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EFFECT OF SALT STRESS ON PHYSIOLOGICAL, BIOCHEMICAL, GROWTH AND YIELD VARIABLES OF WHEAT *(Triticum aestivum* L.)

N.M.Yadav, D.L.Bagdi and B.L.Kakralya

Department of Plant Physiology,
S.K.N. College of Agriculture, Jobner-303 329, India

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ABSTRACT

A field experiment was conducted to study the harmful effect of salinity on physiological, biochemical traits, growth and yield of wheat genotypes namely, Raj-3077, Raj-3765 (salt tolerant) and Raj-1482, PBW-502 (salt susceptible), were grown in cemented pots under different levels of salinity (0, 4.0, 6.0 and 8.0 dSm-1) at 30 DAS, 60 DAS and anthesis stage. Salinity was found to decrease significantly the photosynthesis rate, transpiration rate, stomatal conductance, relative water content, chlorophyll content, osmotic potential, soluble sugar content, plant height, leaf area, number of leaves, number of grains, total number of tillers/plant, test weight, fresh, and dry weight, grain yield, biological yield, and K+ content in grain with an increase in proline content, membrane injury, Na+ content in grain in all the genotypes .The genotypic variations pertaining to these observations were also found significant. The magnitude of decrease in these parameters under salinity was different at different stages of observation. However, the trend was almost similar at all the stages. Salinity tolerant genotypes show a lesser decline in these variables except proline, membrane injury, and Na+ content when compared to salinity susceptible cultivars. Genotype Raj-3077, Raj-3765 was recorded to having the highest value of all these parameters than Raj-1482, PBW-502 except osmotic potential, the value of which was seen highest in PBW-502. The maximum decline in these parameters was recorded at the salinity level of 8.0 dSm^{-1}.

Key words: Biochemical, Growth, Physiological traits, Salinity, Yield

INTRODUCTION

Wheat occupies prime position among the food crops in India. It is the second important food crop being next to rice. Wheat is grown under irrigated and rain fed conditions, both types of agriculture are threatened by salinization. In our country wheat production is limited by various environmental stresses. Drought, salinity and high temperature stresses are some of the major problems influencing crop growth and productivity. These stresses have attracted a number of research workers to investigate the adaptability mechanism and to improve the productivity of major crops. Salt stress is one of the major wide spread environmental stress that limits growth and development of plant (Greenway and Munns, 1980). Salinity generally affects plant growth adversely, which may be attributed to non-availability of water, disturbance in nutrients uptake causing deficiency and ion toxicity to plant. Extra expenditure of energy for osmotic adjustment under salt stress causes growth reduction (Pasternak, 1987). Reclamation of salt affected land by the common practices such as leaching and drainage are expensive or impracticable in many cases. A possible approach to increase the productivity of such areas is to improve salt tolerance of plants. A search of literature revealed that the wheat varieties respond differentially under stress conditions and it is very important to understand these responses. The tolerant varieties may impart tolerance to salinity at cellular/ organ level by adjusting morpo-physiological attributes at various stages. Keeping this in mind present investigation has been planned to understand the mechanism of salt tolerance in contrasting wheat genotypes at cellular/ organ level along with their responses at different stages of their development.

MATERIALS AND METHOD

Field experiment was conducted during the *rabi* season of 2006-7, in pots of cage house on Wheat cv Raj-3077 and Raj-3765 (salinity tolerant) and Raj-1482 and PBW-502 (salinity susceptible), Department of Plant Physiology, S.K.N. College of Agriculture, Jobner. The climate of this region is typically semi-arid. The loamy sand soil of the field was used for filling the pots of the experiment. Physio-chemical properties of the experimental soil, bulk density (Mg m^{-3}) was 1.50, particle density (Mg m^{-3}) 2.65, ECe (dSm^{-1}) at 25^0C was 2.16, organic carbon (%), 0.17, CEC (mol kg^{-1} soil), 5.58, pH, 8.50 and SAR, 13.60.

Forty eight cemented pots with a small bottom hole were filled with 10 kg of well mixed vermicompost soil. Required amount of sodium chloride was dissolved in distilled water (first prepared 1N solution of NaCl by adding 58.44 g of NaCl to distilled water up to one litre. Take 40 ml of N solution for Ec 4.0, 60 ml of N solution for Ec 6.0 and 80 ml of N solution for Ec 8.0 and add distilled water to these N solution up to one litre.Then check the Ec of these solutions by using conductivity meter, and adjusting its accurate Ec level by adding N solution or distilled water. Then applied to pots for making the following treatment as So = Control, S^1= 4.0, S^2=6.0 and S3=8.0 dSm^{-1}. The EC level of the pots during experiment were maintained by applying saline and non saline irrigation water. EC value was measured in soil samples (1:2 ratio of soil and distilled water) using conductivity meter. The experiment was laid out in completely randomized block design with three replication of 16 treatments, three plants in each pot, crop received 6 irrigation up to maturity. The data were recorded at 30, 60 DAS and anthesis stage.

The photosynthesis, transpiration rate and stomatal conductance of upper second leaf from top side of plant was measured with the help of CI-301CO^2 gas analyzer, relative water content was calculated by the formula given by Slavik (1994). The osmotic potential was determined by the direct reading conductivity meter (Janardhan *et al.*, 1975). Chlorophyll content estimated as method suggested by Arnon (1949). Plant height was measured from the upper surface of the soil to the tip of the plant shoot by meter scale. The leaf area (cm^2) per plant was measured directly with the help of leaf area meter (Li-3100), the grain yield per plant was recorded by weighing grains after manual threshing of three selected plants in each pots and the mean value was calculated and biological yield was recorded by taking weight of both straw and grain after manual harvesting and threshing. The amount of sodium and potassium ion in the grains was analyzed with the help of flame photometer. Proline and soluble sugar content was estimated as method given by Bates *et al.* (1973) and Dubois *et al.* (1951) Membrane injury was calculated by the formula given by Sullivan (1972), number of leaves, tillers, grains per plant were counted and mean were calculated. Fresh and dry weight of plant was recorded after drying the sample at 800^{0C} for 48 hours. Test weight was calculated by weighing 1,000-grains from sample of each treatment.

RESULTS AND DISCUSSION

A comparison of genotypes irrespective of treatment showed that salinity tolerant genotypes (Raj-3077 and Raj-3765) always exhibited significantly higher values in all parameters than salinity susceptible genotypes (Raj-1482 and PBW-502) except membrane injury where it was noticed a higher value in salinity susceptible genotypes. A significant genotypic difference was not seen in salinity tolerant and susceptible genotypes in relative water content, photosynthesis rate, transpiration rate, number of leaves, fresh and dry weight of plants at 30DAS.

The maximum decrease in these physiological, biochemical, growth and yield variables was recorded at EC 8.0 dSm^{-1}, while a highest value of proline and Na^+ Content was recorded at this level of salinity. It has been well documented that under low and mild salinity stress, the changes at physiological and biochemical levels may manifest morphologically while under severe stress the physiological changes may lead to various morphological changes such as leaf rolling followed by yellowing, reduced plant height, drying and ultimately death of leaf and then of whole plant (Gupta *et al.*,2002).

A significant decrease in photosynthesis rate (Rottenberg,1997), transpiration rate (Walters, 1991) and relative water content (Gupta *et al.*, 2001)

was recorded up to Ec 8.0 dSm^{-1} in salinity tolerant and susceptible genotypes. However the magnitude of decline in these parameters decreased with advancement of the growth stages with increase in relative water content (Table 1). A significant decrease in photosynthesis rate was noticed up to Ec 12.0 dSm^{-1}because salts within plants reduces the growth by causing premature senescence of old leaves and reduces the supply of assimilates to the growing region (Narayana and Rao 1987). Increasing level of salinity up to Ec 12.0 $dSm^{-1}$was also found to reduce significantly the transpiration rate of leaf over control. A significant decrease in transpiration rate transpiration rate is due to salt stress was attributed to some changes in the frequency, size and movement of stomata (Kirschbaum, 1987).The over production of activated oxygen species in chloroplast of plants under drought stress has been described (Price *et al.*, 1994 and Sairam *et al.,* 2001) and it is hypothesized that a similar mechanism may also operate under salt stress. As soon as the CO^2 concentration decreased upside the chloroplast, as a result of stomata closure, there is a reduced availability of NADP to accept electrons from PS-1, thus initiating oxygen reduction with concomitant generation of activated oxygen species, with a significant increase in osmotic potential of leaf.

For instance, two different theories have been advanced, according to one, the harmful effect of the salt on the plants are due to the osmotic potential of the external salts laden soil solution and according to the other, it is due to toxic effect of ions of the salts.

A significant decrease was also recorded in the chlorophyll of second leaf from the top side of the plant under salt stress because salinity is also known to cause reduction of chl-a molecule (Reddy and Vora, 1986).

The membrane injury was recorded to increase linearly with increasing level of salinity. Almost similar trend was obtained in all the genotypes. The maximum membrane injury was seen in susceptible than tolerant genotypes. Similar results were also reported by Dubey *et al.* (2009) in citrus.

Table 1: Effect of salt stress on physiological traits of wheat.

Treatments	Photosynthesisrate (μmol CO^2 m^{-2} s^{-1})		Transpiration rate (m mol H^2O m^{-2} s^{-1})		Stomatal conductance (cm S^{-1})		Relative water Content (%)		Plant height(cm)		Leaf area(cm^2)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Genotypes												
Raj-3077	18.42	31.72	1.19	1.78	27.17	44.59	85.21	76.23	23.15	67.51	18.69	111.78
Raj-3765	18.32	31.76	1.186	1.782	26.73	44.08	85.34	76.93	23.11	67.88	18.59	112.44
Raj-1482	17.63	23.97	1.147	1.71	22.86	32.42	84.02	71.49	22.35	59.71	17.96	103.85
PBW-502	17.16	20.04	1.135	1.707	20.45	30.07	80.89	71.33	22.23	60.02	17.92	100.59
$SEm\pm$	0.05	0.43	0.013	0.020	0.55	0.74	1.9*	1.17	0.51	1.49	0.05	1.69
C.D. (P=0.05)	NS	1.23	NS	0.067	1.01	1.56	NS	3.38	0.9	2.87	0.71	4.86
Salinity levels(dSm-1)												
Control	20.021	30.036	1.298	1.946	30.19	47.08	90.23	84.17	25.57	70.08	20.55	115.3
4	19.06	29.72	1.238	1.86	26.61	40.29	88.08	79.91	24.65	67.98	19.4	115.14
6	17.19	26.65	1.14	1.494	24.33	37.73	85.06	77.26	22.28	62.08	17.77	108.51
8	15.26	22.74	1.002	1.441	21.18	28.39	77.38	69.24	19.23	53.49	15.45	87.71
$SEm\pm$	0.05	0.43	0.013	0.020	0.55	0.74	1.9*	1.17	0.51	1.49	0.05	1.69
C.D. (P=0.05)	0.72	1.23	0.037	0.067	1.01	1.56	4.09	3.38	0.9	2.87	0.71	4.86

NS=Non significant

Table 2: Effect of salt stress on biochemical traits, growth, yield and ionic status of wheat.

NS=Non significant.

Table 3: Effect of salt stress on biochemical traits, growth, yield and ionic status of wheat.

Treatments	No. of leaves/plant		Fresh weight(g)		Dry weight(g)		Total no. of tillers/plant	Na^+ content in grain	K^+ content in grain
Genotypes	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	After harvesting	After harvesting	After harvesting
Raj-3077	3.82	17.39	1.22	28.98	1.22	0.342	6.82	0.342	0.312
Raj-3765	3.85	17.5	1.23	29.33	1.23	0.338	6.84	0.338	0.315
Raj-1482	3.67	14.79	1.18	25.94	1.18	0.279	5.05	0.279	0.275
PBW-502	3.74	15.08	1.2	26.46	1.2	0.276	5.13	0.276	0.278
S.Em.±	0.05	0.25	0.01	0.31	0.01	0.005	0.08	0.005	0.003
C.D. (P=0.05)	NS	0.71	NS	0.91	NS	0.014	0.24	0.014	0.008
Salinity levels(dSm-1)									
Control	4.24	18.9	1.36	32.2	1.36	0.275	7.16	0.275	0.349
4	3.99	17.11	1.28	29.76	1.28	0.291	6.50	0.291	0.326
6	3.66	15.72	1.17	26.88	1.17	0.316	5.70	0.316	0.286
8	3.2	13.04	1.02	21.86	1.02	0.353	4.39	0.353	0.218
S.Em.±	0.05	0.25	0.01	0.32	0.01	0.005	0.08	0.005	0.003
C.D. (P=0.05)	0.15	0.71	0.04	0.91	0.04	0.014	0.24	0.014	0.008

NS= Non Significant

A genotypic response, irrespective of the salinity treatment, was found significant between salinity tolerant and susceptible genotypes. The osmotic potential, relative water content and stomatal conductance was observed higher in tolerant (Raj-3077 and Raj-3765) over susceptible (Raj-1482 and PBW-502). The salinity treatment irrespective of the genotypes exhibited a linear decline in relative water content and stomatal conductance at 30 and 60 DAS, but a nonsignificant genotypic variations was recorded in relative water content at 30 DAS. The decrease in osmotic potential on account of salinity is a well documented response of glycophytes and halophytes (Morgan, 1984 and Munns, 1990). It is suggested that the reduction in osmotic potential has been attributed to increase in osmoticum and the major osmoticum in plant are inorganic ions, organic acids and soluble sugars (Munns *et al.,* 1982).

The genotypic variation, investigated between the treatments, showed that Raj-3077 and Raj-3765 retained significantly higher soluble sugar content over Raj-1482 and PBW-502 at anthesis stage. The increasing level of salinity was found to cause a reduction in soluble sugar content linearly irrespective of the genotypes. Accumulation of soluble sugar increased on account of starch hydrolysis, synthesis through other pathways or decreased conversion to metabolites (Munns *et al*., 1982), while a significant increase in proline content was also recorded in both the salinity tolerant and susceptible genotypes. The accumulation of proline during salt stress was probably due to the consequence of reduction in cell osmotic potentialfor the maintenance of osmotic balance between cytoplasm and vacuole (Flowers *et al*., 1977).

The membrane injury was noticed to increase linearly with increasing level of salinity. Almost similar trend was obtained in these genotypes. The maximum injury was recorded in susceptible when compared to tolerant genotypes. These results are in accordance with that of Sairam *et al.* (2001). Significant difference in plant height, number of leaves, total number of tillers, leaf area and number of grains/ plant was observed among different genotypes of wheat. The higher value in these variables of wheat was recorded in Raj-3077 and Raj-3765 as compared to Raj-1482 and PBW-502. Effect of salinity was seen in decreasing the value of these growth variables; plant height, number of leaves, total number of tillers, leaf area and number of grains/ plant significantly over control. Maximum reduction was recorded in PBW-502 followed by Raj-1482, Raj-3765 and Raj-3077 (Table 1, 2 and 3).

The significant variation in grain yield, biological yield and test weight among salinity tolerant and susceptible genotypes was also noticed, with significant decrease up to Ec 8.0 dSm^{-1}.

The increasing level of salinity was also found to decrease plant height, number of leaves, total number of tillers, leaf area and number of grains/ plant up to Ec 8.0 dSm^{-1} as compared to control (Table 1,2 and 3). Similar results were also reported by Govil, (1985) in *Commelina communis* . A significant increase was also recorded in Na^+ content of grains with increase in salinity over control. The increase in Na^+ content was more in salinity tolerant than susceptible cultivars. A significant difference in K^+ content of grains was recorded among genotypes. It was observed lower in salinity susceptible genotypes than tolerant. The effect of salinity was also observed to decrease the K^+ content in grains up to Ec 8.0 dSm^{-1}. (Table 3).

This experiment has been carried out to understand the mechanism of salt tolerance in contrasting wheat genotypes at cellular/organ level along with their responses at different stages of their development. Genotype Raj-3077 and Raj-3765 was found to perform better over Raj-1482 and PBW-502. However, in order to draw a final conclusion, further study on molecular aspects of comparing salinity tolerance of these genotypes is required.

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