Electronic Journal of Plant Breeding, 6(2): 555-559 (June 2015)
ISSN 0975-928X

Research Note

Correlation and path analysis for yield and yield contributing characters in bread wheat (*Triticum aestivum* L.)

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(Received: 12 Aug 2014; Accepted: 06 Oct 2014)

Abstract
Correlation analysis in wheat revealed that harvest index, biological yield per plant, spike length and test weight were positively and significantly associated with grain yield per plant. Path analysis revealed that spike density had the high positive direct effect on grain yield per plant followed by spike length, biological yield per plant, harvest index, days to maturity and test weight. Traits *viz,* spikelets per spike, days to heading, number of grains per spike had negative direct effect on grain yield per plant. Most of the other traits had indirect effect via spike length, plant height and test weight. Hence, these characters should be given more weightage in selection programme of high yielding genotypes in wheat.

Keywords
Bread wheat, correlation, path coefficient, grain yield

Wheat (*Triticum aestivum* L.) is a self-pollinated crop of the member of *Poaceae* family and one of the most leading cereals of many countries of the world including India. It is the most important food crop of India and is a main source of protein and energy. In India, wheat is the second most important food crop after rice both in terms of area and production. It has been described as the 'King of cereals' because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade. It is grown in temperate, irrigated to dry and high-rain-fall areas and in warm, humid to dry, cold environments. Wheat is consumed in a variety of ways such as bread, chapatti, porridge, flour, suji etc. Correlation studies along with path analysis provide a better understanding of the association of different characters with grain yield. Correlation is useful in disclosing the magnitude and direction of the relationship between various yield contributing traits and yield. While path coefficient (or) standardized partial regression coefficient that measures the direct effect of a predictor variable upon its response variable and the second component being the indirect effects of a predictor variable. Therefore the efforts were made to analyse grain yield and its attributing traits of wheat by correlation and path coefficient analysis.

The experimental material consisted 14 wheat genotypes *viz,* GW-273, GW-322, GW-366, JW-1201, JW-1202, JW-1203, LOK-1, HD-2864, HD-2932, HI-1544, JW-3336, JW-3288, MP-3269 and JW-3211 which were selected on the basis of yield performance and evaluated in randomized block design with three replications at Seed Breeding Farm, Department of Genetics and Plant Breeding, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P) during *rabi* 2013-14. Each cultivar was grown in two rows of 2 meter row length with spacing of 30 and 10 (cm) between rows and plants respectively. Recommended package of practices and plant protection measures were followed for healthy crop growth during the season. The observations were recorded on various quantitative characters *viz,* days to heading, days to maturity, plant height (cm), spikelets per spike, spike length (cm), spike density, number of grains per spike, test weight (g), biological yield per plant (g), grain yield per plant (g) and harvest index (%). Five randomly selected competitive plants in each row of each replication for all the characters were recorded for all the characters under study except of days to heading and days to maturity which were recorded on plot basis. Further, the value of harvest index was calculated as per the formula given by Donald and Humblin (1976). Correlation coefficient and path coefficient was worked out as method suggested by Al-Jibouri *et al.* (1958) and Dewey and Lu (1959), respectively.

Correlation coefficient analysis measure eleven natural relation between various plant characters (Table 1) and determine the component characters on which selection can be used for genetic improvement in yield. The correlation coefficient estimated highest positive significant genotypic and phenotypic correlation in harvest index (0.576, 0.665), biological yield per plant (0.554, 0.412) and spike length (0.658, 0.373) while test weight (0.550) showed positive significant correlation only at genotypic level. Similar findings were reported by Kumar *et al.* (2014) that harvest index and biological yield per plant showed positive association with grain yield. High genotypic correlation also suggests that there is an inherent relationship between the characters studied. Thus selection for higher yield on the basis of above characters would be reliable.

When characters having direct bearing on yield are selected, their associations with other character are to be considered simultaneously as they will indirectly affect the yield. Days to heading implied positive significant correlation at both levels with days to maturity (0.932, 0.898), spikelets per spike (0.500, 0.465), spike density (0.728, 0.622) and number of grains per spike (0.510, 0.418) while with plant height (0.413) at genotypic level; days to maturity positively correlated with spikelets per spike (0.569, 0.506), spike density (0.678, 0.542) and number of grains per spike (0.642, 0.578); plant height showed positive significant association with spikelets per spike (0.697, 0.576) and spike density (0.517, 0.424) at both genotypic and phenotypic level while spike length (0.393), test weight (0.519) and number of grains per spike (0.448) at genotypic level; spikelets per spike has positive and significant correlation with spike length (0.573, 0.469), spike density (0.695, 0.693) and test weight (0.601, 0.508) at both genotypic and phenotypic level whereas with number of grains per spike (0.433) at genotypic level; spike length was positively correlated with test weight (0.560, 0.456) at both the levels, while with biological yield per plant (0.470) at the genotypic level; number of grains per spike showed positive association with test weight (0.487, 0.423) at genotypic and phenotypic level and with biological yield per plant (0.472) at genotypic level; test weight showed positive correlation with biological yield per plant (0.413) at the genotypic level; biological yield per plant showed negative significant association with harvest index (-0.394) at the phenotypic level. These results showed close resemblance with the report of Bhushan *et al.* (2013) observed that plant height is positively associated with test weight at the genotypic level. It is important to establish the genetic basis of correlation before initiating breeding programme aimed at yield improvement through component traits. Path coefficient analysis is more useful for partitioning of direct and indirect causes of correlation and also enables to compare the component factors on the basis of their relative contributors.

The path coefficient analysis (Table 2) revealed that highest positive direct effects was noted for spike density (3.3041) followed by spike length (2.8465), biological yield per plant (0.9973), harvest index (0.8293), days to maturity (0.7303) and test weight (0.0048) on the dependent character *i.e.* grain yield per plant. Similar results were reported by Bhushan *et al.* (2013) observed highest contribution towards grain yield with harvest index, biological yield per plant and test weight. Therefore, these characters should be considered as main components for selection in a breeding program for higher grain yield. It was also observed that the highest negative direct effect was exerted by spikelets per spike (-3.7999) followed by days to heading (-0.6892), number of grains per spike (-0.2689) and plant heigh (-0.0840). Rangare *et al.* (2010) and Bhushan *et al.* (2013) reported that days to heading and plant height has direct but negative effects on grain yield.

Days to heading had maximum positive indirect effect via spike length (0.0860) and harvest index (0.1082); days to maturity imposed positive indirect effect via days to heading (0.6807), spike density (0.4952) and number of grains per spike (0.4688); plant height showed positive indirect effect by harvest index (0.0117), indirect effect of spike length was positive via spikelets per spike (1.6332), test weight (1.5958), biological yield per plant (1.3405), plant height (1.1207) and number of grains per spike (1.0446); spike density exhibited positive indirect effect via days to heading (2.4060), spikelets per spike (2.2968) and days to maturity (2.2403); number of grains per spike had positive indirect effect via harvest index (0.0955); test weight had positive indirect effect however magnitude is less; biological yield per plant imposed indirect effect via spike length (0.4697), number of grains per spike (0.4711) and test weight (0.4126); maximum indirect effect showed by harvest index via test weight (0.1828), spike length (0.1808) and spikelets per spike (0.1351). These results are in conformity with the findings of Nukasani *et al.* (2013) revealed that spike length had maximum positive indirect effect via plant height. The residual effect (0.0888) on grain yield per plant was negligible, which suggest that most of the yield component was included in the study.

Hence it can be concluded that in wheat, grain yield per plant was positively and significantly correlated with spike length, biological yield per plant and harvest index. In path coefficient analysis, the highest positive direct effect was noted in spike density, spike length, harvest index and biological yield per plant. So, the traits like spike length, harvest index and biological yield per plant showed positive correlation with yield as well as they have direct effect on yield. Hence these traits can be used as selection indices in wheat to bring about the improvement in yield.

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Electronic Journal of Plant Breeding, 6(2): 555-559 (June 2015)
ISSN 0975-928X

Table 1. Genotypic (G) and phenotypic (P) correlation coefficients among various traits of wheat genotypes

Characters		DTM	PH	SPK	SL	SD	NGS	TW	BYP	HI	GYP
DTH	**G**	0.932**	0.413*	0.500**	-0.124	0.728**	0.510**	0.130	-0.001	-0.157	-0.162
	P	0.898**	0.347	0.465*	-0.132	0.622**	0.418*	0.096	-0.012	-0.057	-0.075
DTM	**G**		0.332	0.569**	0.009	0.678**	0.642**	0.195	-0.026	-0.105	-0.121
	P		0.313	0.506**	0.002	0.542**	0.578**	0.169	-0.051	-0.058	-0.094
PH	**G**			0.697**	0.393*	0.517**	0.448*	0.519**	0.298	-0.138	0.119
	P			0.576**	0.266	0.424*	0.369	0.346	0.158	-0.121	0.0008
SPK	**G**				0.573**	0.695**	0.433*	0.601**	0.229	0.162	0.392
	P				0.469*	0.693**	0.280	0.508**	0.207	0.019	0.185
SL	**G**					-0.188	0.367	0.560**	0.470*	0.218	0.658**
	P					-0.307	0.358	0.456*	0.326	0.076	0.373*
SD	**G**						0.209	0.230	-0.134	-0.010	-0.121
	P						0.019	0.188	-0.028	-0.045	-0.100
NGS	**G**							0.487*	0.472*	-0.355	0.081
	P							0.423*	0.273	-0.114	0.134
TW	**G**								0.413*	0.220	0.550**
	P								0.259	0.109	0.303
BYP	**G**									-0.362	0.554**
	P									-0.394*	0.412*
HI	**G**										0.576**
	P										0.665**

*, ** significant at 5% and 1% level respectively

DTH: Days to heading, DTM: Days to maturity, PH: Plant height, SPK: Spikelets per spike, SL: Spike length, NGS: Number of grains per spike, SD: Spike density, TW: Test weight, BYP: Biological yield per plant, HI: Harvest index, GYP: Grain yield per plant.

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Table 2. Path coefficient showing direct (diagonal) and indirect effect (off diagonal) of different characters on seed yield plant^{-1} in wheat

Characters	DTH	DTM	PH	SPK	SL	SD	NGS	TW	BYP	HI	GYP
DTH	**-0.6892**	-0.6424	-0.2847	-0.3450	0.0860	-0.5019	-0.3521	-0.0897	0.0008	0.1082	-0.1627
DTM	0.6807	**0.7303**	0.2427	0.4156	0.0068	0.4952	0.4688	0.1428	-0.0196	-0.0770	-0.1216
PH	-0.0347	-0.0279	**-0.0840**	-0.0586	-0.0331	-0.0435	-0.0377	-0.0436	-0.0251	0.0117	0.1195
SPK	-1.9021	-2.1625	-2.6492	**-3.7999**	-2.1802	-2.6415	-1.6460	-2.2857	-0.8713	-0.6190	0.3923
SL	-0.3553	0.0265	1.1207	1.6332	**2.8465**	-0.5360	1.0446	1.5958	1.3405	0.6206	0.6583
SD	2.4060	2.2403	1.7099	2.2968	-0.6222	**3.3041**	0.6936	0.7614	-0.4431	-0.0330	-0.1210
NGS	-0.1374	-0.1726	-0.1206	-0.1165	-0.0987	-0.0564	**-0.2689**	-0.1311	-0.1270	0.0955	0.0813
TW	0.0006	0.0009	0.0025	0.0029	0.0027	0.0011	0.0023	**0.0048**	0.0020	0.0011	0.5501
BYP	-0.0012	-0.0267	0.2976	0.2287	0.4697	-0.1337	0.4711	0.4126	**0.9973**	-0.3612	0.5543
HI	-0.1302	-0.0875	-0.1152	0.1351	0.1808	-0.0083	-0.2946	0.1828	-0.3003	**0.8293**	0.5761

Residual Effect = 0.0888

DTH: Days to heading, DTM: Days to maturity, PH: Plant height, SPK: Spikelets per spike, SL: Spike length, NGS: Number of grains per spike, SD: Spike density, TW: Test weight, BYP: Biological yield per plant, HI: Harvest index, GYP: Grain yield per plant.