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Studies on correlation and path coefficient analysis for yield and yield related traits in Rice (*Oryza Sativa* L.)

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Abstract
The present investigation consists of 26 Rice genotypes used for the experiment was conducted during *Kharif*-2019. The aim of the present study was to estimate genetic parameters of 13 yield attributing traits to study genetic variability, heritability, genetic advance and correlation coefficient analysis and path analysis with a view to select better yield attributes in rice. The higher value of phenotypic co- efficient of variation (PCV) compared to the corresponding genotypic coefficient of variation (GCV) for all the studied traits indicated that there was an influence of the environment. Grain yield per plant exhibited high estimates of PCV and GCV followed by biological yield per plant, number of total tillers per hill, number of spikelets per panicle, and number of panicles per hill. High heritability coupled with high genetic advance is recorded for number of spikelets per panicle, all the characters which reflected that the direct selection of these characters based on phenotypic expression by simple select ion method for yield improvement would be more reliable. Grain yield per plant showed significant and positive association with days to 50% flowering, plant height, biological yield per plant, number of panicles per hill, number of total tillers per hill, number of spikelets per panicle, days to maturity, harvest index and panicle length indicating selection of these characters for yield improvement may be rewarding. Both at phenotypic and genotypic level days to 50% flowering, plant height, number of tillers per hill, number of panicles per hill, number of spikelets per panicle, days to maturity, biological yield per plant and harvest index had positive direct effects on grain yield per plant indicating their importance during selection in yield improvement programme.

Keywords: rice, genetic variability, heritability, genetic advance, correlation, path coefficient analysis.

Introduction
Rice, *Oryza sativa* L. (2n=24) belongs to family Poaceae (Gramineae). Rice is a short-day self-pollinated crop. It accounts for about 43% (FAO [Food and Agriculture Organization] (2012) of total food grain production. Before initiating any breeding Programme, the knowledge of variability is a basic pre-requisite for improving the character. About 90% of the world's rice is grown and consumed by Asians. The area under rice cultivation is estimated to be 160.07 million hectares with global production 488.3 Million metric tons. The total food grain production for the year 2018-2019 was places at 275.7 million tonnes, out of which rice contributed about 110.15 million tonnes (Agricultural Statistics at a glance, 2012). Rice plays an important role in Indian economy being the staple food of two third of the population. India has the largest area under rice crop and ranks second in production next to china, knowledge on the genetic architecture of genotypes is necessary to formulate efficient breeding methodology.
The systematic breeding Programme involves the steps like creating genetic variability practicing selection and utilization of selected genotypes to evolve promising varieties. Knowledge of the nature and magnitude of genetic variance present in the breeding material is the most important pre requisite for successful breeding Programme. Parameters such as genotypic and phenotypic variances, as well as co-efficient of variation are useful in detecting the variability present in the germplasm. The success of plant breeding depends on the extent of genetic variability present in a crop. Understanding the nature and magnitude of genetic variation governing the inheritance of quantitative characters like yield and its components is essential for genetic improvement.
Genetic variability refers to the presence of difference among the individuals of plant population results due to the difference either in the genetic constitution of the individuals of a population. Heritability is the transmission of characters from one generation to another generation.

Moreover, knowledge of heritability is essential for selection of yield related component traits for crop yield improvement. Genetic advance measures the difference between mean genotypic values of the selected population and the original population from which these were selected. Genetic parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are useful to identify the amount of variability present in germplasm. Heritability along with high genetic advance would be useful tool in estimating the resultant effect in selection of best genotypes for yield and its attributing traits. It helps in determining the influence environment on the expression the genotypic and reliability of characters.

The use of correlation coefficient is to establish the extent of association between yield and yield component and the other character, which are having decisive role in influencing the yield. However, it is only genetic variation which is heritable and hence important in any selection Programme**.** Path coefficient analysis is a statistical technique of partitioning the correlation coefficients into its direct and indirect effects, so that the contribution of each character to yield could be estimated. Yield is a complex character being governed by a large number of cumulative, duplicate and dominant genes and highly influenced by environment.

Materials and methods

The experimental material consisted of 26 elite rice germplasm and present investigation was carried out at the field experimentation center, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom Institute of Agriculture Technology and Sciences, Allahabad (UP) during Kharif 2018-19. Twenty-one days old seedlings were transplanted in 2 × 1 m2 plot in randomized block design with three replications. Distance between plant to plant and row to row were 20 cm and 15cm respectively. Standard agronomic practices were followed throughout the crop growth period to obtain good harvest. Observations were recorded on five randomly selected plant from each progeny row for 13 biometrical characters *Viz*, days to 50% flowering, plant height, flag leaf length, flag leaf width, tillers per hill, panicles per hill, panicle length, spikelet per panicle, days to maturity, biological yield, harvest index, test weight and grain yield per hill. The Analysis of variance was estimated as per procedure suggested by Panse and Sukhatme (1961), coefficient of variation (GCV and PCV) by Burton (1952) [5]. Heritability for the grain yield and yield components in rice were worked out in broad sense by adopting formula suggested by Burton and de vane (1952). Genetic advance was calculated by the method suggested by Johnson *et al*. (1955). Correlation coefficient and path coefficient was worked out as method suggested by Deway and Lu (1959) respectively.

Results and discussion

The success of plant breeding Programme depends on genetic variability and the relationship between characters. Analysis of variance shown highly significant difference among the genotypes for all the traits studied indicating the presence of considerable genetic variation among the study materials (Table 1).High genetic variability for different traits in rice was reported by Dhanwani *et al.* (2013) [11]. Coefficient of variance is the measure of variance among the different traits (Table 2). The estimates of phenotypic coefficient of variation (PCV) were slightly higher than those of the genotypic coefficient of variation (GCV) for all the traits studied. In this study slight differences are indicated minimum environmental influence. The higher magnitude of genotypic (GCV) and phenotypic coefficients of variation (PCV) was recorded for traits like grain yield per hill, biological yield per hill, number of spikelets per panicle and number of tillers per hill, number of panicles per hill. Similar findings were obtained by Harsha *et al*. (2017).

Heritability plays an important role in deciding the strategy for selection of the character. In the present study high heritability was observed for the traits like; days to maturity, days to 50% flowering, grain yield per hill, number of spikelets per panicle, test weight, number of tillers per hill, number panicles per hill, plant height, panicle length, flag leaf width, flag leaf length and whereas, characters like; harvest index, depicted moderate estimate of heritability and none of the characters showed low estimates of heritability. Similar results are reported by Johnson *et al.* (1955) recorded high heritability for grain yield per hill.

The characters exhibiting high heritability may not be necessary to give high genetic advance. Hanson (1963) reported that high heritability should be accompanied with high genetic advance. The breeder should be cautious during the heritability. In the present study high heritability along with the high genetic advance was exhibited by grain yield per hill, biological yield per hill. Similar results were reported earlier in rice by Bhati *et al.* (2015). Genotypic and phenotypic correlation coefficients (Table 4) indicate the genotypic and phenotypic correlation coefficients were of higher in magnitude than the phenotypic correlation coefficient which might be due to the modified effect of environment at the genetic level.

Grain yield per plant showed the high significant positive correlation with Days to 50% flowering, Plant height, number of tillers per plant, number of panicles, panicle length, number of spikelets per panicle, days to maturity, number of grains per panicle, biological yield per hill, showed positive significant correlation at phenotype and genotypic levels. The positive correlation of grain yield with various traits was supported by the Vinoth *et al.* (2016) for number of tillers per plant, Tripathi *et al.* (2013) for panicle length, sridhar *et al.* (2016) for days to maturity, pandey *et al.*(2017) for number of grains per panicle. The correlation showed non-significant correlation with flag leaf length and flag leaf width both at the genotypic and phenotypic level. In the present study path coefficient analysis has been conducted taking grain yield per hill as the depended variable and the other characters as independent is presented in (Table 4). Path coefficient analysis revealed that days to 50% flowering, plant height, number of tillers per plant, number of panicles per plant, number of spikelets per panicle, days to maturity, biological yield per hill and harvest index has positive direct effect on grain yield per plant. Positive direct effect of these traits indicated that direct selection for these traits would be likely be effective in increasing grain yield. Similar results were also reported by Bhandru *et al.* (2010) for days to 50% flowering and number of tillers per pl.ant, Babu *et al.* (2011) for number of Panicles per plant, Fivaz *et al.* (2011) for number of spikelets per panicle, Yadav *et al.*(2010) for Plant height , Path coefficient analysis shows negative indirect effect on flag leaf length, flag leaf width, and panicle length and test weight. In the present study path coefficient revealed that number of tillers per hill, and plant height had influence on grain yield per hill. Selection of plants on these traits would certainly lead to improvement in grain yield.

Table 1: Table 1. Analysis of variance for different quantitative characters in 26 genotypes of rice

Source of Variations	DF	DF (50%)	PH	FL	FW	T	P	PL	SPP	DM	BYH	HI	TW	GYPH
Replication	2	9.90	16.97	1.71	0.10	0.42	0.34	0.23	91.63	10.50	12.58	36.52	0.13	6.62
Treatments	25	115.08 **	162.17 **	60.66 **	0.07 **	18.73 **	8.05**	10.65**	4715.13 **	113.84**	991.30 **	315.91 *	26.03**	278.16 **
Error	50	2.08	24.74	7.84	0.01	0.97	0.74	1.33	181.44	1.74	51.55	147.73	1.06	8.87

Significant at 1% level ** and Significant at 5%* level of significance respectively

Table 2: Variability parameters for 13 traits in 26 genotypes of rice

Parameter	DF (50%)	PH	FL	FW	T	P	PL	SPP	DM	BYH	HI	TW	GYPH
GCV	6.60	5.84	11.40	9.99	23.48	15.48	5.99	22.67	5.02	37.85	14.68	12.00	45.88
PCV	6.78	7.25	13.71	11.09	25.32	17.68	7.16	23.99	5.13	40.85	28.58	12.74	48.09
h2 (Broad Sense)	94.76	64.93	69.17	81.14	85.97	76.74	70.02	89.28	95.55	85.87	27.66	88.72	91.01
Genetic Advancement 5%	12.31	11.24	7.19	0.28	4.65	2.82	3.04	75.67	12.31	33.79	6.84	5.60	18.62
Gen.Adv as% of Mean 5%	13.23	9.70	19.53	18.53	44.84	27.94	10.33	44.13	10.10	72.26	15.54	23.28	90.16

Table 3: Genotypic Correlation coefficient between yield and its related traits in 26 rice genotypes.

Characters	DF (50%)	PH	FL	FW	T	P	PL	SPP	DM	BYH	HI	TW	GYPH
DF (50%)	1	0.311**	0.086	0.262*	0.432**	0.427**	-0.682**	0.333**	0.906**	0.383**	0.234*	-0.626**	0.459**
PH		1	0.641**	0.523**	0.463**	0.307**	-0.321**	0.542**	0.233*	0.559**	0.658**	-0.078	0.651**
FL			1	0.708**	0.05	0.008	0.026	0.405**	0.042	-0.044	0.229*	0.222	0.172
FW				1	0.121	0.096	-0.264*	0.502**	0.265*	-0.003	0.253*	-0.098	0.121
T					1	0.975**	-0.587**	0.665**	0.406**	0.936**	0.493**	-0.568**	0.928**
P						1	-0.605**	0.636**	0.397**	0.873**	0.445**	-0.627**	0.853**
PL							1	-0.306**	-0.667**	-0.610**	-0.321**	0.704**	0.622**
SPP								1	0.369**	0.514**	0.354**	-0.289*	0.508**
DM									1	0.349**	0.245*	-0.700**	0.404**
BYH										1	0.476**	-0.525**	0.952**
HI											1	-0.192	0.696**
TW												1	-0.549**
DF (50%)													

Table 4: Phenotypic Correlation coefficient between yield and its related traits in 26 rice genotypes.

Characters	DF (50%)	PH	FL	FW	T	P	PL	SPP	DM	BYH	HI	TW	GYPH
DF (50%)	1	0.236*	0.05	0.243*	0.402**	0.365**	-0.560**	0.328**	0.908**	0.364**	0.124	-0.551**	0.428**
PH		1	0.593**	0.498**	0.401**	0.301**	-0.203	0.408**	0.181	0.387**	0.267*	-0.086	0.480**
FL			1	0.636**	0.091	0.074	0.049	0.304**	0.011	-0.026	0.085	0.167	0.091
FW				1	0.135	0.115	-0.178	0.444**	0.244*	0.021	0.108	-0.1	0.08
T					1	0.935**	-0.507**	0.566**	0.381**	0.823**	0.237*	-0.526**	0.818**
P						1	-0.453**	0.501**	0.342**	0.706**	0.158	-0.554**	0.709**
PL							1	-0.267*	-0.551**	-0.475**	-0.076	0.578**	-0.513**
SPP								1	0.355**	0.440**	0.173	-0.245*	0.461**
DM									1	0.333**	0.131	-0.623**	0.383**
BYH										1	0.18	-0.470**	0.877**
HI											1	-0.084	0.363**
TW												1	-0.495**

Table 5: Direct and indirect effects at genotypic level for different quantitative characters on grain yield.

Characters	DF (50%)	PH	FL	FW	T	P	PL	SPP	DM	BYH	HI	TW	GYPH
DF (50%)	-0.1757	0.2493	-0.0043	-0.0662	0.5926	0.0615	0.0802	-0.1400	0.0872	-0.3033	-0.0042	0.0817	0.459**
PH	-0.0546	0.8016	-0.0320	-0.1322	0.6359	0.0441	0.0378	-0.2279	0.0224	-0.4430	-0.0119	0.0102	0.651**
FL	-0.0151	0.5139	-0.0499	-0.1790	0.0690	0.0012	-0.0030	-0.1705	0.0040	0.0346	-0.0041	-0.0290	0.172
FW	-0.0460	0.4193	-0.0353	-0.2527	0.1658	0.0138	0.0310	-0.2110	0.0256	0.0025	-0.0046	0.0128	0.121
T	-0.0758	0.3712	-0.0025	-0.0305	0.3733	0.1403	0.0691	-0.2795	0.0391	-0.7417	-0.0089	0.0742	0.928**
P	-0.0750	0.2457	-0.0004	-0.0243	0.3387	0.1439	0.0711	-0.2675	0.0383	-0.6918	-0.0081	0.0819	0.853**
PL	0.1198	-0.2574	-0.0013	0.0667	-0.8067	-0.0870	-0.1176	0.1285	-0.0642	0.4831	0.0058	-0.0919	0.622**
SPP	-0.0585	0.4344	-0.0202	-0.1268	0.9128	0.0915	0.0359	-0.4205	0.0355	-0.4074	-0.0064	0.0378	0.508**
DM	-0.1591	0.1869	-0.0021	-0.0671	0.5579	0.0572	0.0785	-0.1551	0.0963	-0.2768	-0.0044	0.0914	0.404**
BYH	-0.0673	0.4482	0.0022	0.0008	0.2853	0.1256	0.0717	-0.2162	0.0336	-0.7924	-0.0086	0.0685	0.952**
HI	-0.0410	0.5278	-0.0114	-0.0639	0.6777	0.0640	0.0377	-0.1487	0.0236	-0.3768	-0.0181	0.0251	0.696**
TW	0.1100	-0.0628	-0.0111	0.0248	-0.7804	-0.0903	-0.0828	0.1217	-0.0674	0.4159	0.0035	-0.1306	-0.549**

Table 6: Direct and indirect effects at phenotypical level for different quantitative characters on grain yield.

characters	DF (50%)	PH	FL	FW	T	P	PL	SPP	DM	BYH	HI	TW	GYPH
DF (50%)	0.1355	0.0243	0.0053	-0.0318	0.0682	-0.0099	0.0455	0.0087	-0.1054	0.2121	0.0223	0.0538	0.428**
PH	0.0320	0.1031	0.0627	-0.0652	0.0679	-0.0082	0.0165	0.0108	-0.0210	0.2254	0.0480	0.0084	0.480**
FL	0.0068	0.0612	0.1056	-0.0833	0.0154	-0.0020	-0.0040	0.0081	-0.0013	-0.0149	0.0153	-0.0163	0.091
FW	0.0330	0.0514	0.0672	-0.1309	0.0228	-0.0031	0.0145	0.0118	-0.0283	0.0124	0.0195	0.0097	0.08
T	0.0545	0.0413	0.0096	-0.0176	0.1696	-0.0253	0.0412	0.0150	-0.0442	0.4796	0.0427	0.0514	0.818**
P	0.0494	0.0311	0.0078	-0.0151	0.1586	-0.0271	0.0368	0.0133	-0.0397	0.4112	0.0284	0.0541	0.709**
PL	-0.0759	-0.0209	0.0051	0.0233	-0.0860	0.0123	-0.0812	-0.0071	0.0639	-0.2768	-0.0137	-0.0564	-0.513**
SPP	0.0444	0.0421	0.0321	-0.0581	0.0960	-0.0136	0.0217	0.0266	-0.0412	0.2563	0.0310	0.0239	0.461**
DM	0.1231	0.0186	0.0012	-0.0319	0.0646	-0.0093	0.0447	0.0094	-0.1160	0.1938	0.0236	0.0608	0.383**
BYH	0.0493	0.0399	-0.0027	-0.0028	0.1396	-0.0191	0.0386	0.0117	-0.0386	0.5825	0.0324	0.0459	0.877**
HI	0.0168	0.0275	0.0090	-0.0142	0.0402	-0.0043	0.0062	0.0046	-0.0153	0.1048	0.1799	0.0082	0.363**
TW	-0.0747	-0.0089	0.0176	0.0130	-0.0892	0.0150	-0.0469	-0.0065	0.0723	-0.2737	-0.0150	-0.0976	-0.495**

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