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Research Article

GENETIC VARIABILITY AMONG WHEAT GENOTYPES BASED ON AGRO-MORPHOLOGICAL TRAITS

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Abstract The study revealed highly significant differences for all the characters studied, indicating the presence of substantial genetic variability. The phenotypic and genotypic coefficient of variation (PCV and GCV) was high for grain yield followed by biological yield and grains per plant, respectively. While the traits like biological yield followed by grains per plant, spikelets per plant, grain yield per plant, number of grains per spike and plant height are highly heritable. High heritability coupled with high genetic advance as percent of mean was observed for biological yield per plant followed by grain yield per plant and number of grains per spike. However, Grain yield showed positive and significant correlation with plant height, harvest index and biological yield at phenotypic level whereas direct effect on grain yield was found to be highest for biological yield followed by harvest index and number of grains per plant indicating that these should be considered as selection criteria for increasing grain yield per plant in a breeding programme.

Key words: Correlation, grain, heritability, significant, variation

Introduction

Wheat is the important food crop in most areas of the world and also occupies prominent position in Indian agriculture after rice (Rajput and Kandalkar, 2018). Bread wheat is a self-pollinating annual plant in the true grass family Gramineae (Poaceae), is the largest cereal crop extensively grown as staple food sources in the world (Mollasadeghi and Shahrari, 2011). Major cultivated species of wheat is *Triticum aestivum*, which is hexaploid (2n = 6x = 42), (Bhutto *et al*., 2016, Singh *et al*., 2018). In the coming period leading up to 2020, demand of wheat for human consumption in developing countries is expected to grow at 1.6% per annum (Ortiz *et al*., 2008). Widely hybridization of wheat with grasses, coupled with cytogenetic manipulation of the hybrid material, has been instrumental in the genetic improvement of wheat.

The major objective in wheat breeding is to improve the genetic potential for grain yield which is mainly determined by three components *viz*, number of tillers, number of grain per spike and grain weight. Yield is a quantitative trait controlled by polygenes and is highly influenced by the environmental factor. Variation in yield from year to year due to unpredictable weather and biotic stress can have major economic impact. High magnitude of variability in a population provides the opportunity for selection to evolve a variety having desirable characters (Santosh *et al*., 2013). Therefore, it is necessary to estimate and study the genetic variation and mode of inheritance in different yield parameters to initiate productive wheat breeding programme (Yadawad *et al*., 2015).

Therefore, the current investigation was undertaken to find out the genetic variability, path analysis, and genetic divergence of wheat genotypes and identify the promising sources for further breeding programs.

Methods and materials

The present investigation was conducted during winter season 2015-16 at Experimental Farm, Mata Gujri College, Fatehgarh Sahib, India. The experimental material under the study, comprised of 60 diverse genotypes of wheat received from Indian Institute of Wheat and Barley Research, Karnal and was raised in randomized block design with three replications. Data were recorded for 15 traits. All the recommended package of practices were applied to raise a good and healthy crop. The technique of path coefficient analysis developed by (Wright 1921) and demonstrated by (Dewey and Lu 1959) facilitates the partitioning of correlation coefficients into direct and indirect contribution of various characters on yield.

Result and Discussion

The mean performance of genotypes are presented table 1. The analysis of variance was carried out for all the 15 traits. (Tripathi *et al*., 2015) reported high variability for different traits in wheat.

Variability, Heritability and Genetic Advance

Estimates of different genetic parameters *viz.* general

mean and range, phenotypic variance and coefficient of variation, genotypic variance and coefficient of variation, heritability, genetic advance and genetic advance as percent of mean are presented in table 2.

Genetic variability is evident from the result showed that the phenotypic variance is greater than genotypic variance. Among the yield attributes maximum PCV and GCV was depicted by grain yield per plant (24.76 and 23.70) followed by biological yield (24.75 and 23.08) and number of grains per plant (23.80 and 22.92) respectively. The lowest value for PCV and GCV was shown by days to maturity (4.16 and 3.53). A perusal of table 2 indicated that PCV was higher than respective GCVs for all the traits denoting environmental factors influencing their expression to some degree or other.

All the traits except number of harvest index were found to be highly heritable on the basis of broad sense heritability estimates. Highest being for biological yield (94), followed by number of grains per plant (92), number of spikelet per plant (92), grain yield per plant (91), number of grains per spike (90), plant height (90), number of productive tillers per plant (88), peduncle length (87), 1000 grain weight (83), days to heading (78), days to anthesis (78), spike length (78), days to maturity (72), days to booting (63).The high estimate for heritability indicates that most of the variation is caused by genotype and very small due to environment, therefore, a simple selection procedure would be helpful in improvement of these traits. Moderate heritability was observed for harvest index (58), which indicated that harvest content is moderately influenced by environmental agencies than genotypic differences. High heritability estimates were also reported by (Kumar *et al*., 2013a, Shankarrao *et al*., 2010, Jasmine and Kumar 2017, Singh *et al*., 2019) and by several other workers in different studies which are supportive to the current findings.

Estimate of genetic advance was highest for number of grains per plant (141.83) followed by number of grains per spike (15.65), plant height (14.72), biological yield per plant (11.69) and that for number of productive tillers per plant (2.23) was lowest. In contrast to their high heritability's days to heading (8.90), days to anthesis (8.66), 1000 grain weight (7.92), days to maturity (7.50), days to booting (6.88), peduncle length (6.22), number of spikelet per spike (6.16), grain yield per plant (4.75) and exhibited small magnitude of genetic advance. Similarly, most of the traits with high heritabilities and low genetic advance, like days to maturity (7.50), days to booting (6.88), peduncle length (6.22), number of spikelet per spike (6.16), grain yield per plant (4.75), portrayed a high heritability value but a very low genetic gain.

Genetic advance as per cent of mean was highest for biological yield per plant (48.28) followed by grain yield per plant (46.76) and number of grains per plant (45.66) among yield contributing traits table 2. The lowest value for genetic advance as percent of mean was revealed by days to maturity (6.19) among all the traits under investigation which limits the scope of improvement in this trait through simple selection.

Correlation/ Character Association

The genotypic and phenotypic correlation coefficients estimated between yield and quality traits and inter-correlation among the different yield components and quality traits are furnished in and only significant correlations are discussed here. In general, the magnitude of genotypic correlation coefficient was higher than the corresponding phenotypic coefficient indicating thereby a strong inherent association between various traits under study (Table 3).

Days to booting showed significantly positive correlation with days to anthesis (0.866), days to maturity (0.355), and harvest index (0.155) whereas number of grains per spike (-0.274), 1000 grains weight (-0.033), shows significantly negative correlation with plant height. Days to heading significantly positive correlated with days to maturity (0.454) and harvest index (0.110), while number of productive tillers per plant (-0.096), spike length (-0.190), 1000 grains weight (-0.109) are significantly negative correlated. Days to anthesis was significantly and positively correlated with days to booting (0.866) harvest index (0.121) where as significant negative correlation was observed with number of productive tillers per plant (-0.029), number of grains per plant (-0.220) and 1000 grain weight (-0.107).

Days to maturity showed negative correlation with number of grains per spike (-0.213), number of grains per plant (-0.178), 1000 grain weight (-0.153), biological yield per plant (-0.143) while days to booting (0.355), days to heading (0.454), peduncle length (0.219), number of spikelet per spike (0.165) are positively correlated with days to maturity. Number of productive tillers per plant showed significant positive correlation with number of grains per plant (0.125), biological yield per plant (0.305) and harvest index (0.111) where as negative and significant correlation was observed for days to heading (-0.096), days to anthesis (-0.029), number of grains per spike (-0.172).

Plant height showed negative and significant correlation with number of spikelet per spike (-0.079) whereas significant positive correlation with harvest index (0.001) occurred with plant height. Spike length showed significant negative correlation with days to headings (-0.138) and harvest index (-0.105) whereas significant positive correlation with days to number of grains per spike (0.097). Peduncle length showed significant positive correlation with days to maturity (0.219) and biological yield per plant (0.222) and significant negative correlation with harvest index (-0.009). Number of spikelet per spike showed significant positive correlation with days to maturity (0.165) and number of grains per plant (0.205) where as plant height (-0.079) and 1000 grain weight (-0.111) showed significant negative correlation with number of spikelet per spike.

Number of grains per spike showed significant positive correlation with spike length (0.097) whereas negative significant phenotypic correlation was observed with days to booting (-0.274), days to maturity (-0.213), number of productive tillers per plant (-0.172), 1000 grains weight (0.072) and harvest index (-0.072). Number of grains per plant showed significant positive correlation with number of productive tillers per plant (0.125), number of spikelet per spike (0.205) and harvest index (0.175) whereas days to heading (-0.190), days to anthesis (-0.220) and days to maturity (-0.178) show significant negative correlation with number of grains per plant.1000 grain weight show significant negative correlation with days to booting (-0.033), days to heading (-0.109), days to anthesis (-0.107), days to maturity (-0.153), number of spikelet per spike (-0.111) and number of grains per spike (-0.072) where as it showed significant positive correlation with harvest index (0.054).

Biological yield per plant showed significant negative correlation with days to maturity (-0.145) and harvest index (-

Table 2: Estimates of genetic parameters for various traits of 60 wheat genotypes

Parameters / Characters	Mean ± S.E.	Range		σ^2_p	σ^2_g	PCV (%)	GCV (%)	h^2_{bs} (%)	GA	GA as % of Mean
		Min	Max							
Days to booting	83.68±1.81	71.14	92.27	27.36	17.48	6.25	4.99	63	6.88	8.22
Days to heading	93.03±1.45	82.01	102.48	30.10	23.72	5.89	5.23	78	8.90	9.57
Days to anthesis	99.03±1.45	88.39	109.11	28.99	22.65	5.41	4.78	78	8.66	8.71
Days to maturity	121.22±1.54	107.91	130.66	25.54	18.41	4.16	3.53	72	7.50	6.19
No. of tillers per plant	8.17±0.24	5.40	11.00	1.52	1.33	15.08	14.15	88	2.23	27.38
Plant height(cm)	89.90±1.40	72.02	105.30	62.28	56.40	8.77	8.35	90	14.72	16.37
Spike length(cm)	11.38±0.39	6.94	13.76	2.12	1.66	12.82	11.32	78	2.34	20.59
Peduncle length(cm)	31.30±0.71	23.40	37.52	11.97	10.45	11.05	10.32	87	6.22	19.88
No. of spikelets per spike	20.93±0.51	16.40	26.60	10.49	9.69	15.47	14.86	92	6.16	29.42
No. of grains per spike	52.63±1.47	33.62	71.80	70.22	63.66	15.92	15.16	90	15.65	29.73
No. of grains per plant	311.94±11.57	180.60	538.40	5514.75	5113.04	23.80	22.92	92	141.83	45.66
1000-grain weight(g)	31.97±1.09	22.09	45.06	21.32	17.76	14.43	13.18	83	7.92	24.78
Biological yield per plant(g)	24.21±0.79	12.99	46.60	35.91	34.01	24.75	24.08	94	11.69	48.28
Grain yield per plant(g)	10.16±0.41	6.20	19.65	6.33	5.80	24.76	23.70	91	4.75	46.76
Harvest index (%)	42.51±2.57	27.33	63.21	47.82	27.93	16.26	12.43	58	8.32	19.57

σ^2_p – phenotypic variance; σ^2_g – genotypic variance; PCV – Phenotypic coefficient of variance; GCV – Genotypic coefficient of variance; h^2_{bs} – heritability in broad sense; GA – Genetic advance (at 5% selection intensity i.e. K = 2.06). 2*Values in parenthesis are transformed values.

Table 3: Phenotypic and genotypic contribution to phenotypic correlation for yield traits among 60 genotypes of wheat.

Characters		Days to heading	Days to anthesis	Days to maturity	No. of productive tillers per plant	Plant height (cm)	Spike length (cm)	Peduncle length (cm)	No. of spikelet's per spike	No. of grains per spike	No. of grains per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Grain yield per plant (g)
Days to Booting	G	0.955	0.984	0.593	-0.155	-0.120	0.021	-0.166	0.074	-0.270	-0.166	-0.143	-0.272	0.017	-0.270
	P	0.855	0.866**	0.355**	-0.043	-0.108	-0.094	-0.090	0.015	-0.274**	-0.163	-0.033*	-0.212	0.155**	-0.132
Days to heading	G	1.000	0.974	0.572	-0.187	-0.129	-0.064	-0.160	0.014	-0.3136	-0.215	-0.206	-0.350	0.067	-0.333
	P	1.000	0.933	0.454**	-0.096**	-0.155	-0.138*	-0.113	0.020	-0.327	-0.190**	-0.109*	-0.311	0.110**	-0.249
Days to anthesis	G		1.000	0.620	-0.084	-0.093	-0.081	-0.130	0.018	-0.392	-0.238	-0.19	-0.352	0.075	-0.337
	P		1.000	0.489	-0.029**	-0.097	-0.118	-0.095	0.003	-0.372	-0.220**	-0.107**	-0.307	0.121**	-0.242
Days to maturity	G			1.000	0.097	0.176	-0.217	0.302	0.168	-0.246	-0.260	-0.218	-0.176	0.046	-0.188
	P			1.000	0.089	0.137	-0.171	0.219*	0.165**	-0.213**	-0.178**	-0.153*	-0.143*	-0.053	-0.193
No. of productive tillers per plant	G				1.000	0.122	0.020	0.092	0.212	-0.093	0.108	0.111	0.370	0.030	0.374
	P				1.000	0.050	-0.101	0.106	0.240	-0.172**	0.125*	0.213	0.305**	0.111**	0.356
Plant height (cm)	G					1.000	0.013	0.557	-0.046	0.047	0.135	0.135	0.259	0.027	0.273
	P					1.000	0.095	0.464	-0.079**	0.100	0.101	0.059	0.274	0.001**	0.237**
Spike length (cm)	G						1.000	-0.041	0.236	-0.022	0.064	0.053	0.296	-0.037	0.302
	P						1.000	-0.077	0.150	0.097*	0.018	-0.081	0.306	-0.105**	0.225
Peduncle length (cm)	G							1.000	0.139	0.170	0.049	0.144	0.282	-0.034	0.237
	P							1.000	0.131	0.119	0.056	0.151	0.222*	-0.009**	0.241
No. of spikelet per spike	G								1.000	0.323	0.178	-0.197	0.107	0.064	0.156
	P								1.000	0.257	0.205**	-0.111**	0.079	0.060	0.124
No. of grains per spike	G									1.000	0.506	0.025	0.393	0.008	0.428
	P									1.000	0.440	-0.072**	0.401	-0.072**	0.363
No. of grains per plant	G										1.000	-0.052	0.524	0.301	0.669
	P										1.000	-0.019	0.475	0.175**	0.582
1000-grain weight (g)	G											1.000	0.262	-0.099	0.272
	P											1.000	0.196	0.054**	0.262
Biological yield per plant (g)	G												1.000	-0.331	0.890
	P												1.000	-0.261**	0.814**
Harvest index (%)	G													1.000	0.178
	P													1.000	0.238**

Table 4: Direct and indirect effect (phenotypic) of 14 component characters on Grain yield per plant in wheat

Characters	Days to Booting	Days to heading	Days to anthesis	Days to maturity	No. of productive tillers per plant	Plant height (cm)	Spike length (cm)	Peduncle length (cm)	No. of spikelet per spike	No. of grains per spike	No. of grains per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)
Days to Booting	**0.016**	0.013	0.014	0.006	-0.001	-0.002	-0.001	-0.001	0.001	-0.004	-0.003	-0.001	-0.003	0.002
Days to heading	-0.010	**-0.012**	-0.011	-0.055	0.012	0.019	0.017	0.014	-0.002	0.004	0.023	0.013	0.038	-0.013
Days to anthesis	0.029	0.031	**0.034**	0.016	-0.010	-0.033	-0.004	-0.032	0.001	-0.013	-0.007	-0.004	-0.010	0.004
Days to maturity	-0.014	-0.018	-0.019	**-0.039**	-0.004	-0.005	0.007	-0.008	-0.006	0.008	0.007	0.006	0.006	0.002
No. of productive tillers per plant	-0.001	-0.003	-0.010	0.003	**0.030**	0.002	-0.003	0.003	0.007	-0.005	0.004	0.006	0.009	0.003
Plant height (cm)	0.004	0.006	0.004	-0.005	-0.002	**-0.038**	-0.004	-0.018	0.003	-0.004	-0.004	-0.002	-0.011	-0.001
Spike length (cm)	-0.002	-0.003	-0.002	-0.004	-0.002	0.002	**0.021**	-0.002	0.003	0.002	0.004	-0.002	0.006	-0.002
Peduncle length (cm)	-0.006	-0.007	-0.006	0.014	0.007	0.031	-0.005	**0.068**	0.009	0.008	0.004	0.010	0.015	-0.007
No. of spikelet's per spike	0.001	0.002	0.001	-0.002	-0.003	0.001	-0.002	-0.002	**-0.014**	-0.004	-0.003	0.002	-0.001	-0.001
No. of grains per spike	-0.005	-0.006	-0.007	-0.004	-0.003	0.002	0.001	0.002	0.005	**0.019**	0.008	-0.014	0.076	-0.014
No. of grains per plant	-0.015	-0.017	-0.020	-0.016	0.011	0.009	0.002	0.005	0.018	0.039	**0.090**	-0.017	0.043	0.016
1000-grain weight (g)	-0.002	-0.006	-0.006	-0.009	0.012	0.034	-0.047	0.088	-0.065	-0.042	-0.011	**0.058**	0.011	0.031
Biological yield per plant (g)	-0.180	-0.264	-0.261	-0.122	0.259	0.232	0.260	0.189	0.067	0.340	0.403	0.167	**0.848**	-0.222
Harvest index %	0.068	0.048	0.053	-0.023	0.049	0.008	-0.046	-0.004	0.026	-0.032	0.077	0.024	-0.114	**0.437**
Grain yield per plant (g)	**-0.133**	**-0.250**	**-0.243**	**-0.194**	**0.357**	**0.237**	**0.2257**	**0.241**	**0.125**	**0.363**	**0.582**	**0.262**	**0.814**	**0.238**
Partial R^2	-0.002	0.003	-0.008	0.008	0.011	-0.009	0.005	0.016	-0.002	0.007	0.052	0.015	0.691	0.104

0.261) whereas plant height (0.305) and peduncle length (0.222) show significant positive correlation with biological yield per plant. Harvest index showed significant positive correlation with days to booting (0.155), days to heading (0.110), days to anthesis (0.121), number of productive tillers per plant (0.111), plant height (0.001), number of grains per plant (0.175), 1000 grains weight (0.054) where as spike length (-0.105), peduncle length (-0.009), number of grains per spike (-0.072), biological yield per plant showed significant negative correlation with harvest index. Grain yield shows positive significant correlation with plant height (0.237), biological yield (0.814) and harvest index (0.238). This result was also corroborated with the findings of (Kumar *et al*., 2013b, Pooja *et al*., 2018).

Path-Coefficient Analysis

The simple correlation alone, however, is not a true reflection of the nature of association of the different traits with each other when other characters are held constant. Due to mutual relationship among different characters, which may be positive or negative, these associations become more complex and do not lead to any meaningful interpretations. The path coefficient analysis is a powerful method in analyzing the scheme of causal relationship in the development of various traits. The correlations are partitioned into direct and indirect effects to know the precise direct and indirect cause of associations.

In the present investigation, the phenotypic correlations of grain yield per plant by means of selected yield traits were partitioned into their corresponding direct and indirect effects through path coefficient analysis.

The phenotypic path-coefficient analysis for the selected component traits are presented in Table 4. Analysis revealed that magnitude of direct effect on grain yield per plant was found to be highest for biological yield per plant (0.848) followed by harvest index (0.437) and number of grains per plant (0.090) followed by peduncle length (0.068), 1000 grains weight (0.058), days to anthesis (0.034), number of productive tillers per plant (0.030), spike length (0.021), number of grains per spike (0.019) and days to booting (0.016). The direct effect of days to maturity (-0.039), plant height (-0.038), number of spikelet per spike (-0.014) and days to heading (-0.012) was negative while other traits were observed to be have positive direct effects.

Days to booting exhibited indirect negative effect via plant height (-0.002), spike length (-0.001), peduncle length (-0.001), number of grains per spike (-0.004), number of grains per plant (-0.003), 1000 grain weight (-0.001) and biological yield per plant (-0.003) on grain yield per plant. Days to heading exhibited indirect positive effect via number of productive tillers per plant (0.012), plant height (0.019), spike length (0.017), peduncle length (0.014), number of grains per spike (0.004), number of grain per plant (0.023), 1000 grain weight (0.013), biological yield per plant (0.038) on grain yield per plant.

Days to anthesis showed positive indirect effect on grain yield per plant via days to booting (0.029), days to heading (0.031), days to maturity (0.016), number of spikelet per spike (0.001) and harvest index (0.004) While days to maturity exhibited positive indirect effect via spike length (0.007), number of grains per spike (0.008), number of grains per plant (0.007), 1000 grain weight (0.006), biological yield (0.006) and harvest index (0.002). Number of productive tiller per plant showed negative indirect effect via days to booting (-0.001), days to heading (-0.003), days to anthesis (-0.010), spike length (-0.003), number of grains per plant (-0.005) while plant height exhibited positive indirect effect via days to booting (0.004), days to heading (0.006), days to anthesis (0.004), number of spikelet per spike (0.003).

Spike length exhibited indirect positive effect via plant height (0.002), number of spikelet per spike (0.003), number of grains per spike (0.002), number of grains per plant (0.004), biological yield per plant (0.006) on grain yield per plant. Whereas peduncle length showed negative indirect effects via days to booting (-0.006), days to heading (-0.006), spike length (-0.005) and harvest index (-0.007) on grain yield per plant. Number of spikelet per spike had showed positive indirect effect on grain yield per plant via days to booting (0.001), days to heading (0.002), days to anthesis (0.001), plant height (0.001) and 1000 grains weight (0.002). Number of grain per spike exhibited positive indirect effect via plant height (0.002), spike length (0.001), peduncle length (0.002), number of spikelet per spike (0.005), number of grains per plant (0.008), biological yield per plant (0.076) on grain yield per plant.

Number of grain per plant show positive direct effect via number of productive tillers per plant (0.011), plant height (0.009), spike length (0.002), peduncle length (0.005), number of spikelet per spike (0.018), number of grains per spike (0.039), biological yield per plant (0.043), harvest index (0.016).

1000 grains weight showed positive indirect effect via number of productive tiller per plant (0.012), plant height (0.034), peduncle length (0.088), biological yield (0.011) and harvest index (0.031) on grain yield per plant.

Biological yield show negative indirect effect via days to booting (-0.180), days to heading (-0.264), days to anthesis (-0.261), days to maturity (-0.122) and harvest index (-0.222) whereas harvest index showed positive indirect effects via days to booting (0.068), days to heading (0.048), days to anthesis (0.053), number of productive tillers (0.049), plant height (0.008), number of spikelet per spike (0.026), number of grains per plant (0.077), 1000 grain weight (0.024) on grain yield per plant. (Bhushan *et al*., 2013) reported similar findings on positive direct effects of harvest index and biological yield per plant on grain yield. Similar findings are reported by (Gelalcha and Hanchinal 2013, Fellahi *et al*., 2013, Kumar *et al*., 2014).

Conclusion

The present study showed the presence of considerable variability among the tested wheat genotypes and the possibility of improving yield and other desirable characters through selection. The study also revealed the importance of considering other characters in the process of selection of genotypes for yield. This indicates the need to conduct further study by considering many wheat growing areas of the Punjab for more than one cropping season.

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