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Variability and inter-relationship among yield and quality parameters in bread wheat

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Abstract

The present study was carried out with the objectives of assessing the genetic variability, estimating the association between grain yield and its component traits and among themselves, which is essential to know the effectiveness of selection for simultaneous improvement in these traits. The material consisting of 42 diverse genotypes of bread wheat was grown in randomized block design with three replications in four environments created through manipulation of sowing dates during *rabi* season 2007-2008 at Hisar as well as Bawal locations. The grain yield per plant showed positive and significant correlation with effective tillers per plant, number of grains per ear, 1000 grain weight and biological yield per plant. However, it showed negative significant correlation with plant height in one or more environments. The path coefficient analysis revealed that biological yield per plant is the major contributor towards the grain yield per plant. Hence, main emphasis should be given on biological yield in breeding programme.

Keywords: Genetic variability, character association, grain yield, late sown, wheat

Introduction

Wheat (*Triticum aestivum* L.em.Thell) is one of the most important cereal crops of the world both in terms of area and production. The wide spread cultivation of the crop all along the globe is largely due to high versatility of genome, which enable its adaptation to different agro climatic conditions and the unique property of wheat flour and dough which allows its processing into a range of food products. Wheat is the second most important crop after rice in India and achieved a record wheat production of 84.27 million tones during 2010-11 (DWR Vision 2030). The national wheat production accounts for 12 per cent of global wheat production that made India the 2nd largest wheat producing nation with surplus wheat as against the wheat deficient nation during 1960's.

The development of high yielding wheat varieties for different agro-climatic conditions depends upon the nature and amount of genetic variability in the germplasm collection and extent of transmissibility of characters under consideration. The genotypic and phenotypic coefficient of variation are helpful in understanding the clear picture of existing variability in the populations, where as the estimates of heritability and genetic advance provide the indices of transmissibility of characters. Thus, estimates of variability parameters like coefficients of variation, heritability and genetic advance are very useful for devising suitable selection strategy for evolving high yielding genotypes in wheat crop. These characters play important role in the expression of grain yield in plant. Thus, the estimates of genetic correlations are also useful in understanding and manipulating the magnitude of desirable components traits in wheat breeding. The estimates of genotypic and phenotypic correlation coefficients of grain yield per plant with its component characters indicate some interesting relationship, which would help in formulation of a selection scheme for the improvement of yielding ability of the genotypes.

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Keeping the above facts in view, the proposed study was undertaken with the objective to study the genetic variability parameters for yield, its component and quality traits and to study correlations between grain yield and other related component traits under different environments.

Materials and Methods

The present investigation was carried out on 42 promising genotypes of bread wheat. The genotypes were grown in randomized block design (RBD) with three replications during rabi 2007-08 at two locations with two different sowing dates (i) Research area of Department of Plant Breeding, CCS HAU, Hisar and (ii) Regional Research Station, CCS HAU, Bawal, District Rewari. Each entry was accommodated in a single row of 3 meter length with spacing of 30 cm between row to row and 10 cm between plant to plant in each replication and recommended packages of practices were followed to raise the crop.

Five competitive plants of each genotype in each replication and in each environment were randomly selected and data were recorded on the following characters. viz., days to heading, days to maturity, plant height (cm), effective tillers per plant, number of grains per ear, 1000-grain weight (g), biological yield per plant (g), grain yield per plant (g), protein (%), sedimentation value (ml).

Statistical analysis of data was carried out for every character under each environment as described by Panse and Sukhatme (1967). The statistical parameters like mean, range, standard error, critical difference (CD), coefficient of variation (CV) were worked out to study variability parameters for different characters. The correlation coefficient analysis was carried for individual environments using the formula of Al-Jibouri *et al.* (1958). Path coefficient analysis was worked out according to Dewey and Lu (1959). Genotypic and phenotypic coefficient of variation were estimated according to the formula suggested by Burton (1952)

Results and Discussion

A breeding programme depends on proper management of genetic variability present in the material. High magnitude of variability in a population provides the opportunity of selection to evolve a variety having desirable characters. The variability in a biological population that we can see, measure or study is the result of the genetic constitution of the individuals making up that population. All measurements can only be made at phenotypic level, which is the result of interplay of a large number of genes interacting with each other and also with the environment. The phenotypic variability is thus, composed of genotypic and environmental components. In fact, the genotypic component is ultimately useful in utilizing this variability in a breeding programme.

In the present study, E_1 (timely sown, Hisar) and E_3 (timely sown, Bawal) appeared to be the most favourable for the genetic manifestation of yield and yield contributing characters as compared to E_2 and E_4 (late sown at Hisar and Bawal, respectively). In wheat, timely sown crop with recommended doses of inputs (irrigation and fertilizers) result in high productivity of different characters vis-à-vis grain yield whereas reduction in productivity was observed in this study in late sown and low fertility condition. The analysis of variance (Table 1) indicated the existence of sufficient genetic variation among various genotypes for all the characters studied in all the four environments. Arya *et al.* (2005) also reported sufficient genetic variation among genotypes for all the traits in wheat.

Table 1. Mean, range, coefficient of variation, heritability and genetic advance for 10 characters of wheat

Characters	Mean ±SE	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic advance per cent of mean
Days to heading	85.95±0.487	66.00-98.58	9.26	11.99	59.70	19.63
Days to maturity	125.46±0.292	117.50-129.33	6.76	8.31	66.20	14.61
Plant height (cm)	87.01±0.422	73.50-113.58	7.56	13.25	32.60	11.57
Effective tillers per plant	10.21±0.107	6.18-16.58	20.76	28.99	51.30	42.40
Number of grains per ear	46.84±0.276	32.90-64.24	15.51	19.82	61.20	32.38
1000-grain weight (g)	39.43±0.928	27.44-46.48	6.14	10.50	34.20	9.51
Biological yield per plant (g)	65.21±0.310	42.24-82.03	13.51	16.90	63.90	28.75
Grain yield per plant (g)	29.68±0.114	17.56-40.35	15.53	20.44	57.80	31.43
Protein (%)	12.87±0.380	11.46-14.95	5.23	8.84	35.00	8.23
Sedimentation value (ml)	35.97±0.108	30.08-58.33	6.77	13.10	26.70	9.31

Considering the mean performance of genotypes for different characters studied in different environments, genotypes WH-283, WH157, WH291, WH1056, UP 2425 and Raj 3765 for days to heading; WH 1046, WH 1074, WH 1053, WH 1070, WH283, PBW 550, and WH 291 for days to maturity ; WH416, WH 542 WH 711, DBW 17, PBW 502, WH 595 and WH 736 for plant height (cm); WH 542 PBW 343, DBW 17, PBW 502, PBW 550, WH 730 and WH 1046 for effective tillers per plant; WH 1025, WH 147, WH 416, HD 2687, UP 2338, WH 542, PBW 343 and PBW 502 for number of grains per ear, UP 2425, WH 157, sonak, PBW 343, UP 2338 and WH 283 for 1000 grain weight, Raj 3765, DBW 17, PBW 343, WH 542, WH 283, and WH 416 for biological yield per plant, WH 416, WH 283, HD 2687, UP 2338. WH 542, PBW 343, WH 711, DBW 17, PBW 502, PBW 550 and WH 730 for grain yield per plant, WH 291, WH 1022, WH 1046, WH 1053, WH 1054, WH 1055, WH 1056, and WH 1059 for protein (%), WH 712, WH 711. WH 416 and WH 147 for sedimentation value in all environments were found promising varieties.

Genetic variation

In the present investigation the highest genotypic coefficient of variation (GCV) was observed for effective tillers per plant followed by grain yield per plant, number of grains per plant, biological yield per plant, days to heading, plant height, sedimentation, days to maturity, 1000 grain weight and protein percentage (Table 1).

Phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation for all the characters under study. The highest PCV was recorded for effective tillers per plant followed by grain yield per plant, number of grains per plant, biological yield per plant, plant height, sedimentation value, days to heading, protein % and days to maturity. The highest heritability was recorded for days to maturity followed by biological yield per plant, number of grains per plant, days to heading, grain yield per plant and effective tillers per plant (Table 1). Similar findings were also reported by Shoran (1995) for total biomass and grain yield.

The highest value of genetic advance per cent of mean was observed for effective tillers per plant followed by number of grains per plant, grain yield per plant and biological yield per plant. Moderate value of heritability was observed for these traits. On the other hand, low heritability value along with lower value of genetic advance was observed for protein content (%) and sedimentation value (Table 1). High heritability with high genetic advance indicates additive gene effects and, therefore, these characters can be better exploited through simple selection. The occurrence of high variability for grain yield has also been reported by Shoran (1995) for biological yield by Mehta and Dhagat (1992) and for grains per ear by Nagireddy and Jyothula (2009) and Din *et al.* (2010).

Correlation coefficient

Biological yield exhibited highly significant and positive association with grain yield in all the environments and also with effective tillers per plant in E_1 (Table 2). Positive association of biological yield with these traits has also been reported by Singh *et al.* (2003), Kumar *et al.* (2010). Number of grains per ear showed highly significant association also with 1000 grain weight in (E_4). Days to heading showed positive correlation with days to maturity and plant height in E_1, plant height in E_2, days to maturity in E_3, effective tillers per plant in E_4, while it showed negative and significant association with protein in E_1 and E_2, with 1000-grain weight in E_3 and E_4.

Days to maturity showed positive and significant association with plant height in E_1 and number of grains per ear in E_4. Significant negative correlation with 1000-grain weight in E_3 and effective tillers per plant in E_4. Plant height showed negative significant correlation with grain yield per plant in E_1 and E_2. Likewise, Mohammad *et al.* (2005) reported negative correlation between plant height and grain yield. Generally, taller varieties are susceptible to lodging thus grain development restricted which is responsible for low grain yield. Effective tillers per plant showed highly significant and positive correlation with grain yield per plant in all the environment.

It also showed positive and significant correlation with biological yield per plant in E_1. It revealed that increase in these traits will ultimately increase in grain yield. Positive association between effective tillers per plant and grain yield has been reported by Singh and Singh (1999), Arya *et al.* (2005), Singh *et al.* (2005). Similarly, Sharma and Singh (2009) and Khan and Dar (2010) have also reported positive and significant correlation between effective tillers per plant and biological yield per plant. These characters should be given due importance while breeding for higher grain yield.

Path coefficient analysis

It is apparent that many of the characters are correlated because of a mutual association, positive or negative with characters. Path coefficient analysis proved an effective means of separating direct and indirect causes of association and permits critical evaluation of specific forces acting to produce a given correlation and measure the relative importance of each casual factors. Partitioning of genotypic correlations between yield per plant and its component characters indicated that the direct effects were in general of higher magnitude than that of indirect effects for most of the characters.

Path coefficient analysis (Table 3) indicated that biological yield per plant registered the highest direct and positive effects in E_1, E_3 and E_4 environments followed by days to heading, effective tillers per plant and days to maturity in E_2, effective tillers per plant and 1000-grain height in E_1. The number of grains per ear and effective tillers per plant were another character which had high indirect effect through biological yield in one or other environment. Similar results for one or more characters have also been noticed by Jag Shoran (1995), Singh *et al.* (2005), Kumar *et al.* (2010) and many others. From the foregoing discussion of the results obtained in the present study, it is evident that biological yield per plant was the most important component affecting the grain yield. The number of grains per ear and effective tillers per plant were other important components of grain yield in wheat. Therefore, due emphasis should be given on these characters while selecting for high grain yield in wheat.

Correlation study showed a high positive correlation of grain yield with biological yield per plant, effective tillers per plant and number of grain per ear. Selection for the improvement of grain yield based upon these characters will, therefore, be effective. Path coefficient analysis further revealed that biological yield had high positive direct effect on grain yield. The number of grain per ear was another character which had sufficient effect through biological yield. Thus, these characters should be given due importance while breeding for higher grain yield.

Table 2. Phenotypic correlation coefficients among 42 genotypes of wheat in four environments

Character		Days to maturity	Plant height	Effective tillers per plant	No. of grains per ear	1000-grain weight	Biological yield	Grain yield	Protein	Sedimentation value
Days to heading	E1	0.716**	0.589**	-0.170	-0.063	-0.284	-0.324	-0.265	-0.364*	-0.114
	E2	0.163	0.468*	-0.002	0.001	-0.135	0.053	0.012	-0.374*	-0.078
	E3	0.401*	0.256	0.191	-0.516**	-0.644**	-0.170	0.124	0.009	-0.178
	E4	0.197	0.003	0.336*	-0.459**	-0.685**	-0.142	-0.065	0.019	-0.132
Days to maturity	E1		0.448**	-0.164	-0.150	0.105	-0.156	-0.126	-0.289	-0.076
	E2		-0.108	0.085	0.069	0.094	0.270	0.260	-0.035	0.037
	E3		-0.119	0.185	-0.010	-0.381*	-0.091	-0.057	-0.083	0.120
	E4		0.037	-0.363*	0.355*	-0.187	0.011	-0.164	0.026	0.275
Plant height (cm)	E1			-0.311	-0.223	-0.224	-0.272	-0.420*	-0.282	-0.283
	E2			-0.157	-0.403*	-0.173	-0.160	-0.345*	-0.070	-0.163
	E3			-0.188	-0.158	-0.170	-0.095	-0.299	-0.031	-0.017
	E4			-0.141	-0.083	0.094	0.045	-0.116	0.176	-0.095
Effective tillers per plant	E1				-0.035	0.006	0.524**	0.738**	0.162	-0.078
	E2				0.283	0.013	0.289	0.531**	-0.081	-0.022
	E3				0.160	-0.338*	0.311	0.448**	-0.045	0.043
	E4				-0.284	-0.291	0.140	0.409*	-0.060	-0.231
No. of grains per ear	E1					0.156	0.387*	0.102	-0.332	0.273
	E2					0.166	0.293	0.360*	-0.342	0.053
	E3					0.206	0.249	0.034	0.044	0.454**
	E4					0.425**	0.601**	0.480	0.038	0.324
1000- grain weight (g)	E1						0.311	0.260	-0.076	0.174
	E2						0.439**	0.379*	-0.056	-0.057
	E3						0.225	0.051	0.127	0.154
	E4						0.302	0.176	0.223	0.073
Biological yield per plant (g)	E1							0.752**	0.109	0.164
	E2							0.598**	-0.253	0.294
	E3							0.726**	0.050	0.263
	E4							0.822**	0.085	0.202
Grain yield per plant (g)	E1								0.234	-0.034
	E2								0.158	0.072
	E3								0.035	0.055
	E4								-0.003	0.101
Protein (%)	E1									0.127
	E2									-0.165
	E3									0.002
	E4									0.146

*, **Significant at 5 and 1 percent level, respectively

Table 3. Direct (diagonal) and indirect effects of components traits on grain yield per plant of wheat in four environments

Character		Days to heading	Days to maturity	Plant height	Effective tillers per plant	No. of grains per ear	1000-grain weight	Biological yield per plant	Protein	Sedimentation value	'r' with grain yield
Days to heading	E1	0.187	0.135	0.113	-0.032	-0.011	-0.055	-0.061	-0.083	-0.021	-0.280
	E2	-0.059	-0.018	-0.027	0.001	0.000	0.008	-0.003	0.024	0.004	0.020
	E3	0.510	0.218	0.131	0.097	-0.267	-0.332	-0.088	0.010	-0.089	0.127
	E4	0.024	0.005	-0.001	0.008	-0.011	-0.017	-0.003	0.001	-0.003	-0.069
Days to maturity	E1	-0.020	-0.028	-0.013	0.004	0.004	-0.002	0.004	0.009	0.002	-0.145
	E2	0.097	0.308	-0.093	0.055	0.042	0.066	0.170	-0.035	0.025	0.602**
	E3	-0.097	-0.228	0.029	-0.045	0.001	0.094	0.022	0.024	-0.028	-0.066
	E4	-0.024	-0.119	-0.013	0.044	-0.043	0.023	-0.001	-0.004	-0.033	-0.166
Plant height (cm)	E1	-0.188	-0.142	-0.312	0.102	0.070	0.070	0.087	0.104	0.091	-0.437**
	E2	-0.065	0.042	-0.139	0.022	0.056	0.023	0.022	0.018	0.022	-0.398*
	E3	-0.088	0.044	-0.343	0.066	0.055	0.059	0.032	0.008	0.035	-0.303
	E4	0.004	-0.023	-0.198	0.039	0.026	-0.030	-0.013	-0.095	0.024	-0.218
Effective tillers per plant	E1	-0.060	-0.058	-0.114	0.349	-0.011	0.003	0.186	0.064	-0.028	0.768**
	E2	-0.001	0.079	-0.072	0.444	0.127	0.008	0.130	-0.036	-0.011	0.613
	E3	0.030	0.032	-0.031	0.161	0.027	-0.056	0.051	-0.005	0.007	0.459**
	E4	0.090	-0.098	-0.051	0.263	-0.075	-0.077	0.037	-0.022	-0.063	0.415**
No. of grains per ear	E1	0.009	0.022	0.034	0.004	-0.150	-0.024	-0.058	0.059	-0.041	0.111
	E2	0.000	0.003	-0.009	0.006	0.023	0.003	0.006	-0.008	0.001	0.409**
	E3	-0.035	-0.001	-0.010	0.012	0.067	0.014	0.017	0.002	0.031	0.039
	E4	-0.081	0.065	-0.023	-0.050	0.176	0.075	0.106	0.007	0.057	0.482**
1000- grain weight (g)	E1	-0.028	0.008	-0.021	0.001	0.015	0.094	0.030	-0.009	0.016	0.253
	E2	-0.031	0.047	-0.038	0.004	0.036	0.221	0.097	0.012	-0.012	0.442**
	E3	-0.091	-0.057	-0.024	-0.048	0.029	0.139	0.031	0.018	0.021	0.052
	E4	0.013	0.003	-0.003	0.005	-0.008	-0.019	-0.005	-0.005	-0.001	0.177
Biological yield per plant (g)	E1	-0.199	-0.095	-0.170	0.325	0.238	0.196	0.612	0.079	0.101	0.773**
	E2	0.012	0.124	-0.036	0.066	0.066	0.099	0.225	-0.062	0.067	0.683**
	E3	-0.120	-0.068	-0.066	0.219	0.176	0.158	0.696	0.049	0.184	0.731**
	E4	-0.102	0.008	0.049	0.100	0.428	0.216	0.711	0.074	0.145	0.827**
Protein (%)	E1	0.001	0.001	0.001	0.000	0.001	0.000	0.000	-0.002	0.000	0.247
	E2	0.065	0.018	0.012	0.013	0.059	0.008	0.043	-0.158	0.029	-0.271
	E3	-0.001	0.006	0.001	0.002	-0.001	-0.007	-0.004	-0.056	0.000	0.050
	E4	0.001	0.001	0.019	-0.003	0.002	0.011	0.004	0.039	0.006	-0.010
Sedimentation value (ml)	E1	0.018	0.013	0.047	0.012	-0.044	-0.028	-0.026	0.024	-0.161	-0.040
	E2	0.002	-0.002	0.005	0.001	-0.002	0.002	-0.010	0.006	-0.035	0.090
	E3	0.018	-0.013	0.010	-0.004	-0.048	-0.016	-0.027	-0.000	0.105	0.056
	E4	0.004	-0.009	0.004	0.008	-0.011	-0.002	-0.007	-0.005	-0.034	0.097

Residual = 0.395(E_1), 0.431(E_2), 0.480(E_3), 0.403(E_4)

Conclusion

A substantial amount of genetic variability was observed for all the traits under study. Genotypic coefficients of variation were lower than the phenotypic coefficients of variation. The highest phenotypic and genotypic coefficients of variation were observed for effective tillers per plant in all the environments. Significant and positive correlation of grain yield with biological yield per plant, effective tillers per plant and number of grains per ear were recorded. Effective tillers per plant showed positive and significant correlation with biological yield per plant. The path coefficient analysis suggested that biological yield per plant is the most important component assessing the grain yield per plant in all the environments except days to maturity and effective tillers per plant in E_2.Thus, these characters should be given due importance while breeding for higher grain yield.

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