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Correlation and path coefficient analysis in rice (*Oryza sativa* L.) genotypes for yield and its attributing traits

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Abstract
Yield is one of the most important trait considered in any breeding programme. To find the traits attributing the yield and its effect on yield, the present experiment was done with thirty four rice genotypes using correlation and path coefficient analysis. Twelve characters viz., plant height, days to 50% flowering, days to maturity, number of effective tillers per plant, panicle length, number of spikelets per panicle, number of fertile grains per panicle, biological yield, grain yield, 1000 grain weight and harvest index was taken. Out of the twelve characters, effective number of tillers per plant, number of spikelets per plant, number of fertile grains per plant and biological yield per plant were found to be strong positively correlated with grain yield while plant height, days to 50% flowering, panicle length and flag leaf length had revealed negative correlation with grain yield. Biological yield per plant and harvest index exhibited high positive direct effect on grain yield whereas negative direct effect was exhibited by plant height and days to maturity. The traits like effective number of tillers per plant number of spikelets per plant, number of fertile grains per panicle and biological yield per plant can be utilized for the selection of high yielding rice genotypes and can be further used in crop improvement programme.

Keywords: Yield, Correlation coefficient, Path coefficient

Introduction
Rice (*Oryza sativa* L.) is one of the most important staple cereal crops feeding more than half of the world population. In view of the growing population, the basic objective of the plant breeders would always be towards yield improvement in staple food crops. It has been estimated that the world will have to produce 60% more rice by 2030. Yield and yield attributing parameters are the most widely targeted traits for rice improvement programmes in world.

Yield is a complex polygenic character, resulting from multiple interactions between many yield attributing traits. Associations between these traits can be evaluated by correlation analysis, which helps in the simultaneous selection of one or more than one character (Akhtar *et al.* 2011; Sathya and Jebaraj, 2013; Semahegn and Tesfaye, 2016) [2, 22, 23]. The degree of connection between important plant traits is an index that can be used to predict yield responses in relation to changes associated with a particular character (Malek *et al.* 2014) [15]. So, for rice genotypes, identification of key characters associated with yield and other contributing components is important for maximizing yields (Aditya *et al.* 2011; Meitei *et al.* 2014; Jain *et al.* 2015) [1, 9]. Correlation coefficients alone are insufficient to understand cause and effect relationships among traits associated with yield, whereas path coefficient analysis allows a better understanding of associations between different characters, by breaking down correlation coefficients associated with the main character into direct and indirect effects (Rahman *et al.* 2011; Hossain *et al.* 2015) [20, 8]. The correlation value signifies only the nature and extent of association existing between pairs of characters. The yield is dependent on several contributing characters that are mutually associated and change in any one component is likely to disturb the effect of other. Each contributing characters has two parts of action *viz.*, the direct effect and the indirect effects through yield contributing characters on economic

characters which are not revealed from the correlation coefficient analysis. Path analysis provides an applicable means to partition correlation coefficients into unidirectional and alternative pathways, thus help in critical examination of the specific trait that produce a given correlation; this can then be employed to formulate an effective selection programme (Salahuddin *et al.* 2010; Lal *et al.* 2011; Parmar *et al.* 2013; Jain *et al.* 2015) [21, 12, 18, 9]. Considering the above facts, the present research study was undertaken to evaluate the associations among yield and yield attributing traits for rice genotypes, using correlation and path analysis. This investigation provides information that could lead to the development of desirable genotypes in future breeding programmes.

Materials and methods

The present experiment consisted of 34 rice genotypes collected from Rice Research Section of Bihar Agricultural College, Sabour, Bhagalpur and was conducted at Research Farm of Bhola Paswan Shastri Agricultural College, Purnea. These 34 rice genotypes were grown in randomized block design with three replications. The plant to plant and row to row distance was maintained at 20x15 cm. The recommended agronomical practices were followed to ensure a normal healthy crop. The reading from five tagged plants were averaged replication wise and the mean data of twelve characters namely, days to 50% flowering, days to maturity, plant height, number of effective tillers per plant, panicle length, flag leaf length, number of spikelets per panicle, fertile grains per panicle, biological yield per plant, grain yield per plant, 1000 grain weight and harvest index was used for statistical analysis.

Results and discussion

In the present investigation correlation coefficient analysis measure the mutual relationship between twelve different morphological and reproductive characters to determine the component character on which selection can be emphasized for yield improvement. The phenotypic and genotypic correlation coefficients are presented in Table- 1 & 2 respectively. In general, the magnitudes of genotypic correlation coefficients were higher than the respective phenotypic correlation coefficient. Here phenotypic correlation is discussed in detail.

Phenotypic correlation analysis

Character association of grain yield per plant with other characters

The result shows that the effective tillers/plant (0.726), biological yield/plant (0.705) spikelets/panicle (0.632), fertile grains/panicle (0.614), harvest index (0.513) showed strong positive significant association with grain yield while, significant negative association was found for plant height (-0.113) and panicle length (-0.170). For other characters, like days to 50% flowering (-0.065), days to maturity (-0.067) and flag leaf length (-0.035), the correlation was negative and non-significant.

Characters association among other characters

Days to 50% flowering showed positive and significant association with Plant height, days to maturity and flag leaf length, while significantly negative correlation was observed for 1000grain weight and harvest index. Days to maturity exhibited significant positively association with Plant height, days to 50% flowering and significantly negative correlation was observed with 1000grain weight. The Plant height showed positive and significant association with flag leaf length, days to 50% flowering and days to maturity, while significantly negative correlation was observed with 1000 grain weight. Panicle length showed non-significant association with all characters studied. Effective tillers/plant noted to be significantly and positively associated with spikelets/panicle, fertile grains/panicle, biological yield/plant and harvest index. Flag leaf length observed to have positive significant association with plant height and days to 50% flowering but significant negatively associated with harvest index.

Spikelets/panicle showed positive and significant association with effective tillers/plant, fertile grains/panicle and biological yield/plant.

Fertile grains/panicle showed positive and significant association with effective tillers/plant, spikelets/panicle and biological yield/plant. 1000 grain weight showed negative but significant association with plant height, days to flowering and days to maturity. Biological yield/panicle showed positive and significant association with effective tillers/plant, spikelets/panicle and fertile grains/panicle. Harvest index showed positive significant association with effective tillers/plant and negative but significant association with days to flowering and flag leaf length. The similar result was also obtained by Kumar *et al.,* (2011) [10], Das *et al.,* (2015) [5] and Sharma *et al.,* (2016) [24] in rice.

Estimation of Path coefficient analysis

The direct and indirect effects of the studied characters on grain yield at phenotypic and genotypic level are presented in Table- 3 & 4, respectively. Here phenotypic path coefficient analysis is discussed in detail following the classification given by Lenka and Mishra (1973) [13].

Phenotypic path coefficient analysis

Biological yield/plant (0.699) and harvest index (0.576) had high positive direct effect whereas effective tillers/plant (0.123) had low positive direct effect on grain yield/plant. Negligible positive direct effect was exhibited by days to 50% flowering (0.069), panicle length (0.007), flag leaf length (0.002), fertile grains/panicle (0.067) and 1000grainweight (0.001) whereas negative direct was exhibited by plant height (-0.024), days to maturity (-0.064) and spikelets/panicle (-0.017) on grain yield /plant.

Plant height had negligible indirect positive effect on grain yield/plant via days to 50% flowering, panicle length, flag leaf length, fertile grains/panicle and biological yield/plant while negative indirect effect via days to maturity, effective tillers/plant, spikelets/panicle, 1000grain weight and harvest index.

Days to 50% flowering had negligible indirect positive effect on grain yield/plant via panicle length, effective tillers/plant, flag leaf length, spikelets/panicle and biological yield/plant while negative indirect effect via plant height, days to maturity, fertile grains/panicle, 1000 grain weight and harvest index.

Days to maturity had also positive indirect effect via days to 50% flowering effective tillers/plant, flag leaf length, spikelets/panicle and biological yield/plant while negative indirect effect via plant height, panicle length, fertile grains/panicle, 1000grain weight and harvest index.

Panicle length was observed negligible indirect positive effect on grain yield/ha via days to 50% flowering, days to maturity, flag leaf length, fertile grains/panicle and 1000grain weight

while negative indirect effect via plant height, effective tillers/plant, spikelets/panicle, biological yield/plant and harvest index.

Effective tillers/plant had high positive indirect effect via biological yield/plant while low positive indirect effect via harvest index and negligible positive indirect effect via plant height, days to 50% flowering, flag leaf length, fertile grains/panicle and 1000 grain weight. Negative indirect effect was observed via days to maturity, panicle length and spikelets/panicle.

Flag leaf length had low indirect positive effect on grain yield/ha via biological yield/plant while negligible positive indirect effect via days to 50% flowering, panicle length, effective tillers/plant and fertile grains/panicle. Negative indirect effect was observed via plant height, days to maturity, spikelets/panicle, 1000 grain weight and harvest index.

Spikelets/panicle had high positive indirect effect via biological yield/plant while negligible positive indirect effect via days to maturity, panicle length, effective tillers/plant, flag leaf length, fertile grains/panicle, 1000 grain weight and harvest index. Negative indirect effect was observed via plant height and days to 50% flowering. Fertile grain/panicle had high positive indirect effect via biological yield/plant while negligible positive indirect effect via days to maturity, panicle length, effective tillers/plant, flag leaf length, 1000 grain weight and harvest index. Negative indirect effect was observed via plant height and days to 50% flowering and spikelets/panicle.

1000 grain weight had negligible positive indirect effect via plant height, days to maturity, panicle length, effective tillers/plant, fertile grains/panicle and harvest index while negative indirect effect was observed via days to 50% flowering, flag leaf length, spikelets/panicle and biological yield.

Biological yield/plant was observed negligible positive indirect effect via days to 50% flowering, effective tillers/plant, flag leaf length and fertile grains/panicle while negative indirect effect was observed via plant height, days to maturity, panicle length, spikelets/panicle, 1000grainweight and harvest index.

Harvest index had also negligible positive indirect effect via plant height, days to maturity, effective tillers/plant, fertile grains/panicle and 1000grain weight while negative indirect effect was observed via days to 50% flowering, panicle length, flag leaf length, spikelets/panicle and biological yield/plant.

High positive overall effect on grain yield /plant was observed for the characters like effective tillers/plant, spikelets/panicle, fertile grains/panicle, biological yield/plant and harvest index. These characters have strong correlation with grain yield/plant so, the direct selection for these characters will be rewarding for yield improvement.The findings of the present investigation is in accordance with Patel *et al.* (2014) [19], Yadav *et al.* (2015) [25] and Kumar *et al.* (2016) [11].

Table 1: Phenotypic correlation coefficient between yield and its component traits in 34 rice genotypes

Characters	Days to 50% flowering	Days to maturity	Plant height	Number of effective tillers/plant	Panicle length	Flag leaf length	Number of spikelets / plant	Number of fertile grains/plant	Biological yield/plant	1000 grain weight	Harvest index
Days to 50% flowering	1.00	0.912*	0.432*	0.030	0.109	0.277*	-0.021	-0.021	0.115	-0.484*	-0.255*
Days to maturity		1.00	0.374	-0.020	-0.040	0.251*	-0.056	-0.104	0.098	0.521*	-0.211*
Plant height			1.00	-0.017	0.130	0.443*	0.009	0.094	0.055	-0.272	-0.241*
Number of effective tillers/plant				1.00	-0.186	0.080	0.665*	0.701	0.573*	0.202*	0.290*
Panicle length					1.00	0.072	0.028	0.032	-0.131	0.008	-0.124
Flag leaf length						1.00	0.192	0.134	0.169	-0.086	-0.283*
Number of spikelets/ plant							1.00	0.836*	0.046	0.598*	0.157
Number of fertile grains/plant								1.00	0.530*	0.112	0.175
Biological yield/ plant									1.00	-0.092	-0.154
1000 grain weight										1.00	0.185
Harvest index											1.00
Grain yield/plant	-0.065	-0.067	-0.113	0.726*	-0.170	-0.035	0.632	0.614*	0.703*	0.081	0.513*

Note: *- Show significant result.

Table 2: Genotypic correlation coefficient between yield and its component traits in 34 rice genotypes

Characters	Days to 50% flowering	Days to maturity	Plant height	Number of effective tillers/plant	Panicle length	Flag leaf length	Number of spikelets / plant	Number of fertile grains/plant	Biological yield/plant	1000 grain weight	Harvest index
Days to 50% flowering	1.00	0.981*	0.458*	0.030	0.141	0.338*	-0.049	-0.087	0.171	-0.546*	-0.301*
Days to maturity		1.00	0.465*	-0.020	0.057	0.280*	-0.077	-0.111	0.074	-0.581*	-0.325*
Plant height			1.00	-0.017	0.150	0.534*	-0.041	-0.123	0.202	-0.404*	-0.258*
Number of effective tillers/plant				1.00	-0.135	0.159	0.941*	0.974*	0.803*	0.177	0.448*
Panicle length					1.00	0.145	0.071	-0.010	-0.087	-0.007	0.001
Flag leaf length						1.00	0.178	0.114	0.251	-0.087	-0.421*
Number of spikelets/ plant							1.00	1.060*	0.815*	0.086	0.311*
Number of fertile grains/plant								1.00	0.910*	0.121	0.354*
Biological yield/ plant									1.00	-0.065	-0.252*
1000 grain weight										1.00	0.286*
Harvest index											1.00
Grain yield/plant	-0.035	-0.142	0.002	1.01**	-0.047	0.007	0.959*	1.00*	0.783*	0.117	0.459*

Note: *- Show significant result.

Table 3: Direct and indirect effect of component traits attributing to grain yield (Phenotypic level)

Characters	Days to 50% flowering	Days to maturity	Plant height	Number of effective tillers/plant	Panicle length	Flag leaf length	Number of spikelets / plant	Number of fertile grains/plant	Biological yield/plant	1000 grain weight	Harvest index
Days to 50% flowering	0.069	0.063	0.030	0.001	0.007	0.019	-0.001	-0.001	0.008	-0.033	-0.017
Days to maturity	-0.058	-0.064	-0.024	-0.001	0.002	-0.016	0.003	0.006	-0.006	0.033	0.013
Plant height	-0.010	-0.092	-0.024	0.000	-0.003	-0.010	-0.000	-0.002	-0.001	0.006	0.006
Number of effective tillers/plant	0.001	0.003	-0.001	0.136	-0.023	0.009	0.082	0.086	0.070	0.025	0.035
Panicle length	0.000	-0.000	0.001	-0.001	0.007	0.000	0.000	0.000	-0.001	0.000	-0.000
Flag leaf length	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.003	-0.000	-0.000
Number of spikelets/ plant	0.000	0.001	-0.000	-0.011	-0.000	-0.003	-0.017	-0.014	-0.010	-0.000	-0.002
Number of fertile grains/plant	-0.001	-0.007	0.006	0.047	0.002	0.009	0.056	0.067	0.035	0.007	0.011
Biological yield/ plant	0.080	0.068	0.039	0.401	0.091	0.118	0.418	0.370	0.699	-0.004	-0.107
1000 grain weight	-0.000	-0.000	-0.000	0.000	0.000	-0.000	0.000	0.000	-0.000	0.001	0.000
Harvest index	-0.147	-0.121	-0.139	0.167	-0.071	-0.163	0.090	0.101	-0.088	0.106	0.576
Grain yield/plant	-0.065	-0.067	0.113	0.726	-0.170	-0.035	0.632	0.614	0.705	0.818	0.513

R Square = 0.911, Residual Effect =0.299

Table 4: Direct and indirect effect of component traits attributing to grain yield (Genotypic level)

Characters	Days to 50% flowering	Days to maturity	Plant height	Number of effective tillers/plant	Panicle length	Flag leaf length	Number of spikelets / plant	Number of fertile grains/plant	Biological yield/plant	1000 grain weight	Harvest index
Days to 50% flowering	-0.278	-0.275	-0.127	-0.084	-0.039	-0.094	0.013	0.024	0.152	-0.047	0.084
Days to maturity	0.064	0.065	0.003	-0.001	0.003	0.018	-0.005	-0.007	-0.037	0.004	-0.021
Plant height	-0.026	-0.027	-0.058	0.001	-0.008	-0.031	0.002	0.007	-0.011	0.023	0.015
Number of effective tillers/plant	0.031	-0.021	-0.018	1.049	-0.142	0.167	0.988	1.022	0.843	0.186	0.470
Panicle length	0.029	0.012	0.031	-0.028	0.211	0.030	0.015	-0.002	-0.018	-0.001	0.004
Flag leaf length	-0.014	-0.011	-0.022	-0.006	-0.006	-0.042	-0.007	-0.004	-0.010	0.003	0.017
Number of spikelets/ plant	0.014	0.022	0.011	-0.270	-0.020	-0.051	-0.287	-0.304	-0.234	-0.024	-0.089
Number of fertile grains/plant	0.024	0.031	0.034	-0.276	0.003	-0.032	-0.300	-0.283	-0.257	-0.034	-0.100
Biological yield/ plant	0.098	0.042	0.116	0.461	-0.050	0.144	0.468	0.522	0.574	-0.037	-0.144
1000 grain weight	0.105	0.112	0.078	-0.034	0.001	0.016	-0.016	-0.023	0.012	-0.193	-0.055
Harvest index	-0.085	-0.091	-0.073	0.126	0.005	-0.118	0.087	0.100	-0.071	0.080	0.282
Grain yield/plant	-0.035	-0.142	0.002	1.013	-0.047	0.007	0.959	1.051	0.783	0.117	0.459

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