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GENETIC ANALYSIS AND SELECTION CRITERIA IN ADVANCED BREEDING LINES OF DEEP WATER RICE

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ABSTRACT

Thirty advanced breeding lines of deep-water rice were evaluated during T. Aman season (rainfed ecosystem) with a view to finding out variability and genetic association for grain yield and its component characters. All the tested characters showed significant variation. The highest genetic variability was obtained in filled grains/panicle followed by plant height. Panicles/plant, filled grains/panicle and grain yield had high genetic coefficient of variation and heritability in broad sense coupled with high genetic advance in percentage of mean. Panicle length, panicles/plant, plant height, filled grains/panicle and harvest index showed significant positive association with grain yield. Path coefficient analysis also revealed maximum positive and direct contribution of filled grain to grain yield followed by panicles/plant, 1000-grain weight and flag leaf area. Moreover, plant height had the highest indirect effect on grain yield through filled grains/panicle. Flag leaf area, harvest index and panicle length also had higher positive indirect effect on grain yield through filled grains/panicle.

Key Words: Variability, correlation, path analysis, yield, advanced breeding lines and deep water rice (*Oryza sativa* L.).

INTRODUCTION

Rice is considered as a major crop in Bangladesh as it constitutes 94.38% of the total food grain (rice & wheat) production of 26.7 million metric tons (Anonymous, 2004). Bangladesh is the fourth largest producer and consumer of rice in the world with an annual production of 25 to 26 million metric tons. Although Bangladesh is now on the verge of attaining self sufficiency in cereal production, there is still a major gap between the production and demand. Deep water rice (DWR) or broadcast aman was grown in about 2.0 Mha in Bangladesh during early 1970s with average yield of 0.85 t/ha clean rice (Ahmad, 1975). The area has recently been decreased but the yield has remained more or less the same with slight increase at 0.95 t/ha of clean rice (BBS 1998). Though DWR is cultivated in small areas with low yield, attention should be given to achieve break through in yield potential. Keeping this in mind large number of advanced lines of deep water rice having better yield potential have been developed by BRRI. For successful utilization of these advanced breeding lines in breeding programs, selection criteria for these genotypes need to be developed.

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Yield is a function of total dry matter and harvest index. Therefore, yield can be increased either enhancing the total dry matter or the harvest index or the both. These two parameters of yield depend on different morpho-agronomic characters. Grain yield in rice is a quantitative polygenic character and highly influenced by environment. So, yield along with corresponding yield components should be considered in determining the selection criteria of rice genotypes. The success of breeding programs also depends upon the amount of genetic variability present in the population and the extent to which the desirable traits are heritable. It is, therefore, necessary to know the degrees of relation among the component characters and their relation with yield, so that selection based on the highly sensitive characters to yield can help to get progenies having high yield potential. Therefore, the present study was conducted to explore the major characters responsible for high yield potential.

MATERIALS AND METHODS

The trial was set with thirty advanced breeding lines of deep water rice at Bangladesh Rice Research Institute, Joydevpur, Gazipur in a randomized complete block design with three replications during T. Aman season in 2004. Though the DWR is grown under flooded condition this experiment was conducted under rainfed during T Aman season in 2004. Thirty-five days old seedlings grown in wet seedbed were transplanted in $1\times 2\ m^2$ plots with a spacing of 20 x 20 cm, using one seedling per hill. Fertilizers were applied @ 60:40:40 kg NPK per hectare. All other recommended nutrients were applied except nitrogen at final land preparation. Nitrogen was applied in three equal splits, at 15 days after transplanting (DAT), 45 DAT and just before panicle initiation. Intercultural operations and pest control measures were employed as and when necessary during whole growing period. At maturity, grain yield (t/ha) was taken excluding border area and yield was adjusted at 14% moisture level.

Grain yield in t/ha (GY) along with flag leaf area (FLA), days to maturity (DM), panicle length in cm (PL), panicles/hill (PN), plant height in cm (PH), filled grains/panicle (FG), 1000-grain weight in g (TGW), grain length/breadth ratio (L/B) and harvest index (HI) were recorded from randomly selected five plants from each plot and used in the analysis. Genetic variance (σ^2g), environmental variance (σ^2e), phenotypic variance (σ^2p), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense (Hb), genetic advance in percentage of mean (GAPM), genotypic correlation coefficients (r_g) and phenotypic correlation coefficients (r_p) and path coefficient analysis were performed following Singh and Chaudhury (1985). The estimates of GCV and PCV were classified as low, medium and high (Sivasubramanian and Madhavamenon, 1973). The heritability was categorized as suggested by Robinson *et al*. (1949). Again, genetic advance was classified by adopting the method of Johnson *et al*. (1955).

RESULTS AND DISCUSSION

Genetic Parameters

The analysis of variance of the present study indicated highly significant variation among the varieties for all the characters studied (Table 1). In order to obtain a clear understanding of the pattern of variation, the phenotypic variance has been partitioned into genotypic and environmental variances. The highest genotypic, environmental and phenotypic variances were found in filled grains/panicle followed by plant height. The lowest magnitude of genotypic, environmental and phenotypic variances were recorded in harvest index followed by grain length/breadth ratio.

The PCV and GCV were not very much different from each other for most of the characters except filled grains/panicle and grain yield (t/ha) indicating that they were less responsive to environmental factors for their phenotypic expression. Filled grains/panicle and grain yield (t/ha) showed relatively higher PCV than GCV indicating that they had some sort of interaction with the environment. Hemareddy *et al.* (1994); Singh and Chaudhary (1996) also found similar result in case of grain yield. Iftekharuddaula *et al*. (2001) also reported higher PCV than GCV for panicles/m^2, grains/panicle and yield per plant. The GCV and PCV were the highest for filled grain/panicle followed by grain yield, panicles/plant indicating higher degree of genetic variability in these traits but they were moderate for flag leaf area, 1000-grain weight, grain length/breadth ratio and harvest index. These results were partially confirmed by Chooker *et al.* (1994); Sharma *et al.* (1996). High GCV and PCV for grains/panicle in rice were also observed by Saravanan and Senthil (1997). Days to maturity and panicle length exhibited low genotypic as well as phenotypic coefficient of variation in the present study, which may be due to presence of both positive and negative alleles in the population.

Table 1. Estimate of genetic parameters for 10 characters in 30 advanced lines of deep water rice

Character	Range	MS	σ^2g	σ^2e	σ^2p	GCV	PCV	Hb	GAMP
FLA	19.23- 38.17	47.07**	14.51	3.46	17.97	13.32	14.83	80.76	31.61
DM	120.0- 149.67	141.65**	46.53	2.07	48.59	5.12	5.23	95.75	13.22
PL	21.17- 28.77	11.22**	3.56	0.54	4.10	7.53	8.09	86.77	18.52
PN	71.87- 128.03	4.98**	1.56	0.29	1.85	20.25	22.02	84.57	49.15
PH	62.33- 194.33	365.04**	116.93	14.22	131.15	10.71	11.34	89.16	26.70
FG	62.33- 194.33	2855.98**	875.11	230.67	1105.77	25.66	28.85	79.14	60.27
TGW	15.18- 26.2	28.47**	9.37	0.36	9.73	15.12	15.41	96.3	39.18
L/B	2.57- 4.0	0.39**	0.13	0.005	0.13	11.46	11.66	96.56	29.72
HI	0.25- 0.52	0.02**	0.004	0.006	0.01	17.52	18.47	89.93	43.86
GY	1.77- 4.57	1.65**	0.51	0.10	0.62	22.68	24.84	83.37	54.67

* Significant at 5% level of significance, ** indicates significant at 1% level of significance.
σ^2g = Genetic variance, σ^2p = phenotypic variance, σ^2e = environmental variance, GCV = genotypic coefficient of variation, PCV = phenotypic coefficient of variation, Hb = heritability in broad sense, GAMP = genetic advance in percentage of mean.

FLA=Flag leaf area, DM=Days to maturity, PL=Panicle Length, PN=Panicles/plant, FG=Filled grains/panicle, PH=Plant height, GW=1000-grain weight, L/B=Grain length/breadth ratio, HI=Harvest index, GY=Grain yield

Heritability in broad sense was the highest for 1000-grain weight and grain length/breadth ratio followed by days to maturity and harvest index. High heritability was observed for all the characters studied. Iftekharuddaula *et al*. (2001) reported high heritability for plant height, days to maturity, grains/panicle, 1000-grain weight and harvest index and moderate for panicles/m^2. Although high heritability estimates have been found to be effective in the selection of superior genotypes on the basis of phenotypic performance, Johnson *et al*. (1955) suggested that heritability estimates along with genetic advance will be more useful in predicting the effect for selecting the best individual. High heritability associated with high genetic advance was obtained for all the characters except days to maturity and panicle length. Das *et al*. (1992) also reported similar findings for grains/panicle, 1000- grain weight and grain yield and Kumar *et al.* (1998) reported for flag leaf length, 1000-grain weight, spikelet sterility and grain yield in rice. Among the characters panicles/hill, filled grains/panicle, and grain yield showed high GCV and PCV together with high heritability. The GAPM were also moderately high indicating that there is scope to improve these characters through selection. Partially similar result was found by Sawant *et al.* (1995). Panicles/plant and grain yield showed high GCV and heritability together with high genetic advance in percentage of mean suggesting better scope for selection. Akanda *et al.* (1997) opined that the characters with high values of GCV and heritability accompanied by high genetic advance in percentage of mean indicate that they might be transmitted to their hybrid progenies and therefore, phenotypic selection based on these characters would be effective. The high heritability estimates along with low genetic advance indicates non-additive type of gene action and genotype-environment interaction plays a significant role in the expression of the traits as observed in days to maturity, panicle length and plant height in the present study.

Correlations

Genotypic and phenotypic correlation coefficients between different pairs of characters are presented in Table 2. In most of the cases, genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficient values indicating suppressing effect of the environment, which modified the phenotypic expression of these characters by reducing phenotypic coefficient values. Accordingly, Bai *et al*. (1992) reported that the genotypic correlations were greater than the phenotypic values in medium duration rice varieties.

Table 2. Genotypic (r_g) and phenotypic (r_p) correlations among ten characters in 30 advanced breeding lines of deep water rice

Characters		DM	PL	PN	PH	FG	TGW	L/B	HI	Grain Yield
FLA	G	0.205	0.050	-0.425*	0.36	0.482**	-0.203	-0.370*	0.066	0.136
	P	0.177	0.060	-0.291	0.34	0.382*	-0.174	-0.326	0.086	0.138
DM	G		-0.136	0.172	0.525**	0.082	-0.303	-0.302	-0.226	0.128
	P		-0.152	0.161	0.478**	0.079	-0.286	-0.296	-0.217	0.106
PL	G			-0.177	0.386*	0.419*	0.215	0.009	0.441*	0.464**
	P			-0.156	0.353	0.356	0.185	0.015	0.382*	0.397*
PN	G				-0.221	-0.232	-0.329	0.336	0.107	0.278
	P				-0.163	-0.199	-0.296	0.293	0.125	0.324
PH	G					0.568**	-0.168	-0.386*	0.284	0.391*
	P					0.492**	-0.149	-0.370*	0.243	0.346
FG	G						-0.354	-0.451**	0.518**	0.781**
	P						-0.307	-0.385*	0.411*	0.644**
GW	G							0.430*	0.238	-0.046
	P							0.415*	0.214	-0.029
L/B	G								0.132	-0.075
	P								0.128	-0.078
HI	G									0.685**
	P									0.631**

* Significant at 5% level of probability, ** Significant at 1% level of probability
FLA=Flag leaf area, DM=Days to maturity, PL=Panicle Length, PN=Panicles/plant, FG=Filled grains/panicle, PH=Plant height, GW=1000-grain weight, L/B=Grain length/breadth ratio, HI=Harvest index, GY=Grain yield

From the study, grain yield was found positively and significantly associated with panicle length, filled grains/panicle and harvest index at both genotypic and phenotypic levels and with plant height only at genotypic level. Almost similar associations in rice were also reported by Hossain and Haque (2003); where grain yield was found positively and significantly associated with plant height, panicle length, grains/panicle and 1000-grain weight. Significant and positive correlation of grain yield with panicle length, panicles/plant, panicle weight and filled grains/panicle was also reported by Biswas *et al.* (2000). Yolanda and Das (1995) found similar result for panicle length and filled grains/panicle in rice. Plant height showed significant and positive correlation with days to maturity at both genotypic and phenotypic levels and with panicle length at only genotypic levels; whereas filled grains/panicle showed significant positive correlation with flag leaf area and plant height at both genotypic and phenotypic levels and with panicle length at genotypic level. Filled grains/panicle had also highly significant and positive association with harvest index but negative correlation with grain length/breadth ratio; whereas 1000-grain weight had significant positive correlation with grain length/breadth ratio.

Similarly, Iftekharuddaula *et al*. (2001) reported positive correlation of plant height with days to maturity and filled grains/panicle but significant negative correlation of panicles/plant with filled grains/panicle and 1000 grain weight in modern rice varieties; whereas Biswas *et al*. (2000) obtained significant positive association of panicle length with plant height and filled grains/panicle but significant negative correlation between filled grains/panicle and 1000 grain weight. Hossain and Haque (2003) also found significantly positive correlation of grains/panicle with plant height and panicle length. They also observed significantly positive association between plant height and panicle length.

Path coefficient analysis

From the path coefficient analysis (Table 3) it was revealed that the highest positive direct effect on grain yield was exhibited by filled grains/panicle followed by panicles/plant, 1000-grain weight and flag leaf area. Almost similar result was reported by Iftekharuddaula *et al*. (2001) who reported that filled grains/panicle, 1000-grain weight and panicles/m^2 were the main components, which had direct effects on grain yield and Biswas *et al.* (2000) reported that the panicle weight had the highest positive direct effect on grain yield followed by panicles/plant**.** Among the characters filled grains/panicle had higher positive direct effect and highly significant positive correlation with yield indicating that selection based on this character would be effective. Similar result was reported by Biswas *et al.* (2000). Thousand grain weight had also positive direct effect but its indirect effect through other characters was mostly negative, which consequently resulted negative correlation with grain yield.

Harvest index and panicle length had negative direct effects though most of their indirect effects through other characters e g. filled grains/panicle, 1000-grain weight were positive which finally made them significant positive correlation with yield indicating that for increasing harvest index, other causal factors must be considered simultaneously. Higher positive indirect effect on grain yield were obtained by harvest index, plant height, panicle length, flag leaf area and days to maturity through filled grains/panicle followed by grain length/breadth ratio and harvest index through 1000-grain weight. Das *et al.* (1992) and Iftekharuddaula *et al*. (2001) also reported almost similar indirect effects in rice. The results prescribe that while using plant height, panicle length, harvest index, flag leaf area and days to maturity as selection criteria; filled grains/panicle should also be given due importance.

Table 3. Path coefficient analysis showing direct (bold) and indirect effects of nine characters on grain yield in 30 advanced breeding lines of deep water rice

Characters	Effect through									r_g
	FLA	DM	PL	PN	PH	FG	TGW	L/B	HI	
FLA	**0.050**	-0.014	-0.002	-0.491	0.016	0.801	-0.224	0.038	-0.037	0.136
DM	0.010	**-0.068**	0.006	0.199	0.024	0.135	-0.335	0.031	0.127	0.128
PL	0.003	0.009	**-0.047**	-0.204	0.018	0.696	0.238	-0.001	-0.247	0.464**
PN	-0.021	-0.012	0.008	**1.157**	-0.010	-0.385	-0.364	-0.034	-0.060	0.278
PH	0.018	-0.036	-0.018	-0.255	**0.046**	0.943	-0.185	0.039	-0.160	0.391*
FG	0.024	-0.006	-0.020	-0.268	0.026	**1.661**	-0.391	0.046	-0.291	0.781**
GW	-0.010	0.021	-0.010	-0.380	-0.008	-0.587	**1.106**	-0.044	-0.134	-0.046
LB	-0.018	0.021	0.001	0.389	-0.018	-0.749	0.476	**-0.101**	-0.074	-0.075
HI	0.003	0.015	-0.021	0.124	0.013	0.861	0.264	-0.013	**-0.561**	0.685**

FLA=Flag leaf area, DM=Days to maturity, PL=Panicle Length, PN=Panicles/plant, FG=Filled grains/panicle, PH=Plant height, GW=1000-grain weight, L/B=Grain length/breadth ratio, HI=Harvest index, GY=Grain yield; rg= Genotypic correlation with yield
Residual effect, R = 43%. *Significant at 5% level of probability, ** Significant at 1% level of probability

In spite of highly significant positive correlation with grain yield; harvest index exhibited negative direct effects on grain yield, which has been overcome by its positive and remarkable indirect effects on grain yield through filled grains/panicle, 1000-grain weight and other yield contributing characters. The residual effect of the present study was 0.43, indicating that 57 per cent of the variability in grain yield was contributed by the nine characters studied in the path analysis. It is suggested that maximum emphasis should be given on the above characters in selecting deep- water rice with higher yield. It is also suggested that further study should be made with more characters under deep water condition to find out other traits, which contribute rest of the percentage of the yield.

The correlation and path analysis showed that panicles/plant, plant height, filled grains/panicle and harvest index were the most important traits to be selected for the modern rice varieties. The characters also showed moderate to high heritability and genetic advance in percentage of mean. Number of filled grains/panicle showed highest direct positive effect and as a result it gave highly significant positive correlation with yield which suggests it to be considered as an important yield component.

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