Indian Journal of Agricultural Sciences **91** (5): 683–8, May 2021/Article
https://doi.org/10.56093/ijas.v91i5.112983

Intergeneration correlation and parent-offspring regression in rust resistance derived F_4 and F_5 generations in bread wheat

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Received: 09 November 2020; Accepted: 18 December 2020

ABSTRACT

The present investigation aimed to determine the intergeneration correlation and parent-offspring regression in F_4 and F_5 generations of two wheat crosses, WH 1105 × WH 711 and RAJ 3765 × WH 711 grown during the *rabi* 2015-16 and 2016-17 in research area of Wheat and Barley Section, CCS HAU, Hisar. Correlation studies indicated that grain yield/plant showed a significant positive correlation with almost all the yield attributing traits which may be considered as prime traits during selection. Biological yield/plant had the highest positive direct effect on grain yield/plant, followed by the harvest index. Almost all the characters had high indirect effects through biological yield/ plant and harvest index. The F_4 generation progenies showed highly significant and positive values of intergeneration correlation and regression with F_5 generation progenies for all the characters in both the crosses. Therefore, the performance of the plants in the F_4 generation is a reliable indicator of the performance of their progeny in subsequent generations. Narrow sense heritability values were high for the number of grains/ear, grain weight/ear and grain yield/ plant while response to selection values were high for the number of grains/ear, biological yield/plant, plant height and number of spikelets/ear in the progenies of both crosses. Hence, improvement through selection can be based upon these traits in these crosses. Thus estimation of correlation and regression analysis among yield and yield components may provide effective selection criteria to improve wheat grain yield.

Keywords: Intergeneration correlation, Narrow-sense heritability, Parent-offspring regression, Wheat

Wheat (*Triticum aestivum* L.), the important cereal crop cultivated worldwide is of greatest economic importance in India. The hexaploid (2n = 6x = 42) common bread wheat is being cultivated on roughly 95% of the area occupied by wheat crop. Because of ever-increasing population and demand for global food production, there is an imperative need of 40–60% increase in wheat production to meet the requirements of developing world in coming 40 years (Goutam *et al*. 2015). To sustain wheat production, systematic attempts for wheat improvement are needed through manipulation of various yield components (Hussain and Qamar 2007, Sorrells *et al*. 2007). Most of the plant breeding programmes are aimed at the augmentation of yield, which is an intricate character dependent on many other component characters which are further related among themselves. Therefore, the study of the correlation between traits that determine yield can help in the indirect selection of components of yield. As the number of independent variables influencing particular dependent variable increase, path analysis furnishes a method of partitioning the correlation coefficient into direct and indirect effects and therefore, correlation studies along with path analysis provide a better understanding of the interrelationship of different characters with grain yield.

Intergeneration correlation coefficient gives an idea about the nature of gene action and thus tells about the effectiveness of single plant selection. Due to lesser sensitivity to environmental effects, the parent progeny correlation and regression between two generations is very useful for selection in segregating population for the production of new and improved genotypes. Parent-offspring regression is being used as one of the most common methods for determining narrow-sense heritability of quantitative characters in plant populations which is important to the plant breeder as the effectiveness of selection depends on the additive portion of genetic variance. Correlation studied by using parent-offspring regression helps in estimating the extent of transferring the genetic potentials of the character from one generation to other generation.

MATERIALS AND METHODS

Genetic material consisting of about 240 F_4 and F_5 generation progenies derived from two crosses of bread wheat, viz. WH 1105 × WH 711 and RAJ 3765 × WH 711 was used

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for this study. Both WH 1105 and RAJ 3765 are yellow rust-resistant cultivars/parents, whereas WH 711 is a rust susceptible cultivar/parent. The F_4 and F_5 progenies were sown in the field in paired rows with two replications in a randomised complete block design (RCBD) during *rabi* 2015-16 and 2016-17 at research area of Wheat and Barley Section, CCS HAU, Hisar. Five plants selected randomly from the parents, F_4 and F_5 generation progenies were evaluated for recording data on variation in morphological traits like plant height (cm), number of tillers per plant, ear length (cm), ear weight (g), number of grains per ear, grain weight per ear (g), number of spikelets per ear, 100-grain weight (g), grain yield per plant (g), biological yield per plant (g) and harvest Index. Intergeneration correlation coefficients (r) and parent progeny regression coefficients (b) were calculated for each character between F_4 and F_5 generations. Narrow sense heritability estimates were performed based on the regression of F_5 on F_4 (Cahaner and Hiller 1980). Response to selection was calculated as the difference between the mean phenotypic values of the progeny of selected plants and the original population (Nyquist 1991).

RESULTS AND DISCUSSION

Correlation coefficient analysis: The knowledge about the correlation between economically important traits and characters contributing to them in all combinations helps to decide the parameters for selection. In the present study, the estimates of genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients for all the character combinations, as supported by the findings of Khan and Dar (2010). The results (Table 1) indicated that in F_4 and F_5 generation progenies of both the crosses, the traits namely, number of tillers/plant, ear length, ear weight, number of grains/ear, grain weight/ear, number of spikelets/ear, 100-grain weight, biological yield/ plant and harvest index were found to be positively and significantly correlated with grain yield/plant. Therefore, these traits need more attention in obtaining higher grain yield/ plant. Earlier workers namely, Riaz-Ud-Din *et al.* (2010), El-Mohsen *et al.* (2012), Kalimullah *et al.* (2012), Nukasani *et al*. (2013), Chhibber and Jain (2014), Bhutto *et al.* (2016), Singh *et al*. (2016) and Reddy *et al*. (2017) also reported a positive correlation of these traits with grain yield/plant in wheat. 100-grain weight was negatively and significantly correlated with the number of grains/ear which was similar to as reported by Hama *et al.* (2016). Biological yield/plant had a negative correlation with harvest index. Plant height had non-significant correlation with grain yield/ plant in cross-II, which is supported by finding of Hussain *et al.* (2012).

Path coefficient analysis: To get an idea about the actual effects of a character on grain yield/plant, it is always more appropriate to split the correlation value into direct and indirect effects through path coefficient analysis since it provides a clear and more realistic picture of a complex situation that exists at correlation level (Wright 1921). A critical perusal of path coefficient analysis in both the F_4 and F_5 generations of both the crosses revealed that the residual effect was considerably low (Fig 1 and 2), which shows a high contribution of independent traits to grain yield/plant.

Path coefficient analysis of cross-I (WH 1105 × WH 711): In the F_4 generation, biological yield/plant had the highest positive direct contribution towards grain yield/plant, followed by harvest index while in F_5 generation, the direct effect on grain yield/plant was highest for harvest index while biological yield/plant had a high contribution towards grain yield/plant directly and indirectly through harvest index (Fig 1). Gelalcha and Haninchal (2013), Kumar *et al*. (2014) and Singh *et al*. (2016) also reported the similar results. In the F_4 generation, the number of grains/ear, ear weight and the number of tillers/plant had positive indirect effects through biological yield/plant and harvest index. In the F_5 generation, the negative direct effect was observed in case of ear length, followed by the number of grains/ ear, 100-grain weight, number of tillers/plant, number of spikelets/ear and grain weight/ear to grain yield/plant while all these traits contribute positively via biological yield/ plant and harvest index.

Path coefficient analysis of cross-II (RAJ 3765 × WH 711): In both the F_4 and F_5 generations (Fig 2), the direct positive effect on grain yield/plant was highest for harvest index, followed by biological yield/plant, ear weight and grain weight/ear, hence, these traits may be considered as most important for improvement in grain yield/plant. Similar findings were also reported by El-Mohsen *et al.* (2012), Degewione and Alamerew (2013) and Kumar *et al*. (2016). In the F_4 generation, negative direct effects on grain yield/ plant were observed in case of the number of spikelets/ear and number of grains/ear, whereas in the F_5 generation, negative direct effects were observed for 100-grain weight, number of tillers/plant, plant height, number of grains/ear and ear length which was also reported earlier by Iftikhar *et al.* (2012), Meyari *et al.* (2013) and Singh *et al*. (2016). In the F_5 generation, ear weight, 100-grain weight, number of spikelets/ear, ear length and grain weight/ear contributed indirectly towards grain yield/ plant through biological yield and harvest index, while the number of grains/ear, plant height and number of tillers/plant contributed through harvest index.

Regression analysis, intergeneration correlation, narrow sense heritability and response to selection: Inter-generation correlation studies by using parent-offspring regression tell about the extent of transferring the genetic potential of the character from one generation to other generation. The values of parent-offspring regression coefficient and intergeneration correlation between F_4 and F_5 generations (Table 2) were found significantly positive for all the characters studied in both the crosses which were similar to the findings of Shanatava *et al.* (2014) and Suwarto *et al.* (2015). Results showed that in cross-I, maximum value of regression coefficient (0.830) was observed for number of grains/ear followed by grain weight/ear and number of spikelets/ear (0.705 each) and ear length (0.693). In cross-II, maximum value of regression coefficient (0.566) was observed for number of grains/ear followed by grain

Table 1 Correlation coefficients among various traits in F_4 and F_5 generation progenies of cross-I (WH 1105 × WH 711) and cross-II (Raj 3765 × WH 711) of wheat

Characters	Cross	Generations	Plant height (cm)	No. of tillers/ plant	Ear length (cm)	Ear weight (g)	No. of grains/ ear	Grain weight/ ear (g)	No. of spike-lets/ear	100-grain weight (g)	Grain yield/ plant (g)	Bio-logical yield/ plant (g)	Harvest index (%)
Plant height (cm)	C-I	F_4	1										
		F_5	1										
	C-II	F_4	1										
		F_5	1										
Number of tillers/plant	C-I	F_4	0.203**	1									
		F_5	0.040	1									
	C-II	F_4	-0.041	1									
		F_5	0.009	1									
Ear length (cm)	C-I	F_4	0.295**	0.094	1								
		F_5	0.251**	0.085	1								
	C-II	F_4	0.088	0.147*	1								
		F_5	0.069	0.297**	1								
Ear weight (g)	C-I	F_4	0.265**	0.307**	0.385**	1							
		F_5	0.336**	-0.106	0.551**	1							
	C-II	F_4	0.063	0.035	0.379**	1							
		F_5	0.102	0.051	0.538**	1							
Number of grains/ear	C-I	F_4	0.345**	0.083	0.538**	0.429**	1						
		F_5	0.253**	0.019	0.444**	0.597**	1						
	C-II	F_4	0.030	-0.217**	0.363**	0.485**	1						
		F_5	0.138*	-0.089	0.431**	0.532**	1						
Grain weight/ ear (g)	C-I	F_4	0.295**	0.367**	0.384**	0.891**	0.425**	1					
		F_5	0.360**	-0.096	0.447**	0.826**	0.542**	1					
	C-II	F_4	0.050	-0.059	0.296**	0.558**	0.695**	1					
		F_5	0.119	-0.089	0.364**	0.447**	0.747**	1					
Number of spikelets/ear	C-I	F_4	0.358**	0.133*	0.753**	0.473**	0.614**	0.454**	1				
		F_5	0.291**	-0.025	0.702**	0.721**	0.573**	0.590**	1				
	C-II	F_4	0.110	-0.120	0.694**	0.513**	0.473**	0.372**	1				
		F_5	0.177**	0.107	0.721**	0.746**	0.525**	0.336**	1				
100-grain weight (g)	C-I	F_4	0.064	0.300**	0.023	0.568**	-0.155*	0.649**	0.055	1			
		F_5	0.113	-0.210**	0.086	0.358**	-0.139*	0.575**	0.157*	1			
	C-II	F_4	0.101	0.009	-0.019	0.127*	-0.145*	0.290**	-0.083	1			
		F_5	0.080	-0.004	-0.028	0.043	-0.164**	0.183**	-0.097	1			
Grain yield/ plant (g)	C-I	F_4	0.254**	0.622**	0.289**	0.770**	0.375**	0.835**	0.375**	0.541**	1		
		F_5	0.291**	0.426**	0.359**	0.634**	0.475**	0.780**	0.433**	0.372**	1		
	C-II	F_4	0.001	0.609**	0.398**	0.290**	0.177**	0.394**	0.181**	0.207**	1		
		F_5	0.026	0.525**	0.664**	0.362**	0.306**	0.400**	0.408**	0.208**	1		
Biological yield/plant (g)	C-I	F_4	0.272**	0.562**	0.298**	0.744**	0.333**	0.809**	0.374**	0.526**	0.924**	1	
		F_5	0.191**	0.151*	0.288**	0.307**	0.320**	0.402**	0.283**	0.156*	0.490**	1	
	C-II	F_4	0.043	0.404**	0.145*	0.232**	0.003	0.203**	0.070	0.164**	0.520**	1	
		F_5	-0.021	0.000	0.190**	0.203**	0.078	0.158*	0.180**	0.149*	0.242**	1	
Harvest index (%)	C-I	F_4	-0.011	0.197**	0.074	0.173**	0.164*	0.190**	0.117	0.104	0.330**	-0.031	1
		F_5	0.200**	0.390**	0.232**	0.534**	0.348**	0.642**	0.321**	0.329**	0.830**	-0.067	1
	C-II	F_4	-0.028	0.453**	0.365**	0.190**	0.201**	0.314**	0.171**	0.124*	0.827**	-0.034	1
		F_5	0.035	0.502**	0.527**	0.232**	0.256**	0.299**	0.285**	0.125*	0.838**	-0.313**	1

*Significant at 5%, **Significant at 1%

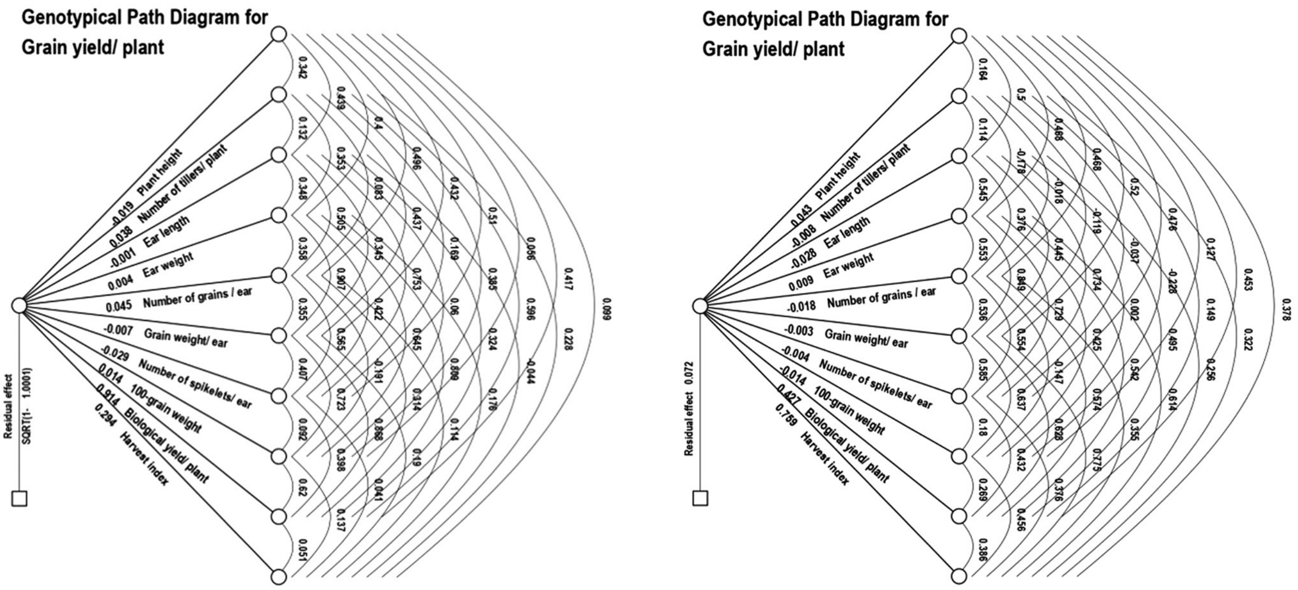

Fig 1 Path coefficient analysis showing direct and indirect effects of different characters on grain yield/plant in (a) F_4 generation and (b) F_5 generation of cross-I.

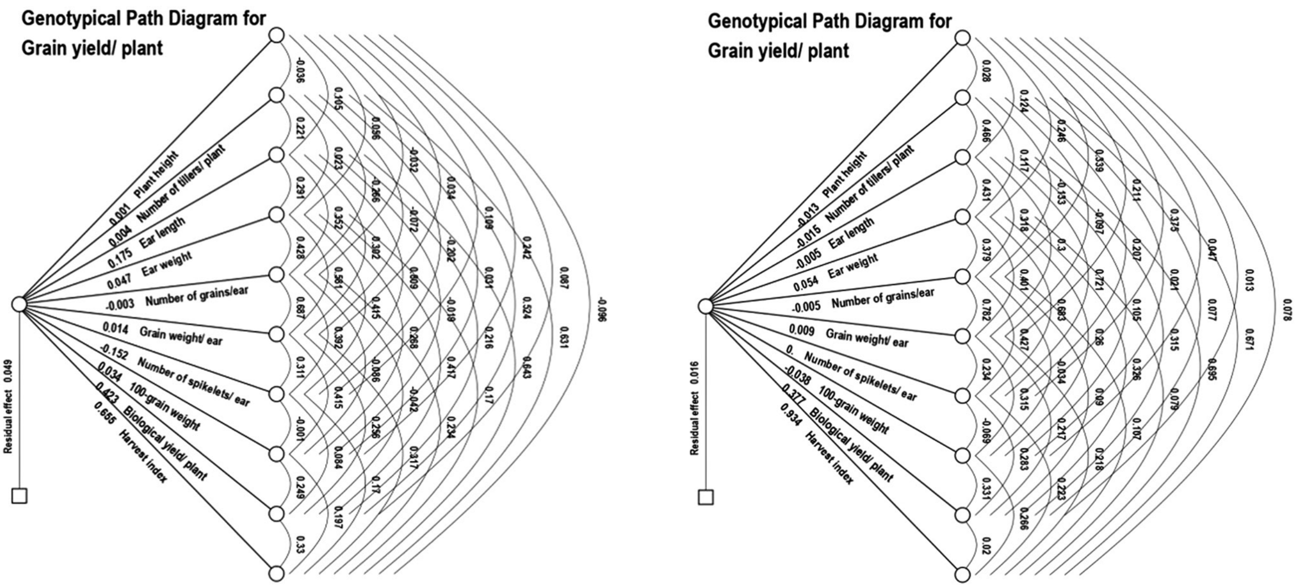

Fig 2 Path coefficient analysis showing direct and indirect effects of different characters on grain yield/ plant in (a) F_4 generation and (b) F_5 generation of cross-II.

weight/ear (0.556), grain yield/plant (0.555) and number of tillers/plant (0.543). The traits showing maximum value of regression coefficient are mostly governed by additive gene action and are suitable for selection in the advanced generations of segregating progenies to identify the lines that will give higher grain yield/plant.

As narrow sense heritability includes only the fixable components, *i.e.* additive and additive × additive variances, so the chances of improving the characters showing high values of narrow-sense heritability are high through selection. In cross-I, narrow-sense heritability was recorded highest for the number of grains/ear, followed by grain weight/ear and number of spikelets/ear, ear length, grain yield/plant, ear weight, plant height, 100-grain weight and the number of tillers/plant and harvest index (Table 2). Similarly, in cross-II, the maximum values were observed for the number of grains/ear, followed by grain weight/ear and grain yield/plant, the number of tillers/plant, harvest index, ear length and plant height, ear weight, and number of spikelets/ear. Kumar *et al*. (2018) reported that the traits showing more than 30% narrow sense heritability could be rewarding for further improvement in grain yield in bread wheat. Response to selection values were high for the number of grains/ear, biological yield/plant and plant height in the progenies derived from the cross-I, whereas for the number of grains/ear, harvest index, biological yield/

Table 2 Regression coefficient, intergeneration correlation, narrow sense heritability and response to selection in both the crosses of wheat for different characters

Character	Cross-I (WH 1105 × WH 711)				Cross-II (RAJ 3765 × WH 711)			
	b	r	h^2 ns (%)	Response to selection	b	r	h^2 ns (%)	Response to selection
Plant height (cm)	0.593^{**}	0.662^{**}	47	1.50	0.374^{**}	0.361^{**}	30	-3.51
Number of tillers/plant	0.459^{**}	0.524^{**}	37	-0.32	0.543^{**}	0.570^{**}	43	0.07
Ear length (cm)	0.693^{**}	0.634^{**}	55	0.17	0.369^{**}	0.365^{**}	30	0.59
Ear weight (g)	0.603^{**}	0.678^{**}	48	0.47	0.334^{**}	0.331^{**}	27	0.29
Number of grains/ear	0.830^{**}	0.807^{**}	66	4.45	0.566^{**}	0.570^{**}	45	2.79
Grain weight/ear (g)	0.705^{**}	0.818^{**}	56	0.50	0.556^{**}	0.552^{**}	44	0.31
Number of spikelets/ear	0.705^{**}	0.740^{**}	56	0.39	0.262^{**}	0.264^{**}	21	1.03
100-grain weight (g)	0.532^{**}	0.697^{**}	43	0.43	0.155^{**}	0.172^{**}	12	0.23
Grain yield/plant (g)	0.666^{**}	0.722^{**}	53	0.46	0.555^{**}	0.633^{**}	44	1.58
Biological yield/plant (g)	0.221^{**}	0.357^{**}	18	2.36	0.149^{**}	0.171^{**}	12	1.95
Harvest index (%)	0.460^{**}	0.229^{**}	37	-2.59	0.463^{**}	0.472^{**}	37	2.78

b = Regression coefficient; *, ** - significant at 5% and 1% level, respectively; r = intergeneration correlation

plant, grain yield/plant and number of spikelets/ear in the progenies of the cross-II. Hence, improvement through selection can be based upon these traits in these crosses.

Amelioration of yield is the ultimate aim of a plant breeder in any crop improvement programme. Yield is a complex trait and direct selections by considering yield components may not always produce desirable results, so the pattern of association assumes significance. The results of the field evaluation of F_4 and F_5 generation progenies of two crosses showed the significant positive relationship of grain yield/plant with several traits including the number of tillers/plant, ear length, ear weight, number of grains/ear, biological yield/plant and harvest index. The path coefficient analysis revealed that biological yield/plant, harvest index, 100- grain weight, number of tillers/plant, ear weight and number of grains/ear were the major contributors towards grain yield/plant. Positive and significant values of intergeneration correlation and regression were observed for all the characters in both the crosses which indicated the effectiveness of selection for these characters. Narrow sense heritability values based on parent-offspring regression coefficient were of higher magnitude for the number of grains/ear, grain weight/ear, grain yield/plant, ear length and the number of spikelets/ear in both the crosses. Response to selection values was high for the number of grains/ear, biological yield/plant and grain yield/plant. It indicates that these characters were governed by additive variance. Therefore, the selection will be effective for such traits based on phenotypic observations. Therefore, these traits may be given attention during selection.

ACKNOWLEDGEMENTS

The author is grateful to the Department of science and technology (DST-INSPIRE) for providing fellowship and other grants.

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