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GENETICS AND PLANT BREEDING

Grain Yield Components Analysis in Locally Adapted Rice Varieties

M.Z. Shamim*, V.K. Sharma, H. Manzar and S. Bhushan

Department of Agricultural Biotechnology and Molecular Biology, Rajendra Agricultural University, Bihar, Pusa, India

*Corresponding author: mzshamim85@gmail.com

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ABSTRACT

Analysis of variance of eighteen locally adapted rice varieties indicated that all the varieties were significantly different with respect to all the sixteen quantitative characters which were studied. Biological yield plant^{-1}, grain yield plant^{-1}, number of effective tillers plant^{-1} and 100-grain weight had recorded high PCV, GCV, heritability and genetic advance as percent of mean. Grain yield plant^{-1} had a significant and positive association with biological yield plant^{-1}, days to maturity, days to 50% flowering, leaf blade width, flag leaf width, number of effective tillers plant^{-1}, leaf blade length and panicle length both at phenotypic and genotypic level. The path analysis revealed that 100-grain weight, number of effective tillers plant^{-1}, leaf blade width, days to maturity, harvest index, days to 50% flowering, plant height and flag leaf length shows positive and direct effect on grain yield plant^{-1} at genetic level. Present study suggest that leaf blade width, number of effective tillers plant^{-1}, days to maturity and 100-grain weight should be given more emphasis during selection of parental lines for high yielding variety.

Highlights

- The characters viz., leaf blade width, number of effective tillers plant^{-1}, days to maturity and 100-grain weight are important traits of high grain yield producing rice varieties.

Keywords: Rice, PCV, GCV, correlation, path analysis

Rice (*Oryza Sativa* L.) (2n=24), belonging to the family Graminae, is the principle staple food for more than 50% of the world's population and occupies one-fifth of the total land area covered under cereals. It is grown under diverse eco-geographical conditions in various tropical and subtropical countries, including India. Further scope of crop improvement in this crop for augmentation of its production to meet the demand for rice to feed the burgeoning population basically depends on effective and sustainable utilization of genetic resource and exploitation of genetic variability and diversity in plant breeding programmes, in addition to biotechnological intervention. There is wide genetic variability available among varieties of rice leaving a wide scope for future rice improvement programmes (Shamim *et al*. 2016). Rice is a major food crop of Bihar, state in India. Bihar has very rich diversity of locally adapted rice varieties. For development of high yielding variety which should be suitable according to the climate of Bihar, it is necessary to study about the variation and association of yield components of different rice varieties which is mainly grown in Bihar. Morphological characterization is the first step in the classification and evaluation of the germplasm (Smith *et al*. 1991; Shamim *et al*. 2014a). The grain yield is complex phenomenon and contributed by a number of components (Patil *et al*. 2016). In order to develop high yielding varieties it is essential to select parental lines which have high yield contributing traits (Shamim *et al*. 2014b).

The selection of parental lines for high yielding variety it is necessary to study about the existing variation and estimation of correlation coefficient and path coefficient of different yield components to determine clear picture about yield and yield components. In the point of view the present investigation was performed to estimate the variation, correlation coefficient and path analysis to determine the major yield contributing traits in locally adapted varieties of rice.

MATERIALS AND METHODS

Eighteen rice varieties were evaluated at research farm of Rajendra Agricultural University, Bihar, Pusa, India during wet season of 2011. The experiment was laid out in a randomized block design with three replications of 3m length. Row to row and plant to plant spacing were maintained at 20×15 cm. All the recommended agronomic practices were followed to raise a good crop. Observation were recorded for sixteen quantitative traits *viz*., leaf blade length (cm), leaf blade width (cm), days to 50% flowering, flag leaf length (cm), flag leaf width (cm), panicle length (cm), number of effective tillers plant^{-1}, plant height (cm), days to maturity, 100-grain weight(g), grain length (cm), grain width (cm), grain shape index, grain yield plant^{-1} (g), biological yield plant^{-1} (g) and harvest index. Five random plants/replication/variety were tagged for recording observations. Mean value was used for calculating the genotypic and phenotypic variance Johnson *et al*. (1955). The heritability and other variability parameters were estimated as per Burton and Devane (1953). Genotypic and Phenotypic correlation coefficient were estimated following the method of Al-Jibouri *et al*. (1958). The path analysis was done as per the procedure suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance (Table 1) for all the characters studied showed significantly differences among the entries. Genotypic variation between varieties or population is the expression of their genetic differences and phenotypic variation is the result of interaction between genetic differences and environment. In all cases phenotypic variance was higher than genotypic variance indicating the polygenic nature of the characters under study and also the involvement of additive genes in the control of the characters. The difference between the phenotypic and genotypic variance was for biological yield plant^{-1}, grain yield plant^{-1} and plant height was high which indicates that these character are highly influenced by environment. The moderate value of phenotypic and genotypic variance difference was reported for leaf blade length, flag leaf length, days to maturity, days to 50%flowering, number of effective tillers plant^{-1} shows that these characters are not much influenced by environment. The very close value of phenotypic and genotypic variance was reported for flag leaf width, 100-grain weight, grain length, grain width, leaf width, grain shape index and panicle length, indicates that these characters can be considered as stable character. The low level of genotypic variance was reported for grain width, grain length, leaf blade width, flag leaf width, grain shape index and 100-grain weight is the indication of unstable nature of these characters. Similar kind of result on phenotypic and genotypic variation variance have earlier been reported by Kishor *et al*. (2008).

The phenotypic coefficient of variation measure total relative variability due to genotypic and environmental variability, where as the genotypic coefficient variation provides a measure to compare the genetic variability present in various quantitative characters. The highest phenotypic coefficient of variation (PCV) was recorded for biological yield plant^{-1} (43.19) followed by grain yield plant^{-1} (35.746), 100-grain weight (28.410), pant height (25.428), number of effective tillers plant-1 (23.393) and harvest index (21.373) (Table 2). The highest genotypic coefficient of variation (GCV) was recorded for biological yield plant^{-1} (37.617) followed by grain yield plant^{-1} (31.372), 100-grain weight (28.397), plant height (25.158) and number of effective tillers (20.284) (Table 2). PCV were higher in all the cases when compared to GCV showing the different levels of influences of environmental factors on the expression of the character under study. The high value of phenotypic and genotypic coefficient of variation indicating the existence of high amount of variability for these traits. Similar result was also reported by Ganesan *et al*. (1995), Mruthunjaya *et al*. (1995), Manonmani *et al*. (1996). Shivani *et al*. (2000) and Kishor *et al*. (2008).

Table 1: Analysis of variance for different quantitative characters in locally adapted rice

Characters	d.f.	Leaf blade length (cm)	Leaf blade width (cm)	Days to 50% flowering	Flag leaf length (cm)	Flag leaf width (cm)	Panicle length (cm)	Number of effective tillers plant^{-1}	Plant height (cm)	Days to maturity	100-Grain weight (g)	Grain length (cm)	Grain width (cm)	Grain shape index	Biological yield plant^{-1} (g)	Harvest index	Grain yield plant^{-1} (g)
								MSS									
Replication	2	9.829	0.002	3.500	5.840	0.003	0.361	0.113	5.815	0.797	0.003	0.001	0.001	8.190	58.179	4.150	16.605
Genotype	17	140.058**	0.107**	352.441**	45.561**	0.115**	22.140**	23.926**	2049.364**	413.705**	1.217**	0.064**	0.004**	1.308**	1971.867**	210.010**	257.201**
Error	34	3.534	0.002	2.833	3.208	0.001	0.470	2.371	14.594	3.110	0.001	0.001	0.001	0.160	139.340	33.293	23.261

** *Significant at 1% probability level*

Table 2: Estimates of variance components and genetic parameters for different characters

Characters	σ^2_p	σ^2_g	σ^2_e	PCV	GCV	h^2(%)	GA	GA(%) mean
Leaf blade length (cm)	49.042	45.508	3.534	15.887	15.303	92.794	13.387	30.368
Leaf blade width (cm)	0.037	0.035	0.002	17.717	17.328	95.659	0.378	34.913
Days to 50% flowering	119.369	116.536	2.833	10.378	10.254	97.626	21.973	20.871
Flag leaf length (cm)	17.326	14.117	3.208	13.193	11.909	81.482	6.987	22.145
Flag leaf width (cm)	0.039	0.038	0.001	15.133	14.864	96.482	0.395	30.077
Panicle length (cm	7.693	7.223	0.470	11.699	11.336	93.888	5.365	22.626
Number of effective tillers plant^{-1}	9.556	7.185	2.371	23.393	20.284	75.184	4.788	36.230
Plant height (cm)	692.851	678.256	14.594	25.428	25.158	97.890	53.106	51.276
Days to maturity	139.975	136.865	3.110	8.490	8.395	97.778	23.831	17.101
100-Grain weight (g)	0.406	0.405	0.001	28.410	28.397	99.906	1.312	58.470
Grain length (cm)	0.022	0.021	0.001	15.061	14.961	98.669	0.291	30.613
Grain width (cm)	0.002	0.001	0.001	14.587	14.483	98.578	0.078	29.622
Grain shape index	0.543	0.3826	0.160	17.811	17.644	98.129	1.308	36.005
Biological yield plant^{-1} (g)	750.182	610.842	139.34	43.191	37.617	75.885	44.139	67.491
Harvest index	92.198	58.905	33.293	21.373	17.084	63.890	0.126	28.130
Grain yield plant^{-1} (g)	101.241	77.980	23.261	35.746	31.372	77.024	15.965	56.718

Table 3: Phenotypic (P) and Genotypic (G) correlation coefficient among different characters in locally adapted rice

Characters		Leaf blade width	Days to 50% flowering	Flag leaf length	Flag leaf width	Panicle length	Number of effective tillers plant^{-1}	Plant height	Days to maturity	100-Grain weight	Grain length	Grain width	Grain shape index	Biological yield plant^{-1}	Harvest index	Grain yield plant^{-1}
Leaf blade length	P	0.545*	0.694**	0.506*	0.542*	0.479*	-0.025	0.830**	0.570*	0.190	-0.040	0.080	-0.075	0.399	-0.074	0.376
	G	0.563*	0.715**	0.490*	0.540*	0.506*	-0.037	0.867**	0.599**	0.198	-0.048	0.095	-0.093	0.466	-0.149	0.421
Leaf blade width	P		0.603**	0.320	0.969**	0.435	-0.112	0.475*	0.543*	0.258	0.253	-0.130	0.336	0.468*	0.087	0.569*
	G		0.628**	0.351	0.984**	0.474*	-0.122	0.478*	0.566*	0.263	0.256	-0.127	0.338	0.558*	0.131	0.676**
Days to 50% flowering	P			0.325	0.584*	0.443	0.297	0.436	0.931**	-0.101	-0.228	-0.007	-0.165	0.740**	-0.231	0.715**
	G			0.345	0.600**	0.455	0.333	0.447	0.931**	-0.101	-0.230	-0.007	-0.166	0.857**	-0.297	0.821**
Flag leaf length	P				0.319	0.419	-0.035	0.214	0.133	-0.185	-0.057	-0.366	0.255	-0.074	0.423	0.143
	G				0.323	0.436	-0.064	0.238	0.136	-0.204	-0.066	-0.394	0.269	-0.116	0.534*	0.130
Flag leaf width	P					0.338	-0.173	0.440	0.529*	0.256	0.195	-0.094	0.256	0.477*	0.115	0.580*
	G					0.358	-0.201	0.448	0.545*	0.261	0.194	-0.085	0.251	0.541*	0.158	0.663**
Panicle length	P						0.396	0.408	0.355	0.187	0.458	-0.207	0.578*	0.259	0.090	0.393
	G						0.448	0.428	0.364	0.195	0.476*	-0.219	0.604**	0.269	0.109	0.412
Number of effective tillers plant^{-1}	P							-0.208	0.397	-0.323	-0.054	-0.074	0.029	0.406	-0.082	0.480*
	G							-0.236	0.449	-0.371	-0.049	-0.099	0.058	0.378	-0.161	0.429
Plant height	P								0.384	0.429	0.186	0.213	-0.006	0.292	-0.267	0.156
	G								0.395	0.431	0.189	0.0216	-0.006	0.328	-0.328	0.171
Days to maturity	P									-0.127	-0.224	0.005	-0.199	0.848**	-0.398	0.751**
	G									-0.127	-0.246	0.003	-0.198	0.985**	-0.501*	0.867**
100-Grain weight	P										0.780**	0.593**	0.187	0.017	0.114	0.065
	G										0.785**	0.597**	0.189	0.021	0.140	0.074
Grain length	P											0.277	0.631**	-0.124	0.276	0.017
	G											0.281	0.630**	-0.132	0.343	0.031

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Grain width	P											0.567*	0.118	-0048	0.067
	G											-0.565*	0.133	-0.077	0.067
Grain shape index	P												-0.201	0.288	-0.032
	G												-0.220	0.368	-0.020
Biological yield plant^{-1}	P													0.484*	0.860**
	G													-0.498*	0.889**
Harvest index	P														-0.001
	G														-0.052

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

Table 4: Path coefficient analysis showing direct and indirect effects of different characters on grain yield plant^{-1} in locally adapted rice at phenotypic (P) and genotypic (G) level

Characters		Leaf blade length	Leaf blade width	Days to 50% flowering	Flag leaf length	Flag leaf width	Panicle length	Number of effective tillers plant^{-1}	Plant height	Days to maturity	100-Grain weight	Grain length	Grain width	Grain shape index	Biological yield plant^{-1}	Harvest index	Grain yield plant^{-1}
Leaf blade length	**P**	**-0.308**	-0.075	-0.077	0.063	0.313	0.070	-0.012	-0.082	0.330	0.137	0.024	-0.001	-0.001	0.007	-0.010	0.376
	G	**-0.433**	0.482	0.139	0.052	-0.109	-0.203	-0.036	0.110	0.331	0.217	0.033	-0.016	0.002	-0.106	-0.043	0.421
Leaf blade width	P	-0.168	**-0.138**	-0.067	0.040	0.559	0.064	-0.055	-0.047	0.314	0.185	-0.149	0.002	0.006	0.009	0.012	0.569
	G	-0.244	**0.856**	0.122	0.037	-0.198	-0.191	-0.117	0.061	0.313	0.288	-0.178	0.022	-0.007	-0.127	0.038	0.676
Days to 50% flowering	P	-0.214	-0.083	**-0.111**	0.041	0.337	0.065	0.145	-0.043	0.538	-0.073	0.134	0.000	-0.003	0.013	-0.032	0.715
	G	-0.310	0.538	**0.195**	0.037	-0.121	-0.183	0.320	0.057	0.515	-0.111	0.160	0.001	0.004	-0.195	-0.085	0.821
Flag leaf length	P	-0.156	-0.044	-0.036	**0.125**	0.184	0.062	-0.017	-0.021	0.077	-0.133	0.034	0.007	0.005	-0.001	0.059	0.143
	G	-0.212	0.301	0.067	**0.106**	-0.065	-0.175	-0.062	0.030	0.075	-0.224	0.046	0.068	-0.006	0.026	0.154	0.130

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Flag leaf width	P	-0.167	-0.133	-0.065	0.040	**0.577**	0.050	-0.085	-0.043	0.306	0.184	-0.115	0.002	0.005	0.009	0.016	0.580
	G	-0.234	0.842	0.117	0.034	**-0.201**	-0.144	-0.193	0.057	0.301	0.286	-0.135	0.015	-0.005	-0.123	0.045	0.663
Panicle length	P	-0.148	-0.060	-0.049	0.052	0.195	**0.147**	0.193	-0.040	0.205	0.134	-0.269	0.004	0.011	0.005	0.013	0.393
	G	-0.219	0.406	0.089	0.046	-0.072	**-0.402**	0.430	0.054	0.201	0.214	-0.331	0.038	-0.013	-0.061	0.031	0.412
Number of effective tillers plant^{-1}	P	0.008	0.015	-0.033	-0.004	-0.100	0.058	**0.489**	0.020	0.230	-0.232	0.032	0.001	0.001	0.007	-0.012	0.480
	G	0.016	-0.104	0.065	-0.007	0.040	-0.180	**0.961**	-0.030	0.248	-0.406	0.034	0.017	-0.001	-0.177	-0.046	0.429
Plant height	P	-0.256	-0.065	-0.048	0.027	0.254	0.060	-0.102	**-0.098**	0.222	0.308	-0.109	-0.004	-0.000	0.005	-0.038	0.156
	G	-0.375	0.409	0.087	0.025	-0.090	-0.172	-0.227	**0.127**	0.218	0.472	-0.131	-0.004	0.000	-0.075	-0.094	0.171
Days to maturity	P	-0.176	-0.075	-0.103	0.017	0.305	0.052	0.194	-0.038	**0.578**	-0.091	0.132	-0.000	-0.004	0.015	-0.056	0.751
	G	-0.259	0.485	0.182	0.014	-0.110	-0.146	0.431	0.050	**0.553**	-0.139	0.171	-0.001	0.004	-0.224	-0.144	0.867
100-Grain weight	P	-0.059	-0.036	0.011	-0.023	0.148	0.028	-0.158	-0.042	-0.073	**0.718**	-0.459	-0.011	0.004	0.000	0.016	0.065
	G	-0.086	0.225	-0.020	-0.022	-0.053	-0.078	-0.356	0.055	-0.070	**1.100**	-0.545	-0.103	-0.004	-0.005	0.040	0.074
Grain length	P	0.012	-0.035	0.025	-0.007	0.113	0.067	-0.026	-0.018	-0.130	0.561	**-0.588**	-0.005	0.012	-0.002	0.039	0.017
	G	0.021	0.219	-0.045	-0.007	-0.039	-0.191	-0.047	0.024	-0.136	0.860	**-0.695**	-0.049	-0.013	0.030	0.099	0.031
Grain width	P	-0.025	0.018	0.001	-0.046	-0.054	-0.030	-0.036	-0.021	0.003	0.426	-0.163	**-0.018**	0.011	0.002	-0.001	0.067
	G	-0.041	-0.109	-0.001	-0.042	0.017	0.088	-0.095	0.003	0.002	0.654	-0.195	**-0.173**	0.012	-0.030	-0.022	0.067
Grain shape index	P	0.023	-0.046	0.018	0.032	0.148	0.085	0.014	0.001	-0.115	0.134	-0.371	-0.010	**0.019**	-0.004	0.040	-0.032
	G	0.040	0.289	-0.032	0.029	-0.051	-0.243	0.056	-0.001	-0.110	0.207	-0.438	0.098	**-0.021**	0.050	0.106	-0.020
Biological yield plant^{-1}	P	-0.123	-0.064	-0.082	-0.009	0.275	0.038	0.198	-0.029	0.490	0.012	0.073	-0.002	-0.004	**0.018**	0.068	0.860
	G	-0.202	0.478	0.167	-0.012	-0.109	-0.108	0.363	0.042	0.545	0.023	0.092	-0.023	0.005	**-0.227**	-0.143	0.889
Harvest index	P	0.023	-0.012	0.026	0.053	0.066	0.013	-0.040	0.026	-0.230	0.082	-0.162	0.000	0.005	0.009	**0.140**	-0.001
	G	0.065	0.112	-0.058	0.057	-0.032	-0.044	-0.155	-0.042	-0.277	0.153	-0.238	0.013	-0.008	0.113	**0.288**	-0.052

Residual effect (P) = 0.399; Residual effect (G) = 0.126

100-grain weight had highest heritability (99.906) followed by grain length (98.669), grain width (98.578), grain shape index (98.129), plant height (97.890), days to maturity (97.778), days to 50% flowering (97.626), flag leaf width (95.659) (Table 2). The high heritability of the above characters indicates that these characters are negligible or low influenced by environment. Only estimates of heritability is not much useful for selection of the best individuals because, it includes the effect of both additive gene as well as non-additive gene. High genetic advance occurs only due to additive gene action (Panse 1957). The heritability estimates coupled with the genetic advance would be more useful than heritability alone for selection of best individual (Kishor *et al*. 2008). The highest genetic advance as percentage of mean observed for biological yield (67.491) followed by 100-grain weight (58.470), grain yield plant^{-1} (56.718), plant height (51.276), number of effective tillers plant^{-1} (36.230), leaf blade width (34.913), grain length (30.613) and flag leaf width (30.077) (Table 2). After consideration of both genetic heritability and genetic advance it was observed that leaf blade width, number of effective tillers plant^{-1}, Plant height, biological yield plant^{-1} and grain yield plant^{-1} is the suitable traits for direct selection of best individuals. This finding is in general agreement with those recorded by Rema Bai *et al*. (1992), Kishor *et al*. (2008) and Verma *et al*. (2010).

The correlation coefficient provides a measure of association between characters and gives an indication of characters that may be useful as an indicator of the most important ones under consideration. Further, the correlation studies at different levels provide the clear understanding about the contribution of characters in respect of establishing the association by genetic and non-genetic factors. Both genotypic and phenotypic correlations among and between pairs of agronomic traits provide scope for indirect selection in a crop breeding program (Pavan *et al.* 2011; Patil *et al*. 2016). The higher order of correlation between any two attributes arises mainly due to linkage, the correlation in positive direction will considerably accelerate the rate of genetic improvement in correlated characteristics on exercising selection. In the present investigation the genotypic correlation coefficient were, in general higher than the phenotypic correlation (Table 3) and thus suggest that observed relationships among the characters were due to genetic factors. Grain yield plant^{-1} indicated highly significant and positive association with biological yield plant^{-1}. The days to maturity, days to 50% flowering, leaf blade width, flag leaf width, number of effective tillers plant^{-1}, showed positive and significant association both at phenotypic and genotypic level except number of number of effective tillers plant^{-1} which shows non-significant but positive association at genetic level. Besides these leaf blade length, panicle length, plant height, flag leaf length, 100-grain weight, grain weight and grain length showed positive but weak association with grain yield plant^{-1} both at phenotypic and genotypic level. This findings are comparable to the earlier findings reported by Chaturvedi *et al*. (2008), Kishor *et al*. (2008) and Promin *et al*. (2010).

The dependent but variable grain yield was a result of interaction between component traits, which are either positively or negatively associated with each other. The total correlations are insufficient to explain true association for an effective manipulation of characters. Path coefficient analysis, being free from physical unit, furnishes a method for separating out correlation coefficient into measures of the direct and indirect effects and shows the relative importance of the causal factors involved. The path analysis (Table 4) revealed that at phenotypic level 100-grain weight has highest positive and direct effect on grain yield plant^{-1} followed by days to maturity, flag leaf width, number of effective tillers plant^{-1}, panicle length, harvest index, flag leaf length, grain shape index and biological yield plant^{-1} but grain length, leaf blade length, leaf blade width, days to 50% flowering, plant height and grain width shows negative direct effect on grain yield plant^{-1} at phenotypic level. 100-grain weight has highest positive and direct effect on grain yield plant^{-1} at genetic level followed by number of effective tillers plant^{-1}, leaf blade width, days to maturity, harvest index, days to 50% flowering, plant height, and flag leaf length shows positive and direct effect on grain yield plant^{-1}, whereas grain length, leaf blade length, panicle length, biological yield plant^{-1}, grain width, grain shape index and flag leaf width show negative and direct effect on grain yield plant^{-1} at genetic level. The findings of present study are

in accordance with the findings of Sarwagi *et al*. (2000), Chaturvedi *et al*. (2008), Kishor *et al*. (2008) and Ashok *et al*. (2016). 100-grain weight, number of effective tillers plant^{-1}, leaf blade width, harvest index, days to 50% flowering and plant height had high genotypic effect than phenotypic effect on grain yield plant^{-1}, indicating that environmental factors pertaining to the expression of these traits had a suppressing effect. The phenotypic residual effects is 0.399 indicating about some other factors which affecting grain yield plant^{-1} was not analysed in present study. The genetic residual effect is 0.126 indicates that the traits under study are sufficient to account variability in grain yield plant^{-1}. The result of phenotypic residual effect and genotypic residual effect clearly indicating that environmental factor has important role on grain yield plant^{-1}.

The result of present study suggest that leaf blade width, number of effective tillers plant^{-1}, days to maturity and 100-grain weight are most important characters which mainly effects the grain yield plant^{-1}. Therefore, the most emphasis should be given on these characters for selection of parental lines from locally adapted rice varieties of Bihar for high yielding variety, which should be suitable according to the climatic condition of Bihar.

REFERENCES

Al-Jibouri, H.A., Muller, P.A. and Robinson, H.P. 1958. Genetic and environmental variance and covariance in an upland cotton crop of interspecific origin. *Agron. J*., **30**: 633-636.

Ashok. S, Jyothula, D.P.B., Ratnababu. D. 2016. Character association and path analysis for yield components and grain quality parameters of rice (*Oryza sativa* L.). *IJASR*., **6(6)**: 253-258.

Burton, G.W. and Devane, E.W. 1953. Estimating heritability in tall fescue (*Fastuca arundinaceae*) replicated clonal material. *Agron. J*., **4**: 78

Chaturvedi, S., Lal, P., Pandey, M.P., Verma, S. and Singh, A.P. 2008. Component analysis for grain yield in hybrid rice under tarai condition. *Oryza.*, **45(1)**: 1-6.

Dewey, D.R. and Lu, K.K. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J*., **51**: 515-518.

Ganesan, K., Manuel, W. W. and Sundaram, G. 1995. Analysis of yield and yield components in rice. *Oryza*., **32(2)**: 111-112.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soyabeans. *Agron. J*., **47**: 314-318.

Kishor, C., Prasad, Y., Haider, Z.A., Kumar. R. and Kumar, K. 2008. Quantitative analysis of upland rice. *Oryza*., **45(4)**: 268-272.

Manonmani. S., Sreerangaswamy, S.R. and Ranganathan, B. 1996. Variability and heritability in earlier lines of indica rice. *Madras. Agric. J*., **83**: 75-76.

Mrutunjaya, C., Wali and Mahadevappa, M. 1995. Genetic variability, heritability and genetic advance for yield and its contributing characters in ratoon crop in rice (*Oryza sativa* L.). *Mysore. J. Agric. Sci*., **29**: 285-288.

Panse, V.G. 1957. Genetics of quantitative characters in relation to plant breeding. *Indian. J. Genet*., **17(2)**: 318-328.

Patil, S.M., Kumar, K., Jakhar, D.S., Rai, A., Borle, U.M. and Singh, P. 2016. Studies on variability, heritability, genetic advance and correlation in maize (*Zea mays* L.). *IJAEB*., **9(6)**: 1103-1108.

Promin, L., Kumar, M. and Sharma, P.R. 2010. Yield component analysis in hybrid rice varieties under rainfed conditions of Manipur valley. *Oryza*., **47(4)**: 272-275.

Rema Bai, N., Ahmed, R., Devika, R. and Joseph, C.A. 1992. Genetic variability and association of characters in medium duration rice genotypes. *Oryza*., **29(1)**: 19-22.

Sarwagi, A.K., Rastogi, N.K., Verma, R. and Wade, L.J. 2000. Character association in improved shallow rainfed lowland rices. *Oryza*., **37(4)**: 271-276.

Shamim, M.Z., and Sharma, V.K. 2014a. Assessment of variability and genetic diversity among different rice varieties for qualitative traits. *Indian J. Agric. Res.*, **48(3)**: 237-240.

Shamim, M.Z., and Sharma, V.K. 2014b. Study of genetic diversity among different rice varieties using quantitative characters. *Oryza*., **51(1)**: 86-89.

Shamim, M.Z., Manzar, H., Sharma, V.K. and Kumar, P. 2016. Microsatellite marker based characterization and divergence analysis among rice varieties. *Indian. J.Biotechnol*., **15**: 182-189.

Shivani, D. and Reddy, N.S.R. 2000. Variability, heritability and genetic advance for morphological and physiological in certain rice hybrids. *Oryza*., **37(3)**: 231-233.

Verma, O.P., Ram, P.C., Singh, P.N., Verma, G.P., Ismail, A., Singh, R.K. and Kumar, M. 2010. Genetic variation in promising rice genotypes for sodicity tolerance. *Oryza*., **47(4)**: 276-279.