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Assessment of genetic variability, heritability, genetic advance and relationship of yield and its contributing traits in wheat genotypes (*Triticum aestivum* L.)

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Abstract

Analysis of variance (ANOVA) expresses significance for all characters except spike length and spike weight. The highest mean was observed for days to maturity (107.90) followed by plant height (77.20), days to 50% flowering (73.90) and number of grains per spike (44.70). The estimates of PCV were slightly higher than GCV for all traits. The highest genotypic and phenotypic coefficient of variation was recorded for biological yield per plant, grain yield per plant and number of tillers per plant. High heritability (h^2) coupled with high genetic advance for plant height, biological yield per plant, flag leaf area, grain yield per plant, number of grains per spike, days of 50 % flowering and tillers per plant. The results revealed that these traits may serve as effective selection attributes during selection in the breeding program for yield improvement in wheat. Grain yield per plant was positive and showed a highly significant relation with days to 50 % flowering, tillers per plant, flag leaf area, plant height, days to maturity, biological yield per plant, spike weight and test weight. It revealed that by increasing the value of these traits, grain yield can be drastically increased. Spike length per plant was also significant and can be considered in breeding programs. The highest positive direct effect on grain yield per plant was observed by Biological yield per plant followed by Harvest Index, Days to Maturity and Spike Length, while remaining traits showed negative and direct effect on grain yield per plant. Hence, for the development of high-yielding wheat varieties these traits possessing highly significant positive associations should be given more weightage in breeding or selection programme.

Key words: Wheat, (*Triticum aestivum* L), ANOVA, variability, h^2 and genetic advance.

Introduction

Wheat (*Triticum aestivum* L.) is a hexaploid species having chromosome number 2n = 6x = 42, belongs to family Gramineae. It is a self-pollinating annual plant in the true grass family Gramineae (Poaceae) and largest cereal crop extensively grown as staple food sources in the world. It is a C_3 plant grown from temperate, irrigated to dry and high rain-fall areas and from warm, humid to dry and cold environmental conditions. Wheat is the second most important cereal staple food crop consumed by nearly 35% of world population and provides 20% food calories. Wheat is grown over a range of latitudes and known for its remarkable adaptation to a wide diversity of environments. The main wheat growing countries includes China, India, U.S.A., Russia, France, Canada, Germany, Turkey, Australia and Ukraine. India is the second largest wheat growing country of the world after the China. The world acreage under wheat crop during 2021-2022 was 221.67 million hectare with production of 778.83 million tonnes with an average yield of 33.08 qt./h. In India, the total area for wheat crop during 2021-2022 was 31.68 million hectare with production of 106.41 million tones and average productivity was 28.5 quintal / hectare. Uttar Pradesh ranked first with an area of 9878 hectare with the production of 30 million tonnes with average productivity of 30.76 qt./ha.

Materials and methods

Investigation comprising of twenty-three genotypes and two check of bread wheat (*Triticum aestivum* L.) was conducted during 2017-2018, to determine the association of various genetic parameters of yield and related traits. The climate of district Ballia is typically semi-arid having subtropical climate. Ballia district is the easternmost part of Uttar Pradesh state and borders with Bihar. The district lies between the parallels of $25^0 33^1$ and $26^0 11^1$ North latitudes and $83^0 38^1$ and $84^0 39^1$ East longitudes. The experimental material for the study was raised at Nidharia Agricultural Research Farm, S. M. M. Town Post Graduate College, Ballia, during Rabi season of 2017–2018 in a Randomized Block Design with three replications. The twenty-three genotypes and two check i.e, total 25 genotypes were tested in randomized block design with three replication during *Rabi* 2017–2018. Every entry was to make suitable in a single row of 2.5 m length with a spacing of 0.3 m row to row. To make acceptable to agronomical practices and plant protection measures were followed for the successful increment of the crop. Five selective plants per genotype in every replication were randomly selected for listing observation on different characters viz. days 50 % flowering, number of tillers per plant, flag leaf area $(cm)^2$, plant height (cm), spike length per plant (cm), days to maturity, biological yield per plant (g), spike weight per plant (g), 1000-grain weight (g), harvest index (%). The analysis of variance for RBD was presented by linear model given by Panse and Sukhatme (1985). The genotypic coefficient of variation, which amounts the magnitude of genetic variation show in a special character, was estimated as per the formula given by Burton and De Vane (1953). The phenotypic coefficient of variation, which estimated as per magnitude of phenotypic variation exhibit in a special the formula given by Burton and De Vane (1953). The predicted genetic advance under selection (GA) and heritability were estimated as the formula defined by Allard (1960). The genetic advance suggested as percentage of mean was computed by method developed by Johnson *et. al.,* (1955).

Results and discussion

Analysis of variance (ANOVA) was carried out for yield contributing characters are presented in Table-1 which showed that treatments differ significantly for all the characters except spike length and spike weight. Similar observations have been reported by Ashif *et al.* 2004, Joshi *et al.* 2018 and Ubale *et al.* 2018. The mean performance of various genotypes has also showed good range of variability for various characters, which were studied in present investigation (Table 2). The range recorded for days to 50% flowering (65.33-78.33), number of tillers per plant (4.80-9.80), flag leaf area (18.83-27.10), plant height (64.39-102.76), spike length (7.79-11.53), days to maturity (101-111), biological yield per plant (13.88-38.08), spike weight per plant (1.67-2.49), numbers of grains per spike (34.66-57.66), test weight (23.0-36.0), harvest index (26.60-52.26) and grain yield per plant (6.99-14.60). The estimates of PCV were slightly higher than GCV for all traits. The magnitudes of PCV over GCV for all traits were due to some influence of environment on phenotypic expression. The highest phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) values were observed for biological yield per plant (25.16/24.96) followed by grain yield per plant (2174/21.44), number of tillers per plant (16.68/16.13) and harvest index (13.59/13.0). However it was observed that there was very less difference between the genotypic and phenotypic coefficient of variation indicating very less effect of variation due to environment. This laid the basis for large scope of selection due to genotypic coefficient of variation as these characters were genetically potent for selection in crop like wheat. These results are in accordance with the earlier reports of Gupta *et al.* (2009) and Khan *et al.* (2011). The result indicate that breeders have opportunity for selection of desirable plants through the attributes had higher magnitudes of PCV/GCV.

Heritability estimates and provides the information and assessment of amount of transmissible variability of a population/genotypes. It is one of the most important basic factors that determine the genetic improvement or response due to selection, especially superior plants of the population/genotypes. In the present investigation, the range of heritability values in broad sense was recorded from 79% to 99% for all the characters under study. High estimates of heritability were recorded for 10 characters *viz;* plant height (99), biological yield per plant (98), grain yield per plant (97), flag leaf area (97), number of grains per spike (96), days to 50% flowering (95), number of tillers per plant (93), test weigh (92), harvest index (91) and spike length (90). The high heritability of plant height, biological yield per plant and grain yield per plant at par with flag leaf area was accompanied by high genetic gain. This indicated the presence of additive nature of genes. It can be concluded that since these characters were highly responsible to selection, superior genotype can be evolved through selection expressing these characters. These findings get full support from the findings of Gupta *et al.* (2009) and Kumar *et al.* (2014). The estimates of genetic advance for twelve characters studied, which range from 0.44% to 18.16%. Highest genetic advance was recorded for plant height (18.16), biological yield per plant (11.64), number of grains per spike (11.04) and harvest index (10.97). The moderate genetic advance was recorded for test weight (7.06), days to 50% flowering (6.85) and flag lea

Table 1 - Analysis of variance for 12 characters in Wheat (*Triticum aestivum L.*) MEAN SUM OF SQUARE

Sources of Variation	df	Days to 50% flowering	Number of tillers per plant	Flag leaf area (cm)2	Plants height (cm)	Spike length per plant (cm)	Days to maturity	Biological yield per plant (g)	Spike weight per plant (g)	Number of grains per spike	Test weight (g)	Harvest index (%)	Grain yield per plant (g)
Replication	2	0.2133	0.2183	0.0209	1.5466	0.0262	0.9733	1.3786	0.0046	1.6933	0.2800	3.1248	0.1996
Treatment	24	35.3189*	4.2019*	18.5452*	236.0879*	2.1331	16.6589*	97.8766*	0.1885	90.7478*	39.4811*	95.9745*	12.8937*
Error	48	0.5606	0.0962	0.1714	0.7251	0.0765	0.7372	0.5218	0.0151	1.1794	1.1411	2.9251	0.1207

* Significant at 5% level of significance

Table. 2- Mean, range, critical difference, PCV, GCV, heritability and genetic advance of 12 characters in wheat (Triticum aestivum L.)

S. N.	*Characters*	*Mean*	*Range*		*CD*	*PCV*	*GCV*	*Heritability (h^2) in broad sense (%)*	*Genetic advance*	*Genetic advance as % of mean*
			Min	*Max*	*5% = 1.73*				*5%*	*5%*
1	***Days to 50% flowering***	*73.99*	*65.33*	*78.33*	*1.23*	*4.71*	*4.60*	*95*	*6.85*	*9.26*
2	***Number of tillers per plant***	*7.25*	*4.80*	*9.40*	*0.51*	*16.68*	*16.13*	*93*	*2.33*	*32.11*
3	***Flag leaf area $(cm)^2$***	*23.01*	*18.83*	*27.11*	*0.68*	*10.90*	*10.76*	*97*	*5.03*	*21.85*
4	***Plants height (cm)***	*77.19*	*64.40*	*102.76*	*1.40*	*11.53*	*11.47*	*99*	*18.16*	*23.53*

5	***Spike length per plant (cm)***	*9.71*	*7.79*	*11.57*	*0.45*	*8.99*	*8.53*	*90*	*1.62*	*16.67*
6	***Days to maturity***	*107.89*	*101.00*	*111.00*	*1.41*	*2.28*	*2.14*	*88*	*4.45*	*4.12*
7	***Biological yield per plant (g)***	*22.82*	*13.89*	*38.09*	*1.19*	*25.16*	*24.96*	*98*	*11.64*	*51.01*
8	***Spike weight per plant (g)***	*2.00*	*1.67*	*2.50*	*0.20*	*13.50*	*12.02*	*79*	*0.44*	*22.05*
9	***Number of grains per spike***	*44.69*	*34.67*	*57.67*	*1.78*	*12.46*	*12.23*	*96*	*11.04*	*24.70*
10	***Test weight (g)***	*31.04*	*23.00*	*36.00*	*1.75*	*12.02*	*11.52*	*92*	*7.06*	*22.73*
11	***Harvest index (%)***	*42.85*	*26.61*	*52.27*	*2.81*	*13.59*	*13.00*	*91*	*10.97*	*25.59*
12	***Grain yield per plant (g)***	*9.63*	*6.99*	*14.61*	*0.57*	*21.74*	*21.44*	*97*	*4.19*	*43.55*

Where, **PCV** – Phenotypic coefficient of variation, **GCV** – Genotypic coefficient of variation and **C.D.** – Critical difference

Table 3 - Genotypic and penotyic correlation coefficient for 12 characters in Wheat *(Triticum aestivum* L.*)*

No	Characters	Days to 50% Flowering	Number of Till-ers Per Plant	Flag Leaf Area $(cm)^2$	Plants Height (cm)	Spike Length Per Plant (cm)	Days to Maturity	Biological Yield Per Plant (g)	Spike Weight Per Plant (g)	Number of Grains Per Spike	Test Weight (g)	Harvest Index (%)	Grain Yield Per Plant (g)
1	Days to 50% Flowering	r(g)	0.4769 **	-0.0820	0.2177	0.1896	0.8421 **	0.5484 **	-0.0596	0.1290	0.4424 **	-0.0745	0.6050 **
		r(p)	**0.4581 ** **	**-0.0888**	**0.2153**	**0.1771**	**0.7550 ** **	**0.5336 ** **	**-0.0539 ** **	**0.1407**	**0.4036 ** **	**-0.0691**	**0.5848 ** **
2	Number of Tillers Per Plant		r(g)	0.2916 **	0.3199 **	-0.1715	0.6769 **	0.6041 **	-0.3149 **	-0.4260 **	0.4861 **	-0.0615	0.6755 **
			r(p)	**0.2771 * **	**0.3050 ** **	**-0.1338**	**0.6091 ** **	**0.5828 ** **	**-0.2517 * **	**-0.3994 ** **	**0.4419 ** **	**-0.0562**	**0.6457 ** **
3	Flag Leaf Area $(cm)^2$			r(g)	0.3162 **	0.4174 **	0.1117	0.3042 **	0.0203	0.2395 *	0.0745	-0.0233	0.3230 **
				r(p)	**0.3079 ** **	**0.3846 ** **	**0.1149**	**0.2921**	**0.0212**	**0.2201**	**0.0682**	**-0.0295**	**0.3075 ** **
4	Plants Height (cm)				r(g)	0.2109	0.1506	0.6053 **	0.1126	-0.0686	0.2617 *	-0.3133 **	0.4394 **
					r(p)	**0.1914**	**0.1344**	**0.5981 ** **	**0.1095**	**-0.0669**	**0.2496 * **	**-0.2961 ** **	**0.4329 ** **
5	Spike Length Per Plant (cm)					r(g)	0.2220	0.1333	0.5845 **	0.5942 **	0.2795 *	0.1306	0.2893 *
						r(p)	**0.2313 * **	**0.1311**	**0.5170 ** **	**0.5464 ** **	**0.2582 * **	**0.1267**	**0.2813 * **

6	Days to Maturity						r(g) **r(p)**	0.4371 ** **0.4104 **	-0.2143 **-0.1685**	0.0056 **-0.0167**	0.4960 ** **0.4524 **	-0.0471 **-0.0502**	0.5416 ** **0.4982 **
7	Biological Yield Per Plant (g)							r(g) **r(p)**	0.0909 **0.0923 **	-0.0378 **-0.0330**	0.6083 ** **0.5808 **	-0.4997 ** **-0.4822 **	0.7584 ** **0.7439 **
8	Spike Weight Per Plant (g)								r(g) **r(p)**	0.5297 ** **0.4554 **	0.2515 * **0.2538 ***	0.3262 ** **0.2877 ***	0.3064 ** **0.2768 ***
9	Number of Grains Per Spike									r(g) **r(p)**	-0.2192 **-0.2016**	0.1812 **-0.1729**	0.0674 **0.0708**
10	Test Weight (g)										r(g) **r(p)**	-0.1532 **-0.1468**	0.6089 ** **0.5735 **
11	Harvest Index (%)											r(g) **r(p)**	0.1681 **0.2014**
12	Grain Yield Per Plant (g)												

Significance Levels **0.05** **0.01** ** Significant at 1%
If correlation r => > 0.2271584 0.2957008 * Significant at 5%

Table 4 - Direct and indirect effects at genotypic level of different quantitative characters on yield in Wheat (*Triticum aestivum* L.)

Sr. No.	Characters	Days to 50% Flowering	Number of Tillers Par Plant	Flag Leaf Area (cm)2	Plants Height (cm)	Spike Length Par Plant (cm)	Days to Maturity	Biological Yield Par Plant (g)	Spike Weight Par Plant (g)	Number of Grains Par Spike	1000 Grain Weight Par Plants(g)	Harvest Index (%)	Grain Yield Par Plant (g)
1	Days to 50% Flowering	**-0.1725**	-0.0823	0.0141	-0.0376	-0.0327	-0.1453	-0.0946	0.0103	-0.0222	-0.0763	0.0129	0.6050
2	Number of Tillers Par Plant	-0.0415	**-0.0871**	-0.0254	-0.0279	0.0149	-0.0590	-0.0526	0.0274	0.0371	-0.0423	0.0054	0.6755
3	Flag Leaf	0.0060	-0.0212	**-0.0726**	-0.0230	-0.0303	-0.0081	-0.0221	-0.0015	-0.0174	-0.0054	0.0017	0.3230

	Area (cm)2												
4	Plants Height (cm)	-0.0069	-0.0102	-0.0101	**-0.0319**	-0.0067	-0.0048	-0.0193	-0.0036	0.0022	-0.0083	0.0100	0.4394
5	Spike Length Par Plant (cm)	0.0229	-0.0207	0.0504	0.0255	**0.1209**	0.0268	0.0161	0.0706	0.0718	0.0338	0.0158	0.2893
6	Days to Maturity	0.1956	0.1572	0.0259	0.0350	0.0516	**0.2322**	0.1015	-0.0498	0.0013	0.1152	-0.0109	0.5416
7	Biological Yield Par Plant (g)	0.6908	0.7609	0.3832	0.7625	0.1679	0.5505	**1.2596**	0.1145	-0.0476	0.7662	-0.6294	0.7584
8	Spike Weight Par Plant (g)	0.0038	0.0201	-0.0013	-0.0072	-0.0373	0.0137	-0.0058	**-0.0638**	-0.0338	-0.0160	-0.0208	0.3064
9	Number of Grains Par Spike	-0.0102	0.0336	-0.0189	0.0054	-0.0469	-0.0004	0.0030	-0.0418	**-0.0789**	0.0173	-0.0143	0.0674
10	1000 Grain Weight Par Plants(g)	-0.0240	-0.0263	-0.0040	-0.0142	-0.0151	-0.0269	-0.0329	-0.0136	0.0119	**-0.0542**	0.0083	0.6089
11	Harvest Index (%)	-0.0589	-0.0486	-0.0184	-0.2474	0.1031	-0.0372	-0.3945	0.2575	0.1431	-0.1210	**0.7895**	**0.1681**

R SQUARE = 0.9902 **RESIDUAL EFFECT = 0.0988**

area (5.03). The low estimate of genetic advance was recorded for days to maturity (4.45), grain yield per plant (4.19), number of tillers per plant (2.33), spike length (1.62) and spike weight (0.44). It suggested that these traits could be considered as reliable for selection and higher responses of this trait could be expected from selection. Similar findings were also reported by Singh and Sharma (2007) and Ullah *et al.* (2011).

Grain yield per plant was positive and showed highly significant relation with days 50 % flowering, tillers per plant, flag leaf area, plant height, days to maturity, biological yield per plant, spike weight and test weight. It revealed that by increasing the value of these traits, grain yield can be drastically increased. Spike length per plant was also significant and can be considered in breeding programs. Few other characters were also correlated with each other and they were indirectly responsible for increasing grain yield, they were days to 50 % flowering with tiller per plant, days to maturity, biological yield per plant and test weight. Similar result was reported by Jee *et al.* (2019), Kumar *et al.* (2019) and Verma *et al.* (2019). This implies that late flowering resulted in increase of the above characters. Tillers per plant showed highly positive and significant correlation with flag leaf area i.e. more number of tillers resulted in greater flag leaf area, plant height which reviles more number of tillers resulting in taller plants. More number of also resulted in late maturity, higher biological yield per plant less spike weight, less number of grains per spike and more test weight. Flag leaf area was highly correlated with plant height, spike length per plant, biological yield per plant and number of grain per spike which implies that higher flag leaf area can be used in breeding program to increase plant height, spike length, biological yield and number grains in spikes. Similarly increase in plant height resulted in higher biological yield, higher test weight and decrease in harvest index while higher spike length increase spike weight, number of grain per spike and test weight. Plant which matured late resulted in increase of biological yield and test weight while biological yield per plant also increase the test weight but had negative and impact on harvest index. Increase spike weight resulted in number grain per spike, test weight and harvest index. These finding are in accordance with earlier reports on Mohammed *et al.* (2011), Singh *et al.* (2012) and Tambe *et al.* (2013).

The genotypic correlation coefficient of day to 50 % flowering with grain yield per plant was positive and highly significant due to positive and indirect effect of flag leaf area, spike weight per plant and harvest index but since most of the characters had negative effect including the direct effect, residual effect also played an important role. Tillers per plant had positive and highly significant genotypic association with yield, probably due to positive and indirect effect via spike length, spike weight, number of grain per spike and harvest index which negated the rest of the negative effects including the direct. There was positive and highly significant association between flag leaf area and grain yield. Except days to 50 % flowering and harvest index which had indirect and positive effect, all other characters including the direct effect were negative which suggested that there was ample amount of residual effect. Plant height was positively correlated with grain yield per plant probably due to positive and indirect effect of number grains per spike and harvest index while rest of the characters being negative suggesting the role of residual effect on this characters. The positive and direct effect of spike length per plant resulted in positive and significant correlation with grain yield per plant while all the characters except tillers per plant showed positive and indirect association.

Day to maturity had highly positive and significant association with grain yield per plant due to high positive and direct effect of this character and positive and indirect effect of all the characters except spike weight per plant and harvest index. The positive and indirect effect of days to 50 % flowering, tillers per plant, flag leaf area, plant height, spike length, days to maturity, spike weight and test weight while high positive and direct effect of biological yield per plant result in high positive and significant correlation with grain yield per plant. Spike weight per plant had positive and significant association with grain yield despite negative and direct effect which was probably negated by positive and indirect effect of day to 50 % flowering, tillers per plant and days to maturity. The non-significant association of number of grains per spike with grain yield per plant was a result of very low positive and indirect effects of tillers per plant, plant height, biological yield and test weight while the direct effect was negative. The high positive and significant association of test weight with grain yield per was due to positive and indirect effect of number of grains per spike and harvest index while residual effect is also considerable due to the fact that rest of the characters including the direct effect was negative. The association between harvest index and grain yield per plant was positive and non-significant probably due to positive and indirect effect of spike length, spike weight and number of grains per plant while direct value was highly positive. The above findings are in vicinity with thought of Khokhar *et al.* (2010), Singh *et al.* (2012), and Fellahi *et al.* (2013).

Conclusion

The increasing the value of traits, grain yield was drastically increased. Spike length per plant was also significant and with consideration to breeding programs. The highest positive direct effect on grain yield per plant was observed by biological yield per plant followed by Harvest Index, days to maturity and spike length, while remaining traits showed negative and direct effect on grain yield per plant. So, for development of high-yielding wheat varieties these traits possessing highly significant positive associations should be given more weightage in breeding programme.

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