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Estimation of degree and direction of relationship between the yield contributing characters and yield in bread wheat

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Abstract
The present investigation was carried out on seventy six genotype of bread wheat including six checks with in objective to study the correlation of different quantitative traits with grain yield per plant and among themselves, direct and indirect effects of various yield components for select of superior genotypes. The experiment was carried out during the Rabi season at the research farm of RPCAU, Pusa. The observations were recorded on Germination %, Early vigour, Root: Shoot ratio, Relative leaf water content, Plant height, Flag leaf area, Specific leaf weight, Number of productive tillers per plant, Spikelet sterility, Number of grains per spike, 1000- grain weight, Grain yield per plant, Biological yield per plant, Harvest-index. The mean data with respect to these traits were subjected to statistical analysis. Correlation studies exhibited positive and highly significant correlation for almost all the traits studied with grain yield per plant except spikelet sterility and plant height, Biological yield per plant, harvest index, flag leaf area and root: shoot ratio showed maximum positive direct effects on grain yield per plant. Most of the quantitative traits showed maximum indirect effect through biological yield per plant.

Keywords: Estimation, relationship, contributing characters

Introduction
Triticum aestivum L. is the highly evolved and widely cultivated among all wheat species. In India, systematic wheat research was initiated at the Imperial Agricultural Research Institute, Pusa, Bihar in 1906. Among the earliest successful wheat varieties, evolved through pure line selection from the local mixture of indigenous materials, NP-4, NP-6, NP-12 are worth mentioning.

During recent years a number of high yielding good varieties resistant to biotic stresses for timely sown as well as for late sown situation were evolved which are doing extremely well in the farmers field. But, most of these varieties are suitable for normal land. Wheat is now being grown in wide range for land situation influenced by quite different ecological and socio-economic conditions. With increasing competition for good quality land and water reserves, agriculture will be pushed more and more into marginal environment. The waste lands which now cover a huge area are being put up for different crop cultivation including wheat. The most dominating and wide spread waste lands are saline and alkali effected soils put under cultivation. According to an estimate of CSSRI, Karnal, the total saline and alkaline area in the country is about 10.9 m ha out of which 4 lakh ha., falls only in Bihar.

Correlation studies along with path analysis provide a better understanding of the association of grain yield with different characters. 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 effect(s) of a predictor variable (Dewey and Lu, 1959) [6]. Therefore the efforts were made to study the extent of variability, heritability and possible amount of genetic gain expected to occur during the selection for yield improvement. Similarly, an attempt was made to analyze grain yield and its attributing traits of wheat by correlation and path coefficient analysis.

Materials and Methods
The present investigation was undertaken during the Rabi season in the research farm of RPCAU, Pusa, Bihar which is located at an attitude of 52.18m above mean sea level, longitude

of $85^0$67'E and latitude of $25^0$98'N. The pH and EC of the soil before sowing and after harvesting of the crop were 8.80 and 6.4dSm^{-1} and 8.93 and 4.2Sm^{-1}, respectively. The Experimental material consisted of 70 genotype of wheat (*Triticum aestivum* L.) with 6 checks. These genotype were collected from Central Soil Salinity Research Institute, Karnal. The experimental material was sown in augmented block design. There were 7 blocks of 3m length spaced 23cm apart from row to row. Each block consisted of 10 genotype and 6 checks distributed randomly. In this way, each block had different genotype of the same set of checks distributed randomly. The recommended package of practices were followed to raise a good crop of wheat. Five plant were selected randomly from each genotype and observations were recorded with respect to the following physiological and yield attributing traits including yield *viz*., Germination %, Early vigour (1 to 5 scale), Root: Shoot ratio, Relative leaf water content (%), Plant height (cm), Flag leaf area (cm^2), Specific leaf weight (mg cm^{-2}), Number of productive tillers per plant, Spikelet sterility (%), Number of grains per spike, 1000- grain weight (g), Grain yield per plant (g), Biological yield per plant (g), Harvest-index (%).The phenotypic correlation coefficient and path coefficient Wright (1921) were computed by using the formula of Dewey and Lu, (1959) [6]. Grain yield (kg/ha)was taken as the dependent variable or the effect influence by other characters, the independent variables or the courses. The independent variable was assumed to be affected by independent variable directly as well as indirectly (via other characters). The portion of variation in the grain yield which could not be attributed to any of the associated characters was presumed to be due to an unknown residual 'R' uncorrelated with Other factor.

Results and Discussion

Like in many crop plants, it is the seed yield, which is of prime concern in wheat. Seed yield is not a simple character but the total proliferation of a number of quantitative characters. These characters, in their turn may be influenced on one way or the other by the environment. Evidently, it becomes imperative to investigate and find out the correlation, existing between yield and other component characters and also between and amongst different attributing characters Rajshree and Singh (2016) [15], In present investigation simple correlation coefficients were computed between the characters and presented in Table1.

Persual of Table 1 revealed that germination, early vigour, root: Shoot ratio, relative leaf water content, flag area, specific leaf weight, number of productive tillers per plant, number of grain per spike, 1000 grain weight, biological yield and harvest index showed positive and highly significantly correlation with grain yield whereas the spikelet sterility was significantly and negatively correlated with grain yield per plant.

Among the component traits germination was positively and significantly correlated with early vigour, root: shoot ratio, relative leaf water content, flag leaf area, specific leaf weight, number of productive tillers per plant, number of grain per spike, 1000 grain weight, biological yield per plant and harvest index whereas, significant negative correlation was found with spikelet sterility. Early vigour was observed to show positive and highly significant correlation with all the characters including grain yield per plant except plant height and sterility. Sterility was negatively correlated with early vigour (Ayer et al. 2017) [3].

Similarly root: shoot ratio, relative leaf water content, flag leaf area, specific leaf weight, and number of productive tillers per plant were found to show significant positive correlation with number of grains per spike, 1000 grain weight, biological yield per plant and harvest index. The above component traits showed negative significant correlation with spikelet sterility. Correlation between plant height and other component traits including yield were non-significant.

Spikelet sterility was positively and significantly associated with number of grain per spike, 1000 grain weight, biological yield and harvest index. Biological yield and harvest index were found to show positive significant correlation with grain yield per plant. In present investigation almost all the traits studied were found to show positive and significant correlation with grain yield per plant and these traits were the main yield components in the crop under salinity condition and selection for these traits would result in the increase in grain yield per plant. Grain yield per plant showed negative and significant correlation with spikelet sterility whereas for plant height it was non-significant. The present results on correlation studies corroborates with the result of Ahmad et al. (1978) [1], Sinha and Sharma (1980) [21], Singh (1984) [18], Anderson (1986) [2], Singh et al. (1989) [19], Tahara et al. (1990) [22], Namatullah (1991) [12], Budak et al. (1999) [4], Gupta et al. (1999) [8], Mondal et al. (2001) [11], Prasad (2003) [14], Sakhare and Ghawat (2011) [16], Fano et al. (2016) [7].

Path analysis gives a better picture of relative importance of direct and indirect effects of each of the independent variables on the resultant character, the economic yield. In the present investigation, the phenotypic correlation of yield with yield attributing traits were computed and partitioned into their corresponding direct and indirect effects through the plant coefficient analysis and the result obtained was presented in Table-2.

The analysis (Table-2) revealed that amongst the characters studies the important characters having high direct effects on grain yield per plant were biological yield, harvest index, and flag leaf area. Besides these three characters, all other characters had low direct effect on grain yield per plant. Early vigour, plant height and spikelet sterility showed negative direct effects on grain yield per plant. Germination showed a direct effect of 0.0133 on yield, however, its indirect effect on grain yield per plant via biological yield per plant was maximum (0.5368) followed by indirect effects via spikelet sterility (0.1576) and harvest index (0.1279). Early vigour showed negative direct effect on yield and its maximum indirect effect on yield was observed via biological yield per plant (0.3227). Indirect effects via spikelet sterility, harvest index, flag leaf area and root: shoot ratio were also high.

Root: shoot ratio showed positive direct effect on yield and maximum indirect effects via biological yield per plant followed by spikelet sterility, harvest index and flag leaf area. It showed negative indirect effect via early vigour. Relative leaf water content showed low direct effect on grain yield per plant and like other characters it also showed maximum indirect effect on grain yield per plant via biological yield per plant followed by spikelet sterility, harvest index and flag leaf area. Plant height showed no association with grain yield per plant. Its direct effect on grain yield and indirect effects via most of the traits were observed to be negative.

Flag leaf area higher and positive direct effect on grain yield per plant. Its indirect effect on grain yield via biological yield per plant was maximum (0.5440) followed by spikelet

sterility, harvest index and root: shoot ratio. Specific leaf weight, number of productive tillers per plant, number of grains per spike and 1000 grain weight showed low and positive direct effects on grain yield per plant and indirect effects of these traits via biological yield per plant were maximum as also observed in other traits. Other important traits for indirect effects were spikelet sterility and harvested index.

Spikelet sterility showed negative significant correlation with yield per plant and its direct effect on grain yield and indirect effects on grain yield via different yield attributing traits were observed to be negative. Biological yield per plant was observed to be the most important yield contributing traits as it showed positive significant correlation with grain yield per plant and its direct effect on yield was also positive and maximum (0.5995). its indirect effect on yield via early vigour was negative like other traits. Harvest index was found to be the next significant yield attributing traits after biological yield per plant. Its direct effect on grain yield was positive and high (0.2468) and indirect effects on yield were high via biological yield per plant and spikelet sterility ojha et al. (2018) [13].

In the present investigation it was found that out of thirteen traits four traits *viz*., biological yield per plant, harvest index, flag leaf area, root: shoot ratio showed positive direct effect of higher magnitude on grain yield per plant with highly significant positive correlation with yield. This indicate that these traits might have played major role in the enhancement of the grain yield per plant. Similar results were also reported by Singh (1984) [18], Sharma and Singh (1991), Singh (1995) [20], Ismail (2001) [9], Prasad (2003) [14], Tsegaya et al. (2012) [23], Dargicho et al. (2015) [5], Lad (2003) [10] and Ayer et al. (2017) [3].

Table 1: Phenotypic correlation coefficient between pairs of fourteen quantitative traits in wheat genotypes

Characters	Early vigour	Root: shoot ratio	Relative leaf water content	Plant height	Flag leaf area	Specific leaf weight	Number of productive tillers per plant	Spikelet sterility	Number of grains per spike	1000-grain weight	Biological yield per plant	Harvest-index	Grain yield per plant
Germination	0.5356**	0.9245**	0.9045	-0.0091	0.9219**	0.7447**	0.8823**	-0.9188**	0.9148**	0.9301**	0.8954**	0.5182**	0.9426**
Early vigour		0.5283**	0.5498**	0.8270	0.4928**	0.4707**	0.5542**	-0.5470**	0.5409**	0.5592**	0.5583**	0.2125*	0.5356**
Root: shoot ratio			0.9238**	-0.0917	0.9448**	0.7955**	0.9416**	-0.9571**	0.9351**	0.9365**	0.8963**	0.5442**	0.9595**
Relative leaf water content				-0.1130	0.9389**	0.8137**	0.9305**	-0.9631**	0.9431**	0.9280**	0.8969**	0.5338**	0.9570**
Plant height					0.1133	-0.1025	-0.1156	0.1218	-0.1039	-0.0871	-0.0936	0.0453	-0.0829
Flag leaf area						0.7763**	0.9563**	-0.9758**	0.9611**	0.9533**	0.9047**	0.5844**	0.9819**
Specific leaf weight							0.7795**	-0.8086**	0.7919**	0.7906**	0.7666**	0.4291**	0.8062**
Number of productive tillers per plant								-0.9624**	0.9535**	0.9347**	0.8918**	0.5509**	0.9589**
Spikelet sterility									0.9624**	0.9686**	0.9270**	0.5533**	-0.9895**
Number of grains per spike										0.9432**	0.9086**	0.5563**	0.9721**
1000- grain weight											0.9284**	0.5183**	0.9736**
Biological yield per plant												0.2545**	0.9390**
Harvest-index													0.5669**

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

Table 2: Direct and indirect phenotypic effects of different characters towards grain yield in wheat genotypes

Characters	Germination	Early vigour	Root: shoot ratio	Relative leaf water content	Plant height	Flag leaf area	Specific leaf weight	Number of productive tillers / plant	Spikelet sterility	No. of grains per spike	1000-grain weight	Biological yield / plant	Harvest-index	Grain yield per plant
Germination	0.0133	-0.0005	0.0209	0.0094	0.0000	0.0503	0.0003	0.0067	0.1576	0.0189	0.0010	0.5368	0.1279	0.9426**
Early vigour	0.0071	-0.0008	0.0119	0.0057	-0.0004	0.0269	0.0002	0.0042	0.0938	0.0112	0.0006	0.3227	0.0524	0.5356**
Root: shoot ratio	0.0123	-0.0004	0.0226	0.0096	0.0004	0.0515	0.0004	0.0072	0.1642	0.0193	0.0010	0.5373	0.1343	0.9595**
Relative leaf water content	0.0120	-0.0005	0.0208	0.0104	0.0005	0.0512	0.0004	0.0071	0.1652	0.0195	0.0010	0.5377	0.1317	0.9570**
Plant height	-0.0001	-0.0001	-0.0021	-0.0012	-0.0043	-0.0062	-0.0000	-0.0009	-0.0209	-0.0021	-0.0001	-0.0561	0.0112	-0.0829
Flag leaf	0.0123	-0.0004	0.0213	0.0097	0.0005	0.0545	0.0003	0.0073	0.1675	0.0199	0.0010	0.5440	0.1442	0.9819**

area														
Specific leaf weight	0.0096	-0.0004	0.0179	0.0084	0.0004	0.0423	0.0004	0.0060	0.1387	0.0164	0.0008	0.4596	0.1059	0.8062**
Number of productive tillers / plant	0.0117	0.0005	0.02012	0.0096	0.0005	0.0521	0.0003	0.0076	0.1651	0.0195	0.0010	0.5346	0.1360	0.9589**
Spikelet sterility	-0.0122	-0.0005	-0.0216	-0.0100	-0.0005	-0.0532	-0.0004	-0.0074	-0.1715	-0.0199	-0.0010	-0.5547	-0.1365	-0.9895**
No. of grains per spike	0.0122	-0.0005	0.0211	0.0098	0.0004	0.0524	0.0004	0.0072	0.1655	0.0207	0.0010	0.5447	0.1373	0.9721**
1000-grain weight	0.0124	-0.0005	0.0211	0.0096	0.0004	0.0520	0.0004	0.0071	0.1661	0.0195	0.0010	0.5565	0.1279	0.9736**
Biological yield / plant	0.0119	-0.0005	0.0202	0.0093	0.0004	0.0495	0.0003	0.0068	0.1590	0.0188	0.0010	0.5995	0.0628	0.9390**
Harvest-index	0.0069	-0.0002	0.0123	0.0055	-0.0002	0.0319	0.0002	0.0042	0.0949	0.0115	0.0005	0.1526	0.2468	0.5669**

Residual effect = 0.0333

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

Conclusion

Out of seventy genotypes, NW(S) 02-13 was found to be the best for germination percentage, early vigour, root: shoot ratio, flag leaf area, number Of productive tillers per plant, spikelet sterility percentage, number of grains per spike and grain yield per plant. The maximum 1000 grain weight was found in Genotype KLPO-265 and KYZO-295 whereas, the best genotype with respect to biological yield per plant and harvest index were KLP-18 and KYZO-291, respectively. Correlation studies exhibited positive and highly significant correlation for almost all the traits studied with grain yield per plant except spikelet sterility, which showed negative and significant correlation with grain yield, and plant height, for which it was non-significant. Path coefficient revealed that the characters namely biological yield per plant, harvest index, flag leaf area and root: shoot ratio had high and positive direct effects on grain yield per plant. Almost all the component traits showed maximum indirect effect via biological yield per plant followed by harvest index, spikelet sterility and flag leaf area.

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