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RESEARCH ARTICLE

Genetic variability, heretability, correlation co-efficient and path analysis of yield and yield contributing traits in bread wheat (*Triticum aestivum* L.)

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SUMMARY

Genetic variation, heritability, genetic advance and correlation co-efficient studied among the fifty wheat genotypes and were evaluated for eleven quantitative characters *viz.*, days to 50 per cent flowering, days to reproductive phase, days to maturity, plant height (cm), number of reproductive tillers per plant, spike length (cm), number of spikelets per spike, number of grains per spike, grain weight per spike (g), test weight (g) and grain yield per plant (g). All the characters under study showed considerable amount of variability, phenotypic co-efficient of variability was higher than genotypic co-efficient of variability. A persual of co-effiecient of variability indicates that PCV and GCV were quiet high for grain weight per spike. Moderate PCV and GCV were recorded in yield per plant, spike length, number of reproductive tillers per plant, number of spikelets per spike and lowest observed in days to maturity, days to 50 per cent flowering, days to reproductive phase and test weight. A high estimate of heritability was found for plant height. High genetic advance was observed for grain weight per spike (28.85g) and minimum in days to maturity (6.88). Genotypic correlation co-efficients were higher than the corresponding phenotypic correlation co-efficients for all the character combinations. Grain yield per plant showed highly positive association ship with days to 50 per centflowering, days to reproductive phase, plant height, spike length, grain weight per spike and number of grains per spike.

Key Words : Genetic variation, Heritability, Genetic advance, Correlation co-efficient, Path analysis

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Wheat with scientific name *Triticum aestivum* (L.)em. Thell ,is the first cereal and most important crop in the world. It is a member of Graminae family (Sub-family Poaceae) and genus *Triticum* and the world leading cereal grain.It has been described as the 'King of cereals' because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade.Wheat is a cereal grain (botanically, a type of fruit called caryopsis) and is a self-pollinated C3 plant with cleistogamous condition.The optimum temperature for wheat growth is 25°C with minimum and maximum growth temperatures of 30°C to 40°C and 30°C to 32°C, respectively.Wheat is a major diet component because of wheat plants agronomic adaptability, ease of grain storage and ease of converting grain into flour for making edible, palatable and satisfactory foods.

Wheat provides 20 per cent dietary calories of the world. Wheat is the most important source of carbohydrate in majority of countries. Wheat contains minerals, vitamins and fats and with a small amount of nutrition's. It contains 70 per cent carbohydrates, 22 per cent crude fibres, 12 per cent protein, 12 per cent water, 2 per cent fat, and 1.8 per cent minerals. A predominately wheat-based diet is higher in fibre than a meat-based diet.

The United States Department of Agriculture (USDA) estimates that the World wheat production 2015-2016 is 733.14 million metric tons. India is the largest wheat producing country in the world after China and account for more than 13.06 per cent of the world's wheat production. During the crop year 2014-15, India harvested 95.85 million tonnes of wheat in an area of 31 million hectares with productivity of 2800 kg/ha. As per second advance estimates for 2015-16, total production of wheat estimated at 96.76 million tons with coverage area of 259.37 lakh hectare is a new record. U.P. is the leading state in wheat production.

Bread wheat (*Triticum aestivum*) 2n=42, macaroni wheat (*Triticum durum*) 2n=28and emmer wheat (*Triticum dicoccum*) 2n= 28 occupy the place of prominence among the seven cultivated species of wheat grown in the world. Among these, first two occupies maximum acreage and production and have great significance for human and animal consumption. Bread and macaroni wheat's are widely cultivated under different agro climatic condition due to their versatile genotype which has wider adaptation in diverse agro ecological condition. Nevertheless,the crop offer sizeable opportunities of quantum jump by accelerating its yield potential through genetic manipulation.These gains could be realized by utilizing vast and enormous magnitude of genetic variability available in these species.

Grain yield is a complex polygenic character with great genetic, physio-morphological, ecological and pathological dependence. The hereditary potential of a genotype depends upon stability and yielding.Genetically, yield contributing attributes their genetic nature and magnitude of association are responsible for realization of yield potential influenced by changing edaphic, agro climatic condition.Therefore, it is highly important to investigate the genetic variation of the verities and lines of this plant in breeding programme. Estimation of genetic variation level among accessions is prerequisite for germplasm conservation and breeding programme.

For genetic manipulation of quality as well as grain yield in cereals, there is need to examine the nature of genetic variability for the quality constituents and yield related attributes. This aspect need an extensive investigation, as most of the quality components of wheat are having reverse relationship with yield.

The idea of heritability which offers an index of the transmissibility to measure the genetic relationship of a character in the population, if heritability of a character is high it should be fairly easy to improve that trait. Genetic advance estimates give an idea of improvement in the mean performance of the selected families over the base populations. Correlation co-efficient analysis appears to be quiet powerful tool to understand the interrelationship of various yield attributes. This parameter is tool to understand the interrelationship of various yield attributes. This parameter also the estimates of the inter relationship between grain yield and other yield attributes and among themselves would facilitate effective selection schemes to improve the yield. Path co-efficient measures the magnitude of direct and indirect contribution of the independent characters on a dependent character by splitting the correlation co-efficient of seed yield and concerned trait. Consequently path co-efficient analysis is considered as the most common and useful statistical method used for this purpose and it can also be used to estimate the quantitative impact of direct and indirect effects caused by one or other components of grain yield and their relationship between these components.

MATERIAL AND METHODS

The experimental materials comprised of 50 wheat genotypes from Indian originwas carried out during *Rabi* 2015-16 at research farm Nawabganj of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P). All the genotypes were sown in Randomized Complete Block Design with three replications.The present research is based on eleven characters namely days to 50 per cent flowering,days to reproductive phase, days to maturity, plant height, spike length, number of reproductive tillers per plant, number of spikelet per spike, number of grains per spike, grains weight per spike, test weight and grain yield per plant was taken to obtain sufficient information about characters and there by to make significant improvement in yield. Each genotype was sown in two lines in 5.0 m long and 1.38 m broad plots and space planted at 23 x 5 cm between row to row and plant to plant distance, respectively.

The mean performance of individual genotypes was embayed for statistical analysis. Analysis of variance to test the significance for each character was carried out as per methodology given by Panse and Sukhatme (1967). Genetic advance were calculated by the formula given by Johansan *et al.* (1955).Correlation co-efficient and path co-efficient were worked out as per methods suggested by Dewey and Lu (1959), respectively.

RESULTS AND DISCUSSION

Bread wheat (*Triticum aestivum*) is an important food crop for more than one third of the population. The demand of wheat is increasing day by day due to increasing the population. Ways to sustain increasing productivity should be explored, it is now realized that sustaining as well as increasing productivity may be essential. The knowledge of factors responsible for high yield has been rendered difficult as yield is complex character (Singh *et al.*, 2010). Grain yield is a complex trait and highly influenced by many genetic factors and environmental fluctuations.In plant breeding programme successful selection depends on the information on the genetic variability, association of morpho agronomic traits with grain yield, direct and indirect effect of various characters on yield and their diversity.Magnitude and nature of variability present in a population is a pre-requisite for any crop improvement programme. Variation in variability is a result of its genotype and genotype x environment interactions. Only heritable component of variation is of prime importance from breeding point of view. So it is necessary to divide the total variability into its heritable and non-heritable component of variation.Asif *et al.* (2004) and Lal *et al.* (2009) observed wide range of variation for plant height, number of grains per spike and days to maturity.It is clear that the genotypes were more variable for plant height, number of grains per spike, days to maturity and days to reproductive phase. Therefore emphasis should be given for these characters while adopting selection for crop improvement.

Analysis of variance (Table 1) showed significant differences among all the genotypes under study.It basically represented presence of large variability in the materials which could be successfully exploited in future breeding programme for developing high yielding new plant type varieties.Paul *et al.* (2006) showed the similar observations.

The phenotypic co-efficient of variation (Table 2) was higher than genotypic co-efficient of variation for all the characters indicating the effect of environment on these characters.Phenotypic and genotypic co-efficient of variation was maximum for grain weight per spike (50.97 and 49.85) followed by spike length (15.94 and 14.92). Minimum phenotypic and genotypic co-efficient of variation were recorded for days to maturity (3.40 and 3.37), days to 50 per cent flowering (4.95 and 4.80) followed by test weight (6.48 and 6.14). These were also reported by Yousaf *et al.* (2008); Zecevic *et al.* (2010) and Khan *et al.* (2012). Sachan and Singh (2003) reported high estimates of genotypic and phenotypic co-efficients of variability for grain weight per spike, while little variability was recorded for days to 50 per cent flowering and maturity. It indicates that the selection based on grain weight per spike, may be advantageous as compared to other characters under study.

Heritability in broad sense (h^2) and genetic advance in percent of mean as direct selection parameters provide index of transmissibility of traits which gives expression

Table 1 : Analysis of variance (ANOVA) for eleven characters in fifty bread wheat genotype

Source of variance	d.f	Days to 50% flowering (50%)	Days to reproductive phase	Days to maturity	Plant height (cm)	Spike length (cm)	Number of reproductive tillers per plant	Number of spikelets per spike	Number of grains per spike	Grain weight per spike(g)	Test weight (g)	Yield per plant (g)
Replication	2	1.30	1.08	0.32	0.07	0.02	0.02	0.15	0.001	0.001	0.74	0.66
Treatment	49	28.26**	30.51**	42.99**	180.99**	6.92**	2.72**	16.4**	76.12**	0.80**	18.34**	2.65**
Error	98	0.59	0.61	0.27	0.20	0.31	1.65	1.38	0.53	0.01	0.67	0.35

* and ** indicate significance of values at P=0.05 and 0.01, respectively

about the effectiveness of selection in improving the characters.The estimates of heritability help the plant breeder not only in assessing the extent of transmissibility of heritable variation but also in deciding the intensity of selection. Higher the heritability value of character lesser the number of plants needed to be selected for the effective improvement and vice versa.

High heritability (Table 3) estimates were found for eleven characters under study. High heritability was recorded for plant height followed by days to maturity and number of grains per spike, grain weight per spike, days to 50 per cent flowering, days to reproductive phase and test weight. It was minimum for grain yield per plant followed by number of spikelets per spike, number of reproductive tillers per plant and spike length.Result are in conformity with the findings of Wahid Abdul Baloch *et al.* (2014) for high heritability for number of grains per spike and plant height and Kumar *et al.* (2013) revealed that characters exhibited high heritability by test weight, similar observation were reported by Khan *et al.* (2012) and Nukasani *et al.* (2013) who reported high heritability coupled with high genetic advance for traits plant height, number of reproductive tillers per plant, grain weight per spike and spike length. According to Paul *et al.* (2006) high heritability along with high genetic advance were observed for days to 50 per cent flowering, plant height, days to maturity and test weight.

Studies on variability, heritability and genetic advance showed that plant height, days to maturity, number of grain per spike, grain weight per spike followed by days to reproductive phase, days to 50 per cent flowering are having considerable importance to breeder for selection.

The correlation co-efficient is the measure of degree of symmetrical association between two variables or the nature and magnitude of association among yield and yield components and provides opportunity for indirect selection.Genotypic and phenotypic correlations (Table 4) for the above characters were determined. Observations revealed that the genotypic correlations of grain yield were higher with almost all the characters

Table 2 : Phenotypic and genotypic co-efficient of variation among fifty genotype for eleven characters in bread wheat

Sr. No.	Characters	PCV	GCV
1.	Days to 50% flowering	4.95	4.80
2.	Days to reproductive phase	6.64	6.45
3.	Days to maturity	3.40	3.37
4.	Plant height (cm)	9.76	9.74
5.	Spike length (cm)	15.94	14.92
6.	Number of reproductive tillers per plant	13.65	12.49
7.	Number of spikelet per spike	13.72	12.14
8.	Number of grains per spike	10.55	10.44
9.	Grain weight per spike(g)	50.97	49.85
10.	Test weight(g)	6.48	6.14
11.	Yield per plant (g)	11.71	9.69

Table 3: Heritability (h^2) %, genetic advance and genetic advance per cent over mean among fifty genotype for eleven characters in bread wheat

Sr. No.	Characters	Heritability per cent (h^2)%	Genetic advance at 5%	Genetic advance per cent over mean 5%
1.	Days to 50% flowering	94	6.07	9.59
2.	Days to reproductive phase	94	6.31	12.89
3.	Days to maturity	98	7.70	6.88
4.	Plant height(cm)	99.94	15.96	20.03
5.	Spike length(cm)	88	2.86	28.77
6.	Number of reproductive tillers per plant	84	1.74	23.55
7.	Number of spikelet per spike	78	4.08	22.14
8.	Number of grains per spike	98	10.23	21.27
9.	Grain weight per spike(g)	96	1.04	28.85
10.	Test weight(g)	90	4.73	11.97
11.	Yield per plant(g)	69	1.50	16.53

than phenotypic correlations but in the same direction in the present research. Grain yield per plant was positively correlated with days to 50% flowering, days to reproductive phase, plant height, spike length, number of grains per spike and grain weight per spike at both genotypic and phenotypic level.Similar observation were also reported by Wahid Abdul Baloch *et al.* (2014) and Khan *et al.* (2012). Lad *et al.* (2003) observed positive

Table 4 : Phenotypic (P) and genotypic (G) correlation co-efficient among the eleven characters on fifty bread wheat genotype

Characters		Days to 50% flowering	Days to reproductive phase	Days to maturity	Plant height (cm)	Spike length (cm)	Number of reproductive tiller per plant	Number of spikelets per spike	Number of grains per spike	Grain weight per spike (g)	Test weight (g)	Grain yield per plant (g)
Days to 50% flowering	P	1.000	-0.328**	0.529**	0.112	-0.147	0.022	0.242**	-0.150	-0.196*	0.108	0.007
	G	1.000	-0.351**	0.547**	0.116	-0.159	-0.008	0.268**	-0.161*	-0.211**	0.118	0.001
Days to reproductive	P	-0.328**	1.000	0.5700**	-0.134	-0.173*	0.097	-0.041	0.059	0.068	0.061	0.020
phase	G	-0.351**	1.000	0.594**	-0.139	-0.179*	0.113	-0.035	0.062	0.070	0.068	0.056
Days to maturity	P	0.529**	0.570**	1.000	-0.043	-0.294**	0.106	0.157	-0.091	-0.056	0.154	-0.009
	G	0.547**	0.594**	1.000	-0.044	-0.316**	0.101	0.192*	-0.090	-0.053	0.165*	-0.022
Plant height (cm)	P	0.113	-0.134	-0.043	1.000	0.032	0.092	0.013	0.077	-0.193*	0.122	0.059
	G	0.116	-0.138	-0.044	1.000	0.033	0.103	0.013	0.078	-0.198*	0.013	0.065
Spike length (cm)	P	-0.147	-0.173*	-0.295**	0.032	1.000	0.164*	-0.138	0.044	0.185*	-0.036	0.106
	G	-0.159	-0.179*	-0.316***	0.032	1.000	0.167*	-0.154	0.049	0.184*	-0.076	0.110
Number of reproductive	P	0.023	0.097	0.106	0.092	0.164*	1.000	0.261**	0.039	0.162*	0.366**	-0.035
tillers per plant	G	-0.008	0.113	0.101	0.103	0.167*	1.000	0.292**	0.045	0.167*	0.396**	-0.078
Number of spikelets per	P	0.243**	-0.041	0.157	0.014	-0.138	0.261**	1.000	-0.065	-0.045	0.090	-0.175*
spike	G	0.268**	-0.035	0.192*	0.013	-0.154	0.293**	1.000	-0.074	-0.053	0.118	-0.217**
Number of grains per	P	-0.150	0.059	-0.091	0.077	0.043	0.039	-0.065	1.000	-0.071	-0.050	0.112
spike	G	-0.161*	0.062	-0.090	0.078	0.049	0.045	-0.074	1.000	-0.076	-0.054	0.131
Grain weight per spike	P	-0.196*	0.068	-0.056	-0.193*	0.185*	0.162*	-0.045	-0.071	1.000	0.127	0.048
	G	-0.212**	0.070	-0.053	-0.198*	0.186*	0.167*	-0.053	-0.076	1.000	0.135	0.051
Test weight	P	0.108	0.061	0.154	0.122	-0.036	0.367**	0.090	-0.050	0.127	1.000	-0.070
	G	0.118	0.068	0.165**	0.129	-0.076	0.396**	0.118	-0.54	0.134	1.000	-0.094

* and ** indicate significance of values at P=0.05 and 0.01, respectively
If correlation => 0.160 0.2097

Table 5: Direct (bold) and indirect effects of eleven components traits on seed yield of bread wheat as independent variable at genotypic level

Characters	Days to 50% flowering	Days to reproductive phase	Days to maturity	Plant height (cm)	Spike length (cm)	Number of reproductive tillers per plant	Number of spikelets per spike	Number of grains per spike	Grain weight per spike (g)	Test weight (g)
Days to50% flowering	-5.547	1.950	-3.037	-0.643	0.883	0.047	-1.489	0.896	1.175	-0.653
Days to reproductive phase	1.987	-5.651	-3.358	0.781	1.013	-0.643	0.196	-0.351	-0.398	-0.385
Days to maturity	3.562	3.867	6.508	-0.293	-2.058	0.659	1.254	-0.585	-0.347	1.077
Plant height (cm)	0.015	-0.019	-0.006	0.137	0.004	0.014	0.002	0.011	-0.027	0.018
Spike length (cm)	-0.053	-0.060	-0.106	0.011	0.335	0.056	-0.052	0.016	0.062	-0.025
Number of reproductive tillers per plant	0.001	-0.013	-0.012	-0.012	-0.019	-0.119	-0.035	-0.005	-0.019	-0.047
Number of spikelets per spike	-0.028	0.003	-0.020	-0.001	0.016	-0.030	-0.105	0.008	0.005	-0.012
Number of grains per spike	-0.018	0.007	-0.010	0.009	0.006	0.005	-0.008	0.112	-0.008	-0.006
Grain weight per spike (g)	0.082	-0.027	0.020	0.077	-0.072	-0.065	0.028	0.029	-0.389	-0.052
Test weight (g)	-0.001	-0.001	-0.001	-0.001	0.001	-0.003	-0.001	0.001	-0.001	-0.008
Yield per plant (g)	0.001	0.056	-0.022	0.065	0.110	-0.079	-0.217	0.131	0.052	-0.093

correlation of number of grains per spike and grain weight per spike, Asif *et al*. (2004) with plant height and test weight, Muhammad and Ihsan (2004) for plant height, spike length, number ofgrains per spike and test weights, Sherif *et al*. (2005)for number of grains per spike. Chaitali and Bini (2007) and Anwar *et al.* (2009) showed similar observation. Thus, observations revealed that the genotypic correlations of grain yield were higher with almost all the characters than phenotypic correlations.

Path analysis has emerged as a powerful and widely used technique for understanding the direct and indirect contribution of different characters to economic yield in crop plants so that the relative importance of various yield contributing characters can be assessed.

Path co-efficient analysis (Table 5) revealed that characters *viz.,* days to 50 per cent flowering, days to reproductive phase, plant height, spike length, number of grains per spike, grain weight per spike having positive correlations with grain yield per plant indicates that grain yield per plant can be improved by considering the above mentioned six characters. Ayccek and Yldrm (2006) found positive correlation was observed between grain yield per plant with plant height and grain weight per spike.Various workers also reported direct effect on grain yield for the various characters like grain weight per spike (Singh, 2003; Lad *et al.,* 2003 and Khan *et al.,* 2005).

A large number of characters contributed to total grain yield per plant via several agronomic and yield related traits. So improving these characters will finally improve grain yield.

Residual effects of study were high (0.9612). It indicates that many traits which were contributing to the yield were not included in the study.

Conlcusion :

Studies on variation indicated that considerable amount of variation for grain weight per spike, followed by spike length, number of reproductive tillers per plant, number of spikelets per spike, plant height and number of grains per spike which could be utilized for breeding for improvement. All traits showed high heritability except grain yield per plant (69%).The higher genetic advance showed in grain weight per spike (28.85) and low in days to maturity (6.88).Correlation and path analysis provide information about yeild components.Thus, it helps in selection of superior genotype from diverse genetic population. Path co-efficient analysis provide informaton about highly positive association ship of grain yield per plant with days to 50 per cent flowering, days to reproductive phase, plant height, spike length, grain weight per spike and number of grains per spike, indicated maximum emphasis should be given while making selection for improving yield.

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