

CHARACTER ASSOCIATION ANALYSIS IN YIELD AND YIELD COMPONENTS IN BREAD WHEAT (*TRITICUM AESTIVUM* L.) GENOTYPES

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Abstract: A study was undertaken to estimate correlation and path coefficient analysis of yield and yield contributing traits in 50 wheat cultivars grown in Randomized Block Design with three replications during *rabi* season 2013-14. The grain yield per plant has significant and positive correlations both at genotypic and phenotypic levels with biological yield per plant, grain weight per main spike, 1000 grain weight and number of grains per main spike. The path coefficient analysis revealed high and positive direct effects of the number of effective tillers per plant, number of grains per main spike, 1000 grain weight, biological yield per plant and harvest index on grain yield per plant. Thus, these traits are to be considered as the most important yield contributors and due emphasis should be given while attempting yield improvement in wheat.

Keywords: Characters, Correlation, Direct & indirect effects, Grain yield

INTRODUCTION

Wheat (*Triticum aestivum* L. em. Thell.) is a self-pollinated crop of the member of Poaceae family and one of the most leading cereal 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. Globally, demand for wheat by the year 2020 is forecasted around 950 million tonnes to meet future demands imposed by population growth. This target will be achieved only, if global wheat production is increased by 2.5% per annum (Singh *et al.*, 2011).

Wheat is a unique gift of nature to the mankind as it can be moulded into innumerable products like chapatis, breads, cakes, biscuits, pasta and many hot and ready-to-eat breakfast foods. Wheat grain contains starch (60-68%), protein (6-21%), fat (1.5-2.0%), cellulose (2.0-2.5%), minerals (1.8%) and vitamins (Das, 2008). The uniqueness of wheat in contrast to other cereals is that wheat contains gluten protein which enables leavened dough to rise by forming minute gas cells and this property enables bakers to produce light breads.

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 (DWR Vision 2030). The knowledge of patterns of genetic variation of a crop species in any given region or country is very important for planning future germplasm collection missions and for efficient utilization of collected germplasm in crop improvement programmes (Nagi *et al.* 2013).

Understanding of interrelationship between component characters helps in determining which character to select when improvement of the related complex character is desired. The correlation coefficient measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for the improvement in associated complex character–yield (Sokoto *et al.*, 2012; Mohammadi *et al.*, 2012). Simple correlation is partitioned into phenotypic (that can be directly observed), genotypic (inherent association between characters) and environmental (environmental deviation together with nonadditive genetic variation) components. The knowledge of association among the yield and yield contributing characters would be of great help in constructing a suitable plant type and in planning breeding programme. Grain yield, being a complex trait, depends upon component variables and their interaction. Degree and direction of relationship between two or more variables lead to estimation of correlation. Correlation studies provide better understanding of yield component which helps the plant breeder during selection (Robinson *et al.*, 1951 and Johnson *et al.*, 1955). However, the correlation coefficient does not give any indication about comparative magnitude of contribution made by various component characters. Therefore, genotypic path coefficient analysis was carried out to find the direct and indirect effects of yield components and their correlation with grain yield per plant.

MATERIAL AND METHOD

Fifty genotypes of bread wheat were sown in a Randomized Block Design (RBD) with three replications during *rabi* 2014. Each genotype was accommodated in a single row of 2.5 m length with a

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spacing of 22.5 cm between rows. The experiment was surrounded by two guard rows to avoid damage and border effects. Other recommended agronomical practices in vogue were followed for reaping good crop. The observations were recorded on 14 quantitative characters viz., days to 50% flowering, grain filling period, days to maturity, plant height, number of effective tillers per plant, length of main spike, peduncle length of main spike, number of spikelet per main spike, number of grains per main spike, grain weight per main spike, 1000 grain weight, grain yield per plant, biological yield per plant, harvest index. Five randomly selected competitive plants in each row of each replication for all the characters were recorded for all the traits under study except of days to 50 per cent flowering, grain filling period and days to maturity which were recorded on plot basis. The data subjected to different statistical analysis viz., Phenotypic and genotypic correlation coefficients of all the characters were worked-out as per Al-Jibouri *et al.* (1958) and path coefficient analysis was carried-out as per the method suggested by Dewey and Lu (1959).

RESULT AND DISCUSSION

Analysis of variance revealed that highly significant differences among the genotypes were observed for all the traits. Which indicating the presence of good amount of genetic variability among the material studied. The breeder is always concerned for the selection of superior genotype on the basis of phenotypic expression. However, for the quantitative characters, genotypes are influenced by environment, thereby effecting the phenotypic expression. Information regarding the nature and extent of association of morphological character would be helpful in developing suitable plant type, in addition to the improvement of yield a complex character for which direct selection is not effective.

The genotypic correlations were higher than the phenotypic correlation for most of the character studied that indicating least environmental effects on the expression of the traits (Table 1).

Grain yield per plant (g)

Grain yield per plant was found to be significantly and positively correlated with biological yield per plant, grain weight per main spike, 1000 grain weight and number of grains per main spike at both the genotypic and phenotypic levels. The positive genotypic association have been reported between grain yield per plant and biological yield per plant (Yadav *et al.*, 2009 and Gelalcha and Hanchinal, 2013); grain weight per main spike (Kumar *et al.*, 2009b); 1000 grain weight (Kumar *et al.*, 2013a) and number of grains per main spike (Gelalcha and Hanchina, 2013). The grain yield per plant with positive correlation at phenotypic level with number

of effective tillers per plant has been reported by Singh *et al.*, 2012 and Gelalcha and Hanchinal, 2013.

Days to 50% flowering

The days to 50% flowering showed negative and significant correlation both at genotypic and phenotypic levels with harvest index, grain filling period and grain weight per main spike. This character showed positive and significant correlation both at genotypic and phenotypic levels with days to maturity (Kumar *et al.*, 2013b), plant height and number of spikelet per main spike (Sharma *et al.*, 2006). Whereas remaining characters were non-significant at both the levels.

Grain Filling Period

Significant and negative correlation both at genotypic and phenotypic levels for this trait with grain filling period have been also reported by Munir *et al.*, 2007, 1000 grain weight by Singh *et al.*, 2003 and Yadav *et al.*, 2006a and grain weight per main spike by Yadav *et al.*, 2006a. The character grain filling period exhibited positive and significant correlation at genotypic and phenotypic levels with peduncle length of main spike, which have been also reported by Sharma *et al.*, 2006 and Khan *et al.*, 2010.

Days to maturity

The days to maturity showed negative and significant correlation at genotypic level with grain weight per main spike and harvest index, while positive and highly significant at both genotypic and phenotypic levels with plant height and number of spikelet per main spike. The association of days to maturity was positive and highly significant with harvest index at phenotypic level by Sharma *et al.*, 2006 and Khan *et al.*, 2010.

Plant height (cm)

The plant height exhibited significant but negative correlation for harvest index at genotypic level, while positive and significant association with length of main spike, peduncle length of main spike, number of spikelet per main spike and biological yield per plant both at genotypic and phenotypic levels by Sharma *et al.*, 2006 and Khan *et al.*, 2010.

Number of effective tillers per plant

Number of effective tillers per plant exhibited positive and significant association with biological yield per plant, length of main spike and number of spikelet per main spike at genotypic and phenotypic levels. This character showed highly significant and negative correlation with harvest index and significant and negative with grain weight per main spike at genotypic level by Sharma *et al.*, 2006 and Khan *et al.*, 2010.

Length of main spike (cm)

Length of main spike exhibited highly significant and positive correlation with number of spikelet per main spike and biological yield per plant. Length of main spike exhibited significant and positive correlation with number of grain per main spike at both genotypic and phenotypic levels. Whereas significant

and negative correlation with harvest index and 1000 grain weight was found for this character. (Singh *et al.*, 2012 and Gelalcha and Hanchinal, 2013)

Peduncle length of main spike (cm)

Peduncle length of main spike was significantly and positively correlated with the grain weight per main spike only at genotypic level. Whereas remaining characters were non-significant at both the levels.

Number of spikelet per main spike

Number of spikelet per main spike showed highly significant and positive correlation with biological yield per plant and number of grain per main spike at both the genotypic and phenotypic levels. Significant and negative correlation between number of spikelet per main spike and harvest index and 1000 grain weight at genotypic and phenotypic levels were observed.

Number of grains per main spike

The number of grains per main spike was significant and positively correlated with grain weight per main spike and biological yield per plant.

Grain weight per main spike (g)

This trait showed highly significant and positive correlation with 1000 grain weight and biological yield per plant at both genotypic and phenotypic levels while harvest index was highly significantly and positively correlated at genotypic level and it was significant and positive at phenotypic level.

1000 grain weight (g)

The trait 1000 grain weight showed positive and significant correlation with biological yield per plant at genotypic level only.

Biological yield per plant (g)

The biological yield per plant showed highly significant and negative genotypic associations with harvest index at genotypic level only.

Present finding are conformity with those reported earlier in wheat by Sharma *et al.*, 2006; Khan *et al.*, 2010; Bhushan *et al.*, 2013; Gelalcha and Hanchinal, 2013; Kumar *et al.*, 2013b and Kumar *et al.*, 2014b.

The present results on correlation coefficients thus, revealed that the biological yield per plant, grain weight per main spike, number of grains per spike, number of effective tillers per plant, 1000 grain weight, length of main spike and harvest index were the most important traits and may contribute considerably towards higher grain yield. The interrelationship among yield components would help in increasing the yield levels and therefore, more emphasis should be given to these components while selecting better types in wheat.

Path coefficient analysis

While correlation values clarifies the inter-relationship between different characters, path coefficient splits the amount of inter relationship into components, direct and indirect effects as exerted on

dependent character. Therefore, in the present investigation the direct and indirect effect of different component characters as exerted on grain yield plant¹ were estimated and presented in Table 2.

Path coefficient analysis indicated that the number of effective tillers per plant, number of grains per main spike, 1000 grain weight, biological yield per plant and harvest index exhibited high and positive direct effects on grain yield per plant. Thus, these characters turned-out to be the major components of grain yield. The characters like days to 50 % flowering, grain filling period, days to maturity and number of spikelet per spike exerted low and negative direct effects on grain yield per plant. The characters like plant height, length of main spike and peduncle length of main spike exerted low and positive direct effects on grain yield per plant.

The characters grain weight per main spike exerted high but negative direct effects on grain yield per plant. Bhushan *et al.* (2013) and Gelalcha and Hanchinal, (2013) reported high and positive direct effect of biological yield per plant and harvest index on grain yield per plant in wheat. High and positive direct effects on yield via number of effective tillers per plant have been reported by Bhushan *et al.* (2013); number of grains per main spike by Sen and Toms (2007) and 1000 grain weight by Bhushan *et al.* (2013). The positive direct effects of plant height on grain yield have been reported earlier by Rangare *et al.* (2010); length of main spike by Ihsan *et al.* (2004) and peduncle length of main spike by Ihsan *et al.* (2004).

The negative direct effects of days to maturity on grain yield have been reported earlier by Singh *et al.* (2012). The grain filling period, days to 50 % flowering and number of spikelet per main spike exhibited negative direct effect on grain yield per plant have been reported earlier by Singh *et al.* (2007). The grain weight per main spike exhibited high and negative direct effect on grain yield per plant have been reported earlier by Rangare *et al.* (2010) and Bhushan *et al.* (2013).

The direct effect of number of grains per spike was high and positive on grain yield per plant, with positive effects via grain weight per main spike, number of spikelet per main spike, biological yield per plant and length of main spike. The direct effect of 1000 grain weight on grain yield was high and positive. This character also contributed indirectly by exhibiting positive effect *via* grain filling period, peduncle length of main spike, grain weight per main spike, biological yield per plant and harvest index. The character biological yield per plant exhibited high and positive direct effect and contributed indirectly by exerting positive indirect effect *via* all characters expect harvest index.

Table 1. Genotypic (r_g) and phenotypic (r_p) correlation coefficients among 14 characters in 50 genotypes of bread wheat

Characters		Days to 50% flowering	Grain Filling Period	Days to maturity	Plant height (cm)	Number of effective tillers per plant	Length of main spike (cm)	Peduncle length of main spike (cm)	Number of spikelet per main spike	Number of grains per main spike	Grain weight per main spike (g)	1000 grain weight (g)	Biological yield per plant (g)	Harvest index (%)
Grain yield per plant (g)	r_g	-0.2468	0.1581	-0.2077	0.2284	0.2012	0.2713	0.2543	0.1607	0.5027**	0.7855**	0.5421**	0.8010**	0.1576
	r_p	-0.1057	0.1779	-0.0254	0.2089	0.5894**	0.2521	0.209	0.1851	0.4199**	0.6271**	0.3473**	0.8483**	0.2722
Days to 50% flowering	r_g		-0.4912**	0.9121**	0.4513**	0.2464	0.1463	-0.0672	0.4457**	-0.0767	-0.3607**	-0.3137*	0.1773	-0.6928**
	r_p		-0.4624**	0.8839**	0.3937**	0.1917	0.1465	-0.0626	0.4060**	-0.0589	-0.2954*	-0.2957*	0.1617	-0.4809**
Grain filling period	r_g			-0.0909	0.2527	-0.0638	0.1994	0.4546**	0.1145	0.2031	0.1897	0.1747	0.1358	0.0143
	r_p			0.0060	0.1788	0.0087	0.1582	0.3534*	0.0983	0.1744	0.2022	0.1457	0.1507	0.0547
Days to maturity	r_g				0.6349**	0.2517	0.2611	0.1371	0.5634**	0.0079	-0.3231*	-0.2764	0.2666	-0.7853**
	r_p				0.5383**	0.2208	0.2487	0.1158	0.5098**	0.0256	-0.2265	-0.2566	0.2618	0.5135**
Plant height (cm)	r_g					0.2272	0.5989**	0.5799**	0.5316**	0.2802*	0.0926	-0.0922	0.4942**	-0.5131**
	r_p					0.1800	0.5663**	0.5742**	0.4967**	0.2735	0.1288	-0.0663	0.3837**	-0.3048*
Number of effective tillers per plant	r_g						0.4786**	-0.1003	0.4636**	-0.0609	-0.2897*	-0.1942	0.5181**	-0.5572**
	r_p						0.3068*	-0.0032	0.3107*	0.0582	-0.0242	-0.0953	0.6239**	-0.0410
Length of main spike (cm)	r_g							0.1913	0.6146**	0.3234*	-0.0236	-0.3122*	0.4995**	-0.4201**
	r_p							0.1988	0.5906**	0.3347*	0.0443	-0.2919*	0.4313**	-0.2962*
Peduncle length of main spike (cm)	r_g								0.0849	0.2683	0.2886*	0.0962	0.2153	0.0213
	r_p								0.1058	0.2508	0.2552	0.0963	0.2046	0.0066
Number of spikelet per main spike	r_g									0.4960**	-0.0321	-0.4466**	0.5552**	-0.6883**
	r_p									0.4636**	-0.0104	-0.4065**	0.4437**	-0.4365**
Number of grains per main spike	r_g										0.6955**	-0.2664	0.3861**	0.1511
	r_p										0.6634**	-0.2469	0.3657**	0.1154
Grain weight per main spike (g)	r_g											0.4525**	0.4288**	0.4782**
	r_p											0.4139**	0.4623**	0.2924*
1000 grain weight (g)	r_g												0.2985*	0.2901
	r_p												0.2103	0.2124
Biological yield per plant (g)	r_g													-0.4549**
	r_p													-0.2589

*, ** Significant at 5% and 1% levels, respectively

Table 2 Genotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on grain yield in 50 genotypes of bread wheat

Characters	Days to 50% flowering	Grain Filling Period	Days to maturity	Plant height (cm)	Number of effective tillers per plant	Length of main spike (cm)	Peduncle length of main spike (cm)	Number of spikelet per main spike	Number of grains per main spike	Grain weight per main spike (g)	1000 grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Genotypic correlation with grain yield/plant
Days to 50% flowering	-0.1991	0.0978	-0.1816	-0.0899	-0.0491	-0.0291	0.0134	-0.0887	0.0153	0.0718	0.0625	-0.0353	0.1379	-0.2468
Grain Filling Period	0.1154	-0.2349	0.0214	-0.0594	0.0150	-0.0468	-0.1068	-0.0269	-0.0477	-0.0466	-0.0410	-0.0319	-0.0034	0.1581
Days to maturity	-0.0164	0.0016	-0.0180	-0.0114	-0.0045	-0.0047	-0.0025	-0.0102	-0.0001	0.0058	0.0050	-0.0048	0.0141	-0.2077
Plant height (cm)	0.0317	0.0178	0.0447	0.0703	0.0160	0.0421	0.0408	0.0374	0.0197	0.0065	-0.0065	0.0348	-0.0361	0.2284
Number of effective tillers/plant	0.0292	-0.0076	0.0298	0.0269	0.1185	0.0567	-0.0119	0.0549	-0.0072	-0.0343	-0.0230	0.0614	-0.0660	0.2012
Length of main spike (cm)	0.0097	0.0132	0.0173	0.0396	0.0316	0.0661	0.0126	0.0406	0.0214	-0.0016	-0.0206	0.0330	-0.0278	0.2713
Peduncle length of main spike (cm)	-0.0029	0.0195	0.0059	0.0249	-0.0043	0.0082	0.0429	0.0036	0.0115	0.0124	0.0041	0.0092	0.0009	0.2543
Number of spikelet per main spike	-0.0455	-0.0117	-0.0575	-0.0542	-0.0473	-0.0627	-0.0087	-0.1020	-0.0506	0.0033	0.0456	-0.0567	0.0702	0.1607
Number of grains per main spike	-0.0516	0.1368	0.0053	0.1887	-0.0410	0.2178	0.1807	0.3340	0.6734	0.4683	-0.1794	0.2600	0.1018	0.5027**
Grain weight per main spike (g)	0.1234	-0.0649	0.1105	-0.0317	0.0991	0.0081	-0.0987	0.0110	-0.2379	-0.3421	-0.1548	-0.1467	-0.1636	0.7855**
1000 grain weight (g)	-0.1898	0.1057	-0.1673	-0.0558	-0.1175	-0.1889	0.0582	-0.2702	-0.1612	0.2738	0.6051	0.1806	0.1755	0.5421**
Biological yield per plant (g)	0.1065	0.0816	0.1602	0.2969	0.3112	0.3001	0.1293	0.3335	0.2320	0.2576	0.1793	0.6007	-0.2733	0.8010**
Harvest index (%)	-0.1574	0.0032	-0.1784	-0.1166	-0.1266	-0.0955	0.0048	-0.1564	0.0343	0.1087	0.0659	-0.1034	0.2272	0.1576

*, ** Significant at 5 % and 1% levels, respectively

Residual effect, R = 0.1307

N.B.: Values at diagonal indicate direct effects of respective character

In the present study, the characters like number of grains per main spike, grain weight per main spike, 1000 grain weight and biological yield per plant showed positive and significant association with grain yield per plant, as well as high and positive direct effect on grain yield per plant except grain weight per main spike. Hence, these characters may be considered as the most important yield contributing characters and due emphasis given on these components while breeding for high yielding types in wheat.

This type of relationship is due to manifold effect of gene(s). It therefore becomes very difficult to partition such effects by selecting particular characters that are so related. Information obtained from correlation study cannot reflect or give complete idea about the contributors of each character. Therefore, 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 however, more useful for partitioning of direct and indirect causes of correlation and also enables breeders to compare the component factors on the basis of their relative contributors.

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