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Impact of Biparental Mating on Correlation Coefficients in Bread Wheat

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Summary. Phenotypic and genotypic correlation coefficients and path-coefficients were studied in the biparental (BIPs) and F_3 self progenies of the two wheat crosses. A comparison of correlation coefficients in the BIPs and the F_3's revealed that as many as twelve new significant correlations were noticed in case of the BIPs in cross I although some of them occurred in the undesirable direction. On the other hand, only three new correlations were observed in the BIPs of cross II, although as many as fifteen correlations were not significant. Results suggested that intermating in the F_2 was effective in breaking the linkages. Path-coefficient analysis further revealed that the direct effect of tillers/plant on grain yield was important and remained unchanged in both populations of cross I. In cross II, the direct effect of tillers/plants on grain yield was also high and it increased in the BIPs. Intermating seemed to have influenced considerably both the direct and indirect effects.

Key words: Phenotypic – Genotypic Correlation – Path coefficient – Biparental progenies

Introduction

Research on the means of wheat improvement has revealed that grain yield in wheat is primarily dependent on three major components, namely, tillers/plant, grain weight and grains/ear. Hence, breeding for component characters has received considerable attention in the recent past.

Grafius (1959) even doubted the existence of genes for yield and thus advocated a component breeding approach in cereals. Supportive evidence for this approach were later made available in barley (Borthakur and Poehlman 1970; Rasmusson and Cannell 1970) and in wheat (Borojevic and Cupina 1968, 1969; Paroda and Joshi, 1970a, b). However, a major limitation to this approach lies in the fact that the component characters invariably have negative associations amongst themselves (Smocek 1969; Paroda and Joshi 1970b; Knott and Talukdar 1971; Hsu and Walton 1971; Jatasra and Paroda 1978). Linkage, which is the probable cause of associations, further limits the recombination potential of genes (Clegg et al. 1972).

Inter-mating in early segregating generations has been reported to have caused shifts in the genetic correlations in self-pollinated crops (Miller and Rawling 1967; Matzinger and Wernsman 1968; Gill et al. 1973; Redden and Jensen 1974; Verma et al. 1979). The objective of the present investigation was to compare the nature and degree of correlations amongst various characters in the biparental progenies (BIPs) and F_3 selfs in two crosses of wheat. The genotypic correlations were further partitioned into direct and indirect effects through path-coefficient analysis.

Materials and Methods

Thirty-six randomly selected male plants were each mated to three randomly selected female plants using North Carolina Design I (NCI) in each of the two space-planted F_2 populations of two wheat crosses, namely, 'Kalyansona' × 'K 68' (Cross I) and 'HD-2009' × 'Sonalika' (Cross II). The 108 BIPs from the NCI, and 144 F_3 progenies thus produced were each assigned to single row plots in a randomized block design with three replications, in two experiments relating to two different crosses. The sowing was done by dibbling the seeds at a distance of 10 cm in 2.5 m rows spaced 30 cm apart. Observations were recorded on ten randomly selected competitive plants per plot for ten characters, viz., days to heading, days to maturity, plant height, tillers/plant, ear length, spikelets/ear, grains/ear, weight of grains/ear, 1000-grain weight and yield/plant. Plot means were used for statistical analysis. Although both the selfs and BIPs were raised together, separate analysis of variance for each population was carried out. Phenotypic and genotypic correlation and path-coefficient analyses were worked out following the methods of Dewey and Lu (1959).

Results and Discussion

The phenotypic and genotypic correlation coefficients between various combinations of all the ten characters studied in the biparental progenies (BIPs) and F_3 selfs

Table 1. Phenotypic and genotypic correlation coefficients between various characters in BIPs (above diagonal) and F_3 (below diagonal) in cross I, 'Kalyansona' × 'K 68'

Character		1	2	3	4	5	6	7	8	9	10
Days to heading	rp		0.698**	0.379**	0.112	0.268**	0.316**	0.379**	0.280**	−0.331**	0.207*
	rG		0.858	0.534	0.156	0.358	0.424	0.500	0.370	−0.312	0.313
Days to maturity	rp	0.711**		0.297**	0.092	0.278**	0.286**	0.310**	0.218*	−0.318**	0.177*
	rG	0.915		0.515	0.048	0.323	0.404	0.464	0.365	−0.298	0.262
Plant height (cm)	rp	0.408**	0.388**		0.097	0.385**	0.165	0.196*	0.295**	0.174*	0.222*
	rG	0.554	0.663		0.061	0.553	0.188	0.321	0.407	0.156	0.328
Tillers/plant	rp	0.008	−0.085	−0.095		0.183*	0.149	0.142	0.202	0.095	0.737**
	rG	−0.023	−0.165	−0.315		0.205	0.046	0.114	0.299	0.111	0.840
Ear length (cm)	rp	0.302**	0.322**	0.377**	0.110		0.317**	0.323**	0.305**	−0.032	0.307**
	rG	0.448	0.552	0.524	−0.211		0.465	0.396	0.497	0.072	0.432
Spikelets/ear	rp	0.283**	0.252**	0.281**	0.031	0.261**		0.450**	0.196*	−0.313**	0.174*
	rG	0.334	0.306	0.360	−0.136	0.330		0.622	0.332	−0.489	0.151
Grains/ear	rp	0.156	0.167*	0.148	0.048	0.234**	0.447**		0.695**	−0.330**	0.391**
	rG	0.152	0.151	0.210	−0.279	0.091	0.576		0.822	−0.437	0.454
Grain weight/ear (g)	rp	0.088	0.105	0.257**	−0.007	0.261**	0.316**	0.663**		0.018	0.485**
	rG	0.091	0.124	0.337	−0.258	0.283	0.387	0.718		0.001	0.671
1000-grain weight (g)	rp	−0.208**	−0.176*	0.004	0.299**	0.046	−0.123	−0.151	0.184*		0.097
	rG	−0.284	−0.286	−0.114	0.314	−0.013	0.276	−0.405	0.162		0.086
Yield/plant (g)	rp	0.111	0.041	0.097	0.698**	0.238**	0.202*	0.338**	0.349**	0.408**	
	rG	0.214	0.047	0.022	0.691	0.024	0.171	0.250	0.313	0.309	

* $p < 0.05$, ** $p < 0.01$
BIPs = biparental progenies; rp = phenotypic correlation coefficient; rG = genotypic correlation coefficient

Table 2. Phenotypic and genotypic Correlation coefficients between various characters in BIPs (above diagonal) selfs (below diagonal) of cross II, 'HD 2009' × 'Sonalika'

Character		1	2	3	4	5	6	7	8	9	10
Days to heading	rP		0.560**	0.032	0.233**	0.041	0.331**	0.144	0.138	−0.335**	0.210*
	rG		0.738	0.018	0.335	0.094	0.485	0.271	0.197	−0.443	0.277
Days to maturity	rP	0.728**		0.059	0.225*	0.104	0.228**	0.167	0.221*	−0.091	0.233**
	rG	0.861		0.063	0.318	0.181	0.338	0.239	0.251	−0.170	0.246
Plant height	rP	−0.011	−0.006		0.082	−0.073	0.095	−0.172	−0.150	0.043	0.070
	rG	−0.012	−0.022		0.065	−0.131	0.078	−0.219	−0.220	0.059	0.067
Tillers/plant	rP	0.235**	0.216**	0.097		0.103	0.060	0.118	0.201*	−0.053	0.694**
	rG	0.354	0.296	0.093		0.102	0.038	0.094	0.202	−0.038	0.824
Ear length	rP	0.126	0.216**	0.149	0.205*		0.177*	0.181*	0.134	−0.024	0.140
	rG	0.156	0.258	0.190	0.151		0.181	0.182	0.131	−0.056	0.038
Spikelets/ear	rP	0.322**	0.299**	0.215**	0.095	0.248**		0.241**	0.158	−0.221*	0.131
	rG	0.420	0.389	0.231	0.126	0.326		0.384	0.223	−0.361	0.175
Grains/ear	rP	0.185*	0.217**	0.030	0.129	0.302**	0.359**		0.654**	−0.210*	0.312**
	rG	0.263	0.272	0.039	0.138	0.313	0.514		0.667	−0.915	0.320
Grain weight/ear	rP	0.101	0.202*	0.152	0.198*	0.372**	0.229**	0.629**		0.119	0.456**
	rG	0.120	0.228	0.164	0.124	0.412	0.229	0.702		0.144	0.515
1000-grain weight	rP	−0.086	−0.007	0.171*	0.364**	0.163*	−0.033	0.023	0.332**		0.119
	rG	−0.149	−0.057	0.224	0.477	0.216	−0.106	−0.044	0.473		0.149
Yield/plant	rP	0.272**	0.294**	0.173*	0.709**	0.341**	0.198*	0.353**	0.483**	0.523**	
	rG	0.335	0.414	0.182	0.788	0.356	0.293	0.414	0.529	0.667	

* $p < 0.05$; ** $p < 0.01$

are given in Tables 1 and 2 for cross I and II, respectively. The genotypic correlation coefficients were, in general, higher in magnitude than the phenotypic correlation coefficients for almost all the characters in both populations of the two crosses. This suggested that the association between various characters, in general, was genetically inherited.

A comparison of the phenotypic and genotypic correlation coefficients among the characters between the BIPs and F_3 selfs revealed that, in cross I as many as twelve additional correlations became established in the former population compared to the latter. In the BIPs of cross I yield/plant showed improvement towards a positively significant correlation coefficient with attrbitues such as days to heading, days to maturity and plant height. Grains/ear established positive significant associations with days to heading and plant height but changed into negative associations with 1,000-grain weight. Similarly, 1,000-grain weight showed a positive significant correlation with plant height but had a negative correlation with spikelets/ear. Grain weight/ear exhibited positive significant associations with days to heading, days to maturity and tillers/plant, whereas ear length showed positive significant correlation with tillers/plant in BIPs compared to F_3 selfs. In addition, positive significant correlations of 1,000-grain weight with yield/plant, grain weight/ear and tillers/plant and between plant height and spikelets/ear observed in F_3 selfs, disappeared in the BIPs of this cross.

The situation observed in cross II was, however, different than that seen in cross I in that as many as fifteen correlations among various combinations of characters noticed in F_3 selfs, were all reduced to non-significant levels and only three new correlations, negative significant correlations of 1,000-grain weight with those of grains/ear, days to heading and spikelets/ear were established in the BIPs of this cross. It may be pointed out here that none of the characters in this cross showed an increase in variation in favour of the BIPs (Yunus 1980). It was thus evident that the reshuffling of genes responsible for correlations amongst some characters resulted in newer recombinants which, presumably, were due to changes from a coupling to repulsion phase linkages. Gill et al. (1973) also reported an additional positive significant correlation between grain yield and ear length, and a negative significant correlation between 1,000-grain weight and tillers/plant in BIPs, whereas the positive significant correlation of 1,000-grain weight with yield, and similar correlations of tillers/plant with plant height and grains/ear and of ear length with 1,000-grain weight were all reduced to non-significant levels. Both increases and decreases in correlations between various characters have also been reported in wheat by Verma et al. (1979). They reported that the correlations between grain yield and rust reaction, grain yield and 100-grain weight, and days to heading and grain weight increased in magnitude in the BIPs. Changes in the direction of correlation (from negative to positive or vice versa) between days to heading and plant height, and plant height and rust reaction were also observed. Shifts in correlation matrixes have also been reported in cotton by Miller and Rawlings (1967) after several cycles of intercrossing. They suggested that breakage of coupling phase linkages tended to decrease the correlation, whereas that of repulsion phase linkages increased their magnitude (ignoring the sign). Under this assumption, the results of the present investigation appear to have involved both coupling and repulsion phase linkages as both increases and decreases in correlations, irrespective of the directions otherwise desired, were observed. The effectiveness of the biparental approach would, therefore, depend on the existing phase of linkages, i.e. coupling or repulsion.

Path-coefficient analysis further provided an insight into the inter-relationships of various characters with grain yield. Earlier studies in wheat have revealed that tillers/plant have the highest direct effect on grain yield followed by grains/ear and grain weight (Fonseca and Patterson 1968; Jaimini et al. 1974; Quick 1978), whereas several other studies indicated grain weight and tillers/plant to have the highest direct effects on grain yield (Paroda and Joshi 1970b; Das 1972; Virk and Verma 1972; Virk and Singh 1972). The results of path-coefficient analysis in the F_3 progenies of the two crosses were in agreement with previous studies. In cross I (Table 3), tillers/plant, grain/ear and 1,000-grain weight showed 0.733, 0.661 and 0.371 direct effects respectively, and 0.414, 0.383 and 0.553 direct effects on yield/plant in cross II, respectively (Table 4).

A comparison of the direct and indirect effects of various characters on grain yield in F_3 selfs and the BIPs, revealed that the changes in the nature and degree of association amongst various characters were accompanied by the changes in their direct and indirect effects. The direct effect of tillers/plant on grain yield was high and positive in both populations of cross I, whereas the direct effect of grains/ear was positive but lower in the BIPs compared to the F_3 population. However, the indirect effect of grains/ear via grain weight/ear was positive and strong as against the negative effect in the F_3. The direct effects of days to heading and 1,000-grain weight were changed from positive in the F_3 to negative in the BIPs, whereas the reverse trend was observed for days to maturity and grain weight/ear. Similarly, changes in the indirect effects via some characters, such as days to heading, days to maturity, tillers/plant and grain weight/ear were also observed in the BIPs. The negative direct effect of days to heading on grain yield in the BIPs revealed the possibility of selection for early genotypes coupled with high yield in the BIPs of this cross.

Table 3. Correlation coefficients and direct (diagonal) and indirect effects of various characters on grain yield in F_3's and BIPs of cross 'Kalyansona' × 'K68'

Character	Effects via									Correlation coefficients with yield/plant	
F_3	1	2	3	4	5	6	7	8	9	Genotypic	Phenotypic
Days to heading	0.588	−0.442	0.092	−0.017	0.044	−0.041	0.101	−0.006	−0.106	0.214	0.111
Days to maturity	0.538	−0.482	0.109	−0.121	0.055	−0.038	0.100	−0.008	−0.106	0.047	0.041
Plant height	0.326	−0.320	0.165	−0.231	0.052	−0.044	0.139	−0.021	−0.042	0.022	0.097
Tillers/plant	−0.104	−0.080	−0.052	0.733	−0.021	0.017	−0.185	0.016	0.117	0.691	0.698**
Ear length	0.264	−0.267	0.087	−0.155	0.099	−0.041	0.050	−0.018	−0.005	0.024	0.238**
Spikelets/ear	0.197	−0.148	0.059	−0.100	0.033	−0.124	0.381	−0.024	−0.103	0.171	0.202*
Grains/ear	0.089	−0.073	0.035	−0.205	0.009	−0.071	0.661	−0.045	−0.151	0.250	0.338*
Grain weight/ear	0.053	−0.060	0.056	−0.189	0.028	−0.048	0.475	−0.062	0.060	0.313	0.349**
1000-grain weight	0.167	0.138	−0.019	0.230	−0.001	0.034	−0.268	−0.010	0.371	0.309	0.408**
Residual	0.145										
BIPs											
Days to heading	−0.128	0.114	0.051	0.114	0.035	−0.059	0.058	0.117	0.010	0.303	0.207*
Days to maturity	−0.110	0.133	0.049	0.035	0.031	−0.056	0.054	0.115	0.010	0.262	0.177*
Plant height	−0.068	0.069	0.096	0.044	0.054	−0.026	0.037	0.128	−0.005	0.328	0.222*
Tillers/plant	−0.020	0.006	0.006	0.731	0.020	−0.006	0.013	0.094	−0.004	0.840	0.737**
Ear length	−0.046	0.043	0.053	0.150	0.097	−0.064	0.046	0.157	−0.002	0.432	0.307**
Spikelets/ear	−0.054	0.054	0.018	0.034	0.045	−0.138	0.072	0.105	0.016	0.151	0.174*
Grains/ear	−0.064	0.062	0.031	0.083	0.038	−0.086	0.116	0.259	0.015	0.454	0.391**
Grain weight/ear	−0.047	−0.049	0.039	0.218	0.048	−0.046	0.095	0.315	−0.000	0.671	0.485**
1000-grain weight	0.040	−0.040	0.015	0.081	0.007	0.068	−0.051	0.000	−0.034	0.086	0.097
Residual	0.077										

* $p < 0.05$; ** $p < 0.01$

Table 4. Correlation coefficients and direct (diagonal) and indirect effects of various characters on grain yield in F_3 and BIPs of cross 'HD2009' × 'Sonalika'

Character	Effects via									Correlation coefficients with yield/plant	
F_3	1	2	3	4	5	6	7	8	9	Genotypic	Phenotypic
Days to heading	– 0.042	– 0.224	– 0.000	0.146	0.005	0.019	0.101	– 0.016	– 0.082	0.355	0.272**
Days to maturity	0.036	– 0.201	– 0.001	0.123	0.008	0.017	0.104	– 0.031	– 0.032	0.414	0.294**
Plant height	0.001	– 0.006	0.016	0.039	0.006	0.010	0.015	– 0.022	0.124	0.183	0.173*
Tillers/plant	– 0.015	0.077	0.002	0.414	0.005	0.006	0.053	– 0.017	0.264	0.788	0.709**
Ear length	– 0.007	0.067	0.003	0.062	0.033	0.015	0.120	– 0.056	– 0.119	0.356	0.341**
Spikelets/ear	– 0.018	0.101	0.004	0.052	0.011	0.045	0.197	– 0.041	– 0.059	0.293	0.198*
Grains/ear	– 0.011	0.071	0.001	0.057	0.010	0.023	0.383	– 0.096	– 0.024	0.414	0.353**
Grain weight/ear	– 0.005	– 0.059	0.003	0.052	0.014	0.013	0.069	– 0.136	0.261	0.529	0.483**
1000-grain weight	0.006	– 0.015	0.004	0.198	0.007	– 0.005	– 0.017	– 0.064	0.553	0.667	0.523**
Residual	0.098										
BIPs											
Days to heading	– 0.090	0.060	0.001	0.263	– 0.013	0.078	0.045	0.039	– 0.107	0.277	0.210*
Days to maturity	– 0.066	0.082	0.003	0.250	– 0.026	0.055	0.040	0.050	– 0.041	0.346	0.233**
Plant height	– 0.002	0.005	0.048	0.051	0.018	0.013	– 0.037	– 0.044	0.014	0.067	0.070
Tillers/plant	– 0.030	0.026	0.003	0.787	– 0.014	0.006	0.016	0.040	– 0.009	0.824	0.694**
Ear length	– 0.008	0.015	– 0.006	0.080	– 0.141	0.029	0.031	0.026	0.014	0.038	0.140
Spikelets/ear	– 0.044	0.028	0.004	0.030	– 0.026	0.161	0.064	0.044	– 0.087	0.175	0.131
Grains/ear	– 0.024	0.019	– 0.010	0.074	– 0.026	0.062	0.168	0.133	– 0.076	0.329	0.312**
Grain weight/ear	– 0.018	0.021	– 0.010	0.159	0.018	0.036	0.112	0.199	0.035	0.515	0.456**
1000-grain weight	0.040	– 0.014	0.003	– 0.030	– 0.008	– 0.058	– 0.053	0.029	0.241	0.149	0.119
Residual	0.130										

* $p < 0.05$; ** $p < 0.01$

In cross II, the direct effect of tillers/plant on grain yield was highest and it improved considerably in the BIPs, whereas the direct effects of days to maturity and grain weight/ear were positive in the BIPs compared to their negative effects in the F_3. However, the reverse trend was observed for the direct effect of ear length on grain yield. The indirect effects via this character were mostly negative in the BIPs compared to the mostly positive indirect effects observed in the F_3 population. The negative indirect effects of 1,000-grain weight via most of the other characters were responsible in reducing its correlation with grain yield in the BIPs.

From the foregoing discussion it has become evident that biparental matings are likely to be useful under specific situations, especially when repulsion phase linkages are prevalent, Changes in correlation coefficients, particularly from unfavourable to favourable ones, would provide greater scope for increasing the frequency of rare recombinants under the biparental mating approach.

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