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SALT STRESS GENOTYPIC RESPONSE: RELATIVE TOLERANCE OF WHEAT CULTIVARS TO SALINITY

Achla Sharma[1]*, Ankita[1], Mohd Shamshad[1], Sukhjit Kaur[1], Avtar Singh[2], Puja Srivastava[1], G S Mavi[1], Balkaran Sandhu[3], N S Dhaliwal[3] and V S Sohu[1]

[1]*Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana-141004, Punjab*
[2]*PAU Regional Research Station, Bathinda -151001, Punjab*
[3]*Krishi Vigyan Kendra (PAU), Muktsar -152026, Punjab*

ABSTRACT

The commercial wheat genotypes released for cultivation under timely sown irrigated conditions in Punjab along with known salt tolerant genotypes and few advance breeding lines were evaluated for salt stress tolerance at seedling stage under simulated stress conditions and at adult plant stage in actual saline fields at Rattakhera, Sri Mukatsar Sahib (Punjab), to find out the best suitable wheat variety for the salt affected areas. Twelve wheat varieties, seven advance breeding lines, one wheat genotype popular in salt stressed regions of Punjab and Kharchia, a universal donor for stress tolerance to salt were tested. PBW 765 and PBW 780 had highest tolerance among advance germplasm, HD 3086, HD 2967, KRL 210 could be categorized in one group whereas PBW 725 showed moderate tolerance to salt stress. These identified genotypes are most suitable for regions having moderate to high salinity stress as these were less affected due to salinity.

Keywords: Adult plant tolerance, Seedling stage, Salt stress, Tolerant genotypes, Wheat

Worldwide, more than 20% of the cultivable land is affected by salinity while in India, about 6.73 million hectare land is salt affected out of which 3.77 and 2.96 million hectares are under sodicity and salinity, respectively (Mondal *et al.,* 2010). Due to climate change and anthropogenic activities, the salt affected area is increasing each day (Munns 2008, Dadshani *et al.,* 2019). The productivity of wheat is often adversely affected by salt stress which is associated with decreased germination percentage, reduced growth, early flowering, altered reproductive behaviour and stressed maturity. Adverse effects on plant growth are mostly due to osmotic stress, ion toxicity and nutritional imbalance or a combination of these factors (Singh *et al.,* 2018). Wheat (*Triticum aestivum*) is a moderately salt-tolerant crop. In the field, where the salinity rises to 100 mM NaCl [Electrical Conductivity (EC) about 10 dS m^{-1}], rice (*Oryza sativa*) plants die before maturity, while wheat yield gets reduced (Munns *et al.,* 2006, Genc *et al.,* 2019).

Punjab, known as the wheat bowl of India has around 35 million hectare area under wheat cultivation annually. In view of changing climate, many stresses have emerged in different niches in Punjab, calling for the emergent changes in the main wheat breeding objectives focussing on development of niche specific cultivars. The salinity stress (may or may not be coupled with water logging), primarily in the South Western districts of Punjab has emerged as a major threat to wheat production recently. Sri Muktsar Sahib, in South Western Punjab has been facing abiotic stresses like high salinity, water logging, high water table, poor underground water quality, etc. since last few years. These stresses are increasing at an alarming rates. Salinity has been identified to be the major factor affecting productivity of wheat crop in this Malwa belt. The soil and irrigation water in this region of Punjab is totally different from whole of the Punjab state (Sandhu and Dhaliwal, 2017). The shallow ground water of the district is saline (EC- 8.9 dS/m). Wheat genotypes differ in response to salinity and hence, evaluation of cultivars released for cultivation in a region for their tolerance is the first step to identify the varieties that can be recommended for cultivation in affected areas (Ashraf *et al.,* 2015). The other, long term remedy is to develop cultivars having stress tolerance which could give good yield under salt affected soils. The present study reports the genotypic variation for salt stress tolerance and yield performance of few advance breeding lines and commercially released varieties of bread wheat.

MATERIALS AND METHODS

Plant material

A set of nine wheat varieties, seven advance breeding lines, three KRL varieties bred for salt affected areas, Kharchia 65 (a salt tolerant cultivar) and Berbet (farmer's selection popular in some areas of Punjab) constituted the plant material. The details of the

*Corresponding author : achla@pau.edu
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genotypes are given in Table 1.

Seedling studies

This study was performed in the Research Laboratory of Wheat Section, Department of Plant Breeding and Genetics, Punjab Agricultural University (PAU), Ludhiana Punjab. Experiment was set up in a completely randomized design with three replications. NaCl was used to induce salinity stress at germination and seedling stage. Different concentrations of NaCl [$T_{1,}$ control (distilled water), T_2 (75mM), T_3 (100mM), T_4 (125mM), T_5 (150mM)] were used to choose the appropriate concentration so as to get the best treatment that differentiates among genotypes. A solution of 100 mM NaCl was prepared by dissolving 5.85 g of NaCl in 1L distilled water, 125mM by dissolving 7.35g of NaCl in 1L distilled water and 150mM by dissolving 8.775g of NaCl in 1L distilled water. Single ear method was used to get pure seeds and to minimize heterogeneity. The seeds were surface sterilized with 70% ethanol (v/v) for 2 min and then with a sodium hypochlorite solution containing 3% (w/v) active chlorine and were finally rinsed 10 times with distilled water. 10 uniform seeds (one replication) were selected from surface-sterilized seed stock and placed on brown germination paper folded into a roll (modified cigar roll method, (Zhu *et al.,* 2005). Seedlings were germinated in dark at 25°/22°C in a growth chamber for 3 days, the seeds were considered to have germinated after the emergence of radicle. Pots containing rolls were transferred to a growth chamber and incubated at 24^0C ± 1^0C; with 60% relative humidity during the day and at 19^0C ± 1^0C during the night under a 16/8 h (light/dark) light cycle with a light intensity of 200 μmoL m^{-2} s^{-1}. After 12 days, cigar rolls were unrolled and length of seedlings was recorded. Growth parameters *viz.,* germination percentage (germinated seeds/total no. seeds incubated × 100), length of root (RL) and shoot (SL), vigour index [VI; average root length + average shoot length) × germination percentage] were measured.

Field experiment

A controlled plot experiment was performed in the fields at Rattakhera, Sri Mukatsar Sahib, Punjab. This area in village Rattakhera, located at distance of ~30 kms from Mukatsar, has been known to possess highly

Table 1. The wheat genotypes used in the study and their pedigree

S. No	Genotype	Pedigree
1	Unnat PBW 343	PBW 343/TC+Lr 37//3*PBW 343/4/WH 890-Ae. umb.3732 amph/cs(s)//WL 711 NN/3/3*PBW 343
2	Unnat PBW 550	PBW550//Yr15/6*Avocet/3/2*PBW550
3	PBW 1 Zn	*T. dicoccum* CI 9309/*Ae. squarrosa* (409)/3/MILAN/S 87230//BAV 92/4/2*MILAN/S 87230// BAV 92
4	PBW 725	PBW 621//GLUPRO/3* PBW 568/3/PBW 621
5	PBW 677	PFAU/MILAN/5/CHEN/Ae. Sq.//BCN/3/ VEE#7/BOW/4/PASTOR
6	HD 3086	DBW 14/HD 2733//HUW 468
7	WH 1105	MILAN/S 87230//BABAX
8	HD 2967	ALD/CUC//URES/3/HD 2160 M/HD 2278
9	PBW 621	KAUZ//ALTAR 84/AOS/3/MILAN /KAUZ/4/HUITES
10	PBW 765	HD 2967/4/BW 9250*3//Yr10/6*Avocet/3/
11	PBW 766	NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR/5/KACHU/6/KACHU
12	PBW 768	HD 2967/3/Yr15/6*Avocet//3* PBW343
13	PBW 780	HD 2967/4/PBW 343+Lr24+Lr28*3//Yr10/6* Avocet/3/PBW 343+Lr24+Lr 28*3// Yr15/6*Avocet/5/2*HD2967
14	PBW 783	HD 2967/4/BW 9250*3//Yr10/6*Avocet/3/BW 9250*3//Yr15/6*Avocet/5/ 2*HD 2967
15	PBW 800	HD 2967/4/BW 9250*3// Yr10/6*Avocet/3/BW9250*3//Yr15/6*Avocet/5/2* HD 2967
16	PBW 841	PBW 621//HD 3549//BWL 2763/BWL 1800
17	Berbet	Farmer Selection, Punjab India
18	KRL 19	
19	KRL 210	PBW 65/2*PASTOR
20	KRL 213	Cndo/r143//Ente/mexi-2/*3 Ae. Squarrosa* (taus) weaver/5/2*KAUZ
21	Kharchia 65	kharchia local/EG 953

saline soils. Department of Plant Breeding & Genetics, PAU has been conducting trials at Rattakhera village since last few years.

The field experiment was conducted during *rabi* 2017- 18, and *rabi* 2018-19 at village Rattakhera, Sri Muktsar Sahib (Punjab), to investigate the response of wheat genotypes to salinity stress in the salinity affected soils in the fields. The geographical location of experimental site is 74°30'32" east longitude, 30°26'35" North latitude. The area has semi-arid type of climate and cold winters. The soil is loamy, alkaline in reaction (pH 8.9), high EC (8.9 dS/m) and has high ground water table. Rice was grown as the previous *Kharif* crop in experimental plot since last five years. Total twenty-one genotypes were sown in randomised complete block design with two replications. The recommended package of practices was followed for raising the crop except irrigation schedule. Due to the high-water table, only need based irrigation was applied. The crop was sown in the first week of November and harvested in mid-April during *rabi* 2017-18 and *rabi* 2018-19. The yield and yield contributing parameters were recorded including days to flowering, number of effective tillers per meter, plant height, 1000 grain weight and grain yield as per standard procedure.

Statistical analysis

The PROC UNIVARIATE procedure (α =0.05) of SAS version 9.4 (SAS, Institute 2013) for descriptive statistics and Pearson correlation analysis were used. We used the PROC GLM procedure (α =0.05) of SAS 9.4 for analysis of variance (ANOVA) using a model suggested by McCullagh and Nelder (1982, 2nd edition 1989)

$$Y_{ijk} = \mu + G_i + E_j + (GE)_{ij} + B_{k(ij)} + E_{ijk}$$

where μ is general mean, G_i is the genotypic effect of i^{th} genotypes, E_j is the environment effect of j^{th} environment (location), $(GE)_{ij}$ is the interaction effect between i^{th} genotype and j^{th} environment (location) $B_{k(ij)}$ is the effect of replication within j^{th} environment and ε_{ijk} is the random error following N (0, σ). The mean obtained from the PROC GLM with LSMEANS were further used to draw various graphics using R 4.0.2 packages.

RESULTS AND DISCUSSION

The results are discussed in two parts, viz.; evaluation of genotypes at seedlings stage for salinity stress tolerance under controlled conditions and evaluation in salinity affected soils under field condition.

Seedling evaluation

Germination percentage was taken as the ratio of number of seeds germinated to the total number of seeds sown and expressed as percentage. Increasing NaCl salinity levels adversely affected germination attributes of all the wheat cultivars. The seed germination rate significantly decreased as salt concentration increased. Wheat genotypes responded differently to increasing salinity levels. Seed germination was found to be highest in distilled water (control). The seed germination in control condition was 98% while in salinity stress condition the average was 65% at 75mM NaCl concentration. However, germination percentage decreased with increasing salinity concentrations. The study revealed a remarkable reduction in germination percentage and seedling traits at 125mM and 150mM NaCl concentrations. The low salinity levels (75mM and 100mM NaCl) affected the germination percentage and seedling traits to lesser degree than required to differentiate the cultivars, whereas, higher salinity (125mM) treatment showed very clear differences. Effect of treatment was completely inhibitory to the germination at 150mM NaCl for almost all the wheat genotypes. Hence, the dose of 125mM solution to artificially induce salt stress was finalized for detailed studies.

Germination percentage

Germination percentage of wheat genotypes was significantly affected by the salt stress. Kharchia 65 (93%), KRL 213 (96.67%) and KRL 210 (87%) were least affected. Advance breeding lines PBW 780, PBW 765 and PBW 783 showed comparatively less reduction in germination percentage as compared to released genotypes. PBW 677, WH 1105, PBW 621 and *Unnat* PBW550 were the worst affected (Fig. 1). Salinity, in general, has inhibitory effects on germination of seeds (Elouaer and Hannachi, 2012; Afzal *et al.,* 2016). This is a major hindrance in cultivation of crops in saline areas. Therefore, in order to select salt tolerant variety of crops for cultivation in saline belt, the germination potential of seeds in the saline conditions should be considered. The decline in germination percentage under salinity has been attributed to combined effect of osmotic pressure (Moud and Maghsoudi, 2008) and toxicity of salts (Saboora and Kiarostami, 2006, Almodares *et al.,* 2007) that leads to osmotic stress. The inability of seeds to germinate under saline conditions may be due to embryo damage by Na^+/Cl^- ions or inhibition of water uptake or exosmosis (Rahman *et al.,* 2008).

Root and shoot length

The reduction in shoot and root growth is one of the most commonly observed responses to salinity. Highly significant decrease in root length and shoot length was recorded (Fig. 2) under the salt stress. *Unnat* PBW 550 and *Unnat* PBW 343 showed maximum decrease in root length, while Kharchia-65 showed minimum decrease in root length among all

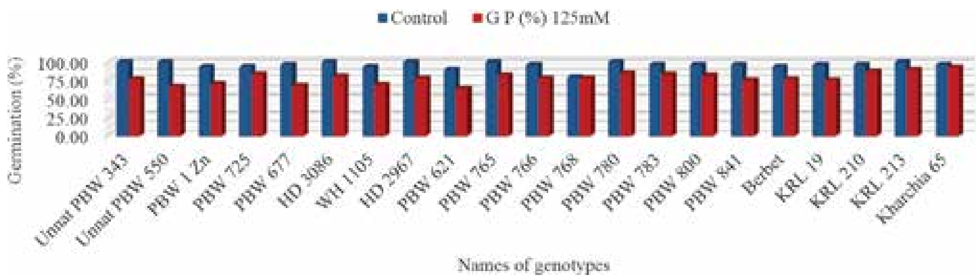


Fig. 1. Germination percentage (%) of twenty-one wheat genotypes at 125mM NaCl

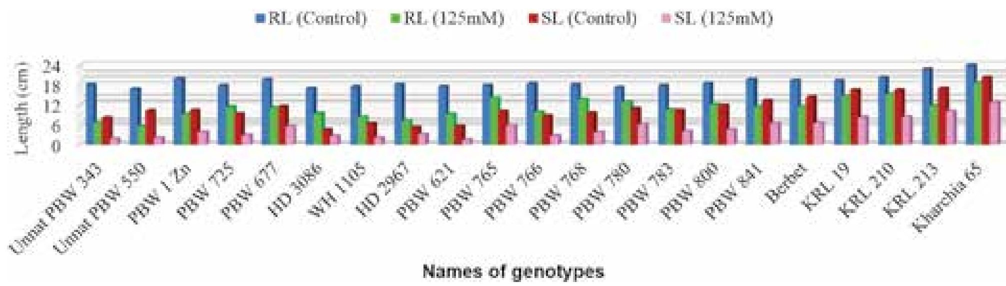


Fig. 2. Root and shoot length of twenty-one wheat genotypes under controlled and 125mM NaCl

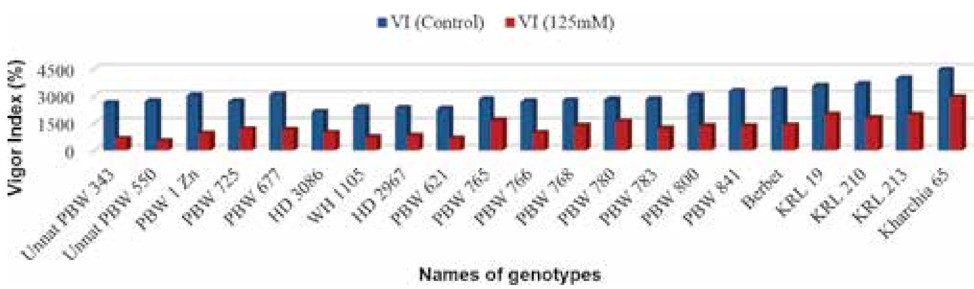


Fig. 3. Vigour index of twenty-one wheat genotypes at controlled and 125mM NaCl

the wheat cultivars followed by KRL 19, KRL 210 and PBW 765. The maximum shoot length was observed in Kharchia 65 followed by KRL 213, KRL 19, Berbet and minimum was observed in PBW 621. Least effect of salinity stress on shoot length was observed in Kharchia 65 followed by HD 3086, HD 2967, KRL 210, PBW 765 and PBW 780. Shoot growth was found to be more adversely affected than the root growth under salt stress at seedling stage. Vigor Index (VI) was calculated from shoot length and root length which gave the exact tolerance index of a genotype under stress (Fig. 3). Kharchia 65 was ranked to be the first based upon vigor Index (Table 2). None of the released cultivars or advance breeding lines had salinity tolerance similar to this cultivar. However, the rust resistant genotypes having alien segments carrying resistant genes in elite backgrounds, PBW 765 and PBW 780 ranked next to Kharchia 65. These genotypes ranked better than salinity tolerant varieties KRL 19 and KRL 210.

Field experiments

All the genotypes varied for days to flowering, tillers numbers, grain yield and grain weight during both years (Table 3). Genotypes differed in their response to salt stress in field and salinity causes yield reduction but the extent varied. Over the two years of experimentation, salinity stress significantly decreased the grain yield, grain weight, days to flowering and plant height (Table 3, $P<0.05$).

Days to flowering were highly reduced, stress induced early flowering in all the genotypes (Fig. 4 & 5). The average value of days to flowering under controlled condition was 102.71 ± 0.35 (mean ± standard error), while the average days to flowering under stress was 97.82 ± 0.40 days. Days to flowering reduction is due to less absorption of nutrients, such as nitrogen, phosphorus and iron due to saline stress and affects the crop cycle of the plants (Kumar *et al.,* 2012).

Salinity stress reduced the plant height of all the wheat genotypes (Fig. 6). However, PBW 768 and PBW 677 showed significant reduction in plant height (Fig. 7, $P< 0.05$). The average plant height under controlled condition was 101.22 ± 0.81 cm (mean ± standard error), while the average plant height under stress was 97.47

Table 2. Ranking of wheat genotypes based on seedling and field experiments

Genotype	Ranking (Seedling)	Ranking (Field)	Genotypes	Ranking (Seedling)	Ranking (Field)
Unnat PBW 343	20	20	PBW 766	15	17
Unnat PBW 550	21	18	PBW 768	6	16
PBW 1 Zn	18	11	PBW 780	3	7
PBW 725	10	10	PBW 783	11	13
PBW 677	14	19	PBW 800	9	12
HD 3086	**8**	**8**	PBW 841	13	14
WH 1105	17	21	Berbet	12	5
HD 2967	16	6	KRL 19	4	3
PBW 621	19	15	**KRL 210**	**7**	**9**
PBW 765	2	4	KRL 213	5	2
			Kharchia 65	1	1

Table 3. Pooled Analysis of variance for yield and yield contributed traits under Controlled and stress conditions during *rabi* 2017-2018 and *rabi* 2018-19

	df	Days to flowering	Plant height	Tiller Number	Grain yield	Grain weight
Genotypes	20	60.2***	342.7***	560.6***	33.7***	83.9***
Year	1	18.14*	84.29**	13.2	4.7**	491.18***
Treatment(trt)	1	1004.5***	589.13***	2720.9***	794.31***	553.14***
Rep(year)	2	32.26**	3.37	15.47	0.81	17.75**
cultivar*trt	20	4.44	10.88	32.63	9.79***	15.59**

* p = 0.05 level ** p = 0.01 level

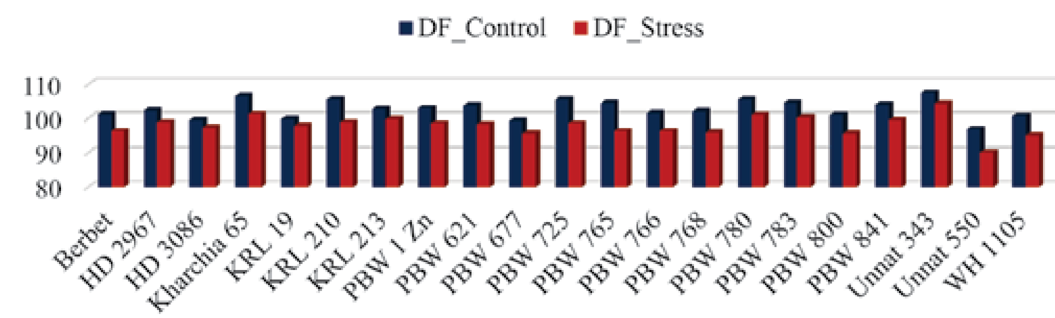


Fig. 4. Effect of salinity stress on days to flowering of wheat genotypes under field conditions

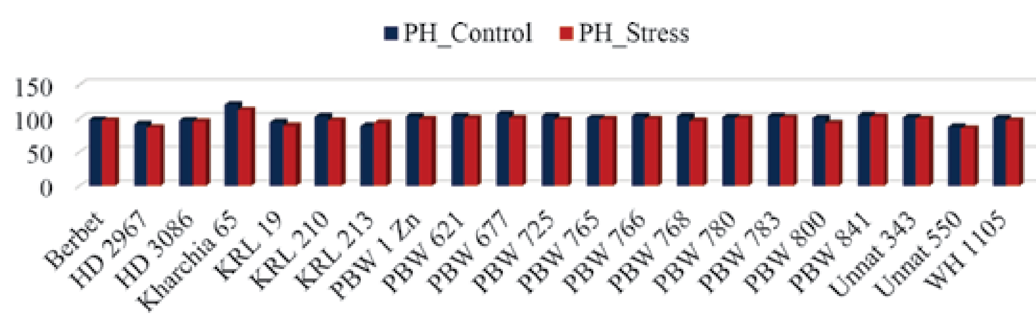


Fig. 5. Effect of salinity stress on plant height of wheat genotypes

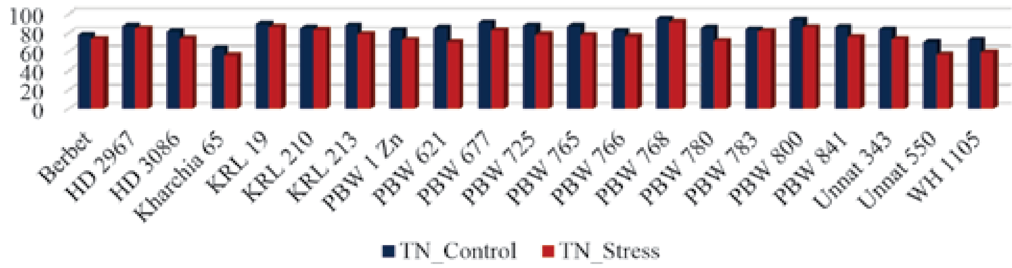


Fig. 6. Effect of salinity stress on tiller number of wheat genotypes

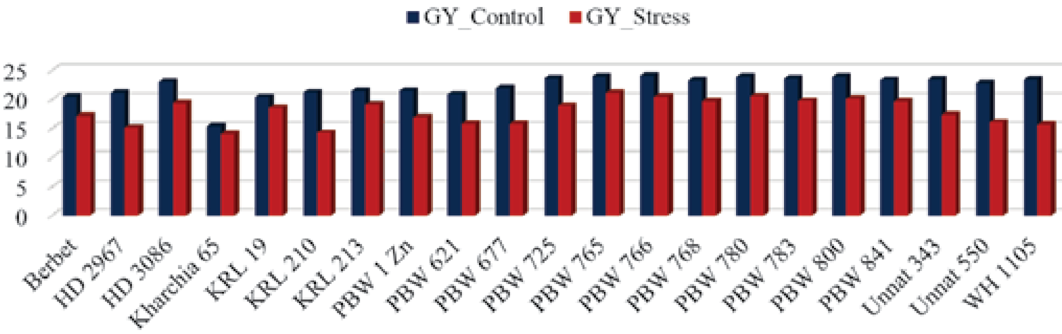


Fig. 7. Effect of salinity stress on yield of wheat genotypes

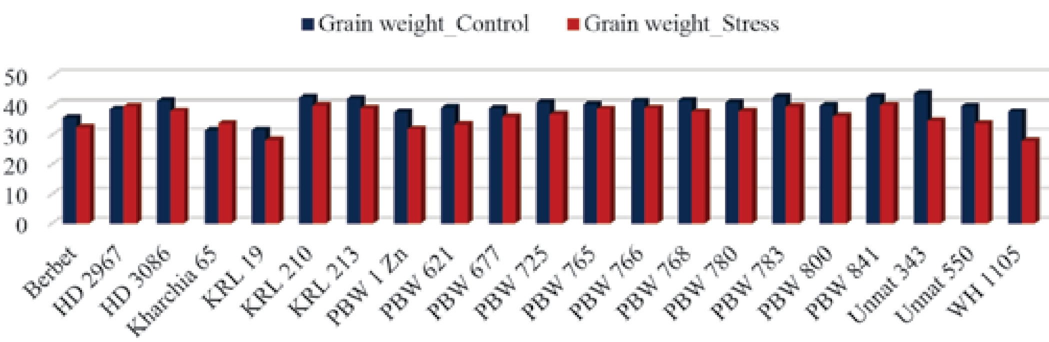
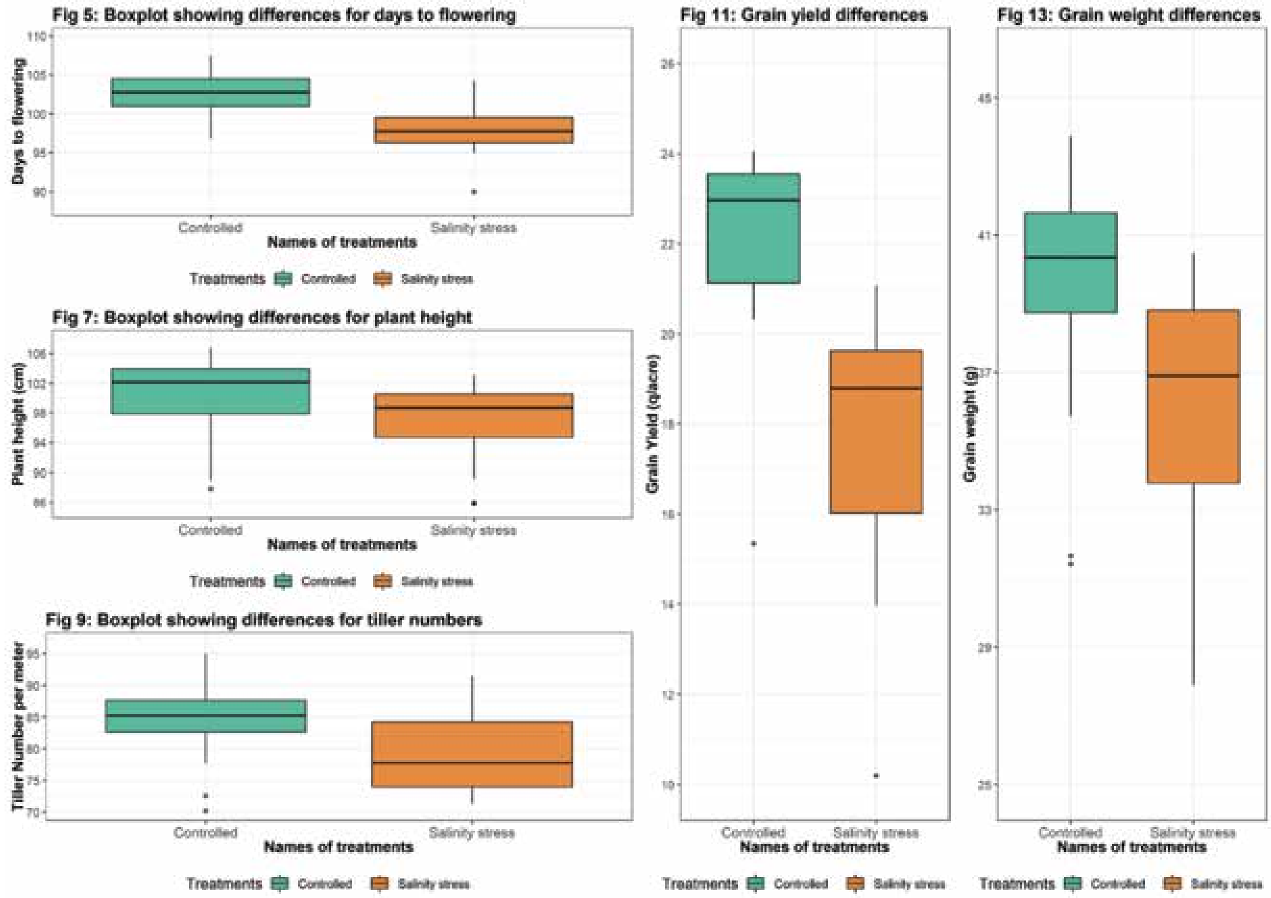


Fig. 8. Effect of salinity stress on grain weight of wheat genotypes

± 0.74 cm. Least reduction was observed for PBW 780 and Berbet (0.9 and 1.4 percent reduction, respectively). The stress may alter the metabolic processes of the plant resulting in stunted growth and development. All the wheat genotypes showed the reduction of tiller numbers due to the salinity stress (Fig. 8). PBW 725, Unnat 343 and PBW 677 showed significant reduction of tiller number (Fig. 9, P< 0.05). Highest reduction of tiller numbers was recorded in *Unnat* 550, WH 1105 and PBW 621 (19.2, 18.5 and 17.8 percent reduction respectively) and least reduction of tillers numbers was observed for KRL 19, PBW 783, HD 3086 and KRL 210.

Grain yield is the trait of utmost importance while evaluating genotypes for their performance under stress. The salinity stress in field caused the reduction of grain yield (Fig. 10). The average grain yield under control conditions was 22.17 ± 0.23 q/acre (mean ± standard error), while the average grain yield under stress was 17.82 ± 0.29 q/acre. Highest reduction of grain yield was observed in WH 1105 and Unnat 550 (33.1 and 29.5 percent reduction, respectively). While minimum reduction of grain yield was observed for KRL 213, KRL 19, Kharchia 65 (9.7, 9.0 and 9.0 percent reduction, respectively). The wheat genotypes PBW 765, PBW 780 and PBW 766 showed remarkable grain yield under salinity stress (21.1, 20.5 and 20.4 q/acre respectively). These genotypes may be used for cultivation under salinity stress conditions. Grain weight is the most important subcomponent of yield. Salinity stress caused reduction in grain weight of all the wheat genotypes (Fig. 12). The KRL 210 and Kharchia 65 showed better grain weight under salinity stress. However, Unnat 550, PBW 1Zn, WH 1105 and HD 2967 showed significant reduction of grain weight under salt stress (Fig. 13, P< 0.05). The average grain weight under non stress conditions was 39.62 ± 0.47g



Figs. 9 - 13. Boxplot showing the effect of salinity stress on days to flowering, plant height, tiller numbers, grain yield and grain weight of wheat genotypes.

(mean ± standard error), while the average grain weight under stress was 31.99 ± 0.49 g.

Soil salinity is one of the major abiotic stresses affecting germination, crop growth and productivity (Ghogdi *et al*., 2012). The detrimental effects of high salinity on plants may be expected as the death of plants resulting in failure of the crop or decrease in productivity. The key to improving salt tolerance in wheat is finding sufficient variation within adapted germplasm and identifying resistant or tolerant genotypes. Further, the targeted breeding program to breed tolerant genotypes must be focussed. Seed germination and early seedling stages are the most crucial and important stages in the life cycle of any crop plant as it determines the crop stand at maturity and yield at harvesting. The ranking of the genotypes at germination (Table 2) revealed that the Kharchia 65 is the best salt tolerant cultivar and none of our varieties or advance lines is better than this. KRL 19, KRL 210 and KRL 213 developed by ICAR-Central Soil Salinity Research Institute, Karnal, showed good tolerance at germination as well as in field. Berbet, a farmer's selection which has gained popularity in Rajpura and Patiala of Punjab did not show good germination and seedling traits but it overall performed well in salt affected soils. Any other mechanism of tolerance at reproductive stage may be operative in this genotype. Among the commercial cultivars, Unnat PBW 343, Unnat PBW 550, PBW 1 Zn, PBW 677, WH 1105, PBW 621 showed minimum stress tolerance at seedling stage as well as in field experiments. These cultivars lead to much reduction in yield when grown on hostile soils and hence, should not be cultivated on salt affected fields. PBW 725 was ranked 10th at both stages indicating its moderately tolerant behaviour to stress. Advance breeding lines PBW 765 and PBW 780 ranked 2nd and 3rd at seedling stage, performing better than the commercial cultivars. Top five genotypes at seedling stage included these two advance breeding lines, Kharchia 65, KRL 19 and KRL213. PBW 768, HD3086 and KRL 210 were almost similar in terms of vigour index. Kharchia 65 was consistent in its performance in field (ranking 1st) and along with KRL 213, KRL 19, PBW 765 and Berbet constituted the top five genotypes group. HD 2967 and PBW 780 ranked 6th and 7th, thus showing above average stress tolerance when grown in salt affected soils. These were followed by HD3086 and

Table 4. Field performance of the genotypes for grain yield and 1000 grain weight under normal and salinity stress conditions (Rattakhera, Sri Muktsar Sahib)

Genotype	Rabi 2018-19				Rabi 2019-20			
	Grain yield (q/acre)		1000 grains weight (g)		Grain yield (q/acre)		1000 grains weight (g)	
	Control	Salinity	Control	Salinity	Control	Salinity	Control	Salinity
Berbet	20.6	17.4	36.1	30.7	20.2	16.9	35.4	34.3
HD 2967	20.9	10.9	36.9	38.2	21.3	19.3	40.7	41.3
HD 3086	23.0	19.7	39.1	36.5	23.0	18.9	44.0	39.7
Kharchia 65	15.0	14.0	28.7	32.6	15.8	14.0	34.2	35.0
KRL 19	20.9	18.9	30.3	26.5	19.8	18.2	33.1	29.8
KRL 210	21.4	19.0	42.7	38.3	20.9	9.5	42.8	41.8
KRL 213	20.8	19.4	40.6	39.7	22.0	18.7	43.7	38.4
PBW 1 Zn	22.2	17.0	36.9	30.2	20.7	16.8	38.4	33.8
PBW 621	20.9	16.0	37.6	30.7	20.8	15.5	41.0	36.4
PBW 677	22.3	16.5	37.4	35.1	21.5	15.1	40.5	37.2
PBW 725	22.9	19.7	37.7	37.0	24.2	18.0	44.1	36.9
PBW 765	23.6	21.2	39.7	37.6	24.3	21.0	41.0	40.1
PBW 766	23.7	20.1	41.5	37.4	24.5	20.7	41.4	40.8
PBW 768	23.5	19.8	40.4	33.2	23.0	19.5	43.0	42.4
PBW 780	23.8	21.2	39.2	36.9	24.0	19.8	42.7	39.1
PBW 783	24.0	19.9	38.0	36.6	23.1	19.5	47.8	42.5
PBW 800	23.9	20.1	39.8	32.8	23.9	20.1	40.0	39.8
PBW 841	23.9	19.2	38.0	36.5	22.7	20.0	47.8	43.7
Unnat 343	23.9	17.7	38.9	33.1	22.9	16.9	48.9	36.5
Unnat 550	23.3	16.0	39.6	33.2	22.2	16.1	39.8	34.5
WH 1105	23.3	16.3	38.8	26.5	23.4	15.0	37.0	29.3
LSD	G = 0.91		G = 2.18		G = 0.91		G = 2.18	

KRL 210 at 8th and 9th rank. HD 3086, already released commercial cultivar had almost at par performance with KRL 210. Among the advance germplasm lines, PBW 765 and PBW 780 performed significantly better than commercial cultivars and almost at par with KRL cultivars. These lines must be further tested in saline soils and can be released for cultivation under salt stress conditions.

Some of the genotypes performed better in field but had poor germination percentage and vigour index at seedling stage. This may be discussed in view of stringent and uniform stress on seedlings in controlled experiments whereas; the plant may face more heterogeneous conditions in fields as compared to uniform saline root medium conditions. These differences have also been reported by (Ashraf and McNeilly, 1991, Ahmad *et al.,* 2005, Mwando *et al.,* 2020). Water and nutrient availability, salt content and weather conditions under field situation can be substantially different from solution culture conditions in controlled chamber experiment. Also, under field conditions the seeds are sown directly into the saline/ sodic soil and the seedlings have to undergo salt stress immediately after their germination but this stress may not be uniform in micro environments. There is every possibility that differences in plant growth conditions under the two situations might alter the response of cultivars to salt stress. Most crop plants attain increased salt tolerance at later growth stages due to development of ‘induced tolerance through acclimatization’, which may also contribute to variable responses between systems. To conclude, it can be said that specific salt tolerant varieties must be bred by wheat breeders and until then, the identified cultivars like PBW 765, PBW 780, HD 3086 and HD 2967 should be made available to the farmers in salt affected belt so as to reduce their losses due to salinity.

Authors’ contribution

Conceptualization and designing of research work (AS, PS, VSS): Execution of field/lab experiments and data collection (AS, A, SK, PS, BS, AS, NSD);

Analysis of data and interpretation (AS, MS, PS, GSM); Preparation of Manuscript (AS, MS, A, VSS).

LITERATURE CITED

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