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Original scientific article

MULTI-ENVIRONMENT CHARACTERIZATION OF BREAD WHEAT GENOTYPES FOR WATERLOGGING TOLERANCE

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The improvement in waterlogging tolerance of wheat may help to enhance the productivity of crop in regions having high and untimely rainfalls with poor drainage. The present study was undertaken to characterize waterlogging tolerance of 65 different bread wheat genotypes. The traits like grain yield, biological yield, tillers per meter, grain filling duration, spike weight and plant height under waterlogged conditions were found sensitive. The spike weight, tillers per meter, 1000 grain weight, biological yield and harvest index showed significant correlations with grain yield under both normal and waterlogged conditions. Waterlogging tolerance index (WTI) showed positive correlation with plant height, tillers per meter, biological yield, thousand grain weight and grain yield. These agronomic traits along with WTI were used to identify tolerant genotypes with high yield potential. Wheat genotypes SSDC3-264, SSDC3-347, NW 5054 and PBW 550 were identified as tolerant and could be utilized for improving the waterlogging tolerance of wheat.

Keywords: wheat, waterlogging tolerance index, correlation, agronomic traits

INTRODUCTION

Wheat yield is a complex, polygenic trait and the result of the value of the yield components, such as plant height, the number of productive tillers, the number of grain spike per spike, the grain weight per spike, the thousand grains mass and other traits. Assessment of multi-environment yield trials is significant issue for breeders. Environment interaction (GEI) is commonly encountered in multi-environment yield trials. Multi-environment trials are conducted to assess genotype performance based on GEI as well as genotypes (AKTAS, 2020; POPOVIĆ *et al*., 2020a; 2020b; LAKIĆ *et al*., 2020; LJUBIČIĆ *et al*., 2021; KOSTIĆ *et al*., 2021).Waterlogging is a widespread problem for wheat production, especially in the sodic/alkaline soils of India

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(YADUVANSHI *et al*., 2010). Waterlogging affects about 25% of the global wheat area, thus the development of waterlogging tolerant cultivars lags behind progress that has been made for other abiotic stresses (ARGUELLO *et al*., 2016). The waterlogging tolerance by plants is defined as the capability to maintain high rates of growth, biomass accumulation and grain yield under waterlogged conditions (SETTER and WATERS, 2003; SUNDGREN *et al*., 2018). During a waterlogging event, water displaces air from the pore spaces in the soil and soil microorganism and plant roots respire the remaining oxygen and the reservoirs may be rapidly emptied (SUNDGREN *et al*., 2018). The total grain yield was impacted by lower kernel weight per spike resulting from reductions in kernels number per spike and 1000 kernel weight, total biomass (ARGUELLO *et al*., 2016); tillers number (SINGH *et al*., 2018a) under waterlogged conditions. Earlier studies evaluated the impact of soil waterlogging on grain yield particularly under field conditions (SINGH *et al*., 2018a; BALLESTEROS *et al*., 2015) but the yield penalty depends on factors such as duration of waterlogging events (MARTI *et al*., 2015); developmental stage (SETTER and WATERS, 2003). Various phenotyping approaches have been used to determine the waterlogging tolerance under field conditions. VAN GINKER *et al*., (1992) found that the visual scores of foliar chlorosis correlated strongly with yield under waterlogged conditions. In another study, COLLAKU and HARISSON (2002) reported that tiller number at maturity was the most affected trait and it has been identified as a potential criterion for high throughput phenotyping in waterlogged environments based on a proposed physiological link to root traits (SINGH *et al*., 2018b). The importance of tillering to waterlogging tolerance was highlighted by researchers in the UK on wheat (BELFORD, 1981; CANNELL and BELFORD, 1982) and in Western Australia on wheat (SETTER and WATERS, 2003). BALLESTEROS *et al*., (2015) calculated an index based on the proportion shoot or root biomass produced under waterlogged relative to control conditions for identification of tolerant genotypes. Further, the Yield Stability Index (YSI) selection index based on proportion of yield under waterlogging relative to normal conditions was also reported by SINGH *et al*. (2018a) and Stress Susceptibility Index (SSI) by SINGH *et al*. (2017; 2020a; 2020b). However, it was shown that the actual grain yield was a better selection criterion (SETTER *et al*., 1999). Therefore, the development of waterlogging tolerant wheat varieties is an effective and economical approach to improve grain yield under waterlogging conditions (SINGH *et al*., 2018a). Thus keeping in view the above criteria, our aim was to: 1) to characterize the genotypes for waterlogging tolerance for utilization in wheat improvement program, 2) to identify phenotypic traits associated with waterlogging tolerance and 3) to identify waterlogging tolerant genotypes.

MATERIAL AND METHODS

The present investigation was carried out at the experimental trial fields of the ICAR-Indian Institute of Wheat and Barley Research (IIWBR), Karnal, Haryana and Narendra Deva University of Agricultural and Technology (NDUAT), Faizabad, UP during the two growing seasons of 2015/2016 and 2016/2017. The experimental material was comprised of 65 wheat genotypes including checks (HD 2967, HD 2009, KRL 99, KRL 3-4 and KH 65) and the experiments were conducted for two consecutive years (2015-16 and 2016-17) under normal and waterlogging conditions. The genotype HD 2967 has been shown as a tolerant wheat genotype released for under timely sown irrigated conditions, while wheat genotype HD 2009 is a susceptible variety for waterlogged conditions, whereas KRL 99, KRL 3-4 and KH 65 are better performing varieties for waterlogged conditions. The experiments were conducted in an augmented block design (FEDERER, 1956) in which the experimental field was divided into five equal blocks. Each block consisted of 17 wheat genotypes including 05 checks, while the same set of checks was replicated in each block. Each genotype was planted in two rows of two meter length with a spacing of 23 cm between rows and 10 cm between plants within rows. The planting of trials was carried out under normal and waterlogged conditions at both Karnal (latitude: N29º 42.172; Longitude: E76º 59.516) and Faizabad (latitude: N26º 32.678; Longitude: E81º 49.484). The soil type was sandy loam (neutral, pH 7.2) and alkaline silt loam (sodic, pH 8.5) at Karnal and Faizabad, respectively. Recommended fertilizer dose of 120:60:40 N:P:K kg/ha was applied to raise the crop. To create the waterlogging condition, the stagnation of water was allowed for a week at four important growth stages of the crop, *viz*.; crown root initiation stage (21 days after sowing), tillering stage (40 days after sowing), reproductive stage (60 days after sowing) and grain-filling stage (75 days after sowing) at both the locations during both the years. The observations were recorded on days to 75 percent heading (DTH), days to maturity (DTM), grain filling duration (GFD), plant height (PH), tillers per meter (TPM: number of tillers per meter row length), spike weight (SW), 1000-grain weight (TGW), biological yield per plot (BY), harvest index (HI) and grain yield per plot (GY) for all the tested genotypes and checks under both normal and waterlogged conditions at both the locations during both the years. The data thus recorded were then subjected to statistical analysis using GenStat 18th Edition (VSN International Ltd, Hemel Hempstead, UK). The estimates of genetic variability and phenotypic correlation coefficients among yield components, with grain yield under both non-waterlogging as well as waterlogging conditions were calculated with adjusted mean. The percent reduction (PR) in grain yield and its component traits was calculated based on the mathematical relationships between traits value under both conditions. The waterlogging tolerance of the test genotypes was calculated based on the equation:

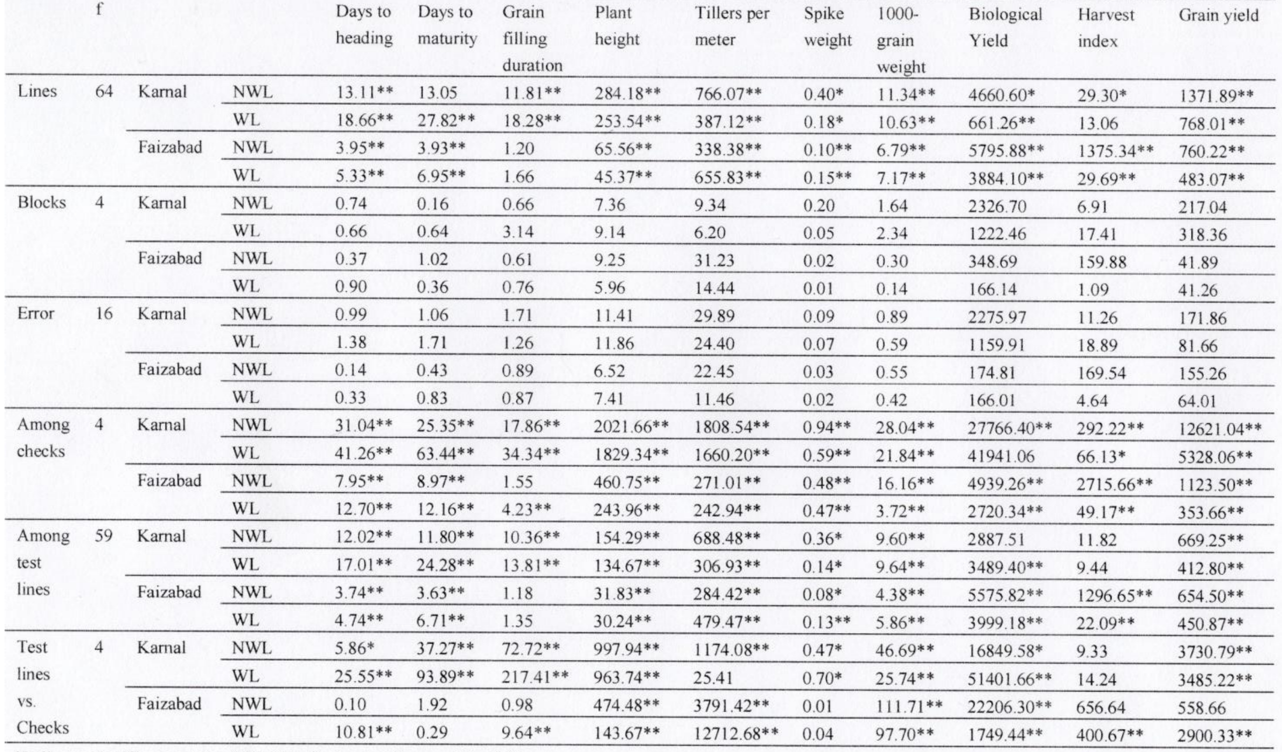
$$GY_{WL}/GY_{NWL}$$

where GY_{WL} and GY_{NWL} are the grain yields under waterlogging and normal (well drained) soil conditions. The data thus recorded were then subjected to statistical analysis using GenStat 18th Edition Trial Version (VSN International Ltd, Hemel Hempstead, UK).

RESULTS AND DISCUSSION

The results of analysis of variance indicated significant differences for all studied traits under both waterlogging as well as normal conditions (Table 1), revealing variable performance of genotypes in different environments. The phenotypic variations in the present set of breeding materials were observed for grain yield and yield components under both conditions indicating that the response of genotypes differed in waterlogged conditions. A common adaptation of plants to waterlogging is the survival and growth of seminal roots and production of numerous adventitious roots with aerenchyma (THOMSON *et al*., 1992; SETTER and WATERS, 2003). Aerenchyma is a specialized plant tissue containing enlarged gas spaces enabling roots to respire aerobically. Root aerenchyma enhances gas exchange and supply oxygen to the root tips from aerial part of plant tissues under hypoxic condition of waterlogged soils.

Table 1. Analysis of variance for various yield components under non-waterlogging and waterlogging conditions



Source	Df	Locations	Conditions	Mean square									
				Days to heading	Days to maturity	Grain filling duration	Plant height	Tillers per meter	Spike weight	1000-grain weight	Biological Yield	Harvest index	Grain yield
Lines	64	Karnal	NWL	13.11**	13.05	11.81**	284.18**	766.07**	0.40*	11.34**	4660.60*	29.30*	1371.89**
			WL	18.66**	27.82**	18.28**	253.54**	387.12**	0.18*	10.63**	661.26**	13.06	768.01**
		Faizabad	NWL	3.95**	3.93**	1.20	65.56**	338.38**	0.10**	6.79**	5795.88**	1375.34**	760.22**
			WL	5.33**	6.95**	1.66	45.37**	655.83**	0.15**	7.17**	3884.10**	29.69**	483.07**
Blocks	4	Karnal	NWL	0.74	0.16	0.66	7.36	9.34	0.20	1.64	2326.70	6.91	217.04
			WL	0.66	0.64	3.14	9.14	6.20	0.05	2.34	1222.46	17.41	318.36
		Faizabad	NWL	0.37	1.02	0.61	9.25	31.23	0.02	0.30	348.69	159.88	41.89
			WL	0.90	0.36	0.76	5.96	14.44	0.01	0.14	166.14	1.09	41.26
Error	16	Karnal	NWL	0.99	1.06	1.71	11.41	29.89	0.09	0.89	2275.97	11.26	171.86
			WL	1.38	1.71	1.26	11.86	24.40	0.07	0.59	1159.91	18.89	81.66
		Faizabad	NWL	0.14	0.43	0.89	6.52	22.45	0.03	0.55	174.81	169.54	155.26
			WL	0.33	0.83	0.87	7.41	11.46	0.02	0.42	166.01	4.64	64.01
Among checks	4	Karnal	NWL	31.04**	25.35**	17.86**	2021.66**	1808.54**	0.94**	28.04**	27766.40**	292.22**	12621.04**
			WL	41.26**	63.44**	34.34**	1829.34**	1660.20**	0.59**	21.84**	41941.06	66.13*	5328.06**
		Faizabad	NWL	7.95**	8.97**	1.55	460.75**	271.01**	0.48**	16.16**	4939.26**	2715.66**	1123.50**
			WL	12.70**	12.16**	4.23**	243.96**	242.94**	0.47**	3.72**	2720.34**	49.17**	353.66**
Among test lines	59	Karnal	NWL	12.02**	11.80**	10.36**	154.29**	688.48**	0.36*	9.60**	2887.51	11.82	669.25**
			WL	17.01**	24.28**	13.81**	134.67**	306.93**	0.14*	9.64**	3489.40**	9.44	412.80**
		Faizabad	NWL	3.74**	3.63**	1.18	31.83**	284.42**	0.08*	4.38**	5575.82**	1296.65**	654.50**
			WL	4.74**	6.71**	1.35	30.24**	479.47**	0.13**	5.86**	3999.18**	22.09**	450.87**
Test lines vs. Checks	4	Karnal	NWL	5.86*	37.27**	72.72**	997.94**	1174.08**	0.47*	46.69**	16849.58*	9.33	3730.79**
			WL	25.55**	93.89**	217.41**	963.74**	25.41	0.70*	25.74**	51401.66**	14.24	3485.22**
		Faizabad	NWL	0.10	1.92	0.98	474.48**	3791.42**	0.01	111.71**	22206.30**	656.64	558.66
			WL	10.81**	0.29	9.64**	143.67**	12712.68**	0.04	97.70**	1749.44**	400.67**	2900.33**

*Indicates significance at P = 0.05; **Indicates significance at P = 0.01

Moreover, a part of oxygen transported to plant root tips through the aerenchyma leaks out into the surrounding soil and results in a small zone of oxygenated soil around the roots that can prevent the influx of potentially toxic soil components (COLMER, 2003) such as nitrites and sulphides of Fe, Cu and Mn. Therefore, aerenchyma formation is thought to be one of the most important morphological adaptations for the tolerance to hypoxic or anoxic stress. The bulk of the recovery growth is by adventitious roots (main axes and laterals) that resume extension, as seminal root apices can die within few days of waterlogging (MALIK *et al*., 2002). In contrast to seminal roots losing their ability to re-grow within days of waterlogging, the tips of adventitious roots remained alive and resumed extension upon re-aeration (MALIK *et al*., 2002). Wheat plants can form aerenchymatous adventitious root, in response to waterlogging, which contains a partial barrier to radial oxygen loss and can consume only 20% of the total O_2 entering a root through aerenchyma (THOMSON *et al*., 1992). This preferential resource allocation to root growth would be a major reason explaining the reduced shoot growth following a period of waterlogging (MALIK *et al*., 2002; ROBERTSON *et al*., 2009). Tolerance is not only by its ability to undergo morphological adaptations, but also by the ability to recover from transient waterlogging.

In the present study, the mean performance of all studied traits declined numerically under waterlogging (WL) conditions except DTH and DTM at both the locations and HI at Karnal (Table 2). The characters viz., GY (39.6 %), BY (31.5 %), TPM (26.4 %), GFD (15.6 %), SW (10.3 %) and PH (10.0 %) were found to be more sensitive to WL at both locations. The traits like TGW (4.9%), DTM (3.9 %) and DTH (-2.3 %) were found to be less affected and showed less than 5-6 % reduction under waterlogged conditions. The results presented here are similar to the previous study in winter wheat that has reported a reduction of 44 % (COLLAKU and HARRISON, 2002). In wheat, SINGH *et al*. (2018a) reported a 50% reduction in total grain yield along with other yield traits viz., TPM (37.8%), PH (17.6%), GNPS (15.2%) and TGW (14.6%) due to waterlogging stress as similar to the findings of the present study. The impact of waterlogging on the plant growth varies with different developmental stages (HAYASHI *et al*., 2013). Waterlogging during the vegetative stage reduces grain yield due to a decrease in tiller number (CANNELL *et al*., 1984; MUSGRAVE and DING, 1998). Whereas, waterlogging during jointing reduced yield through decreased grain number per spike, not via reduced tiller number (BELFORD *et al*., 1985).

The correlation coefficient analysis was done between grain yield and grain yield contributing traits for both NWL and WL conditions (Table 3). The significant and positive correlations was observed among grain yield, biological yield, harvest index, spike weight and 1000- grain weight under both conditions at Karnal except TGW in NWL. Similarly positive and significant correlations were observed among grain yield and tillers/meter, spike weight, 1000 grains weight, biological yield and harvest index at Faizabad. The traits SW, TGW, BY and HI showed positive and significant correlations with GY under both conditions as well as at both the locations. The correlations were also worked out among the waterlogging tolerance and the yield components for both the locations (Table 4). The tillers/meter, 100 grain weight, biological yield and grain yield exhibited significant positive correlation with waterlogging tolerance for both the locations, thus indicative of the usefulness of these traits for waterlogging tolerance. Therefore these traits along with waterlogging tolerance values were used to identify stable genotypes with high yield potential under waterlogging conditions. Significant and positive correlation among grain yield and yield components under waterlogging stress conditions in wheat crop was also reported (SINGH *et al.*, 2018a).

Table 2. Mean performance and percent reduction in yield components under waterlogged conditions

Traits	Karnal			Faizabad					
	2015-16			2015-16			2016-17		
	NWL	WL	RP	NWL	WL	RP	NWL	WL	RP
Days to heading	87	89	-2.3	64	65	-1.6	85	88	-3.5
Days to maturity	127	122	3.9	102	103	-0.9	125	128	-2.4
Grain filling duration	39.2	33.1	15.6	38.1	37.8	0.8	40.1	39.4	1.8
Plant height	100	90	10.0	80.1	62.4	21.9	84.7	70.5	16.4
Tillers per meter	87	64	26.4	168.6	117.9	30.1	148.6	101.9	31.3
Spike weight	2.24	2.01	10.3	1.76	1.48	17.2	2.36	1.88	19.59
1000- grain weight	39.2	37.3	4.9	37.8	35.45	5.95	37.7	35.9	4.5
Biological yield	572	392	31.5	447	284	35.3	708	327	53.8
Harvest index	35.3	31.3	11.3	35.4	39.6	-12.7	31.8	36.6	-15.1
Gain yield	202	122	39.6	157	111	28.4	225	117	48.0

NWL-Non waterlogging, WL- Waterlogging, RP-reduction percentage

*Table 3. **C**orrelation among yield and yield components under normal and waterlogged conditions*

Locations	Karnal		Faizabad			
Year	2015-16		2015-16		2016-17	
Traits	NWL	WL	NWL	WL	NWL	WL
Days to heading	0.09	-0.15	0.04	-0.01	-0.08	0.04
Days to maturity	0.00	-0.26^{*}	-0.26^{*}	-0.05	-0.13	-0.02
Grain filling duration	-0.09	-0.17	-0.17	0.03	-0.07	-0.12
Plant height	-0.47^{**}	-0.13	0.22^{*}	0.36^{**}	0.09	0.20
Tillers per meter	-0.09	0.20	0.03	0.45**	-0.05	0.35**
Spike weight	0.35^{**}	0.22^{*}	0.07	0.30**	0.13	0.29**
1000- grain weight	0.15	0.33^{**}	0.01	0.39**	0.42^{**}	0.55^{**}
Biological yield	0.54^{**}	0.82^{**}	0.81^{**}	0.63^{**}	0.75^{**}	0.74^{**}
Harvest index	0.75^{**}	0.43^{**}	0.14	0.22*	0.58^{**}	0.30^{**}

*, **=Significance at P = 0.05, P = 0.01, respectively, NWL- Non waterlogging, WL- Waterlogging

The correlation between grain yield and tillers number across all genotypes was positive and significant was also reported (COLLAKU and HARRISON, 2002). The association of the selection index with grain yield, as well as, yield components has importance in formulating the indirect selection criterion. The waterlogging tolerance showed significant correlation with PH, TPM, BY, TGW and GY at both locations. Therefore, these traits along with waterlogging tolerance values could be used for identifying stable genotypes with high yield potential under waterlogging conditions. The positive and significant correlation between grain yields under waterlogged and normal conditions in bread wheat reported earlier are in agreement with the findings of the present study (SINGH *et al*., 2017). Under waterlogged conditions, significant and positive correlations were demonstrated for tillers/m and grain yield.

Table 4. Correlation coefficient among yield components and waterlogging tolerance under waterlogged condition

Locations	Karnal	Faizabad	
Trait/ Year	2015-16	2015-16	2016-17
Days to heading	-0.21	-0.12	0.07
Days to maturity	-0.03	-0.11	-0.04
Grain filling duration	0.17	-0.03	-0.22*
Plant height	0.41**	0.24*	0.18
Tillers per meter	0.39**	0.36**	0.29**
Spike weight	-0.21	0.24**	0.33**
1000- grain weight	0.32**	0.32**	0.41**
Biological yield	0.54**	0.34**	0.74**
Harvest index	0.07	0.19	0.01
Grain yield	0.55**	0.64**	0.78**

The waterlogging tolerance is defined as the grain yield under waterlogging relative to grain yield under drained or non-waterlogged conditions. The estimates of waterlogging tolerance in descending order for 64 test lines and 5 checks based on pooled data were compared for both the locations. The best performing 15 genotypes along based on their waterlogging tolerance index better than best check on pooled basis are presented in Table 5. The higher values of waterlogging tolerance have been reported as selection criteria for the identification of high yielding and stable waterlogging tolerant genotypes. The wheat genotypes SSDC3-253, SSDC3-24, SSDC3-264, NW 2036, SSDC3-140, HD 3118, SSDC3-347, HD 2888, SSDC3-113, DBW 71, SSDC3-143, PDW 314, NW 5054, PBW 550 were found better than best check KRL 3-4 based on pooled analysis at Karnal location. Similarly, genotypes SSDC3 264, SSDC3 347, NW 5054, PBW 550, WH 1080, SSDC1-351, SSDC1-325, HD 2985, DBW 17, SSDC3-346, HI 1563, SSDC3-140, DBW 88, SSDC3-436 and NW 1014 were found to be better than best check HD 2967 based on pooled analysis at Faizabad location. The significant and positive correlations among waterlogging tolerance, grain yield and yield components indicated that the traits associated with yield, as well as waterlogging tolerance can be used for the short listing of waterlogging tolerant genotypes. The present finding was in accordance with the finding of ARDUINI *et al*. (2016). However, the wheat breeders need relatively simple methods for selecting wheat varieties with improved waterlogging tolerance (SINGH *et al*., 2018b). In order to identify genetic resources for waterlogging tolerance and use them for the breeding, it is important to determine the phenotypic differences in the waterlogging tolerance of wheat cultivars with wide genotypic variation (HAYASHI *et al*., 2013). It is well recognized that utilizing high-yielding and waterlogging tolerant lines as donor parents in hybridization could be very effective for developing wheat cultivars with high yield potential as well as better adaptation under waterlogging conditions. Waterlogging tolerant genotypes have been identified in previous studies based on some yield based selection indices viz., GMP, MP, STI, YSI and HM (SINGH *et al*., 2018a). The selection indices that showed highly significant correlations with grain yield under waterlogged and normal soil conditions are generally suitable for selecting tolerant genotypes in wheat (SINGH *et al*., 2017). The high yielding genotypes doesn't necessarily possess the tolerance genes (ZHANG *et al*., 2017). Therefore, SINGH *et al*., (2018a) selected the genotypes based on high value of yield based selection index (YSI) with high biomass. The lines which were common based on high mean grain yield and waterlogging tolerance values under waterlogged stress conditions at individual location, as well as, both the locations were found promising to be utilized for increasing waterlogging tolerance of wheat genotypes.

Table 5. Waterlogging tolerant genotypes and their ranking at Karnal and Faizabad locations under waterlogging condition.

WL Tolerance ranking	Karnal		Faizabad	
	Genotypes	WL Tolerance (Pooled)	Genotypes	WL Tolerance (Pooled)
1	SSDC3-253	0.827	SSDC3 264	0.932
2	SSDC3-24	0.826	SSDC3 347	0.956
3	SSDC3-264	0.816	CBW 38	0.908
4	NW 2036	0.767	WH 1080	0.850
5	SSDC3-140	0.747	SSDC1-351	0.846
6	HD 3118	0.720	SSDC1-325	0.801
7	SSDC3-347	0.700	HD 2985	0.791
8	HD 2888	0.699	DBW 17	0.785
9	SSDC3-113	0.694	SSDC3-346	0.770
10	DBW 71	0.694	HI 1563	0.768
11	SSDC3-143	0.688	PBW 550	0.765
12	PDW 314	0.664	SSDC3-140	0.754
13	NW 5054	0.659	SSDC3-261	0.747
14	PBW 550	0.674	DBW 88, NW 5054	0.742
15	WH 1105	0.654	SSDC3-436, NW 1014	0.714
16	KRL 3-4 (C)	0.701	HD 2967 (C)	0.721

CONCLUSIONS

Based on waterlogging tolerance index, the wheat genotypes SSDC3 264, SSDC3 347, NW 5054 and PBW 550 were identified to be tolerant to waterlogging and could be used as donors for breeding tolerant genotypes. These tolerant lines can be further investigated for better understanding of the physiological mechanism associated with waterlogging tolerance.

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VIŠELOKACIJSKA KARAKTERIZACIJA GENOTIPOVA HLEBNE PŠENICE ZA TOLERANCIJU NA POPLAVE

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Izvod

Poboljšanje tolerancije pšenice na plavljenje može pomoći da se poveća produktivnost useva u regionima sa velikim i neblagovremenim padavinama sa lošom drenažom. Ova studija je urađena da bi se okarakterisala tolerancija 65 različitih genotipova hlebne pšenice. Osobine kao što su prinos zrna, biološki prinos, broj klasova po metru, trajanje nalivanja zrna, težina klasova i visina biljke u uslovima viška vode su se smatrali pokazateljima osetljivosti. Masa klasova, broj klasova po metru, masa 1000 zrna, biološki prinos i žetveni indeks su pokazali značajnu korelaciju sa prinosom zrna I u normalnim i u vlažnim uslovima. Indeks tolerancije na vodu (WTI) je pokazao pozitivnu korelaciju sa visinom biljke, brojem klasova po metru, biološkim prinosom, masom hiljadu zrna i prinosom zrna. Ove agronomske osobine zajedno sa WTI korišćene su za identifikaciju tolerantnih genotipova sa visokim potencijalom prinosa. Genotipovi pšenice SSDC3-264, SSDC3-347, NW 5054 i PBW 550 identifikovani su kao tolerantni i mogli bi se koristiti za poboljšanje tolerancije pšenice na višak vode.

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