Studies on Characters Related to Yield and Quality of Wheat (*Triticum aestivum* L.) Grown in Gangetic Plains of West Bengal, India

Bhanu Priya[1*], Subhra Mukherjee[1], Bimal Das[1], N. Hari Satyanarayana[1]. K. K. Sarkar[1], B. L. Uikey[2] and S. K. Mukhopadhayay[3]

[1]Department of Plant Breeding, BCKV, Nadia, West Bengal (741 252), India
[2]Department of Entomology, BCKV, Nadia, West Bengal (741 252), India
[3]Division of Agronomy, AICW&BIP, BCKV, Kalyani, Nadia, West Bengal (741 235), India

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Correspondence to

E-mail: bpriya543@gmail.com

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Abstract

Forty nine genotypes of wheat including two triticale varieties were studied for two years in Nadia, West Bengal district during 2010-11 and 2011-12. A wide range of variability was noticed for all characters except days to maturity. Minimum differences between PCV and GCV was found in all characters except number of tillers plant^{-1}, chlorophyll-b content and grain protein content indicating very little environmental influence on most of these characters, providing enough scope for exploitation of genetic variability through selection on the basis of phenotypic values. High heritability coupled with moderate to low genetic advance were observed for days to heading, days to flowering, plant height and spike length and moderate to high heritability coupled with high genetic advance for number of spikelets spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1}, flag leaf area, chlorophyll-a content, chlorophyll-b content, total chlorophyll content and yield plant^{-1} were highlighted. Yield plant^{-1} showed significantly positive correlation with plant height, number of tillers plant^{-1}, spike length, number of grains spikes^{-1} and weight of grains spike^{-1} at both genotypic and phenotypic levels and the characters viz. days to flowering, plant height, number of tillers plant^{-1}, number of spikelets spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1}, chlorophyll-a and chlorophyll-b content had shown high direct positive effects toward grain yield and number of tillers plant^{-1} has been identified as the main contributor to grain yield and on the basis of these characters the genotypes can be utilized for maximization of yield.

1. Introduction

Wheat is the 2nd most important food crop of the country and contributes nearly 1/3rd of the total food grain production. The annual production of wheat in India during 2011-12 was 93.9 mt (Sharma, I., 2012) which was a tremendous improvement over the production level 4 decades back (12.57 mt in 1964) due to the rapid growth in irrigated areas and popularization of high yielding varieties. Wheat is also most important cereal crop after rice in West Bengal with an average productivity of 2800 kg ha^{-1} (Agricultural Statistics at a Glance, 2012). Wheat in West Bengal is generally cultivated after the harvest of AMAN paddy which results in late sowing of wheat.

To initiate breeding programme, study on genetic variability and transmissibility of characters into the progeny is essential for making effective selection (Sharma et al., 2005). Yield being a complex character is a function of several component characters and their interaction with environment. Assessment of mutual relationship among various characters contributing to the yield is essential to make effective selection for yield improvement on the basis of genotypic and phenotypic correlation. Path coefficient analysis also provides an effective means of untangling the complex correlation into direct and indirect effects of the component character of yield so as to find out the efficient characters contributing effectively towards the yield.

2. Materials and methods

The experiment was conducted at two locations of Nadia district, West Bengal during Rabi season for consecutive growing years 2010-2011 and 2011-2012 following randomized block design with two replication for forty nine genotypes which were collected from Directorate of Wheat Research, Karnal through All India Coordinated Wheat & Barley Integrated Project of

Kalyani centre, B.C.K.V. The experimental site was situated at Gangetic Plains of West Bengal. Soil texture was alluvial sandy loam having soil p^H 6.9 to 7.0 with good drainage facility. The genotypes considered in the experiment were HD3076, HD 3077, HD 3078, HD 3079, HD 3080, HD 3081, HD 3082, HD 3083, PBW 661, PBW 662, PBW 663, PBW 664, PBW 665, WH 1113, WH 1114, WH 1115, WH 1116, WH 1117, UP 2815, UP 2816, UP 2817, UP 2818, UP 2819, RAJ 4240, RAJ 4241, RAJ 4242, RAJ 4243, RAJ 4244, DBW 78, DBW 79, DBW 80, DBW 81, DBW 82, NW 5048, NW 5053, HUW 650, HUW 651, K 1001, K 1002, RW 3702, RW 3710, JAUW 595, WCW 2007-21, TL 2977, TL 2978, PBW 343, DBW 017, K 9107, HD 2733. Records on different characters viz. days to heading, days to flowering, days to maturity, plant height (cm), number of tillers plant^{-1}, spike length (cm), number of spikelets spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1} (g), flag leaf area (cm^2), chlorophyll-a content (mg g^{-1}), chlorophyll-b content (mg g^{-1}), total chlorophyll content (mg g^{-1}), thousand grain weight (g), grain protein content (%) and yield plant^{-1} (g) were taken from ten randomly selected plants from each replication. Pooled analysis was done according to Singh and Choudhury (1985).

3. Results and discussion

3.1. Estimation of genetic parameters for yield and its attributing characters

Mean values for each character with their ranges, standard error of difference of the treatment means, phenotypic, genotypic and environmental variances, coefficient of variation (CV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance (GA) and genetic advance as percentage of mean of 49 genotypes of wheat are presented in Table 1.

A wide spectrum of variability was noticed for all the characters indicating sufficient scope for further selection in these traits. The analysis of variance revealed the significant differences among the 49 genotypes against all the characters except days to maturity. The wide range of variation that was observed for fifteen characters viz. days to heading, days to flowering, plant height, number of tillers plant^{-1}, spike length, number of spikelets spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1}, flag leaf area, chlorophyll a content, chlorophyll b content, total chlorophyll content, 1000 grain weight, grain protein content, grain yield plant^{-1} may give scope for selection on the basis of phenotypic value of component characters. The estimate of phenotypic and genotypic variances were high for number of grains spike^{-1}, plant height, days to flowering and days to heading while chlorophyll a content, chlorophyll b content, total chlorophyll content, days to maturity, number of tillers plant^{-1}, weight of grains spike^{-1}, grain protein content, spike length and number of spikelets spike^{-1} showed very low genotypic and phenotypic variances.

The magnitude of PCV was higher than GCV for all the characters suggesting the influences of the environmental forces on the expression of these characters. High PCV and GCV values were observed in chlorophyll a content, chlorophyll b content, flag leaf area and grain yield plant^{-1} while days to heading, number of tillers plant^{-1}, spike length, number of spikelets spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1}, total chlorophyll content and grain protein content exhibited moderate GCV and PCV values therefore there was a large scope for improvements of this characters. The present findings are partially in conformity with Kalimullah et al. (2012) who found high GCV and PCV for number of tillers plant^{-1}, flag leaf area and grain yield plant^{-1}, whereas remaining traits like number of grains spike^{-1} and 1000 grain weight exhibited moderate to low PCV and GCV estimates. Ali et al. (2008) also reported high GCV and PCV for number of tillers plant^{-1}, number of grains spike^{-1} and yield plant^{-1}.

The heritability values ranged from 20.4 percent in days to maturity to 97.40 percent for plant height and genetic advance as percentage of mean 0.46 percent in days to maturity to 37.32 percent for flag leaf area. High heritability associated with moderate to low genetic advance were observed for days to heading, days to flowering, plant height and spike length. Moderate heritability coupled with moderate to low genetic advance were recorded in number of tillers plant^{-1}, 1000 grain weight and grain content suggesting that the inheritance of such traits might be under the control of both additive and non-additive gene effects. Moderate to high heritability coupled with high genetic advance as percent of mean for number of spikelets spike^{-1}, number of grains spike^{-1},weight of grains spike^{-1}, flag leaf area, chlorophyll a content, chlorophyll b content, total chlorophyll content and yield plant^{-1} indicated predominance additive gene action to control these characters while low heritability estimates along with low genetic advance observed for days to maturity which suggested that dominance and epistatic genes were involved in controlling the traits. Jedynski (2001) and Kumar et al. (2003) reported high heritability coupled with high genetic advance for number of grains spike^{-1}, the result corroborated to the above finding. The above finding on yield plant^{-1} was supported by Sidharthan et al. (2007) who found high heritability coupled with high genetic advance for yield plant^{-1}. Dwivedi and Biswas (2011) reported the variability of morphological and biochemical characters.

3.2. Character association

The genotypic and phenotypic correlation coefficients among the biometrical traits are presented in Table 2. The correlation coefficients at genotypic level were in general higher than phenotypic correlation values. This finding was supported

Table 1: Mean, Range and other genetic parameters in *Triticum aestivum* L. [Pooled over two environment]

A	B	C	D	E	F			CV	GCV	PCV	ECV	G	H	I
					GV	PV	EV							
1.	Days to heading	55.50-82.00	71.37	1.818	50.223	53.552	3.328	10.200	9.928	10.252	2.546	0.937	14.125	19.806
2.	Days to flowering	58.75-85.00	74.54	1.780	50.314	53.510	3.196	9.774	9.525	9.824	2.391	0.939	14.157	19.028
3.	Days to maturity	115.00-118.25	116.70	1.080	0.338	1.504	1.167	1.064	0.452	1.047	0.925	0.204	0.540	0.462
4.	Plant height (cm)	71.00-110.67	94.28	1.404	75.576	77.660	2.084	9.257	9.180	9.303	1.494	0.974	17.568	18.663
5.	No. of tillers plant^{-1}	5.00-7.50	6.17	0.615	0.429	0.809	0.380	14.583	10.629	14.620	10.019	0.532	0.983	15.943
6.	Spike length (cm)	9.08-13.70	11.21	0.471	1.204	1.450	0.245	10.694	9.775	10.739	4.215	0.832	2.061	18.390
7.	No. of spikelet spike^{-1}	13.75-25.75	18.63	0.764	4.957	5.564	0.606	12.486	11.847	12.537	4.094	0.894	4.300	23.061
8.	No. of grains spike^{-1}	44.25-77.25	58.59	4.404	72.611	98.426	25.814	16.883	14.556	16.906	7.362	0.756	15.243	26.301
9.	Wt. of grain spike^{-1} (g)	1.57-2.72	2.23	0.190	0.092	0.132	0.041	16.346	13.548	16.225	8.530	0.719	0.526	23.540
10.	Flag leaf area (cm^2)	11.33-28.81	19.35	0.750	18.283	18.894	0.610	22.346	22.099	22.466	3.863	0.967	8.659	44.787
11.	Chlorophyll a (mg g^{-1})	0.13-0.31	0.20	0.012	0.001	0.001	0.000	19.058	18.283	19.284	6.125	0.898	0.070	35.710
12.	Chlorophyll b (mg g^{-1})	0.04-0.11	0.07	0.009	0.000	0.000	0.000	21.952	19.736	23.039	11.885	0.734	0.000	34.829
13.	Total chloro-phyll (mg g^{-1})	0.19-0.41	0.28	0.013	0.002	0.002	0.000	16.964	16.443	17.146	4.794	0.920	0.084	32.491
14.	1000 grain wt. (g)	30.69-46.60	37.72	2.672	12.297	20.274	7.978	11.719	9.221	11.712	7.142	0.644	5.651	15.025
15.	Grain protein (%)	11.59-17.02	15.10	0.894	1.637	2.486	0.849	10.383	8.425	10.438	5.927	0.662	2.144	14.193
16.	Yield plant^{-1} (g)	10.40-17.68	13.84	0.802	8.140	8.784	0.644	21.309	20.574	21.386	5.816	0.925	5.647	40.777

GCV=Genotypic coefficient variation; PCV=Phenotypic coefficient variation; H^2=Heritability (broad sense); GA= Genetic advance

A=Sl.no; B=Characters; C=Range; D=Mean; E= SED; F=Variances; G=H^2 broad sense; H=Genetic advancement; I=Genetic advance % of mean (at 5%) (GA)

earlier by Chaubey et al. (1994) and Prasad et al. (2006).

Yield plant^{-1} showed positively significant genotypic as well as phenotypic correlation with plant height, number of tillers plant^{-1}, spike length, number of grains spikes^{-1}, weight of grains spike^{-1} where as negatively significant correlation could be noticed with days to maturity at genotypic level. Positive but non significant association were observed between grain yield and other characters like days to heading, days to flowering, number of spikelets spike^{-1}, flag leaf area, chlorophyll-b, total chlorophyll content, 1000 grain weight and grain protein content at both genotypic and phenotypic levels. But negative and non-significant correlation between grain yield and chlorophyll-a content could be recorded at both the levels.

3.3. Path coefficient analysis

Majority of the characters viz. days to flowering, plant height, number of tillers plant^{-1}, number of spikelets spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1}, chlorophyll-a and chlorophyll-b content had positive direct effects toward grain yield (Table 3). Maximum positive direct effect was imparted by days to flowering (1.979) followed by chlorophyll-a content (1.581), chlorophyll-b content, number of tillers plant^{-1}, weight of grains spike^{-1}, number of spikelets spike^{-1}, plant height and number of grains spike^{-1} respectively.

Days to heading imparted the maximum negative direct effect followed by total chlorophyll content, days to maturity, grain protein content, flag leaf area, 1000 grain weight and spike length. Yield was positively and significantly correlated with plant height, number of tillers plant^{-1}, spike length, number of grains spike^{-1}, weight of grains spike^{-1}. Correlation coefficient between yield and spike length was significant but the direct effect was negative and positive correlation may be shown through indirect effect by a number of characters. Plant height and number of grains spike^{-1} were directly related with grain yield but it had very negligible direct effect. Number of tillers plant^{-1} and weight of grains spike^{-1} had high positive direct effect and also had highly positive significant correlation coefficient with grain yield. Therefore, direct selection for these

Table 2: Genotypic (G) & Phenotypic (P) correlation among grain yield & its attributing characters in *Triticum aestivum* L. [Pooled over 2 environment]

Characters		Days to flowering	Days to maturity	Plant height (cm)	No. of tillers plant^{-1}	Spike length (cm)	No. of spikelet spike^{-1}	No. of grains spike^{-1}	Wt. of grains spike^{-1} (g)	Flag leaf area (cm^2)	Chl-a (mg g^{-1})	Chl-b (mg g^{-1})	Total Chl. (mg g^{-1})	1000 grain wt. (g)	Grain protein (%)	Yield plant^{-1} (g)
Days to heading	G	1.000**	0.930**	0.333*	0.064	0.296*	0.430**	0.223	0.201	-0.146	-0.339*	-0.135	-0.318*	-0.122	0.040	0.167
	P	0.998**	0.287*	0.324*	0.040	0.260	0.412**	0.194	0.168	-0.143	-0.308*	-0.103	-0.290*	-0.089	0.020	0.161
Days to flowering	G		0.932**	0.331*	0.070	0.291*	0.430**	0.215	0.199	-0.147	-0.338*	-0.131	-0.317*	-0.124	0.038	0.168
	P		0.288*	0.321*	0.042	0.253	0.407**	0.188	0.162	-0.144	-0.309*	-0.099	-0.289*	-0.093	0.012	0.159
Days to maturity	G			-0.044	-0.194	-0.018	0.236	-0.183	-0.442**	-0.451**	-0.103	-0.087	-0.114	-0.215	-0.359**	-0.278*
	P			0.001	-0.066	0.056	0.130	0.026	-0.030	-0.147	0.004	-0.055	-0.016	-0.013	-0.070	-0.047
Plant height (cm)	G				0.124	0.404**	0.431**	0.144	0.445**	0.196	-0.241	-0.024	-0.201	0.353*	0.136	0.364**
	P				0.100	0.359**	0.407**	0.133	0.360**	0.185	-0.229	-0.027	-0.196	0.255	0.111	0.346*
No. of tillers plant^{-1}	G					0.232	-0.169	0.104	0.291*	0.221	-0.092	0.201	-0.010	0.186	0.049	0.772**
	P					0.156	-0.110	-0.017	0.052	0.192	-0.021	0.155	0.036	0.047	0.021	0.652**
Spike length (cm)	G						0.540**	0.515**	0.550**	0.120	-0.030	0.269	0.062	0.067	-0.007	0.499**
	P						0.546**	0.475**	0.501**	0.126	-0.005	0.196	0.066	0.080	0.086	0.459**
No. of spikelet spike^{-1}	G							0.607**	0.489**	-0.128	-0.063	0.002	-0.055	-0.021	0.170	0.241
	P							0.520**	0.448**	-0.115	-0.053	-0.024	-0.055	-0.000	0.124	0.229
No. of grains spike^{-1}	G								0.655**	0.140	0.011	0.082	0.037	-0.326*	0.259	0.510**
	P								0.679**	0.145	0.013	0.047	0.029	-0.261	0.197	0.467**
Wt. of grains spike^{-1} (g)	G									0.184	-0.056	0.173	0.012	0.194	0.187	0.819**
	P									0.157	-0.076	0.147	-0.007	0.196	0.126	0.717**
Flag leaf area (cm^2)	G										-0.222	-0.042	-0.190	0.127	0.014	0.221
	P										-0.195	-0.012	-0.161	0.105	0.036	0.219
Chl- a (mg g^{-1})	G											0.459**	0.954**	0.108	-0.022	-0.039
	P											0.329*	0.935**	0.098	0.057	-0.033
Chl- b (mg g^{-1})	G												0.702**	-0.023	0.009	0.245
	P												0.639**	0.007	-0.016	0.220
Total chl. (mg g^{-1})	G													0.076	-0.012	0.049
	P													0.079	0.042	0.052
1000 grain wt. (g)	G														-0.064	0.206
	P														-0.023	0.169
Grain protein (%)	G															0.159
	P															0.104

*Significant at 5% level; **Significant at 1% level

two characters would be effective for yield improvement in wheat. Number of tillers plant^{-1} has been identified as the main contributor to yield by Jag Shoran et al. (2005), Sharma et al. (2006), Sidharthan et al. (2007) and Ali et al. (2008) which corroborated the present findings that a highly significant direct effect of the character on yield was noticed.

Table 3: Matrix of direct (diagonal) & indirect effect of yield attributing traits on wheat yield [Pooled over two environment]

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Days to heading	-1.946	1.979	-0.068	0.000	0.028	-0.006	0.051	-0.005	0.150	0.006	-0.484	-0.107	0.576	0.002	-0.007	0.167
Days to flowering	-1.947	1.979	-0.068	-0.000	0.032	-0.006	0.051	-0.005	0.149	0.006	-0.482	-0.109	0.575	0.002	-0.007	0.168
Days to maturity	-2.664	2.757	-0.067	-0.004	-0.154	0.000	0.028	-0.013	-0.263	0.026	-0.740	-0.194	1.058	0.006	0.048	-0.278*
Plant height (cm)	-0.469	0.450	0.004	0.011	0.071	-0.009	0.048	0.000	0.304	-0.007	-0.372	-0.011	0.370	-0.016	-0.013	0.364**
No. of tillers plant^{-1}	0.344	-0.369	0.018	-0.006	0.674	-0.005	-0.020	0.005	0.203	-0.007	0.296	0.132	-0.467	-0.008	-0.014	0.772**
Spike length (cm)	-0.220	0.186	0.002	0.002	0.156	-0.024	0.062	0.005	0.371	-0.009	0.066	0.134	-0.221	-0.002	-0.009	0.499**
No. of spikelet spike^{-1}	-0.630	0.616	-0.015	0.005	-0.109	-0.012	0.114	0.003	0.316	0.001	-0.010	-0.086	0.080	0.002	-0.032	0.241
No. of grains spike^{-1}	-0.121	0.093	0.015	0.001	0.077	-0.012	0.070	0.010	0.419	-0.011	0.083	0.097	-0.181	0.016	-0.045	0.510**
Wt. of grains spike^{-1}(g)	-0.018	-0.022	0.033	0.001	0.188	-0.013	0.053	0.015	0.662	-0.010	-0.044	0.134	-0.097	-0.013	-0.050	0.819**
Flag leaf area (cm^2)	0.294	-0.296	0.032	0.001	0.144	-0.003	-0.017	0.007	0.116	-0.045	-0.376	0.015	0.359	-0.007	-0.003	0.221
Chl-a (mg g^{-1})	0.604	-0.608	0.010	-0.002	-0.046	0.000	-0.008	0.001	-0.039	0.010	1.581	0.268	-1.823	-0.002	0.012	-0.039
Chl-b (mg g^{-1})	0.289	-0.298	0.007	0.000	0.134	-0.006	0.002	0.002	0.113	0.000	0.632	0.695	-1.327	0.000	-0.002	0.245
Total chl. (mg g^{-1})	0.586	-0.593	0.011	-0.002	0.005	-0.001	-0.006	0.002	0.006	0.008	1.489	0.474	-1.939	-0.001	0.008	0.049
1000 grain wt. (g)	0.428	-0.453	0.015	0.001	0.121	-0.001	-0.004	0.001	0.147	-0.002	0.358	-0.052	-0.315	-0.042	0.004	0.206
Grain protein (%)	-0.181	0.191	0.027	0.003	0.039	-0.002	0.015	0.015	0.093	-0.001	-0.225	0.029	0.208	0.002	-0.059	0.159

*Significant at 5% level; **Significant at 1% level Residual Effect=0.063

A=Characters; B=Days to heading; C=Days to flowering; D=Days to maturity; E=Plant height (cm); F=No. of tillers plant^{-1}; G=Spike length (cm); H=No. of spikelet spike^{-1}; I=No. of grains spike^{-1}; J=Wt. of grains spike^{-1} (g); K=Flag leaf area (cm^2); L=Chl-a (mg g^{-1}); M=Chl-b (mg g^{-1}); N=Total Chl. (mg g^{-1}); O=1000 grain wt. (g); P=Grain protein (%); Q=Genotypic Yield plant^{-1} (g)

4. Conclusion

From the present study, it is clear that the characters number of tillers^{-1} and weight of grains spike^{-1} are influenced by both additive and non additive genes a complex breeding method like population improvement with cyclic selection may be suggested for yield improvement.

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