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Correlation and path coefficient analysis of thirteen rice genotypes for grain yield and other yield attributing traits

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Abstract
The present investigation is carried out to study the correlation and path coefficient analysis in 13 genotypes of rice (*Oryza sativa* L.). Field experiment was conducted in a randomized block design with three replications during the *Kharif* season in 2014-15 at students instructional farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad. Correlation coefficient analysis revealed that grain yield per plant showed highly significant and positive correlation with biological yield per plant, harvest index, flag leaf area and spikelets per panicle, while significant positive correlation with grains per panicle. Path analysis exhibited that spikelets per panicle, spikelets fertility and biological yield per plant showed positive direct effect on grain yield per plant. So, the improvement in grain yield would be effective and economical, if the selection is based on these component traits.

Keywords: correlation coefficient, path coefficient, grain yield per plant

Introduction
Rice (*Oryza sativa* L., 2n = 2x= 24) is the principal staple cereal food and source of calories for more than half of the world's population. Grain yield is a complex character and is controlled by many factors. Selection for desirable types should not only be restricted to grain yield alone but other components related to grain yield should also be considered. The correlation coefficient may help to identify characters that have little or no importance in the selection programme. The existence of correlation may be attributed to the presence of linkage or pleiotropic effect of genes or physiological and development relationship or environmental effect or in combination of all (Oad *et al.* 2002) [14]. Path coefficient analysis is a statistical technique of partitioning the correlation coefficients into its direct and indirect effects (Dewey and Lu, 1959) [2] so that the contribution of each character to yield could be estimated. It is used in plant breeding programs to determine the nature of the relationships between yield and yield components that are useful as selection criteria to improve the crop yield. The goal of the path analysis is to accept descriptions of the correlation between the traits, based on a model of cause and effect relationship and to estimate the importance of the affecting traits on specific traits (Milligan *et al.* 1990) [11].
In this study, an attempt was made to study the direct and indirect influences of some important yield components on grain yield in breeding lines by adopting correlation and path coefficent analysis under thrace conditions. The results might be used to adopt selection criteria in further studies. It may increase the selection
Efficiency. Therefore, breeders save time and expenses during selection.

Materials and Methods
The experiment was conducted in the Student instructional farm of NDUA&T in *Kharif* 2014-15. The site is located between latitude of 24^0 47' north to 26^0 56" north and longitudes of 81^0 12' east and 83^0 98' east, on an altitude of 113 meters above the mean sea level. The seeds of rice genotype were sown in nursery bed. After 21 days, single seedling per hill was transplanted with 20 cm row to row and 15 cm plant to plant spacing in randomized block design (RBD) with three replications. Observations were recorded on days to 50% flowering, days to maturity, plant height(cm), panicle bearing tillers per plant, spikelet's per panicle, grains per panicle, spikelet's fertility (%), test weight (g), biological yield per plant (g), harvest index (%) and grain yield per plant(g).

Results and Discussion

Correlation coefficient

The simple correlation coefficients between yield and its related characters were estimated and the results are presented in Table 1 and Table 2.

At phenotypic level, grain yield per plant showed highly significant and positive correlation with biological yield per plant (0.83), harvest index (0.66), flag leaf area (0.43) and spikelets per panicle (0.40), while significant positive correlation with grains per panicle (0.33). These results were in consonance with the earlier reports of Shashidhar *et al.* (2005) [17]; Krishna *et al.* (2008) [6]; Naik *et al.* (2005) [12]; Akhtar *et al.* (2011) [1]; Gulzar *et al.* (2012) [3]. Harvest index showed highly significant and positive correlation with flag leaf area (0.51) and significant positive correlation with spikelets per panicle (0.31), while plant height (-0.34) showed significant and negative correlation. Biological yield per plant showed significant and positive correlation with spikelets per panicle (0.35) (Laxmi *et al.* 2014; Venkann *et al.* 2014) [9, 18]. Test weight showed significant and negative correlation with spikelets per panicle (-0.47). Days to maturity (-0.39) and grains per panicle (-0.38) showed significant negative association with test weight, while spikelets fertility showed significant and positive correlation. Spikelets fertility showed significant and positive correlation with panicle bearing tillers per plant (0.37) and plant height (0.33), while days to maturity (-0.40) and days to 50% flowering (-0.34) showed significant negative correlation with spikelets fertility. Grains per panicle showed highly significant and positive correlation with spikelets per panicle (0.92) (Haider *et al.* 2012). Panicle bearing tillers per plant showed significant and negative correlation with days to maturity (-0.34). Plant height showed significant and negative correlation with days to maturity (-0.35). Days to maturity showed significant and positive correlation with days to 50% flowering (0.92) (Madhavilatha, 2002) [10].

Phenotypic path coefficient analysis

Path coefficient analysis were estimated at phenotypic levels and genotypic levels to resolve the direct and indirect effects of different characters on grain yield per plant are depicted in Table 3 and 4.

The highest positive direct effect on grain yield per plant during *Kharif* 2014-15 was exhibited by spikelets per panicle (2.75), spikelets fertility (1.00) and biological yield per plant (0.57). The direct effects of remaining characters were too low to be considered important. Haradari and Hittalmani (2017) [5] and Kumari *et al.* (2018) [8]. Spikelets per panicle exhibited indirect positive effect on grain yield per plant per plant *via* grains per panicle (2.53), biological yield per plant (0.96), harvest index (0.87), flag leaf area (0.54), days to maturity (0.19), panicle bearing tillers per plant (0.06) and days to 50% flowering (0.03), while negative indirect effect via test weight (-1.30), plant height (-0.72) and spikelets fertility (-0.69). Spikelets fertility exhibited positive and high indirect effect on grain yield per plant *via* panicle bearing tillers per plant (0.37), plant height (0.33), test weight (0.31), grains per panicle (0.11) and flag leaf area (0.02), while negative indirect effect *via* days to maturity (-0.40), days to 50% flowering (-0.34), spikelets per panicle (-0.25), harvest index (-0.19) and biological yield per plant (-0.02). Biological yield per plant exhibited positive and high indirect effect on grain yield per plant *via* spikelets per panicle (0.20), grains per panicle (0.17), harvest index (0.16), flag leaf area (0.15) and panicle bearing tillers per plant (0.05), while negative indirect effect *via* days to maturity (-0.14), days to 50% flowering (-0.11), plant height (-0.04), test weight (-0.03) and spikelets fertility (-0.01) Rangare *et al.* (2012) [15]; Krishnamurthy and Kumar, 2012 [7] and Reddy *et al.* (2013).

Genotypic path coefficient analysis

The highest positive direct effect on grain yield per plant under field condition during *Kharif* 2014-15 was exhibited by spikelets per panicle (1.15), biological yield per plant (0.63) and spikelets fertility (0.30) (Nikhil *et al.* 2014) [13]. The direct effects of remaining characters were too low to be considered important.

Spikelets per panicle exhibited indirect positive effect on grain yield per plant *via* grains per panicle (1.07), harvest index (0.58), biological yield per plant (0.50), flag leaf area (0.23), days to maturity (0.08) and panicle bearing tillers per plant (0.05), while negative indirect effect via test weight (-0.56), plant height (-0.31)and spikelets fertility (-0.29). Biological yield per plant exhibited positive and high indirect effect on grain yield per plant *via* spikelets per panicle (0.20), grains per panicle (0.17), harvest index (0.16), flag leaf area (0.15) and panicle bearing tillers per plant (0.05) and negative indirect effect *via* days to maturity (-0.14), days to 50% flowering (-0.11), plant height (-0.04), test weight (-0.03) and spikelets fertility (-0.01). Spikelets fertility exhibited indirect positive effect on grain yield per plant per plant *via* panicle bearing tillers per plant (0.21), plant height (0.10), test weight (0.10) and grains per panicle (0.03), while negative indirect effect *via* days to maturity (-0.13), days to 50% flowering (-0.11), harvest index (-0.08), spikelets per panicle (-0.07) and biological yield per plant (-0.02).

Conclusion

In this study, correlation analysis indicated that grain yield was positively and significantly correlated with biological yield per plant, harvest index, flag leaf area, spikelets per panicle and grains per panicle. Path coefficient analysis indicated that among yield components spikelets per panicle, spikelets fertility and biological yield per plant showed a positive direct effect on grain yield and therefore, may be considered as selection criteria for the improvement of grain yield.

Table 1: Estimates of phenotypic correlation coefficient between 12 characters in rice during *Kharif* 2014-15

S. No.	Character	Days to 50% flowering	Days to maturity	Plant height (cm)	Panicle bearing tillers/plant	Flag leaf area (cm^2)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility (%)	Test weight (g)	Biological yield (g)	Harvest index	Grain yield /plant (g)
1.	Days to 50% flowering	1.00	0.92**	-0.46**	-0.22	-0.09	0.01	-0.10	-0.34*	-0.29	-0.19	0.16	-0.08
2.	Days to maturity		1.00	-0.35*	-0.34*	-0.16	0.07	-0.06	-0.40*	-0.39*	-0.24	-0.01	-0.19
3.	Plant height			1.00	0.02	-0.23	-0.26	-0.18	0.33*	0.15	-0.07	-0.34*	-0.22
4.	Panicle bearing tillers/plant				1.00	0.27	0.02	0.16	0.37*	-0.009	0.09	0.19	0.16
5.	Flag leaf area (cm^2)					1.00	0.19	0.20	0.02	-0.03	0.26	0.51**	0.43**
6.	Spikelets/panicle						1.00	0.92**	-0.25	-0.47**	0.35*	0.31*	0.40**
7.	Grains/panicle							1.00	0.11	-0.38*	0.31	0.24	0.33*
8.	Spikelet fertility (%)								1.00	0.31*	-0.02	-0.19	-0.11
9.	Test weight (g)									1.00	-0.06	0.09	0.01
10.	Biological yield (g)										1.00	0.29	0.83**
11.	Harvest index											1.00	0.66**

*, ** significant at 5 and 1% probability levels, respectively

Table 2: Estimates of genotypic correlation coefficient between 12 characters in rice during *Kharif* 2014-15

S. No.	Character	Days to 50% flowering	Days to maturity	Plant height (cm)	Panicle bearing tillers/plant	Flag leaf area (cm^2)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility (%)	Test weight (g)	Biological yield (g)	Harvest index	Grain yield/ plant (g)
1.	Days to 50% flowering	1.00	0.98	-0.51	-0.36	-0.08	0.006	-0.11	-0.35	-0.31	-0.19	0.14	-0.08
2.	Days to maturity		1.00	-0.41	-0.52	-0.17	0.07	-0.07	-0.44	-0.43	-0.29	0.04	-0.18
3.	Plant height			1.00	0.02	-0.23	-0.26	-0.19	0.33	0.15	-0.06	-0.50	-0.21
4.	Panicle bearing tillers/plant				1.00	0.56	0.05	0.31	0.68	0.06	0.48	0.49	0.48
5.	Flag leaf area (cm^2)					1.00	0.20	0.21	0.02	-0.04	0.31	0.87	0.49
6.	Spikelets/panicle						1.00	0.93	-0.25	-0.48	0.43	0.50	0.48
7.	Grains/panicle							1.00	0.10	-0.39	0.37	0.39	0.39
8.	Spikelet fertility (%)								1.00	0.32	-0.07	-0.27	-0.16
9.	Test weight (g)									1.00	-0.04	0.10	-0.02
10.	Biological yield (g)										1.00	0.90	1.03
11.	Harvest index											1.00	0.97

*, ** significant at 5 and 1% probability levels, respectively

Table 4.1: Direct and indirect effect (phenotypic) of 12 characters on grain yield per plant in rice during *Kharif* 2014-15.

S. No.	Character	Days to 50% flowering	Days to maturity	Plant height (cm)	Panicle bearing tillers/plant	Flag leaf area (cm^2)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility (%)	Test weight (g)	Biological yield (g)	Harvest index	Grain yield /plant (g)
1.	Days to 50% flowering	-0.00	-0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	-0.00	0.66
2.	Days to maturity	-0.06	-0.07	0.02	0.02	0.01	-0.00	0.00	0.02	0.02	0.01	0.00	0.83
3.	Plant height	0.08	0.06	-0.18	-0.00	0.04	0.04	0.03	-0.06	-0.02	0.01	0.06	0.01
4.	Panicle bearing tillers/plant	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.11
5.	Flag leaf area (cm^2)	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.33
6.	Spikelets/panicle	0.03	0.19	-0.72	0.06	0.54	2.73	2.53	-0.69	-1.30	0.96	0.87	0.40
7.	Grains/panicle	0.26	0.16	0.49	-0.43	-0.54	-2.44	-2.63	-0.30	1.00	-0.82	-0.63	0.43
8.	Spikelet fertility (%)	-0.34	-0.40	0.33	0.37	0.02	-0.25	0.11	1.00	0.31	-0.02	-0.19	0.16
9.	Test weight (g)	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.22
10.	Biological yield (g)	-0.11	-0.14	-0.04	0.05	0.15	0.20	0.17	-0.01	-0.03	0.57	0.16	-0.19
11.	Harvest index	0.06	-0.00	-0.13	0.07	0.20	0.12	0.09	-0.07	0.03	0.11	0.39	-0.08

Residual Effect = 0.3038

Table 4.2: Direct and indirect effect (genotypic correlation) of 12 characters on grain yield per plant in rice during *kharif* 2014-15.

S. No.	Character	Days to 50% flowering	Days to maturity	Plant height (cm)	Panicle bearing tillers/plant	Flag leaf area (cm^2)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility (%)	Test weight (g)	Biological yield (g)	Harvest index	Grain yield /plant (g)
1.	Days to 50% flowering	0.01	0.01	-0.00	-0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00	-0.08
2.	Days to maturity	-0.02	-0.02	0.00	0.01	0.00	-0.00	0.00	0.01	0.00	0.00	-0.00	-0.18
3.	Plant height	0.02	0.01	-0.04	-0.00	0.01	0.01	0.00	-0.01	-0.00	0.00	0.02	-0.21
4.	Panicle bearing tillers/plant	-0.04	-0.07	0.00	0.13	0.07	0.00	0.04	0.09	0.00	0.06	0.06	0.48
5.	Flag leaf area (cm^2)	0.00	0.01	0.01	-0.04	-0.07	-0.01	-0.01	-0.00	0.00	-0.02	-0.06	0.49
6.	Spikelets/panicle	0.00	0.08	-0.31	0.05	0.23	1.15	1.07	-0.29	-0.56	0.50	0.58	0.48
7.	Grains/panicle	0.12	0.08	0.22	-0.34	-0.23	-1.04	-1.11	-0.12	0.43	-0.42	-0.43	0.39
8.	Spikelet fertility (%)	-0.11	-0.13	0.10	0.21	0.00	-0.07	0.03	0.30	0.10	-0.02	-0.08	-0.16
9.	Test weight (g)	0.00	0.00	-0.00	-0.00	0.00	0.00	0.00	-0.00	-0.01	0.00	-0.00	-0.02
10.	Biological yield (g)	-0.12	-0.18	-0.04	0.30	0.19	0.27	0.23	-0.04	-0.03	0.63	0.57	1.03
11.	Harvest index	0.04	0.01	-0.16	0.15	0.27	0.16	0.12	-0.08	0.03	0.28	0.31	0.97

Residual Effect =0.0677

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