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Assessment of heritability and genetic parameters in wheat (*Triticum aestivum* L.) based on agronomic and morphological traits

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Abstract
The present study in thirty wheat (*Triticum aestivum* L.) genotypes was undertaken to get knowledge on genetic variability, heritability and genetic advance in Indian cultivated wheat varieties. Plant materials were planted in a RBD with three replications during two consecutive *rabi* seasons of 2014-15 and 2015-16.The analysis of genetic variability, heritability and genetic advance for sixteen agronomic characters were recorded. Maximum values for genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were recorded for peduncle length (17.62 and 17.45 %) and (18.21 and 18.69 %) during two years, respectively. High heritability in broad sense was observed in plant height (95.28 and 98.07 %) followed by peduncle length (93.57 and 87.16 %) during two years, respectively. Genetic advance for almost all traits were found low to moderate which the maximum value was observed for number of tillers/m (16.2 and 11.59). The results obtained from this study indicated that great magnitude of genetic variability existed among wheat genotypes that could be used for development of new varieties by wheat breeders.

Keywords: Wheat, Genetic variability, GCV, PCV, Heritability, and Genetic advance

Introduction
Selection of physiological traits for the purpose of wheat improvement in recent years improved either single or couple of the traits and lost some other important traits which led to narrowing of the germplasm base and the genetic diversity in wheat. Genetic diversity provide a great scientific basis for studies on species evolution, variety identification, parent selection, variety protection, and ultimately better utilization of germplasm and more efficient breeding (Tian *et al.,* 2015) [17]. Genetic diversity can be identified by several methods such as morphological screening and morphological traits (Akcura, 2011) [2]. Agro-morphological traits will serve as a essential tool to characterize genetic diversity and in plant breeding programs (Salem, *et al*. 2008) [14]. Exploitation of genetic parameters enables us to develop heritable improvements in economically vital traits through selection. Heritability is a good index for transmission of traits from parents to offspring (Rehman *et al*., 2015) [13]. Generally, it is defined as the proportion of the total phenotypic variance of a population, and is represented by the symbol h^2. Successful selection is dependent on a high heritability of traits (Eid, 2009) [8]. Information on the nature and magnitude of genetic variability greatly helps in formulating sound breeding program of crop improvement. Genetic parameters; phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) is not only useful for comparing the relative amount of phenotypic and genotypic variations among different traits but also very useful to estimate the scope for improvement by selection. Khan *et al*. (2015) [10] reported high heritability (bs) was recorded for all the traits (83.0-97.0%) except for traits grain filling period, number of spikelets spike^{-1} and spike length and also reported low genetic gain for days to heading, days to maturity, number of effective tillers m^{-1}, number of spikelets spike^{-1}. They found moderate GCV and PCV for these traits. Bhushan *et al.,* (2013) [5] in a study of 40 wheat cultivars, found the higher magnitudes of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were recorded for grain yield, biological yield, productive tillers per plant and plant height, whereas least genotypic and phenotypic coefficient of variation was obtained for number of spikelets per spike, days to heading, test weight, harvest index, grain filling period and days to maturity. Arati yadawad *et al*., (2015) [3] also reported moderate heritability for number of spikelets per spike, grain yield per plant, yield per meter row and thousand grain weight with a narrow gap between PCV and GCV for plant characters. The present study was conducted in wheat (*Triticum aestivum* L.) varieties with objectives to find out the extent of genetic components, heritability, and genetic advance of quantitative traits.

Materials and Methods

The experiment was conducted during two consecutive *rabi* cropping seasons of 2014-15 and 2015-16 at Crop Research Farm, Department of Agronomy, Allahabad. The experiment was laid out in Randomized Block Design replicated thrice. Thirty wheat genotypes were included in the study, given in (Table 1). Genotypes were grown in a plot size of 1.2m × 2.5m (6 rows of 2.5m length with 20 cm space between rows) with seed rate of 120 kg/ha. Optimum dose of Nitrogen, Phosphorus, and Potassium i.e. @ 120, 60, 40 kg/ha was used respectively at the time of seed bed preparation and crop growth periods. Analysis of variance was done for partitioning the total variation into variation due to treatments and replications according to procedure given by (Panse and Sukhatme, 1967) [12]. The estimates of phenotypic (σ^2ph) and genotypic (σ^2g) variances followed by genotypic and phenotypic coefficients of variation were worked out according to the method suggested by Johnson *et al.* (1955) [9]. Heritability in broad sense (h2) was flow by Burton and De Vane (1953) [6] and genetic advance was given by Johnson *et al.* (1955) [9].

Table 1: List of wheat genotypes and their pedigree

No.	Genotypes	Pedigree/Parentage
1	HD 1982	YT54/N10B//HD845
2	HD2643	VEE"S"/ HD2407 //HD 2329
3	HD2428	HD1949 /HD2160
4	HD2402	HD2177//CNO67/BB/3/HD2160/4/HD2236
5	HD2204	HD 2092 //HD 1962/E 4870/K 65
6	HD 2891	WL711 // HD 2624
7	HD 2177	HD1962-E 4870-K65/HD1593
8	HD 2385	HI686/ HD 2263
9	HD 2270	HD 1962/E4870/ K65/HD 2119 /247
10	HD 2236	HD 2119 / HD 1981
11	HD 2278	HD 2119 //HD 1912 /HD 1592/3/HD 1962/E 4870/4/ K65
12	HD 2954	DL 975-1/BAVIOCRA
13	HD 2824	PTO-1 / CNO 79 / PRL /GAA /3/HD 1951
14	HD 1941	E 5477 * S64
15	HUW 37	KALYANSONA / S 331 // HD 1982
16	HUW 318	HUW 206 / HUW 202
17	HUW 251	WH-147/HD-2160//2*WH-147
18	HUW 213	NORTENO / MOTI // HD 2160
19	HUW 55	E 4870 / HD 1982 // INIA 66 /HD 2189
20	K 88	VEERY "S" / WL 711
21	K 9006	CPAN 1687 /HD 2204
22	K 9533	HI 1077/HUW 234
23	K 8020	KALYANSONA/HD 1982
24	Raj 3765	HD 2402/VL639
25	Raj 6560	TOPDY 6
26	Raj 3077	HD 2267/RAJ 1482/5/BB/INIA66'S'/NAPO
27	Raj 1555	COCORIT'S' / RAJ 911
28	Raj 1972	HD 2195 / HD 2160
29	HD 2687 (Check1)	CPAN 2009 / HD 2329
30	K 9162 (Check2)	K 7827/HD 2204

Results and Discussions

To compare the extent of magnitude of variation among various plant characters, genotypic and phenotypic components of variance, phenotypic coefficient of variations (PCV) and genotypic coefficient of variations (GCV), broad sense of heritability (h2b) and genetic advance were worked out, and depicted in Table 2.

The data of first experimental year Table 2, shows that the phenotypic and genotypic variability (VP or σ^2P and VG or σ^2g) ranged from (211.06 and 114.24) to (0.03 and 0.03) which were recorded for number of tillers/m and the lowest was for grain weight spike^{-1} respectively. Traits such as plant height, peduncle length, spike weight, number of tillers/m, thousand grain weight, grain yield, harvest index and straw yield showed higher genotypic variance. During second experimental year the values obtained for the phenotypic and genotypic variability ranged from (219.21 and 83.26) to (0.03 and 0.0003) that were recorded for number of tillers/m and the lowest was of grain weight spike^{-1} respectively. Plant height, days to heading, physiological maturity, peduncle length, thousand grain weight, grain yield, and harvest index showed higher genotypic variance. The pooled data phenotypic and genotypic variability was ranged from (144.19 and 74.91) to (0.03 and 0.01) which was recorded for trait number of tillers/m and the lowest was of grain weight spike^{-1} respectively. Plant characters like plant height, peduncle length, spike length, number of tillers/m, thousand grain weight, grain yield, harvest index and straw yield showed higher genotypic variance. The traits which showed less difference in genotypic and phenotypic variance and had higher genotypic values, mean that variability present among plant material were mainly due to genetic reason with less influence of environment and are heritable. While the traits that showed more difference in genotypic and phenotypic variance and less genotypic values are influenced by environment, thus less heritable. However, phenotypic variance generally come out higher than their corresponding genotypic variance, but it should be obtained minimum to ensure higher heritability. Similar result was found by (Abinasa *et al.,* 2011) [1] and (Bhushan, *et al.,* 2013) [5]

A wide range of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) observed for the traits under study in the first experimental year. Phenotypic coefficient of variation (PCV) ranged from 2.1 (physiological maturity) to 18.21% (peduncle length). Higher magnitude of PCV was recorded for peduncle length, spike weight, grain weight spike^{-1}, grain yield, harvest index, straw yield, number of tiller/m, grain filling period and plant height. Genotypic coefficient of variation (GCV) ranged from 1.03 (physiological maturity) to 17.62% (peduncle length). Higher magnitude of GCV was recorded for the traits like peduncle length, spike weight, grain yield, number of tiller/m, thousand grain weight, grain yield, harvest index, straw yield and plant height. In second experimental year phenotypic coefficient of variation (PCV) ranged from 2.48 (physiological maturity) to 19.49% (straw yield). Higher magnitude of PCV was recorded for straw yield, peduncle length, harvest index, grain yield, spike weight, grain weight spike^{-1}, number of tiller/m, and grain filling period. Genotypic coefficient of variation (GCV) ranged from 1.1 (grain weight spike^{-1}) to 13.67% (straw yield). Higher magnitude of GCV was recorded for peduncle length, straw yield, harvest index, plant height, thousand grain weight, days to heading and physiological maturity. The pooled data on phenotypic coefficient of variation (PCV) ranged from 1.9 (physiological maturity) to 17.39% (physiological maturity). Higher magnitude of GCV was recorded for peduncle length, straw yield, harvest index, grain yield, spike weight, number of tiller/m and grain weight spike^{-1}. While, genotypic coefficient of variation (GCV) ranged from 0.85 (days to anthesis) to 16.95% (peduncle length). The higher magnitude of GCV was recorded for peduncle length, straw yield, harvest index, thousand grain weight, number of tiller/m, spike weight and plant height. The characters in which PCV showed slightly higher value from its corresponding GCV, can be suggested that the least influence of environment was effect in the expression of those characters. Thus, selection can be effective for these traits and ensuring great scope for genetic improvement through selection for these traits.

Arati yadawad *et al*., (2015) [3] reported a narrow range of PCV and GCV for number of spikelets per spike, grain yield per plant, yield per meter row and thousand grain weight, whereas, Khan *et al*. (2015) [10] found moderate GCV and PCV for these traits.

Successful selection is dependent on a high heritability of a character. In the current study estimated heritability was made up in both experimental years, as presented in Table 2. Heritability in first experimental years ranged from 18.73 to 95.28 %, that were recorded for number of spikelets spike^{-1} and plant height respectively. Plant traits such as plant height, peduncle length, spike weight and thousand and grain yield showed higher heritability, while, number of tillers/m, straw yield, harvest index and grain weight spike^{-1} showed medium heritability. The maximum genetic advance in first experimental year was 16.2 which is moderate value and the remaining traits showed low amounts of genetic advance. In second experimental year the heritability ranged from 1.01 to 98.07%, which was recorded for grain weight spike^{-1} and plant height respectively. Plant character like plant height, pudecal length, grain yield, days to heading, physiological maturity and harvest index showed higher heritability, thousand grain weight, straw yield and grain filling period exhibited medium heritability. All the trait showed a moderate to low amounts of genetic advance. The estimated heritability for pooled data exhibited values ranged from 2.41 to 97.44%, which was recorded for grain weight spike^{-1} and plant height respectively. Plant height, peduncle length, grain yield, harvest index, thousand grain yield, spike weight and straw yield showed higher heritability, on the other hand the trait such as days to heading, physiological maturity, number of tiller/m and grain weight spike^{-1} showed moderate heritability. All the traits showed a low amounts of genetic advance. High heritability was recorded for plant height by Khan *et al.,* (2007) [11], Abinasa *et al.,* (2011) [1] and Arya *et al*. (2013) [4] Chowdhry *et al*. (1997) [7] also reported moderate heritability with high genetic advance for number of tillers. Shukla *et al*., (2000) [16] reported high heritability with high genetic advance for 1000-grain weight. Salim *et al*., (2003) [15] found high heritability with high genetic advance for grain yield. Khan *et al*., 2015 [10] reported high heritability for traits like grain filling period, number of spikelets spike^{-1} and spike length and also repoted low genetic gain for days to heading, days to maturity, number of effective tillers m^{-1}, number of spikelets spike^{-1}.

In general the higher heritability estimates for those traits indicate that environmental factors did not greatly affect phenotypic variation of such characters. The high heritability and low genetic advance under control of non-additive (dominant and/or epistatic) genes which limits the scope for improvement through selection. In the present study many traits recorded higher and moderate heritability coupled with lower genetic advance, which may be attributed to non-additive gene action governing these traits, and characters could be improved through the use of cross hybridization. However, characters exhibiting high heritability may not necessarily give high genetic advance. High heritability and high genetic advance indicates prevalence of additive gene effect, therefore, characters can be better exploited through selection. High heritability accompanied by high genetic advance will be more helpful to arrive at more reliable conclusion.

It can be concluded that the present research revealed that many traits have adequate genetic variability for the various agronomic characters among genotypes studied and showed effectiveness for further breeding program. Lower genetic advance limits the greater scope of improvement but higher phenotypic and genotypic coefficient of variation and higher heritability provides good chance for its further improvement. The results obtained from this study indicated that great magnitude of genetic variability existed among wheat genotypes that could be used for development of new varieties by wheat breeders.

Table 2: Estimated variances and genetic parameters for the characters under the study in 30 wheat genotypes

Traits	**Genotypic variance (GV)**			**Phenotypic variance (PV)**			**Genotypic Coefficient variance (GCV) %**			**Phenotypic Coefficient variance (PCV) %**			**Heritability (%)**			**Genetic advance**		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Days to heading	1.52	6.61	2.11	5.75	8.33	4.79	1.57	3.27	1.85	3.05	3.67	2.79	26.45	79.31	44.09	1.88	2.26	1.71
Days anthesis	1.97	3.37	0.51	5.86	9.78	4.75	1.67	2.19	0.85	2.89	3.73	2.61	33.6	34.45	10.68	1.89	2.45	1.71
Physiological maturity	1.25	5.32	1.88	5.19	6.84	4.15	1.03	2.19	1.28	2.1	2.48	1.9	24.12	77.79	45.44	1.78	2.05	1.59
Grain Filling Period	0.95	3.7	1.02	7.25	8.7	4.36	3.84	9.01	4.33	10.6	13.82	8.95	13.12	42.5	23.44	2.11	2.31	1.63
Plant height	72.45	73.3	76.92	76.04	74.74	78.94	9.34	9.39	9.61	9.57	9.48	9.73	95.28	98.07	97.44	6.83	6.77	6.95
Peduncle length	10.92	10.52	10.04	11.67	12.07	10.55	17.62	17.45	16.96	18.21	18.69	17.39	93.57	87.16	95.13	2.67	2.72	2.54
Spike length	0.04	0.13	0.06	0.57	0.64	0.53	1.88	3.45	2.28	7.09	7.57	6.87	7.00	20.8	11.06	0.59	0.63	0.57
Spike weight	0.16	0.002	0.05	0.18	0.11	0.08	16.87	1.85	9.66	17.91	13.32	11.84	88.76	1.92	66.58	0.33	0.25	0.22
Grain weight per spike	0.03	0.0003	0.01	0.06	0.03	0.03	11.17	1.1	7.31	16.07	10.94	10.67	48.3	1.01	46.94	0.19	0.14	0.13
Number of tillers/ m	114.24	83.26	74.91	211.1	219.21	144.19	9.87	8.26	7.91	13.42	13.4	10.98	54.12	37.98	51.95	16.2	11.59	9.4
Number of grains/spike	4.05	0.89	0.32	17.31	23.02	13.41	4.68	2.23	1.33	9.69	11.31	8.58	23.38	3.88	2.41	3.26	3.76	2.87
Number of spikelets/spike	0.2	0.09	0.11	1.08	1.19	0.6	2.55	1.64	1.87	5.89	6.12	4.36	18.73	7.23	18.42	0.81	0.85	0.6
1000 grain weight	8.16	8.89	4.33	11.55	15.05	6.38	7	7.05	5.01	8.33	9.17	6.08	70.63	59.08	67.86	2.66	3.04	1.98
Grain yield	0.24	0.24	0.17	0.36	0.29	0.21	12.98	13.06	10.93	15.8	14.49	12.26	67.5	81.24	79.5	0.47	0.42	0.36
Straw yield	0.61	1.26	0.75	1.16	2.57	1.21	9.99	13.67	10.8	13.81	19.49	13.71	52.33	49.21	62.13	0.84	1.25	0.86
Harvest index	11.22	21.14	12.11	21.82	27.77	16.18	10.35	14.6	10.89	14.43	16.73	12.59	51.44	76.13	74.84	3.66	4.12	3.15

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