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Assessment of genetic variability in Bread wheat (*Triticum aestivum* L.) sown under rainfed condition

VK Choudhary, Ankit Kumar, SK Singh, Ravi Kant, Rajesh Kumar and Shanti Bhushan

VK Choudhary
Directorate of Seed & Farms; (QSP), TCA Campus, Dholi, Muzaffarpur, Bihar, India

Ankit Kumar
Directorate of Seed & Farms; (QSP), TCA Campus, Dholi, Muzaffarpur, Bihar, India

SK Singh
Department of Genetics & Plant Breeding, RPCAU, Pusa, Samastipur, Bihar, India

Ravi Kant
Department of Genetics & Plant Breeding, TCA, Dholi, Muzaffarpur, Bihar, India

Rajesh Kumar
Department of Plant Breeding and Genetics, VKSCOA, Dumraon (BAU, Sabour), Bhagalpur, Bihar, India

Shanti Bhushan
Department of Plant Breeding and Genetics, VKSCOA, Dumraon (BAU, Sabour), Bhagalpur, Bihar, India

Corresponding Author:
Ankit Kumar
Directorate of Seed & Farms; (QSP), TCA Campus, Dholi, Muzaffarpur, Bihar, India

Abstract
A field experiment was conducted at RPCAU, Pusa, Samastipur, and Bihar during *Rabi* season of 2016-17 by using 24 diverse bread wheat genotypes with the objectives of estimating genotypic variability, heritability and genetic advance for yield & drought-related traits.
All wheat accessions were evaluated using randomized block design with three replications. Analysis of variance showed significant differences among all the bread wheat genotypes for all the characters under consideration. The maximum phenotypic and genotypic variance exhibited by all the traits under study except few traits. High GCV and PCV was observed for drought susceptibility index (DSI) indicating the importance of this trait in evaluation for drought tolerance and selecting the genotypes for drought tolerance. Moderate GCV and PCV was recorded for yield per plant, flag leaf area, number of grains per ear, harvest index, total number of tillers, 1000 grain weight and chlorophyll content. High heritability in broad sense were recorded for almost all the characters namely days to fifty per cent flowering, 1000 grain weight, drought susceptibility index, number of grains per ear, days to maturity, ear length, chlorophyll content, yield per plant, relative water content, number of tillers per plant and flag leaf area. High heritability value for these traits indicated that the variation observed was mainly due to genetic effect and were less influenced by the environment. High heritability coupled with moderate genetic advance as percentage of mean were observed for relative water content, no. of grains per ear and days to maturity. Therefore, it is concluded that simple selection scheme would be more effective to bring genetic improvement in drought tolerance genotypes.

Keywords: Wheat, heritability, genetic advance, drought tolerance indices and rainfed

Introduction
Wheat (*Triticum aestivum* L.) is the world's leading cereal grain and main food crop for people over the entire world occupying commanding position in Indian agriculture, occupying 28 per cent area under cereals and contributing 33 per cent of the total food grain production in the country (Rangare, *et al.*, 2010) [26]. India is the second largest producer of wheat in the world and it is the second most important food crop of the country after rice.
The world acreage under wheat crop is 215.91 million hectares with production of 765.77 million tonnes with an average yield of 3.54 tonnes ha^{-1}. However average yield is quite variable across the world, ranging from less than 1 to over 7 tonnes ha^{-1}. The differences in per hectare yield are due to differences in the level of inputs, agricultural sophistication and agro-climatic conditions.
The most important wheat producers among developing countries are China, India and Turkey. In developing countries about 45 per cent of 120 million hectares sown to wheat are rainfed and are prone to drought (Rajaram, 2001) [25]. In India, wheat is occupying 31.61 million hectares, with production of 109.52 million tonnes with an average productivity of 34.64 quintal per hectare (Annual Report 2021-22) [5]. The production of wheat grain in Bihar is about 5.55 million tonnes in an area of 2.15 million hectares.
Wheat grain yield of the country are highly affected by biotic and abiotic stress or environmental stresses (Shamsi *et al.*, 2010 and Khavarinejad and Karimov, 2012) [29, 16]. Drought is one of the most common abiotic stress that affects growth and development of plants. It is a serious problem influencing global crop production and it will become progressively important due to global climate change (Akbarian *et al.*, 2011) [3]. Drought stress is affecting about 32 per cent of 99 million hectares under wheat cultivation in developed countries (Shamsi *et al.*, 2011) [30]. Therefore, most of the countries of the world are facing the problem of drought.

The insufficiency of water is the principal environmental stress that causes heavy losses. Drought stress can reduce grain yield and average of 17 to 70 per cent yield loss has been estimated (Ahmadizadeh *et al.*, 2011) [2].

The scope of achieving improvement in any crop plant depends mainly on magnitude of genetic variability. Besides gene effects, breeders would also like to know how much of the variation in a crop is genetic and to what extent this variation is heritable, because efficiency of selection mainly depends on genotype, influence of the environment and interaction between genotype and environment. Heritability and genetic advance are other important selection parameters. The estimates of heritability help the plant breeder in determining the character for which selection would be rewarding. The breeders are interested in selection of superior genotypes based on their phenotypic expression. The major function of heritability estimates is to provide information on transmission of characters from the parents to the progeny. Collectively with the heritability, genetic advance provides estimates of attainable gain at a specific strength of selection. Therefore, heritability estimates along with genetic advance are more helpful in laying emphasis in selection for yield and yield components.

Materials and Methods

The present investigation was conducted during *Rabi*, 2016-17 using the experimental materials consisting of 24 diverse genotypes of wheat including two checks (HD 2733 & HD 2888) in experimental plots of Genetics and Plant Breeding, at RPCAU, Pusa. All the experimental materials were grown in rainfed conditions in randomized block design with three replications and recommended packages and practices were followed to grow good and healthy crop but without giving any irrigation except natural rains. Data were recorded on 16 morpho-physiological traits used for the analysis of mean variance, genotypic and phenotypic co efficient of variation, heritability and genetic advance. List of 24 bread wheat genotypes presented in Table-1.

Table 1: List of 24 bread wheat genotypes studied

Sl. No.	Genotypes	Sources	Sl. No.	Genotypes	Sources
1.	RAUW-7	RPCAU	13.	RAUW 172	RPCAU
2.	RAUW-6	RPCAU	14.	RAUW 173	RPCAU
3.	RAUW-4	RPCAU	15.	PBW-58	RPCAU
4.	DBW-14	RPCAU	16.	RAUW 174	RPCAU
5.	RAUW 151	RPCAU	17.	RAUW 177	RPCAU
6.	RAUW 152	RPCAU	18.	RAUW 179	RPCAU
7.	RAUW 161	RPCAU	19.	RAUW 183	RPCAU
8.	WR 544	RPCAU	20.	RAUW 101	RPCAU
9.	RAUW162	RPCAU	21.	RAUW 185	RPCAU
10.	RAUW191	RPCAU	22.	RAUW 188	RPCAU
11.	HD 2967	RPCAU	23.	HD 2733 (C)	RPCAU
12.	RAUW 171	RPCAU	24.	HD 2888 (C)	RPCAU

Results and Discussion

Genetic variability is a pre requisite for any breeding programme. A population is considered superior when it shows high mean coupled with high variability. (Savitha and Usha, 2015) [28]. The present investigation aims to determine the magnitude and extent of variability present in existing genotypes. Analysis of variance revealed highly significant differences among all the genotypes for all the traits under studied (Table-2). Many earlier workers namely, Gautam *et al*. (2000) [11], Asif, *et al.* (2004) [7], Gupta *et al.* (2005) [12], Rahman *et al.* (2016) [24], Khan *et al.* (2013) [14] and Abdel-Aziz *et al.* (2017) [1] have reported variability to a great extent for various characters in wheat. This consecutively is a sign of adequate variability in the evaluated materials that can effectively be employed in a further breeding programme. The mean, standard deviation, cv (%), variances and environmental variances for all the traits have been shown in Table-3.

The phenotypic variances for all the traits under studied were higher than the genotypic variances and same result was obtained by Kyosev and Desheva (2015) [19] (table-4). This may be due to the non-genetic factors which played an important role in the manifestation of these characters. Wide ranges of variance (phenotypic & genotypic) were observed in the experimental material for almost all the characters. The maximum phenotypic and genotypic variance was exhibited by all the traits under study except for few traits. These findings were in accordance of Merah (2001) [22], Sarkar *et al.* (2001) [27], Gupta *et al.* (2005) [12], who also observed high variance for yield and yield component traits among wheat genotypes. The relative water content (RWC) and Chlorophyll content exhibited high genotypic and phenotypic variance in rainfed condition and similar results were obtained by Lonbani and Arzani (2011) [20].

An estimate of GCV and PCV for all the characters under studied revealed that the Phenotypic coefficient of variation (PCV) was higher than their corresponding genotypic coefficient of variation (GCV) indicating the influence of environment on the expression of these characters. High values of PCV and GCV for drought indices implied the existence of greater magnitude of genetic variability and these indices might be controlled by genetic factor. Therefore, selection may be effective based on these indices (Arshadi *et al.*, 2018) [6]. High GCV and PCV was observed for drought susceptibility index (DSI) indicating the importance of this trait in evaluation for drought tolerance and selecting the genotypes for drought tolerance. Moderate GCV and PCV was recorded for yield per plant, flag leaf area, number of grains per ear, harvest index, total number of tillers, 1000 grain weight and chlorophyll content. Similar results were also reported by Shukla, *et al.* (2000) [32] for harvest index and 1000 grain weight, Singh, *et al.* (2003) [33] for HI and number of grain per spike, Mondal and Kour (2004) [23] for number of tillers per plant and 1000 grain weight.

High heritability in broad sense were recorded for almost all the characters namely days to fifty per cent flowering, 1000 grain weight, drought susceptibility index, number of grains per ear, days to maturity, ear length, chlorophyll content, yield per plant, RWC, number of tillers per plant and flag leaf area. High heritability value for these traits indicated that the variation observed was mainly due to genetic effect and were less influenced by the environment. So, these traits may be used as a selection criteria under stress and improved for drought tolerance in confirmation with the result of earlier workers *viz*., Tammam, *et al.* (2004) [35], Gupta *et al*. (2005) [12], Kotal, *et al*. (2010) [17] Sarkar *et al.* (2001) [27], Merah (2001) [22] and Farshadfar, *et al.* (2011) [9], Sharma and Kumar, (2010) [31], Binod, *et al.* (2013) [8], Kumar, *et al.* (2014) [18], Sunil, *et al.* (2014) [34], Alemu and Molla, (2015) [4], Kyosev and Desheva, (2015) [29]. Lush (1949) [21] pointed out that when heritability was high, relevance should be mainly on mass selection or as heritability become lower, more emphasis should be placed on pedigree selection method. Almost all the characters studied, showed low values of genetic gain whereas relative water content (RWC), number of grains per ear and days to maturity had moderate values of genetic advance as per cent of mean (GAM). Estimates of heritability have a role to play in determining the effectiveness of selection for a character, provided they are considered in conjugation with the genetic advance as per cent of mean as suggested by Johanson *et al.* (1955) [13]. High heritability coupled with moderate genetic advance as percent of mean were observed for relative water content, number of grains per ear and days to maturity. Similar findings were in accordance with Fikre *et al.* (2015) [10] for relative water content and number of grains per ear. Traits like days to 50% flowering, 1000-grain weight, drought susceptibility index, ear length, chlorophyll content, yield per plant, total number of tillers and flag leaf area exhibited high heritability along with low genetic advance, indicating greater role of non-fixable genetic effects on the expression of these characters. Therefore, direct selection based on these characters would be less effective.

Table 2: Analysis of variance for different quantitative characters in bread wheat under rainfed condition.

Characters	Mean sum of square		
	Replication	Treatment	Error
Days to 50 per cent flowering	0.12	75.25**	0.87
Plant height (cm)	44.81	161.98**	56.97
Days to maturity	37.09	106.40**	14.40
Total no. of tillers	0.03	2.39**	0.20
Flag leaf area (cm^2)	6.77	72.50**	8.52
Relative water content (%)	1.33	132.79**	6.12
Chlorophyll content (SPAD)	0.54	42.94**	3.43
Canopy temperature (°C)	0.77	3.02**	0.46
Ear length (cm)	0.07	1.31**	0.10
No. of grains per ear	19.01	153.67**	13.79
Spikelet length (cm)	0.005	0.03**	0.007
Spiklet fertility (%)	4.53	49.32**	21.47
1000-Grain weight (g).	0.16	65.11**	2.19
Yield per plant (g)	0.03	30.41**	3.06
Harvest index (%)	2.48	108.29**	25.99
Drought susceptibility index	0.13	0.47**	0.002

** = Significant over check

Table 3: Mean performances of twenty four genotypes of bread wheat for sixteen characters under rainfed condition.

Characters genotypes	DFF	PH	DM	TT	FLA	RWC	CC	CT	EL	GPE	SL	SF	TGW	GY	HI	DSI
RAUW-7	65.00*	89.02*	104.00*	4.70	29.17	80.33*	38.50*	21.70	9.57	51.00	1.07	66.13	44.53	17.77	41.67	1.05
RAUW-6	74.00*	82.77*	105.00*	4.87	27.84*	84.00	39.10*	22.13	9.43	50.33	1.10	56.77	43.77	17.67	44.67	1.04
RAUW-4	65.00*	93.33*	104.00	5.03	23.69	87.00*	39.57*	21.47	9.40	53.33*	1.20	68.50	44.23	20.00*	46.40	0.70*
DBW-14	67.00*	82.60*	109.00*	4.50	25.90	66.33*	34.68*	22.43	9.33	49.67	1.13	60.03	40.90	16.47	43.53	1.07
RAUW 151	76.00*	92.77*	123.00	5.27*	24.61	66.67	33.55*	23.60	10.80	27.67	1.17	63.77	42.97	12.43	44.47	1.59
RAUW 152	76.00*	88.07*	121.00	5.27*	37.64*	63.67	35.03*	23.60	11.10	44.33	1.13	60.87	44.87	15.83	35.50	1.09
RAUW 161	73.00*	91.90*	118.00*	3.47	24.80	84.67	33.27*	23.57	9.93	45.33	1.17	63.80	39.80	11.00	33.80	1.68
WR 544	64.00*	99.37	101.00*	4.20	27.63	70.67	36.77*	22.97	9.60	45.00	1.17	67.23	41.20	11.10	35.23	1.66
RAUW162	75.00*	97.10*	120.00	6.30*	26.07	79.67	29.67*	22.87	9.70	45.00	1.30*	65.67	28.93	16.90	34.73	0.64*
RAUW191	79.00	102.93	122.00	5.57*	31.97*	65.33	31.40*	23.30	9.43	43.67	1.23	63.83	39.43	10.53	35.57	1.53
HD 2967	76.00*	93.40*	116.00*	5.50*	29.77*	72.33	30.70*	22.60	10.07	56.00*	1.07	65.50	43.67	16.27	45.00	1.36
RAUW 171	73.00*	94.37*	112.00*	5.03	21.50	62.67	26.00	21.97	9.80	47.67	1.10	70.27	36.47	11.60	37.50	1.41
RAUW 172	74.00*	98.37*	115.00*	5.53*	30.18*	74.33	28.03	23.37	10.03	38.00	1.27*	54.53	38.37	14.20	37.60	0.77*
RAUW 173	66.00*	101.30	110.00*	5.07	25.65	66.67	29.20*	21.73	9.73	35.33	1.10	54.90	29.17	19.63	46.33	0.62*
PBW-58	70.00*	92.17*	111.00*	5.47*	18.98	83.33	36.60*	21.93	9.53	47.33	1.13	64.13	43.17	19.20	44.68	0.67*
RAUW 174	75.00*	93.67*	119.00	5.20*	27.41	83.80	37.81*	22.37	10.30	37.67	1.07	65.97	32.73	14.47	41.00	0.72*
RAUW 177	75.00*	97.37*	114.00*	5.70*	18.00	76.33	33.90*	21.50	10.30	48.33	1.03	65.20	41.03	18.83	44.67	0.65*
RAUW 179	75.00*	97.57*	111.00*	5.40*	21.10	73.67	26.63	21.00	10.10	51.33	1.20	66.43	43.63	13.67	32.90	0.59*
RAUW 183	74.00*	97.63*	113.00*	4.60	26.83	66.67	32.20*	23.27	10.67	48.33	1.17	65.83	37.63	10.43	31.13	1.33
RAUW 101	73.00*	90.30*	116.00*	5.47*	28.32	78.33	34.50*	21.67	11.03	54.00*	1.23	67.50	44.13	17.80	45.83	1.26
RAUW 185	74.00*	97.23*	116.00*	4.57	25.80	66.00	32.40*	18.40*	9.27	37.00	1.13	66.80	39.80	14.80	36.54	0.66*
RAUW 188	75.00*	79.90*	120.00	4.27	32.30*	68.67	33.13*	22.57	8.40	44.00	0.70	54.87	39.93	13.47	46.07	1.31
HD 2733	79.33	87.90*	116.00*	6.30*	28.70	74.67	36.95*	21.43	9.63	52.67*	1.13	66.63	43.97	17.23	37.80	1.37
HD 2888-C	80.33	110.00	123.00	5.77*	34.97*	66.33	31.60*	20.40	10.97	47.67	1.07	71.07	44.20	17.13	53.40	0.34
Mean	73.18	93.79	114.15	5.13	27.03	73.42	33.38	22.16	9.92	45.86	1.13	64.01	40.36	15.35	40.67	1.05
S.E.	0.52	3.78	1.79	0.22	1.88	2.53	1.08	0.61	0.18	1.74	0.06	2.49	1.04	0.92	2.57	0.09
C.D. 5%	1.49	10.77	5.10	0.63	5.34	7.20	3.09	1.73	0.50	4.96	0.16	7.08	2.96	2.63	7.30	0.27

* = Significant over check

Table 4: Genetic parameter for various characters in bread wheat under rainfed conditions

Characters	σ^2_g	σ^2_p	GCV	PCV	h^2 (Broad sense) %	GA as % of Mean
Days to 50 per cent flowering	21.21	22.04	6.29	6.41	0.96	9.31
Plant height (cm)	32.18	75.14	6.05	9.24	0.43	7.65
Days to maturity	37.11	46.73	5.34	5.99	0.79	11.18
Total no of tillers	0.38	0.53	12.04	14.20	0.72	1.09
Flag leaf area (cm^2)	18.01	28.56	15.70	19.77	0.63	6.94
Relative water content (%)	52.32	71.52	9.85	11.52	0.73	12.74
Chlorophyll content (SPAD)	13.35	16.87	10.94	12.30	0.79	6.69
Canopy temperature (°C)	1.05	2.15	4.61	6.61	0.49	1.47
Ear length (cm)	0.39	0.49	6.33	7.05	0.81	1.16

No. of grains per ear	42.39	51.48	14.20	15.65	0.82	12.17
Spikelet length (cm)	0.01	0.02	8.73	12.34	0.50	0.14
Spiklet fertility (%)	15.77	34.32	6.20	9.15	0.46	5.55
1000-grain weight (g)	20.06	23.31	11.10	11.96	0.86	8.56
Yield per plant (g)	8.33	10.89	18.80	21.50	0.76	5.20
Harvest index (%)	25.33	45.09	12.38	16.51	0.56	7.77
Drought susceptibility index	0.15	0.18	37.01	40.15	0.85	0.74

Conclusion

Analysis of variance revealed highly significant differences among the entries under study for all the parameters. High GCV & PCV were observed for drought susceptibility index with narrow difference between them indicating least influence of environment and it would be practical to select genotypes for drought tolerance. High heritability coupled with moderate genetic advance as percent of mean were observed for relative water content, number of grains per ear and days to maturity indicating that simple selection scheme would be effective for these traits to bring genetic improvement in desired direction.

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