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Genotypic and phenotypic interrelationships of yield related traits in bread wheat (*Triticum aestivum*)

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ABSTRACT

Knowledge of genetic and phenotypic association among economic traits helps plant breeders in outlying efficient breeding strategies for development of high yielding wheat variety. An experiment on 238 progenies of wheat along with parents was conducted to determine the correlation and path coefficient analysis of yield and its attributing traits in wheat. The result reveals the presence of high variability among the 238 progenies of wheat. Grain yield per plant had showed high significant and positive correlation with plant height, number of tillers per plant, number of grains per spike, biological yield per plant and harvest index. Further, it indicates that selection based on these traits in breeding programs could be promising in maximizing grain yield per plant in wheat. Whereas, path coefficient analysis depicts maximum direct effect towards grain yield per plant along with biological yield per plant and harvest index.

Keywords: Correlation, Path coefficient analysis, Variation

Wheat is one of the major staple food crops of the world next to rice. India is the second largest producer after China with about 13.64% share of total world wheat production. The record production in the country during last few years has enabled India to attain the position of being second largest producer of the wheat in the world. Wheat was cultivated on 220.06 mha throughout the world with a production and productivity of 763.18 mt and 3.47 MT/ha respectively, during the year 2018-2019 (USDA 2019). India is the second largest producer of wheat in the world with area, production and productivity of 29.55 mha, 101.20 mt and 3.42 MT/ha, respectively, during 2018-19 (Anonymous 2019). A correlation coefficient is useful in measuring them magnitude and direction of components influence in the determination of main traits. However, it did not provide the relative importance of direct and indirect effects of such components (Da Silva *et al*. 2009). These may be determined through path analysis, with the unfolding of correlation coefficient for analyzed traits, direct and indirect effect, providing greater reliability in interpretations of cause and effect between the studied traits. Path analysis could be used to calculate the quantitative impact on grain yield through direct and indirect effects caused by one or the other component traits (Rajput 2019). It provides an effective means of partitioning correlation coefficients into direct and indirect effects and illuminates the relationship in a more useful way this technique, therefore, provides a critical examination of specific factors producing a given correlation and can be successfully employed in formulating a selection strategy (Larik 1979). Since path-coefficient analysis was applied by Dewey and Lu (1959) on crested wheat grass, this technique being used extensively to facilitate selection in various agriculturally important crops. The present experiment was undertaken with a view to investigating the interrelationship of the yield components and the type and extent of their contribution to the yield of wheat progenies.

MATERIALS AND METHODS

The experimental materials consist of 238 wheat progenies along with their parents were grown during 2014-2015 and 2015-2016 at research farm of Chaudhary Charan Singh Haryana Agricultural University Hisar, which is located at the latitude of 29°10‟N, longitude of 75046‟E and altitude of 215.2 m above sea level in the semi-tropical region of western zone of India. Each progeny was sown in the single row of two-meter length, keeping row to row distance of 20.5 cm. All the recommended package of practices were adapted to raise the healthy crop. Utilizing five randomly selected plants, data were recorded on following traits: Plant height (cm), number of

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tillers per plant, spike length (cm), spike weight (g), number of spikelets per spike, grain breadth (mm), grain length (mm), number of grains per plant, 1000 grain weight (g), grain yield per plant (g), biological yield per plant (g) and harvest index (%). Phenotypic and genotypic correlations were estimated using the standard procedure suggested by Miller *et al.* (1958) and Kashiani and Saleh (2010) from the corresponding variance and covariance components with indostat software. Path coefficient analysis was performed for traits which had significant correlations with grain yield both at genotypic and phenotypic levels in order to know the direct and indirect effect of yield component traits on grain yield using the general formula of Dewey and Lu (1959) by considering grain yield per plant as dependent variable.

RESULTS AND DISCUSSION

Association of traits: Estimates of genotypic and phenotypic correlation coefficients were calculated for all the traits under study for both years during 2014-2015 and 2015-2016 (Tables 1 and 2). Genotypic correlation coefficients were found to be higher in magnitude for both the years than phenotypic correlation coefficients for most of the traits under current study, which clearly indicated the presence of inherent association among various traits. Many earlier research findings also reported lesser magnitude of phenotypic correlation coefficients than the genotypic correlation coefficients (Kotal *et al*. 2010, Dabi *et al.* 2016) revealed the presence of inherent genetic relationships among various characters and the phenotypic expression of these traits were less influenced by the non-heritable factors.

Correlation between yield and its attributing traits: Correlation studies provide information about degree and direction of association of yield attributing traits, and it is an important parameter for taking a decision regarding the nature of selection to be followed for improvement in the crop under study. The estimates of genotypic correlation

Table 1 Phenotypic correlation coefficients for different traits in F_3 and F_4 progenies derived from the cross WH711/WH542

Trait	Year	Plant height (cm)	Number of tillers per plant	Spike length (cm)	Spike weight (g)	Number of grains per spike	Grain length (mm)	Grain breadth (mm)	Number of spikelets per spike	1000 grain weight (g)	Biological yield per plant (g)	Harvest index (%)
Plant height (cm)	2014-2015	1.000										
	2015-2016	1.000										
Number of tillers per plant	2014-2015	0.149*	1.000									
	2015-2016	0.151*	1.000									
Spike length (cm)	2014-2015	0.136*	0.063	1.000								
	2015-2016	0.139*	0.170**	1.000								
Spike weight (g)	2014-2015	0.270**	0.248**	0.286**	1.000							
	2015-2016	0.134*	0.033	0.352**	1.000							
Number of grains per spike	2014-2015	0.083	0.143*	-0.007	0.180**	1.000						
	2015-2016	0.082	0.174**	0.204**	0.057	1.000						
Grains length (mm)	2014-2015	-0.077	-0.075	-0.096	0.022	-0.008	1.000					
	2015-2016	-0.114	0.113	-0.010	-0.025	0.059	1.000					
Grains breadth (mm)	2014-2015	0.212**	0.000	0.059	0.232**	0.042	-0.030	1.000				
	2015-2016	-0.072	-0.047	-0.041	-0.078	-0.012	0.270**	1.000				
Number of spikelets per spike	2014-2015	0.005	0.049	0.062	0.339**	0.226**	0.017	0.076	1.000			
	2015-2016	0.150*	0.035	0.331**	0.203**	0.124	-0.047	0.060	1.000			
1000 grain weight (g)	2014-2015	-0.040	0.140*	0.171**	0.102	-0.211**	-0.124	0.017	0.134*	1.000		
	2015-2016	0.072	0.104	0.101	0.070	-0.233**	-0.040	-0.108	0.121	1.000		
Biological yield per plant (g)	2014-2015	0.105	0.482**	0.144*	0.217**	0.254**	-0.096	0.054	0.075	-0.038	1.000	
	2015-2016	0.173**	0.485**	0.213**	0.054	0.285**	0.083	-0.059	0.199**	0.225**	1.000	
Harvest index (%)	2014-2015	0.108	0.358**	-0.074	-0.073	0.067	-0.015	0.059	-0.047	-0.006	-0.196**	1.000
	2015-2016	0.023	0.154*	0.006	0.086	0.054	0.169**	0.117	-0.007	0.081	-0.148*	1.000
Grain yield per plant (g)	2014-2015	0.150*	0.685**	0.067	0.144*	0.262**	-0.095	0.092	0.033	-0.0067	0.651**	0.573**
	2015-2016	0.158*	0.518**	0.182**	0.108	0.276**	0.180**	0.022	0.164*	0.247**	0.751**	0.539**

*, **: Significant at 5% and 1% level of Significance, respectively

Table 2 Path coefficient analysis showing direct (diagonal and bold) and indirect (off-diagonal) effects of different component traits on grain yield per plant in F_3 and F_4 progenies derived from the cross WH711/WH542

Trait	Year	Plant height (cm)	Number of tillers per plant	Spike length (cm)	Spike weight (g)	Number of grains per Spike	Grain length (mm)	Grain breadth (mm)	Number of spike-lets per spike	1000 grain weight (g)	Biologi-cal yield per Plant (g)	Harvest index (%)
Plant height (cm)	2014-2015	-0.0210	-0.0031	-0.0029	-0.0057	-0.0017	0.0016	-0.0045	-0.0001	0.0008	-0.0022	-0.0023
	2015-2016	-0.0055	-0.0008	-0.0008	-0.0007	-0.0004	0.0006	0.0004	-0.0008	-0.0004	-0.0009	-0.0001
Number of tillers per plant	2014-2015	0.0103	0.0689	0.0044	0.0171	0.0099	-0.0052	0.0000	0.0034	0.0096	0.0332	0.0247
	2015-2016	0.0008	0.0056	0.0009	0.0002	0.0010	0.0006	-0.0003	0.0002	0.0006	0.0027	0.0009
Spike length (cm)	2014-2015	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000			0.0000	0.0000	0.0000
	2015-2016	-0.0008	-0.0009	-0.0055	-0.0019	-0.0011	0.0001	0.0002	-0.0018	-0.0006	-0.0012	0.0000
Spike weight (g)	2014-2015	0.0042	0.0038	0.0044	0.0154	0.0028	0.0003	0.0036	0.0052	0.0016	0.0034	-0.0011
	2015-2016	0.0010	0.0002	0.0026	0.0073	0.0004	-0.0002	-0.0006	0.0015	0.0005	0.0004	0.0006
Grains length (mm)	2014-2015	0.0005	0.0005	0.0006	-0.0001	0.0000	-0.0063	0.0002	-0.0001	0.0008	0.0006	0.0001
	2015-2016	0.0003	-0.0003	0.0000	0.0001	-0.0001	-0.0024	-0.0007	0.0001	0.0001	-0.0002	-0.0004
Grains breadth (mm)	2014-2015	0.0022	0.0000	0.0006	0.0024	0.0004	0.0003	0.0104	0.0008	0.0002	0.0006	0.0006
	2015-2016	0.0004	0.0003	0.0002	0.0004	0.0001	-0.0015	-0.0056	-0.0003	0.0006	0.0003	-0.0007
Number of spikelets per spike	2014-2015	0.0000	-0.0003	-0.0004	-0.0021	-0.0014	-0.0001	-0.0005	-0.0061	-0.0008	-0.0005	0.0003
	2015-2016	0.0001	0.0000	0.0003	0.0002	0.0001	0.0000	0.0001	0.0009	0.0001	0.0002	0.0001
1000 grain weight (g)	2014-2015	0.0007	-0.0025	0.0030	0.0018	-0.0038	-0.0022	0.0003	0.0024	0.0178	-0.0007	-0.0001
	2015-2016	0.0001	0.0001	0.0001	0.0001	-0.0002	0.0000	-0.0001	0.0001	0.0008	0.0002	0.0001
Biological yield per plant (g)	2014-2015	0.0788	0.3610	0.1080	0.1631	0.1905	-0.0721	0.0403	0.0563	-0.0287	0.7489	-0.1471
	2015-2016	0.1466	0.4117	0.1807	0.0455	0.2420	0.0708	-0.0497	0.1691	0.1914	0.8487	-0.1257
Harvest index (%)	2014-2015	0.0751	0.2500	0.0512	-0.0509	0.0467	-0.0108	0.0413	-0.0329	-0.0042	-0.1369	0.6970
	2015-2016	0.0154	0.1027	0.0042	0.0573	0.0360	0.1127	0.0781	0.0043	0.0535	-0.0985	0.6651
r with grain yield per plant	2014-2015	0.1509	0.6858	0.0665	0.1444	0.2616	-0.0951	0.0919	0.0330	-0.0067	0.6510	0.5733
	2015-2016	0.1584	0.5182	0.1824	0.1082	0.2760	0.1804	0.0219	0.1643	0.2470	0.7511	0.5396

Residual effect for the year 2014-15 and 2015-16 respectively - 0.002 and 0.00.

coefficients, in general, were higher in magnitude than phenotypic correlation coefficient for most of the traits indicating least influence of environmental factors in the expression of association among these traits. The result of F_3 generation (Table 1) revealed, grain yield per plant exhibited positive and highly significant correlation with plant height (0.150*), number of tillers per plant, spike weight number of grains per spike , biological yield per plant and harvest index (0.573**). Biological yield per plant also showed a significant positive correlation with number of tillers per plant (0.482**), spike length (0.144*), spike weight (0.217**) and number of grains per spike (0.254**) (Table 1). Thousand grain weight showed significantly negative correlation with number of grains per spike (-0.211**) and harvest index with biological yield per plant (-0.196**), exhibited negative and significant association with grain yield per plant, indicating that the direct selection for these traits may not be helpful for improving the yield. Exhibited a significant negative association with grain yield, thereby, indicating that direct selection for these traits may not be helpful for improving the yield. Among the association of yield attributing traits themselves, 1000 grain weight has a negatively significant association with biological yield per plant indicating that the improvement in 1000 grain, if selection imparted may hamper the per se performance of that character. Present are in confirmation with Khan *et al.* (2013) and Singh *et al.* (2013), Poor *et al*. (2015).

In the case of F_4 generation, the result (Table 1) revealed that grain yield per plant showed a significant positive correlation with plant height (0.158*), number of tillers per plant (0.518**), spike length (0.182**), number of grains per spike (0.276**), grain length (0.180**), number of spikelet per spike (0.164*), 1000 grain weight (0.247**), biological yield per plant (0.751**), and harvest index (0.539**). Biological yield per plant showed a positively significant correlation with plant height (0.173**), number of tillers per plant (0.485**), spike length (0.213**), number of grains per spike (0.285**), number of spikelets per spike (0.199**),

and 1000 grain weight (0.225**). A significantly positive correlation was also observed between number of grains per spike with spike length (0.204**) and number of tillers per plant (0.174**). Spike weight also exhibited significantly positive correlation with spike length (0.352**). The results are in close agreement with Mohsin *et al.* (2009), Riaz-Ud-Din *et al.* (2010), El-Mohsen *et al.* (2012), Iftikhar *et al.* (2012), Kalimullah *et al.* (2012), Degewione and Alamerew (2013), Nukasani *et al*. (2013), Chhibber and Jain (2014), Mohammadi *et al*. (2014), Singh *et al*. (2016) and Reddy *et al*. (2017). However, 1000 grain weight showed significantly negative correlation with number of grains per spike and harvest index with biological yield per plant.

Path coefficient analysis: Path coefficient analysis provides the information about the cause and effect situation in understanding the cause of association between two variables; it permitted the examination of the direct effect of various characters on yield as well as their indirect effects via other component traits (Majumder et al., 2008). Thus, though the estimates of direct and indirect effect, it determines the yield component. It also estimates of residual effects measure the role of other possible independent variables which are not included in the study. The results of the present investigation on path analysis of F_3 generation revealed (Table 2) that the biological yield per plant (0.7489) had highest positive direct effects on grain yield per plant followed by harvest index (0.6970), number of tillers per plant (0.0689), number of grains per spike (0.0181), 1000 grain weight (0.0178), spike weight (0.0154), grain breadth (0.0104). Plant height (-0.0210), and number of spikelets per spike (-0.0061) had negative direct effect on grain yield per plant and positive indirect effect via several traits. The residual effect recorded lower value (0.002). Thus, indicates majority factors influencing the grain yield were considered in the present study. Whereas, in F_4 generation listed in Table 2 revealed that biological yield per plant (0.8487) harvest index (0.6651) had high direct effects on grain yield per plant followed by spike weight (0.0073), and number of tillers per plant (0.0056), whereas, grain breadth (-0.0056), plant height (-0.0055), spike length (-0.0055) and grain length (-0.0024) had negative direct effect on grain yield per plant. The path analysis also indicated that maximum indirect effect was exhibited by grain yield through harvest index. Plant height and number of spikelets per spike exhibited negative indirect effect through most of the traits. The low residual effect signified that the characters other than those studied had no significant impact on grain yield per plant. The residual effect value showed very low (0.005), thus, indicated majority factors influencing the grain yield per plant was considered in the present study. The present findings are in contrast with Khan *et al*. (2013) and Singh *et al.* (2013) and Poor *et al*. (2015).

Based on all these results, it can be summarized that plant height, number of tillers per plant, number of grains per spike and 1000 grain weight were the most important contributing traits towards grain yield per plant which will help in further yield improvement directly and indirectly. Therefore, emphasis on these traits in selection and improvement of grain yield in wheat breeding programme. Correlation between grain yield per plant and six traits namely with plant height, number of tillers per plant, number of grains per spike, spike weight, biological yield per plant and harvest index was found positive and significant and 1000-grain weight was negatively correlated with number of grains per spike across the generations therefore selection for these traits can directly be followed for yield improvement in wheat. Path coefficient analysis in F_3 and F_4 progenies revealed, biological yield per plant had the highest positive direct effect on grain yield per plant followed by harvest index. Almost all these traits contributed to the grain yield per plant and each trait must be given preference in selecting the superior types. The information's so derived could be exploited in devising further breeding strategies and selection procedures to breed new varieties of wheat with high productivity.

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