

Genetic Variability, Heritability, Correlation and Path Coefficient Studies for Yield and Yield Components of Some Promising Rice Hybrids

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ABSTRACT

Eight promising hybrids along with three checks were evaluated for yield and yield contributing traits to observe their genetic variability, heritability, correlation and path coefficient analysis during T. Aman season 2014. The results indicated that the highest genotypic variance was recorded in spikelet panicle⁻¹ followed by effective tiller m⁻². Similarly, the highest phenotypic variances were also found with these two characters. Phenotypic coefficient of variation (PCV) was slightly higher than genotypic coefficient of variation (GCV) for all the traits under this study. Hence, slight differences indicate less or minor environmental influence and greater role of genetic factors on the expression of the traits. High heritability was observed in all the characters studied except effective tiller m⁻². Highly significant and positive correlations of grain yield with effective tiller m⁻², spikelet panicle⁻¹ at genotypic level were observed. Spikelet fertility was found significant at both genotypic and phenotypic level. Path analysis revealed that spikelet fertility had highly positive direct effect on grain yield followed by effective tiller m⁻². On the other hand, spikelet panicle⁻¹ showed positive indirect effect on grain yield. Thus, the results suggested that effective tiller m⁻²; number of spikelet panicle⁻¹ and spikelet fertility (%) could be considered as effective selection criteria for the development of heterotic rice hybrids.

Key words: Genetic variability, heritability, correlation, path analysis, hybrid rice

INTRODUCTION

Rice occupies more than 75.01% of total cropped area of Bangladesh (BBS, 2015). It provides 75% of the calories and 55% of the proteins in the average daily diet of the people (Bhuiyan *et al.*, 2002). Bangladesh is one of the most densely populated countries of the world. To feed the ever increasing population, there is no option other than breaking the yield ceiling of rice. Hybrids may offer to make a breakthrough in the yield ceiling of semi-dwarf rice that began in 1964. Currently, hybrid rice technology is considered as a viable option to increase rice yield globally. China is the first country to exploit of heterosis commercially in rice. During late 90s, about 55% of the rice area in China was under hybrid rice, producing 66% of the total rice

production (Virmani *et al.*, 1998). At present, hybrid rice covers 70% of the total rice area which is about 20 million hectares. The most promising hybrids yielded 20-30% and 15-20% (Yuan, 1998) higher than the best conventional and modern rice varieties, respectively. Initially, after the introduction of hybrid rice in Bangladesh in 1998, over the last one and half decades, about 174 rice hybrids were released for commercial cultivation in different rice growing regions of the country (SCA, 2018). The estimated area under hybrid rice in Bangladesh is about 0.7M ha has contributed 3-4 MT of additional rice to the total rice production in the country (AIS, 2018).

Grain yield is a complex trait, controlled by many genes, environmentally influenced and determined by the magnitude and nature of their genetic variability in which they grow

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(Singh *et al.*, 2000 and Selvaraj *et al.*, 2011). Hence, direct selection for yield is often misleading. Therefore, the characters, which are closely related to grain yield contribution, were identified (Rangare *et al.*, 2012). Genetic variation is the basis of plant breeding and provides a great array of genotypes that can be selected to develop new varieties or breeding materials (Pandey *et al.*, 2009). Variability in terms of genetic divergence for agronomic traits is the component of breeding programmes for broadening the gene pool of rice and requires reliable estimates of heritability to plan an efficient breeding strategy (Akinwale *et al.*, 2011). Path coefficient analysis partitions the genetic correlation between yield and its component traits into direct and indirect effects and hence has effectively been used in identifying useful traits as selection criteria to improve grain yield in rice (Sadeghi, 2011; Lakshmi *et al.*, 2017 and Singh *et al.*, 2018). Genetic improvement of plants for quantitative traits requires reliable estimates of heritability in order to plan an efficient breeding programme. The broad sense heritability is the relative magnitude of genotypic and phenotypic variance for the traits and it gives an idea of the total variation accounted to genotypic effect (Allard, 1960). Correlation coefficient determines the simple relations among the traits. It does not always determine decisive result about determination of plant selection criteria. But path coefficient analyses as well as correlation coefficient give more detailed information on the relations among the yield and yield contributing traits. Present research was conducted to evaluate the heritability and genetic advance for grain yield and some of its related components in order to select the more effective traits which may contribute for the improvement of hybrid rice. This experiment also aimed to study the variation of important agronomic traits and identify the characters of utmost importance which could be used as selection criteria in a hybrid rice breeding programme and to determine the direct and indirect contributions of important yield components on yield.

MATERIALS AND METHODS

Experimental site, seasons, materials and procedures

The experiment was conducted at the experimental farm of BRRI, Gazipur during July to November in T. Aman season 2014. Nine promising rice hybrids viz. IR79156A/BRRI20R, IR79156A/BasmatiR, IR58025A/BasmatiR, Jin23A/BasmatiR, BRRI7A/BRRI31R, BRRI28A/BRRI31R, BRRI33A/BRRI31R, BRRI28A/BRRI26R and three conventional checks viz BRRI dhan49, BR11, BRRI hybrid dhan4 were used as experimental materials in this study. All the promising hybrids along with three checks were sown separately into well prepared seed bed. Twenty-one-day old seedlings were transplanted with a spacing of 15 cm between plants and 20 cm between rows with single seedling per hill in the main field in randomized complete block (RCB) design with three replications. The plot size was 5 x 4 m². Fertilizers were applied @ 150:100:70:60:10 kg ha⁻¹ Urea, TSP, MP, gypsum and ZnSO₄, respectively. Standard agronomic practices were followed and plant protection measures were taken as required following (Anonymous, 2014).

Data collection

An observation and data record for all traits studied was made based on the Standard Evaluation System for rice (IRRI, 1996). Five sample plants were selected randomly in the middle three rows from each plot and observations were recorded on days to maturity, plant height (cm), number of effective tiller m⁻², number of spikelet panicle⁻¹, panicle length (cm), spikelet fertility (%), panicle weight (g), thousand grain weight (g), grain yield (ton hectare⁻¹) and moisture content of grains were measured by moisture meter and adjusted at 14% moisture content. Two border rows were used to minimize the border effects.

Statistical analysis

Analysis of variance was performed using the plant breeding statistical programme MSTAT C software. The genotypic and phenotypic variance, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense (h^2b), genetic advance in percentage of mean (GA), genotypic correlation coefficients (r_g) and phenotypic correlation coefficients (r_p) analysis were estimated following (Singh and Chaudhary, 1985). The estimates of GCV and PCV were classified as low, medium and high (Sivasubramanian and Madhavamenon, 1973). Heritability in broad sense and genetic advance were calculated according to methods given by (Allard, 1960). Path coefficient analysis was done using R-software (Ri386 3.1.2)

RESULTS AND DISCUSSION

Variation and performance of the genotypes

The analyses of variance of nine important quantitative characters for different genotypes showed significant variations among the genotypes for days to maturity, plant height (cm), effective tiller m^{-2} , no. of spikelet panicle⁻¹, panicle length (cm), spikelet fertility (%), panicle weight (g), thousand grain weights (g) and yield ($t ha^{-1}$) (Table 1). These results indicated that there were genotypic variations among the genotypes for these characters.

Genetic variability

Table 2 shows that the highest genotypic variance was obtained in spikelet panicle⁻¹ followed by effective tiller m^{-2} . Similarly the highest phenotypic variances were also obtained for those two characters. On the other hand, the lowest magnitude of genotypic and phenotypic variance was recorded in panicle weight and panicle length respectively. This might be due to the presence of both positive and negative alleles in the hybrids studied. Similar results were reported by Iftekharuddaula *et al.* (2001). The extent of variability for any character is very important for the improvement of a crop through breeding. The variability of the characters was measured by range, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV). The estimates of phenotypic coefficient of variation were slightly higher than those of genotypic coefficient of variation (GCV) for all the traits studied. The extent of the environmental influence on traits is explained by the magnitude of the difference between GCV and PCV. Large differences between GCV and PCV values reflect high environmental influence on the expression of traits. In this study, slight differences indicated environmental influence and consequently greater role of genetic factors on the expression of traits. Similar observations were also noted earlier by Mustafa and Elsheikh (2007) and Kole *et al.* (2008) in rice.

Table 1. Mean squares analysis for morphological traits in promising hybrid rice.

Character	df	Days to maturity	Plant height (cm)	Effective tiller m^{-2}	Spikelet panicle ⁻¹	Panicle length (cm)	Spikelet fertility (%)	Panicle weight (g)	TGW (g)	Yield ($t ha^{-1}$)
Genotypes	10	387.89**	87.38**	2157.44**	2344.38**	6.75**	55.59**	2.71**	31.64**	3.21**
Replication	2	0.21	5.68	425.08	58.30	0.79	5.83	0.01	0.00	0.26
Error	20	0.17	12.89	671.90	172.65	0.61	2.29	0.00	0.00	0.07
CV (%)		0.37	3.05	11.44	6.66	3.00	1.85	1.42	0.17	4.93

*Significant at the 5% level of probability; ** Significant at the 1% level of probability; TGW= Thousand grain weight.

Table 2. Estimate of genetic parameters for grain yield and its contributing traits of promising hybrid rice.

Character	Maximum	Minimum	Mean	Genotypic variance	Phenotypic variance	GCV (%)	PCV (%)	h ² b	GA
Days to maturity	140.00	102.00	114.303	129.239	129.418	9.95	9.95	99.86	23.40
Plant height (cm)	129.20	106.20	117.679	24.828	37.724	4.23	5.22	65.82	8.33
Effective tiller m ⁻²	283.80	158.00	226.539	495.180	1167.081	9.82	15.08	42.43	29.86
Spikelet panicle ⁻¹	249.00	133.00	197.424	723.911	896.557	13.63	15.17	80.74	49.80
Panicle length (cm)	29.20	22.20	25.970	2.047	2.654	5.51	6.27	77.13	2.59
Spikelet fertility (%)	87.00	70.00	81.670	17.765	20.060	5.16	5.48	88.56	8.17
Panicle weight (g)	5.20	2.18	3.687	0.904	0.907	25.78	25.83	99.67	1.96
Thousand grain weight (g)	32.10	20.43	25.66	10.546	10.548	12.65	12.65	99.98	6.69
Yield (t ha ⁻¹)	6.84	2.59	5.374	1.046	1.116	19.03	19.66	93.73	2.04

GCV- Genotypic coefficient of variation; PCV- Phenotypic coefficient of variation; h²b- Heritability in broad sense; GA- Genetic advance.

Heritability

The estimates of broad sense heritability varied from 42.43 to 99.98 % (Table 2). High heritability was observed in all the characters except effective tiller m⁻². Although high heritability suggests high component of heritable portion of variation that can be exploited by breeders in the selection of superior genotypes (Ali *et al.*, 2002). On the basis of phenotypic performance, heritability estimates along with genetic advance will be more useful in predicting the effect for selecting the best individual. Effective tiller m⁻² exhibited moderate heritability which indicates the possibility of using for rice improvement programme but their expression can be influenced more by the environment. High to moderate heritability was reported for different quantitative traits in rice (Zahid *et al.*, 2006; Kole *et al.*, 2008; Khan *et al.*, 2009 and Sadeghi, 2011). The estimate of genetic advance as percent of mean (Table 2) was high for spikelet panicle⁻¹, effective tiller m⁻² and days to maturity; moderate for plant height, spikelet fertility and thousand grain weight; and very low for panicle length, panicle

weight and yield. Therefore, the characters, viz effective tiller m⁻², spikelet panicle⁻¹, spikelet fertility and thousand grain weight (TGW) with moderate to high heritability and genetic advance could be considered effective traits in selection of F₁ genotypes. Similar result was reported by Iftekharuddaula *et al.* (2001). However, effective tiller m⁻² and spikelet panicle⁻¹ could be the most effective selection criteria as these characters had high genotypic and phenotypic variance in addition to high genetic advance.

Correlation coefficient

Table 3 presents genotypic and phenotypic correlation coefficient among grain yield and yield components for promising rice hybrid. Genotypic correlation coefficients were found higher than the phenotypic correlation coefficients in most of the cases which suggested that character association had not been largely influenced by environmental factors. There were highly significant and positive correlations of grain yield with spikelet fertility both at genotypic and phenotypic levels. On the other hand, effective

tiller m⁻² and spikelet panicle⁻¹ were significant and positive correlation of grain yield at genotypic levels, indicating the importance of these traits for yield improvement. The results are in agreement with Rokonzaman *et al.* (2008) and Khan *et al.* (2009) for spikelet panicle⁻¹, Kole *et al.* (2008) and Qamar *et al.* (2005) for effective tiller m⁻² and Ramakrishnan *et al.* (2006) for spikelet fertility. Grain yield had positive and non-significant correlation in days to maturity, plant height, panicle length and thousand grain weight both at genotypic and phenotypic levels. Similar observations were reported for panicle length by Kole *et al.* (2008). On the contrary, Khan *et al.* (2009) and Qamar *et al.* (2005) reported positive and non-significant association between grain yield and days to maturity. In our present study yield showed negative and non-significant association with panicle weight both at genotypic and phenotypic levels.

Interrelationships among yield contributing characters showed both significant positive and negative correlation. Days to maturity possesses significant and negative correlation with panicle length and TGW at both genotypic and phenotypic level. Plant height had significant and positive correlation with thousand grain weight at both genotypic and phenotypic level. Significant and positive correlation was observed for effective tiller m⁻² with spikelet fertility and grain yield at genotypic level only. It was observed that there were significant and positive correlations of spikelet panicle⁻¹ with spikelet fertility at both genotypic and phenotypic level but with grain yield at genotypic level only. Panicle length was highly significant and positive correlation with TGW was at both genotypic and phenotypic level. Finally, panicle weight showed significant and positive correlation with TGW at both the levels.

Table 3. Genotypic (G) and phenotypic (P) correlation coefficients among yield and yield components for promising hybrid rice.

Character		Plant height (cm)	Effective tiller m ⁻²	Spikelet panicle ⁻¹	Panicle length (cm)	Spikelet fertility (%)	Panicle weight (g)	TGW (g)	Yield (t ha ⁻¹)
Days to maturity	G	-0.1087	0.2170	0.2859	-0.8804**	0.4890	0.0369	-0.7110*	0.0785
	P	-0.0843	0.1475	0.2576	-0.7728**	0.4602	0.0364	-0.7102*	0.0739
Plant height (cm)	G		-0.2872	0.1091	0.2123	0.2337	0.5690	0.8859**	0.1875
	P		-0.0557	0.2318	0.2456	0.1756	0.4549	0.7206*	0.1332
Effective tiller m ⁻²	G			0.5439	-0.1765	0.7178*	-0.2841	-0.3622	0.8275**
	P			0.3323	-0.0445	0.4888	-0.1630	-0.2322	0.4532
Spikelet panicle ⁻¹	G				-0.0633	0.6681*	0.2028	0.2453	0.5669*
	P				-0.0235	0.5598*	0.1817	0.2219	0.4707
Panicle length (cm)	G					-0.2474	0.0439	0.9589**	0.2230
	P					-0.1698	0.0358	0.8415**	0.1356
Spikelet fertility (%)	G						0.0889	-0.1045	0.9103**
	P						0.0909	-0.0992	0.8169**
Panicle weight (g)	G							0.6943*	-0.0021
	P							0.6943*	-0.0056
Thousand grain weight (g)	G								0.1886
	P								0.1806

*Significant at the 5% level of probability; ** Significant at the 1% level of probability.

Path coefficient analysis

Genotypic correlation coefficients were partitioned by using path analysis method to find out the direct and indirect effects of yield contributing traits towards the grain yield. Path analysis (Table 4) revealed that the highest positive direct effect and genotypic correlation ($r_g = 0.9103$) with grain yield was obtained by spikelet fertility (1.117) followed by days to maturity (0.655), panicle length (0.404) and effective tiller m^{-2} (0.103). The highest positive direct effect has been reported for spikelet fertility (Agbo and Obi, 2005), days to maturity (Qamar *et al.*, 2005), productive tillers (Agahi *et al.*, 2005; Rokonuzzaman *et al.*, 2008) in rice. Spikelet panicle⁻¹ had negative direct effect with significant genetic correlation with grain yield. On the other hand, effective tiller m^{-2} had positive indirect effect through all the traits except thousand grain weight but days to maturity, plant height, panicle weight and spikelet panicle⁻¹ had negative indirect effect on grain yield through most of the other traits. The indirect effects of spikelet fertility for other traits indicated the importance of

direct selection using spikelet fertility to select high yielding genotypes. The residual effect of the present study was 0.017, indicating that about 98 percent of variability in grain yield might be contributed by these eight yield contributing traits studied in the path analysis. This gives an impression that some other minor characters than those involved in the present study also contributed to the variability of grain yield.

CONCLUSION

The estimation of genetic parameters, correlation and path coefficient of some promising hybrid rice for grain yield and yield contributing characters indicated that spikelet panicle⁻¹ had high both genotypic and phenotypic variance with high heritability and high genetic advance. Effective tiller m^{-2} had high phenotypic variance with high genetic advance. Spikelet fertility had the highest genotypic and phenotypic correlation coefficient on yield.

Table 4. Path coefficient showing direct and indirect effects of yield components on grain yield.

Character	Day to maturity	Plant height (cm)	Effective tiller m^{-2}	Spikelet panicle ⁻¹	Panicle length (cm)	Spikelet fertility (%)	Panicle weight (g)	TGW (g)	Genotypic correlation with grain yield
Day to maturity	0.655	0.011	0.034	-0.044	-0.031	-0.635	0.008	-0.050	0.0785
Plant height (cm)	0.273	0.027	-0.010	-0.077	0.105	-0.939	0.040	-0.003	0.1875
Effective tiller m^{-2}	0.215	-0.003	0.103	0.074	0.060	0.252	0.018	-0.045	0.8275**
Spikelet panicle ⁻¹	0.069	0.005	-0.018	-0.418	0.169	-0.128	0.051	0.020	0.5669*
Panicle length (cm)	-0.051	0.007	0.015	-0.176	0.404	-0.050	0.049	-0.016	0.2230
Spikelet fertility (%)	-0.372	-0.023	0.023	0.048	-0.018	1.117	-0.018	-0.004	0.9103**
Panicle weight (g)	0.063	0.013	0.021	-0.253	0.236	-0.241	0.085	-0.008	-0.0021
Thousand grain weight (g)	0.378	0.001	0.054	0.096	0.074	0.046	0.007	-0.087	0.1886

Bold figures indicate the direct effect, Residual effect=0.017.

On the other hand, effective tiller m⁻² and spikelet panicle⁻¹ had significant only genotypic correlation coefficient on grain yield. Spikelet fertility had high direct effect and highly significant positive correlation with grain yield followed by days to maturity, effective tiller m⁻² and panicle length (cm). Hence these four important traits, could be considered as selection criteria for the development of high yielding hybrid rice varieties.

ACKNOWLEDGEMENT

Authors are thankful to all the staff members of Hybrid Rice Division

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