conditions .Further reference to data of the above Table 2 showed that test weight increased significantly with successive increase in level of ascobin up to 1000 ppm concentration over control. A maximum test weight was recorded due to the application of 1000 ppm concentration of ascobin under non stress and salt stress conditions which was higher by 15.17 per cent followed by 750 ppm (11.98 per cent), 500 ppm (4.31 per cent) concentration over control, respectively. It is clear from the data given in Table 2 that a higher grain yield per plant was recorded by variety Raj-3077 under both non stress and salt stress conditions which was higher by 28.98 per cent over Raj-4037. Further examination of data in the above Table 2 showed that application of ascobin up to 1000 ppm concentration brought significant increase in grain yield of wheat over control under non stress and salt stress conditions. The maximum increase in grain yield was recorded due to use of 1000 ppm concentration of ascobin which was higher by 37.09 per cent, followed by 750 ppm (19.62 per cent), 500 ppm (14.78 per cent) concentration over control, respectively. It is clear from the data given in Table 2 revealed that a significantly higher biological yield per plant was obtained by variety Raj-3077 under non stress and salt stress conditions. The increase in biological yield per plant of Raj-3077 was found 16.02 per cent over Raj-4037, respectively. Further reference to data in the above Table 2 showed that increasing level of ascobin up to 1000 ppm showed significant increase in biological yield per plant of wheat under non stress and salt stress conditions, respectively. The maximum increase in biological yield per plant was recorded under the application of 1000 ppm concentration of ascobin which was higher by 29.74 per cent followed by 750 ppm (21.51 per cent), 500 ppm (2.53 per cent) concentration over control, respectively. It is clear from the data revealed that a significantly higher Harvest index per plant was obtained by variety Raj-3077 under non stress and salt stress conditions. The increase in Harvest index per plant of Raj-3077 was found 8.89 per cent over Raj-4037, respectively. Further reference to data showed that increasing level of ascobin up to 1000 ppm showed significant increase in Harvest index per plant of wheat under non stress and salt stress conditions, respectively. The maximum increase in Harvest index per plant was recorded under the application of 1000 ppm concentration of ascobin which was higher by 19.17 per cent followed by 750 ppm (14.81 per cent), 500 ppm (5.57 per cent) concentration over control, respectively.

4. Discussion

Data Table 1 and 2 showed the reduction in number of spikes per plant, length of spike and number of seeds per spike significantly due to increasing level of saline irrigation water from EC 4 to 8 dSm^{-1}. Higher values for these parameters was observed in Raj-3077 compared to Raj-4037 under salt stress conditions. The results of Ali, *et al.* (2004) [2] 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 Maas and Grieve (1990) [15]. Grieve *et al.* (1992) [10] also found a reduction in tillering capacity, spike length, number of spikelets and kernels per spike of moderately salt-stressed wheat.

Increasing salinity levels resulted in a significant reduction in the grain yield, biological yield, harvest index and test weight (Table 2). Wheat cultivars were markedly inconsistent from each other with respect to these attributes. Among tested cultivars, Raj-4037 was recorded lesser grain, biological yield and test weight as compared to tolerant cultivar Raj-3077 under saline conditions. Reduction in grain yield was significantly higher in KRL 19 than more tolerant Kharchia 65 in salinity stress as reported by Sairam *et al.* (2002).

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 ascobin up to 1000 ppm under saline as well as non-saline conditions and maximum increase in these parameters was recorded with 1000 ppm concentration of ascobin. This is because, foliar application of ascobin 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 Athar *et al.* (2008) [4] and Ahmed, *et al.* (2011) [1]. Talebi *et al.* (2014) [29] conducted Foliar application of citric acid was investigated on stem height, plant height and yield indices (fresh yield, dry yield and root to shoot ratio) of Gazania.

Ascobin was applide on cow pea, these pulse crops showed yield increase of 6-9% Zinab (2014) [34]. Ascobin 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 Ahmed, *et al.* (2011) [1]. Our results further revealed that grain yield, biological yield and test weight increased with increasing ascobin concentration up to 1000 ppm under stress and non-stress conditions of both wheat varieties (Table 1). The higher values for these parameters were obtained at 1000 ppm concentration of ascobin. The findings of Mervat *et al*. (2013) [17, 18] also support the present investigation they observed that treatment with exogenous ascobin at appropriate stage of their development results in increase of crop yield and quality. Use of ascobin up to 1000 ppm was observed to increase significantly grain yield, biological yield and harvest index of clusterbean as reported by Sofy *et al.* (2016) [28] and Aziz *et al*. (2018) [5].

5. Conclusion

It is concluding that ascobin increases plant adaptation to salt stress by stimulating the physiological, biochemical process which would help to minimize yield reduction in wheat plants. Further, the results concluded that cultivar Raj3077 (Salinity tolerant) withstands more effectively than cultivar Raj4037 (Salinity susceptible) under salinity. We believe that cultivar Raj-3077 may be very promising to farmers for cultivation in saline areas up to EC 8 dSm^{-1}.

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