American-Eurasian J. Agric. & Environ. Sci., 14 (5): 387-391, 2014
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2014.14.05.12336

Genetic Variability, Correlation and Path Coefficient Analysis of Morphological Traits in Transplanted Aman Rice (*Oryza sativa* L.)

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Abstract: Twenty one rice varieties were assessed for thirteen morphological characters during T. Aman season, 2008 at Sonagazi Regional Station of BRRI. Analysis of variance raveled significant differences among the varieties for all the traits. Plant height, number of effective tillers per square meter, number of spikelets per panicle, number of effective spikelets per panicle, number of ineffective spikelets per panicle, 1000 grains weight, straw yield and grain yield exhibited that they were controlled by additive gene action and selection for the improvement of these traits would be rewarding. The phenotypic variance was higher than the corresponding genotypic variance for all the characters. All the characters showed moderate to low phenotypic and genotypic coefficient of variation. Genotypic coefficient of variation was the highest for number of ineffective spikelets per panicle (39.96) followed by 1000 grains weight (24.33) and number of spikelets per panicle (18.61). Plant height and 1000 grains weight (95.30) had the highest heritability. Considering the correlation and path analysis number of effective spikelets per panicle, 1000 grain weight, number of effective spikelets per panicle, number of effective tillers per square meter and plant height are important characters for yield improvement.

Key words: Correlation · Morphological Divergence · Path Analysis · Rice

INTRODUCTION

Rice (*Oryza sativa* L.) is a self-pollinated cereal crop having chromosome number 2n=24 under the family Gramineae [1]. It is the staple food for more than half of the global population [2, 3]). The livelihood and calorie needs of large populations in developing countries, especially, in Bangladesh and in some developed countries dependent on rice cultivation [4]. In many developing countries including Bangladesh, rice is the basis of food security and intimately associated with traditional culture and customs in local regions [5, 6]. Bangladesh is the fourth largest producer and consumer of rice in the world [7], with annual production of 33.317 million metric tons in an area of 11.359 million hectare of land [8]. In Bangladesh rice provides 75% of the calories and 55% of the protein in the average daily diet of the people [9]. Therefore, rice is not only the staple food but also "rice is life" in Bangladesh context.

In Bangladesh rice is grown in three seasons, termed as Aus, Aman and Boro seasons. Among these seasons, Aman occupied the highest area coverage (48.74 % of total rice cropped area) [8]. Since we have to give more attention on the improvement of rice varieties to increase rice production in order to satisfy increasing need of food, therefore, improvement in the yield of T. Aman rice varieties could contribute more effectively than the Aus and Boro varieties due to larger area coverage. For the development of effective breeding program to develop high yielding T. Aman rice varieties, correlation and path coefficient analysis are very much important. The traits that have positive effect on rice yield could be selected

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for genetic improvement program to develop new high yielding varieties. Many experiments were done in this context using mainly Boro or Aus rice varieties or using land races. No experiment was conducted based on the improved and modern high yielding T. Aman rice varieties. Therefore, the aim of the study was to assess the genetic parameters, correlation and path coefficient in modern high yielding T. Aman rice varieties.

MATERIALS AND METHODS

The study was conducted to assess the genetic variability, correlation and path coefficient analysis among 21 T. Aman rice cultivars (Table 1) composed of 20 BRRI developed T. Aman HYV and one most popular local variety (Rajasail) at BRRI regional station, Sonagazi, Feni, during July to December 2008. The experiment was laid out in RCBD with three replications. The individual plot area was 3.0 m. × 5.0 m having plot to plot and block to block distance of 0.5 m and 1.0 m, respectively. Recommended fertilizer dose and standard agronomic practices were followed.

Data were recorded on plant height, panicle length, maximum number of tillers/m^2, number of effective tillers/m^2, tiller mortality, number of spikelets/panicle, number of effective spikelets/panicle, number of ineffective spikelets/panicle, spikelet fertility (%), 1000-grain weight, straw yield (t/ha) and grain yield (t/ha). The data were analyzed by MSTAT program for ANOVA. Phenotypic variances (σ^2_p), genotypic variances (σ^2_g) and error variances (σ^2_e) were estimated following Johnson *et al*., [10]. Genotypic and phenotypic coefficients of variation were estimated according to Burton [11]. Broad sense heritability, genetic advance (GA) and genetic advance in percentage of mean (GAPM) were estimated using the formula suggested by Johnson *et al*. [10] and Hanson *et al*. [12]. Genotypic and phenotypic correlation coefficient were carried out using formula suggested by Miller *et al.* [13], Hanson *et al.* [12] and Johnson *et al.* [10]. The correlation coefficient were further partitioned into components of direct and indirect effects by path coefficient analysis developed by Wright [14] and later described by Dewey and Lu [5].

RESULTS AND DISCUSSION

Genetic Variability of the Traits: All the morphological characters showed highly significant variations among the genotypes (Table 2). The phenotypic variance was higher than the corresponding genotypic variance for all the characters and showed moderate to low phenotypic and genotypic coefficient of variation. High phenotypic and genotypic variances with low environmental variance for the characters of plant height (202.65, 193.14 and 9.52, respectively), panicle length (4.44, 3.62 and 0.81, respectively), number of spikelets per panicle (1185.63, 934.54 and 251.09, respectively), 1000 grains weight (21.15, 20.15 and 0.99, respectively), straw yield (0.52, 0.40 and 0.12, respectively) and grain yield (0.36, 0.32 and 0.04, respectively) indicate the expression of the genes controlling these characters are not markedly influenced by the environmental conditions. On the other words, the expressions of these traits are mainly due to the genetic constituents rather than environmental influence. In addition, the differences between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) of these traits are also very low which also reveals that the influence of the environment on the expression of these traits is very little. Among the rest of the characters, higher phenotypic and genotypic variances with medium environmental variance were observed for number of effective tillers/m^2 (806.65, 576.74

Table 1: List of varieties used in this study

Sl. No.	Name of the variety	Year of release	Sl. No.	Name of the variety	Year of release
01.	BR3	1973	12.	BRRI dhan33	1997
02.	BR4	1975	13.	BRRI dhan34	1997
03.	BR5	1976	14.	BRRI dhan37	1998
04.	BR10	1980	15.	BRRI dhan38	1998
05.	BR11	1980	16.	BRRI dhan39	1999
06.	BR22	1988	17.	BRRI dhan40	2003
07.	BR23	1988	18.	BRRI dhan41	2003
08.	BR25	1992	19.	BRRI dhan44	2005
09.	BRRI dhan30	1994	20.	BRRI dhan46	2007
10.	BRRI dhan31	1994	21.	Rajasail	Local variety
11.	BRRI dhan32	1994			

Table 2: Mean, range, genetic component of variations, heritability (h^2_b), genetic advance (GA) and genetic advance in percent of mean for 12 morphological characters in T. Aman rice cultivars

Characters	MSS	CV (%)	Mean	Range	V_g	V_p	V_e	GCV	PCV	H^2_b	GA	GA in % of mean
Plant height (cm)	588.93**	2.70	114.31	80.33-142.40	193.14	202.65	9.52	12.16	12.45	95.30	27.95	24.45
Panicle length (cm)	11.68**	3.52	25.62	20.93-28.83	3.62	4.44	0.81	7.43	8.22	81.67	3.54	13.83
Number of maximum tillers/m^2	5066.85**	13.59	326.17	239.67-402.0	1033.86	2999.14	1965.28	9.86	16.79	34.47	38.89	11.92
Number of effective tillers /m^2	1960.12**	6.88	220.51	187.0-288.67	576.74	806.65	229.91	10.89	12.88	71.49	41.83	18.97
Tiller mortality (%)	142.24**	22.74	31.72	20.13-43.97	30.07	82.11	52.05	17.28	28.56	36.62	6.83	21.55
Number of spikelets per panicle	3054.70**	9.65	164.18	82.80-213.20	934.54	1185.63	251.09	18.61	20.97	78.82	55.91	34.05
No. of effective spikelets/panicle	1635.05**	10.68	131.80	76.27-176.73	478.95	677.14	198.18	16.60	19.74	70.73	37.92	28.77
No. of ineffective spikelets/panicle	595.09**	29.73	32.38	6.53-60.60	167.46	260.17	92.70	39.96	49.81	64.37	21.39	66.05
Spikelets fertility (%)	117.05**	5.68	80.97	68.86-92.05	31.96	53.13	21.17	6.98	9.00	60.16	9.03	11.16
1000 grains weight (g)	61.45**	5.4	18.45	8.48-26.70	20.15	21.15	0.99	24.33	24.92	95.30	9.03	48.93
Straw yield (t/ha)	1.32**	7.00	4.96	3.27-5.87	0.40	0.52	0.12	12.77	14.56	76.94	1.14	23.07
Grain yield (t/ha)	0.99**	5.32	3.84	2.62-4.78	0.32	0.36	0.04	14.62	15.56	88.25	1.09	28.30

** indicates significant at 1% level of significance, MSS = Mean sum of squares, CV (%) = Coefficient of variation, Vg = Genotypic variance, Vp = Phenotypic variance, Ve = Environmental variance, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, H^2_b = Heritability in broad sense, GA = Genetic advance

Table 3: Genotypic (upper right) and phenotypic (lower left) correlation coefficient among twelve morphological characters of T. Aman rice

Characters	Plant height (cm)	Panicle length (cm)	Number of maximum tillers/m^2	Number of effective tillers /m^2	Tiller mortality (%)	Number of spikeletsx of spikelets	No. of effective spikelets per panicle	No. of ineffective spikelets per panicle	Spikelet fertility (%)	1000 grains weight (g)	Straw yield (t/ha)	Grain yield (t/ha)
Plant height (cm)	1.000	0.221	0.584**	0.251	0.355	0.445*	0.466*	0.265	-0.117	-0.422	0.625**	-0.048
Panicle length (cm)	0.196	1.000	0.130	-0.350	0.753**	0.516*	0.235	0.822**	-0.897**	-0.101	0.141	0.249
Number of maximum tillers/m^2	0.346	0.094	1.000	0.767**	0.357	0.241	0.169	0.284	-0.260	-0.616**	0.664**	-0.116
Number of effective tillers /m^2	0.222	-0.323	0.555**	1.000	-0.337	-0.146	-0.066	-0.234	0.234	-0.439*	0.554**	-0.213
Tiller mortality (%)	0.219	0.454*	0.634**	-0.236	1.000	0.449*	0.217	0.693**	-0.707**	-0.155	0.170	0.101
Number of spikelets/panicle	0.397	0.517*	0.074	-0.155	0.209	1.000	0.931**	0.787**	-0.616**	-0.667**	0.285	0.086
No. of effective spikelets/panicle	0.395	0.317	0.035	-0.136	0.135	0.894**	1.000	0.509*	-0.291	-0.796**	0.298	0.192
No. of ineffective spikelets/panicle	0.210	0.591**	0.102	-0.111	0.229	0.692**	0.296	1.000	-0.962**	-0.229	0.170	-0.123
Spikelet fertility (%)	-0.083	-0.582**	-0.109	0.072	-0.217	-0.480*	-0.043	-0.954**	1.000	0.043	-0.110	0.096
1000 grains weight (g)	-0.398	-0.080	-0.348	-0.355	-0.097	-0.552**	-0.629**	-0.165	0.023	1.000	-0.488*	0.105
Straw yield (t/ha)	0.548*	0.126	0.418	0.400	0.194	0.247	0.278	0.078	-0.012	-0.393	1.000	0.103
Grain yield (t/ha)	-0.020	0.161	-0.125	-0.160	0.018	0.052	0.102	-0.054	0.013	0.099	0.094	1.000

** indicates 1% level of significance and * indicates 5% level of significance; df=N-2=21-2=19

and 229.91, respectively) number of effective spikelets per panicle (677.14, 478.95 and 198.18, respectively) and for spikelet fertility (53.13, 31.96 and 21.17, respectively). Low to medium differences between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) of these traits also support that the influence of the environment on the expression of these traits are not very high. High environmental variance along with high differences between PCV and GCV was found in case of number of maximum tillers per square meter (1965.28 and 6.93, respectively), tiller mortality (52.05 and 11.28, respectively) and number of ineffective spikelets per panicle (92.70 and 9.85, respectively) indicate that these characters are largely influenced by the environmental conditions rather than the genetic constituents of the traits.

All the traits, except number of maximum tillers per square meter (34.47%) and tiller mortality (36.62%) showed high heritability in broad sense. Plant height, number of effective tillers per square meter, number of spikelets per panicle, number of effective spikelets per panicle, number of ineffective spikelets per panicle, 1000 grains weight, straw yield and grain yield showed high genetic advance in percent of mean along with high heritability. Therefore, additive gene action controls these traits and selection for the improvement of these characters might be rewarding. The remaining four characters viz. panicle length, number of maximum tillers per square meter, tiller mortality and spikelet fertility are controlled by non-additive gene action and in this case heterosis breeding might be used rather than selection for the improvement of these traits. Hossain *et al*, [15], Sadhukhan and Chattopadhyay [16], Iftekharuddaula et al, [17] and Biswas et al, [18] reported similar results for one or more characters.

Correlation Among the Traits: Yield is a complex product being influenced by several interdependable quantitative characters. Thus developing a breeding protocol for yield improvement may not be effective unless the other yield components influencing it directly or indirectly are taken into consideration. Correlation analysis among the yield and its contributing characters (Table 3) revealed that the genotypic correlation coefficients in most cases were higher than their phenotypic correlation coefficients indicating the association is largely due to genetic reason. In some cases phenotypic correlation coefficients were higher than genotypic correlation indicating suppressing effect of the environment that can modify the expression of the characters at phenotypic level.

Table 4: Path analysis showing direct and indirect effects of 11 traits on yield in 21 T. Aman rice cultivars

Traits	Plant height (cm)	Panicle length (cm)	Number of maximum tillers/m^2	Number of effective tillers /m^2	Tiller mortality (%)	Number of spikelets per panicle	No. of effective spikelets per panicle	No. of ineffective spikelets per panicle	Spikelet fertility (%)	1000 grains weight (g)	Straw yield (t/ha)	Genotypi correlation with grain yeild
Plant height (cm)	0.681	-0.248	-0.960	0.231	0.460	-2.944	3.162	-1.393	0.904	-0.024	0.083	-0.048
Panicle length (cm)	0.151	-1.122	-0.213	-0.322	0.977	-3.413	1.598	-4.324	6.906	-0.006	0.019	0.249
Number of maximum tillers/m^2	0.397	-0.146	-1.643	0.706	0.463	-1.595	1.147	-1.496	1.998	-0.035	0.088	-0.116
Number of effective tillers /m^2	0.171	0.393	-1.261	0.920	-0.437	0.967	-0.447	1.232	-1.799	-0.025	0.073	-0.213
Tiller mortality (%)	0.241	-0.845	-0.587	-0.309	1.298	-2.967	1.475	-3.648	5.442	-0.009	0.022	0.101
Number of spikelets per panicle	0.303	-0.579	-0.396	-0.134	0.583	-6.610	6.325	-4.143	4.739	-0.038	0.038	0.086
No. of effective spikelets/panicle	0.317	-0.264	-0.278	-0.060	0.282	-6.155	6.792	-2.676	2.241	-0.046	0.039	0.192
No. of ineffective spikelets/panicle	0.180	-0.922	-0.467	-0.215	0.900	-5.205	3.455	-5.262	7.406	-0.013	0.022	-0.123
Spikelet fertility (%)	-0.080	1.007	0.426	0.215	-0.918	4.069	-1.977	5.062	-7.698	0.002	-0.015	0.096
1000 grains weight (g)	-0.288	0.113	1.012	-0.404	-0.201	4.410	-5.408	1.207	-0.329	0.057	-0.064	0.105
Straw yield (t/ha)	0.426	-0.158	-1.091	0.509	0.220	-1.883	2.021	-0.893	0.847	-0.028	0.132	0.103

Residual effect=0.406

Bold figures indicate the direct effects.

Significant positive genotypic and phenotypic correlation was found between plant height and straw yield, tiller mortality and panicle length, panicle length and number of spikelets/panicle, panicle length and number of ineffective spikelets/panicle, number of maximum tillers/m^2 and number of effective tillers/m^2, number of spikelets/panicle and number of effective spikelets/panicle and between number of spikelets/panicle and number of ineffective spikelets/panicle.

Such results indicated that the increase of one character will cause increase in the correlated character. Significant negative genotypic and phenotypic correlation between panicle length and spikelet fertility, spikelet fertility and number of spikelets/panicle, spikelet fertility and number of ineffective spikelets/panicle, 1000 grains weight and number of spikelets/panicle and between 1000 grains weight and number of effective spikelets/panicle indicate that the increase of one trait will decrease the negatively correlated trait.

Significant positive genotypic correlation observed between plant height and number of maximum tillers/m^2, plant height and number of spikelets/panicle, plant height and number of effective spikelets/panicle, tiller mortality and number of spikelets/panicle, tiller mortality and number of ineffective spikelets/panicle, number of maximum tillers/m^2 and straw yield and between number of effective tillers/m^2 and straw yield. Significant negative genotypic correlation was found between number of maximum tillers/m^2 and 1000 grains weight, number of effective tillers/m^2 and 1000 grains weight, tiller mortality and spikelet fertility and between 1000 grains weight and straw yield. Tiller mortality showed positive phenotypic correlation with number of maximum tillers/m^2. Though grain yield did not show significant correlation with any character, but it showed high positive correlation with panicle length followed by number of effective spikelets/panicle and 1000 grains weight. Emphasis should be given on these traits during selection.

Path Analysis of the Traits: Path coefficient analysis showed that number of effective spikelets per panicle had the maximum direct effect (6.792) on yield followed by number of effective tillers per square meter (0.920), plant height (0.681), tiller mortality (0.298), straw yield (0.132) and 1000 grains weight (0.057) (Table 4). Spikelet fertility showed the highest direct negative effect on yield (-7.698) followed by number of spikelets per panicle (-6.610), number of ineffective spikelets per panicle (-5.262), number of maximum tillers per square meter (-1.643) and panicle length (-1.122). Though the number of effective tillers per square meter showed positive direct effect on yield but its genotypic correlation with yield is negative due to high negative indirect effect through spikelet fertility (-1.799), tiller mortality (-0.437) and 1000 grains weight (0.025).

Similarly plant height showed high positive direct effect but negative genetic correlation due to high negative indirect effect through number of spikelets and number of ineffective spikelets per panicle (-2.944 and -1.393, respectively), number of maximum tillers per square meter (-0.960), panicle length (-0.248) and 1000 seed weight (-0.024). Spikelet fertility showed negative direct effect on yield but has positive genetic correlation due to positive indirect effect through all other characters except number of effective tillers per square meter. The number of spikelets per panicle also showed negative direct effect but have positive genetic correlation with yield due to high indirect effect on yield through effective spikelets per panicle (6.325), spikelet fertility (4.739) and number of effective tillers per square meter (0.967). Though panicle

length have positive genetic correlation with yield due to having positive indirect effect on yield through spikelet fertility (6.906), effective spikelets per panicle (1.598) and tiller mortality (0.977) but it showed negative direct effect on grain yield.

CONCLUSION

Genetic variability parameters revealed that eight characters viz. plant height, number of effective tillers per square meter, number of spikelets per panicle, number of effective spikelets per panicle, number of ineffective spikelets per panicle, 1000 grains weight, straw yield and grain yield can be improved by selection. Considering the path analysis of various component characters with grain yield and themselves, number of effective spikelets per panicle, number of effective tillers per square meter and plant height are important characters for yield improvement.

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