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GENETIC VARIABILITY, CORRELATION AND PATH COEFFICIENT ANALYSIS FOR YIELD AND YIELD COMPONENTS IN TRANSPLANT AMAN RICE (*ORYZA SATIVA* L.)

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Key words: Genetic variability, Yield components, Correlation, Path coefficient analysis

Abstract

Analysis of variance revealed significant differences among the genotypes for all the traits. Flag leaf area (0.643**), productive tillers per plant (0.450**), 1000-grain weight (0.785**) and harvest index (0.920**) showed positive and strong significant association with grain yield per plant at genotypic level whereas plant height (–0.418*) and per cent spikelet sterility (–0.489**) possessed significant negative correlation with grain yield per plant. Flag leaf area (0.157) productive tillers per plant (0.481), 1000-grain weight (0.228), growth duration (0.080) and harvest index (0.544) exhibited direct effect on grain yield. Considering the correlation and path analysis flag leaf area, productive tiller per plant, 1000-grain weight and harvest index are important characters to be considered for yield improvement.

Introduction

Complex trait controlled by many genes, environmentally influenced and determined by the magnitude and nature of their genetic variability. Yield contributing components are interrelated with each other by bonding a complex relationship and also highly influenced by the environmental conditions. Understanding the relationship between yield and its components is of paramount importance for making the best use of these relationships in selection. Zahid *et al.* (2006) reported that breeding strategy in rice mainly depends upon the degree of associated characters as well as its magnitude and nature of variation. Genetic variability among the traits is important for selecting desirable types in breeding program. Character association derived by correlation coefficient, forms the basis for selecting the desirable plant, aiding in evaluation of relative influence of various component characters on grain yield. Correlation and path analysis establish the extent of association between yield and its components and also bring out relative importance of their direct and indirect effects. Grain yield has been reported to be influenced by high direct effects of number of tillers per plant and flag leaf area, the number of grains per panicle and 1000-grain weight (Yang 1986), the number of filled grains per panicle and plant height number of spikelets per panicle, number of grains per panicle (Ram 1992) filled grains per panicle, spikelets per panicle, spikelets fertility (Hairmansis *et al.* 2010), grains per panicle, days to maturity, number of productive tillers, days to flowering (Sadeghi 2011) and panicle length and grains per panicle (Ullah *et al.* 2011). Path coefficient analysis partitions grain yield into direct and indirect effect presenting correlation in a more meaningful way. Milligan *et al.* (1990) reported plant breeders use path analysis to identify the traits that are most effective in selection to improve the crop yield. Heritability of a trait is important in determining its response to selection.

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Knowledge of heritability plays vital role to plan an efficient breeding program for genetic improvement of plants for quantitative traits (Seyoum *et al.* 2012). The traits which are highly heritable and positively correlated with grain yield are most effective component for increasing grain yield. Partitioning of total correlation into direct and indirect effect by path analysis helps to select genotype most effectively (Falconer 1989). So, this study was aimed to reveal the genetic variability among the yield contributing traits, direct and indirect contribution of these parameters towards grain yield and to identify better combinations as selection criteria for developing high yielding rice genotypes.

Materials and Methods

BRRI released 25 T. Aman rice varieties and seven advanced rice genotypes were evaluated in a randomized complete block design with three replications at the experimental field of Bangladesh Rice Research Institute (BRRI) during T. Aman season 2011(July - December, 2011). The experimental site was at 24.00^0 N latitude and 90.25^0 E. longitudes with an elevation of 8.4 meter from sea level. The soil fertility was ensured by applying additional quantities of urea-TSP-MoP-gypsum @ 194-52-82-60 Kg/ha, respectively. Total urea was applied in three installments at 10 days after transplanting (DAT), 30 DAT and 45 DAT. Total TSP, MoP, and gypsum were applied in the final land preparation. Thirty days old seedlings were transplanted with the spacing of 25 cm × 15 cm. Data were collected from 10 randomly selected plants from each replication. Data were collected on days to 100% flowering, total tillers per plant, plant height (cm), flag leaf area (cm), productive tillers per plant, panicle weight (g), panicle length (cm), grains per panicle, spikelets per panicle, per cent spikelet sterility, thousand grain weight (g), growth duration (days), harvest index, grain yield per plant (g). Flag leaf area was measured by leaf area meter. Panicle weight (g), panicle length (cm), grains per panicle, spikelets per panicle, per cent spikelet sterility was calculated from ten main panicle. The averages of replications were used for analyzing the data. The data were analyzed by MSTAT program for ANOVA. The mean sum of square (MSS) of error (considered as error variance (∂^2e), phenotypic variances (∂^2p), genotypic variances (∂^2g), broad sense heritability and genetic advance were estimated following Johnson *et al.* (1955). GCV and PCV were estimated according to the formula of Burton (1952). Genotypic and phenotypic correlation coefficients were carried out using formula suggested by Miller *et al.* (1958), Hanson *et al.* (1956) and Johnson *et al.* (1955). The correlation coefficient was further partitioned into components of direct and indirect effects by path coefficient analysis developed by Wright (1934) and later described by Deway and Lu (1959).

Results and Discussion

The analysis of variance showed that the mean squares for the genotypes were highly significant for all traits measured. The phenotypic variance was partitioned into heritable and non heritable components. The magnitude of the genotypic variance for all the yield traits were higher than the environmental variance (Table 1) which was also reported by Rahman *et al*. (2012). The estimated phenotypic coefficient of variation (PCV) were higher than those of genotypic coefficient of variation (GCV) for all the traits studied except growth duration. This result was corroborated by Sadeghi (2011). The extent of the environmental influence on traits is explained by the magnitude of the difference between GCV and PCV. Higher difference between GCV and PCV values reflects higher environmental influence on the expression of the traits. In this study difference between PCV and GCV for the test characters was insignificant indicating low sensitivity to environment consequently higher role of genetic factors influencing the characters expression. Kole *et al.* (2008) found no significant difference between PCV and GCV. The GCV and PCV ranged from 6.3 - 43.31 and 6.3 - 40.81 for growth duration and per cent spikelet sterility, respectively. Flag leaf area, effective tillers per plant, grains per panicle, 1000-grain weight, harvest index and grain yield per plant showed moderate GCV and PCV while plant height, panicle length and growth duration showed lowest GCV and PCV. Ullah *et al.* (2011) reported moderate to low GCV and PCV estimates for different quantitative traits of rice. Heritability estimates in broad sense (h^2b) were relatively higher (Table 1) for most of the traits. Plant height, productive tillers per plant, grains per plant and 1000-grain weight exhibited high heritability which was earlier reported by Ullah *et al.* (2011). High heritability estimates have been found to be helpful in making successful selection of superior genotypes on the basis of phenotypic performance. Heritability estimates along with genetic gain would be more useful for selecting the best genotype. High heritability associated with high genetic advance (Table 1) was found in grains per panicle, plant height, per cent spikelet sterility, growth duration and flag leaf area indicated the predominance of additive gene action for the expression of these characters. Therefore, selection of genotypes based on these characters would be more effective to be successful for target plant selection.

Table 1. Genetic parameters for grain yield and yield related traits in T. Aman rice genotypes.

Traits	Mean	MSS	Range	σ^2 p	σ^2 g	σ^2 e	PCV	GCV	ECV	h^2b	GA (1%)
PH	116.33	378.19**	90-142	126.22	125.99	0.24	9.66	9.65	0.42	99.81	29.6
FLA	34.84	218.19**	18.95-55.17	74.71	71.74	2.96	24.81	24.31	4.94	96.03	21.91
PTP	10.99	6.89**	8.00-15.00	2.58	2.16	0.43	14.62	13.36	5.94	83.48	3.54
PL	23.458	11.28**	19.1-27.4	4.01	3.63	0.38	8.54	8.12	2.64	90.46	4.78
GP	119.333	1416.39**	74-179	487.44	464.47	22.96	18.5	18.06	4.02	95.29	55.54
SS	26.218	337.84**	7.00-53.32	114.5	111.67	2.84	40.81	40.31	6.42	97.52	27.55
TGW	21.903	59.877**	11.2-31.0	20.02	19.93	0.09	20.43	20.38	1.39	99.54	11.76
GD	141.021	236.751**	117-155	79.03	78.86	0.16	6.3	6.3	0.28	99.8	23.42
HI	0.434	0.011**	0.28-0.54	0.003	0.002	0.001	14.61	14.06	3.99	92.55	0.16
GYP	0.011	29.503**	10.28-25.23	10.79	9.36	1.44	17.59	16.38	6.42	86.69	7.52

PH: Plant height (cm), FLA: Flag leaf area (cm^2), PTP: Productive tillers per plant, PL: Panicle length (cm), GP: Grains per panicle, SS: Per cent spikelet sterility, TGW: 1000-grain weight, GD: Growth duration, HI: Harvest index, GYP: Grain yield per plant

** = Significant at 1% level, σ^2_g = Genotypic variance, σ^2_e = Environmental variance, σ^2p = Phenotypic variance, h^2b = Heritability in broad sense, GA = Genetic advance, GCV = Genotypic coefficients of variations, PCV = Phenotypic coefficients of variations and ECV = Environmental coefficients of variations.

Correlation analysis among grain yield and yield contributing characters (Table 2) exhibited that the genotypic correlation coefficient in most cases was higher than their corresponding phenotypic correlation coefficients indicating the association is largely due to genetic cause. Chaubey and Singh (1994) and Ojo *et al.* (2006) reported the similar result. The observed positive correlation of grain yield with various traits were supported by findings of earlier workers *viz.* Akhter *et al.* (2011), Haider *et al.* (2012) for 1000-grain weight, Sarawgi *et al.* (1997), Kole *et al.* (2008) for harvest index both at genotypic and phenotypic levels while flag leaf area only at genotypic level indicated the importance of these traits for yield improvement of rice in T. Aman season. Grain yield had significant negative correlation with per cent spikelet sterility both at genotypic and phenotypic level which indicated grain yield reduces with the increases of spikelet sterility. Sarawgi *et al.* (1997) observed spikelet sterility percentage had a high negative correlation with grain yield per plant. Plant height and productive tillers per plant were significantly and negatively correlated with grain yield only at genotypic level. Negative correlation coefficient of plant height with grain yield indicates that tallness of rice plant reduces the grain yield due to high accumulation of photosynthates in vegetative parts compared to reproductive parts and increases lodging susceptibility.

Table 2. Genotypic (r_g) and phenotypic (r_p) correlation coefficients of yield and yield related traits in T. Aman rice genotypes.

Parameters		FLA	PTP	PL	GP	SS	TGW	GD	HI	GYP
PH	rg	0.111	–0.06	0.201	0.283	0.111	–0.347	0.288	–0.456**	–0.418*
	rp	0.109	–0.057	0.191	0.277	0.112	–0.346	0.287	–0.435*	–0.314
FLA	rg		–0.721**	0.326	0.231	0.139	0.545**	0.023	0.153	0.643**
	rp		–0.647**	0.302	0.224	0.135	0.535**	0.022	0.149	0.321
PTP	rg			–0.29	–0.024	–0.303	–0.590**	–0.071	-0.05	0.450**
	rp			–0.258	–0.015	–0.276	–0.537**	–0.067	–0.036	0.293
PL	rg				0.297	–0.158	0.187	–0.177	0.147	0.290
	rp				0.276	–0.147	0.180	–0.165	0.136	0.143
GP	rg					–0.309	–0.388*	–0.168	0.013	0.092
	rp					–0.303	–0.378*	–0.164	0.026	0.090
SS	rg						–0.019	0.248	–0.569**	–0.489**
	rp						–0.02	0.244	–0.543**	–0.406**
TGW	rg							–0.082	0.502**	0.785**
	rp							–0.082	0.483**	0.471**
GD	rg								–0.405*	–0.298
	rp								–0.386*	–0.174
HI	rg									0.920**
	rp									0.673**

PH: Plant height (cm), FLA: Flag leaf area (cm^2), PTP: Productive tillers per plant, PL: Panicle length (cm), GP: Grains per panicle, SS: Per cent spikelet sterility, TGW: 1000-grain weight, GD: Growth duration, HI: Harvest index.

*Indicates significant at 5% level of significance. ** Indicates significant at 1% level of significance.

Considering grain yield as effect and nine characters as causes, genotypic correlation coefficients were partitioned by using method of path analysis to find out the direct and indirect effects of yield contributing characters towards the grain yield. Path coefficient analysis (Table 3) showed that plant height had negative direct effect on grain yield and its indirect effect via all the traits studied were negative except harvest index (0.079). Value of genotypic correlation between plant height and grain yield was significantly negative. Akhter *et al.* (2011) also found negative direct effect of plant height on grain yield but value of genotypic correlation between plant height and grain yield was negative. The direct effect of flag leaf area was positive on grain yield that was similar with the result of Sadeghi 2011. Correlation coefficient with grain

Table 3. Path coefficient analysis showing direct (bold) and indirect effect of yield contributing traits on grain yield.

Parameters	PH	FLA	PTP	PL	GP	SS	TGW	GD	HI	Genotypic correlation with grain yield
PH	–**0.168**	0.018	0.029	–0.096	–0.018	–0.037	0.079	0.023	–0.248	–0.418**
FLA	–0.019	**0.157**	0.444	–0.011	–0.023	–0.046	–0.045	0.002	0.184	0.643**
PTP	–0.010	–0.113	**0.481**	0.011	0.002	0.099	0.124	–0.006	–0.027	0.450**
PL	–0.034	0.051	0.139	–**0.036**	–0.030	0.066	0.149	–0.095	0.080	0.290
GP	–0.048	0.036	0.011	-0.011	–**0.100**	0.201	–0.043	–0.024	0.050	0.072
SS	–0.031	0.022	0.010	0.006	0.031	–**0.327**	0.089	0.020	–0.309	–0.489**
TGW	–0.058	0.085	0.226	–0.007	0.039	0.006	**0.228**	–0.007	0.273	0.785**
GD	–0.109	0.004	0.034	0.006	0.017	–0.098	0.019	**0.080**	–0.251	–0.298
HI	0.079	0.079	0.085	–0.005	–0.001	0.286	–0.114	-0.033	**0.544**	0.920**

PH: Plant height (cm), FLA: Flag leaf area (cm^2), PTP: Productive tillers per plant, PL: Panicle length (cm), GP: Grains per panicle, SS: Per cent spikelet sterility, TGW: 1000-grain weight, GD: Growth duration, HI: Harvest index.

* Indicates significant at 5% level of significance. **Indicates significant at 1% level of significance.

Residual effect, R = 0.4307.

yield was positive and strongly significant which means flag leaf area may be used as reliable character to improve grain yield. Productive tillers per plant showed direct positive effect on grain yield and its indirect effect through all the traits studied was positive. It maintained strong significant and positive correlation with grain yield indicating productive tillers per plant may be the effective parameter to select high yielding genotype. Sadeghi (2011) also reported positive direct effect of productive tillers per plant on grain yield. Panicle length expressed negative direct effect on grain yield and had negative indirect effect via plant height, flag leaf area, grains per panicle, thousand grain weight and harvest index. But its possessed positive correlation with grain yield. It indicated that panicle length would not be authentic criterion for improving grain yield. Grains per panicle had negative direct effect on grain yield and also showed negative indirect effect through plant height, flag leaf area, panicle length and harvest index. On the contrary grain yield per plant and grains per panicle were positively correlated at genotypic level. Therefore, it may not be used as a promising criterion for selecting high yielding genotype. The direct effect of per cent spikelet sterility was negative and its negative indirect effect was found via plant height, flag leaf area and growth duration on grain yield. Likewise genotypic correlation coefficient between grain yield per plant and per cent spikelet sterility was significantly negative. It indicates per cent spikelet sterility could not be used as effective character for improving grain yield. The direct positive effect of thousand grain weight on grain yield per plant and significant positive genotypic correlation between these traits indicates that a direct selection using this trait would be much effective for the improvement of grain yield per plant. Kole *et al.* (2008) also found the direct positive effect of thousand grain weight on grain yield per plant. Growth duration exhibited positive direct effect on grain yield that was unison with the result of Rahman *et al.* (2012) and maintained negative indirect effect via productive tillers per plant, panicle length, grains per panicle, 1000- grain weight and harvest index. Harvest index expressed positive direct effect and it had also positive indirect effect through flag leaf area, panicle length, grains per panicle and 1000-grain weight on grain yield. Genotypic correlation coefficient between harvest index and grain yield was significantly positive. Therefore, harvest index would be effective trait for improving grain yield per plant. The residual effect was 0.4307 indicated that the contribution of component characters on grain yield was 56.93% by the ten characters studied in path analysis, the rest 43.07% was the contribution of other factors, such as traits not studied.

The result of analysis of variance clearly showed that adequate genetic variability present in the studied materials for all the traits. Insignificant difference between PCV and GCV indicating higher role of genetic factors influencing the expression of studied characters. In most cases, genotypic correlation coefficient of studied traits was higher than their corresponding phenotypic correlation coefficients indicating the association is largely depend on genetic factors. Partitioning of correlation value of harvest index showed the highest significant genotypic correlation (0.920*) and positive direct effect on grain yield followed by thousand grain weight (0.785*), flag leaf area (0.643*), and productive tiller per plant (0.450*). Therefore, plant breeders should give more attention to these traits during breeding program for developing high yielding rice.

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