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Genetic Evaluation and Selection Criteria of Hybrid Rice in Irrigated Ecosystem of Bangladesh

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Abstract: Nineteen-hybrid rice were evaluated in order to determine variability and genetic association for grain yield and its component characters. It was observed that all the tested characters had significant variation. The highest genotypic coefficient of variation was found in panicles per m² followed by spikelets per panicles, grain yield, 1000-grain weight and flag leaf area. High heritability was observed for all the tested characters except grains per panicle and harvest index. High heritability and genetic advance was found in panicles per m², spikelets per panicle and 1000-grain weight. Genotypic correlations were higher than the phenotypic correlations in most of the cases. Flag leaf area, days to maturity, grains per panicle, panicles per m², 1000-grain weight and harvest index showed highly significant positive correlation with grain yield both at genotypic and phenotypic levels. Path coefficient analysis of the study revealed that higher harvest index, adequate spikelets per panicle, days to maturity, more panicles per m² and heavy grains had direct effect on grain yield. Grains per panicle had a positive but indirect effect on grain yield through spikelets per panicles and harvest index. Similar trends were also observed in panicle length through spikelets per panicle and in flag leaf area through harvest index.

Key words: Genetic evaluation, selection criteria, hybrid rice, path analysis, heritability, genetic advance

Introduction

The yield level of modern rice varieties obtained from green revolution technologies has reached a plateau especially in irrigated ecosystem. Without an immediate shift in the yield frontier for rice and increased rice production, future rice supplies will not keep up with demand. Hybrid rice helped China in increasing rice production from 129 million tones to 200 million tones annually (Yuan, 1996). Generally hybrid rice offers 30% yield advantage over conventional pure line varieties. Recent breakthrough in tropical hybrid rice technology provide some hope and indication for sustaining future rice production in Bangladesh.

Rice yield depends on many yield-contributing parameters as well as on the environmental factors. As the yield is polygenically controlled and also influenced by its component characters, direct selection for yield is often misleading. Genetic variability, character association pattern and the direct and indirect effect of the yield contributing characters on yield are very useful tools for successful selection of desirable entries. The correlation coefficients between yield and yield components usually show a complex chain of interaction. Considering correlated response, Falconer (1989) suggests that this might sometimes be possible to achieve more rapid progress under selection for a correlated response than from selection for the desired character itself. Accordingly, path coefficient analysis partitions the components of correlation coefficient into direct and indirect effects and visualizes the relationship in a more meaningful way.

At present, the hybrid entries imported and developed by different seed agencies and research stations are being tested every year in on-station and on-farm trials, but no specific selection criteria have yet been reported for the recommendation of hybrid varieties in Bangladesh condition. The present investigation was, therefore, undertaken to study the genetic variability for important economic characters and to determine the nature and types of relationship among yield components through correlation and path analysis, so that appropriate strategies for recommending the suitable hybrid varieties in Bangladesh condition could be worked out.

Materials and Methods

The experiment was conducted at Bangladesh Rice Research Institute, Regional Station, Comilla during boro season in 1998-99, with nineteen hybrid varieties. The entries were tested in a randomized complete block design with three replications. Thirty-five days old seedlings grown in wet seedbed were transplanted in 100 m² plots with 20x15 cm spacing, using single seedling per hill. Fertilizers were applied @ 120:60:72:12.6:2 kg N, P_2O_5, K_2O, S and Zn per hectare. One-fourth nitrogen and all other recommended fertilizers were applied at final land preparation. Remaining nitrogen was applied in three equal splits, at 15 DAT, 35 DAT and at flowering time. Intercultural operations and pest control measures were done as and when necessary. Finally 40m² area was harvested for grain yield excluding border area and adjusted at 14% moisture level.

Yield along with plant height (PH), days to maturity (DM), panicle length (PL), panicle per m² (PN), spikelets per panicle (SN), grains per panicle (GN), 1000-grain weight (GW), flag leaf area (FLA), harvest index (HI) and grain yield were recorded and used in the analysis. Flag leaf area was calculated according to Gomez (1983). Genetic variance (S^2g), environmental variance (S^2e), phenotypic variance (S^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 analyses were performed following Singh and Choudhury (1985).

Results and Discussions

Genetic Parameters: The analysis of variance revealed highly significant variations among the varieties for all the characters evaluated (Table 1). The phenotypic variance has been partitioned into genotypic and environmental variances for a clear understanding of the pattern of variations. The highest genotypic and phenotypic variance was found in panicles per m² while spikelets per panicle exhibited the highest environmental variance. The lowest magnitude of genotypic, environmental and phenotypic variance was recorded in harvest index. Range and genotypic coefficient of variation measured the variability of the characters. Phenotypic coefficients of variation were slightly higher than genotypic ones for all evaluated characters indicating the presence of environmental influence to some degrees in the phenotypic expression of the characters. Similar results were also

Table 1: Estimate of genetic parameters for ten characters in 19 hybrid rice

Characters	Range	MS	S^2g	S^2e	S^2p	GCV	PCV	Hb	GAPM
PH (cm)	93.07-129.0	325.24**	105.70	8.13	113.83	9.48	9.84	92.86	18.83
DM	117-140	127.76**	42.33	0.78	43.11	5.00	5.05	98.18	10.21
PL (cm)	22.60-27.19	6.03**	1.70	0.94	2.63	5.23	6.51	64.44	8.64
PN	236-374	4233.74**	1380.66	96.99	1477.65	13.34	13.81	93.44	26.57
SN	115-181	985.65**	295.97	97.73	393.70	12.35	14.24	75.18	22.05
FG	92-135	327.19**	86.28	68.37	154.64	8.51	11.39	55.79	13.09
GW(g)	22.36-30.76	23.58**	7.69	0.50	8.20	10.85	11.20	93.86	21.65
FLA (cm^2)	22.55-36.42	28.53**	8.67	2.52	11.19	10.01	11.38	77.45	18.16
HI	0.463-0.580	0.004**	0.00	0.00	0.00	6.18	8.28	55.66	9.49
Grain Yield (t/ha)	5.333-8.275	2.179**	0.70	0.09	0.78	12.34	13.09	88.87	23.96

** Significant at 1% level of significance

Table 2: Genotypic (G) and phenotypic (P) correlations among ten characters in 19 hybrid rice

Characters		DM	PL	PN	SN	GN	GW	FLA	HI	Yield
PH	G	0.001	0.475**	-0.327*	0.094	-0.061	-0.280*	-0.074	-0.356**	-0.290*
	P	-0.002	0.445**	-0.299*	0.079	-0.044	-0.266*	-0.075	-0.241	-0.243
DM	G		-0.183	0.382**	-0.009	0.238	-0.010	0.112	-0.210	0.597**
	P		-0.126	0.374**	0.012	0.213	-0.017	0.107	-0.173	0.561**
PL	G			0.032	0.422**	0.016	-0.447**	-0.039	-0.401**	-0.329*
	P			0.051	0.383**	0.040	-0.356**	-0.097	-0.157	-0.239
PN	G				-0.012	-0.147	-0.497**	0.089	-0.237	0.489**
	P				-0.003	-0.108	-0.468**	0.083	-0.165	0.480**
SN	G					0.539**	-0.411**	0.109	-0.355**	-0.086
	P					0.545**	-0.345**	0.068	-0.251	-0.059
GN	G						0.358**	0.618**	0.500**	0.573**
	P						0.266*	0.453**	0.162	0.437**
GW	G							0.437**	0.859**	0.316*
	P							0.370**	0.652**	0.301*
FLA	G								0.654**	0.605**
	P								0.306*	0.523**
HI	G									0.372**
	P									0.281*

* Significant at 5% level of significance, ** Significant at 1% level of significance

Table 3: Path coefficient analysis showing direct (bold) and indirect effects of nine characters on grain yield in 19 hybrid rice

Characters	Effect through									Genotypic correlation with yield
	PH	DM	PL	PN	SN	GN	GW	FLA	HI	
PH	**0.540**	0.001	-0.055	-0.265	0.108	0.050	-0.075	0.030	-0.623	-0.290*
DM	0.000	**0.889**	0.021	0.309	-0.011	-0.195	-0.003	-0.046	-0.367	0.597**
PL	0.257	-0.163	**-0.115**	0.026	0.485	-0.013	-0.120	0.016	-0.702	-0.329*
PN	-0.176	0.339	-0.004	**0.809**	-0.014	0.120	-0.134	-0.036	-0.415	0.489**
SN	0.050	-0.008	-0.049	-0.010	**1.150**	-0.442	-0.111	-0.045	-0.622	-0.086
GN	-0.033	0.211	-0.002	-0.119	0.619	**-0.821**	0.096	-0.255	0.875	0.573**
GW	-0.151	-0.009	0.051	-0.402	-0.473	-0.294	**0.269**	-0.180	1.505	0.316*
FLA	-0.040	0.099	0.004	0.072	0.126	-0.508	0.118	**-0.412**	1.145	0.605**
HI	-0.192	-0.186	0.046	-0.191	-0.408	-0.410	0.231	-0.269	**1.752**	0.372**

* Significant at 5% level of significance, ** Significant at 1% level of significance Residual effect, R = 0.475

reported by Akanda *et al.* (1997). Moderate genotypic and phenotypic coefficient of variation was recorded for panicles per m^2, spikelets per panicle, 1000-grain weight, flag leaf area and grain yield. The findings were almost supported by Saravanan and Senthil (1997), who obtained moderate genotypic and phenotypic coefficient of variation in plant height, spikelets per panicle and 1000-grain weight in rice. On the other hand, plant height, days to maturity, panicle length and harvest index exhibited low genotypic as well as phenotypic coefficient of variation in hybrid rice which may be due to presence of both positive and negative alleles in the population.

High heritability was observed in days to maturity, 1000-grain weight, panicles per m^2, plant height, grain yield, flag leaf area, spikelets per panicle and panicle length while moderate in grains per panicle and harvest index. However, Bhatti *et al.* (1998) reported high heritability for spikelets per panicle, 1000-grain weight and panicles per plant in rice. Although high heritability estimates have been found to be effective in performing selection of superior genotypes 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. High heritability associated with high genetic advance were obtained in panicles per m^2, spikelets per panicle, 1000-grain weight and grain yield which indicated that the characters were simply inherited in nature controlled by a few major genes or possessed additive gene effects. Similar results were also reported by Lal *et al.* (1983) for panicles per plant, days to 50% flowering and grain yield in rice. The high heritability estimates with low genetic advance indicates that non additive type of gene action and genotype x environment interaction plays a significant role in the expression of the traits as observed in panicle length. Panicles per m^2, spikelets per panicle and 1000-grain weight had moderate genotypic and phenotypic coefficient of variation, high heritability and high genetic advance which made these three characters most effective in the selection of hybrid rice.

Correlations: Correlation study was made to establish the extent of association between yield and yield attributes in hybrid rice under irrigated ecosystem. Phenotypic and genotypic correlation coefficients between yield and its component traits besides the inter-correlation coefficients among the component traits are presented in Table 2. It was revealed that, in most of the cases, the genotypic correlations were higher than the corresponding phenotypic correlations suggesting that the character association had not been largely influenced by environment which are also agreed with Das *et al.* (1992).

Plant height showed highly significant positive correlation with panicle length both at genotypic and phenotypic level and significant negative correlation with panicles per m², 1000-grain weight, harvest index and grain yield. However, Mirza *et al.* (1992) reported positive correlation of plant height with panicle length. Days to maturity showed highly significant positive correlation for panicles per m² and grain yield. Panicle length exhibited positive correlation with spikelets per panicle and negative correlation with 1000-grain weight, harvest index and grain yield. Panicles per m² had highly significant negative correlation with 1000-grain weight while positive correlation with grain yield. The correlation of spikelets per panicle were significantly negative with 1000-grain weight and harvest index but significantly positive with grains per panicle. The correlations of grains per panicle with 1000-grain weight, flag leaf area, harvest index and grain yield were significantly positive. In this aspect, Mirza *et al.* (1992) also obtained significant positive correlation between grains per panicle and 1000-grain weight. There were highly significant positive correlations of 1000-grain weight with flag leaf area, harvest index and grain yield both at genotypic and phenotypic levels. Flag leaf area showed highly significant positive correlation for harvest index and grain yield. The correlation between harvest index and grain yield was significantly positive in present study.

In different studies, Tsuzuki and Umeki (1990), Mirza *et al.* (1992) and Kalaimani and Kadambavanasundaram (1988) reported significant positive correlation of grain yield with 1000-grain weight, grains per panicle and panicles per plant in rice. Manuel and Palanisamy (1989) obtained significantly positive correlation of grain yield with days to flowering, flag leaf area, panicles per plant and grains per panicle in hybrid rice. On the other hand, Kennedy and Rengadamy (1988) reported highly significant positive correlation of grain yield with panicles number, harvest index and 1000-grain weight in hybrid rice. This study revealed that the characters flag leaf area, days to maturity, grains per panicle, panicles per m², 1000-grain weight and harvest index were important to be recommended in the selection for yield improvement of hybrid rice.

Path coefficient analysis: Path coefficient analysis (Table 3) revealed that the highest positive direct effect on grain yield was obtained by harvest index followed by spikelets per panicle, days to maturity, panicles per m², plant height and 1000-grain weight. Accordingly, Scores *et al.* (1990) reported positive direct effect of panicles per m², spikelets per panicle and 1000-grain weight on grain yield in rice, while Selvarani and Rengadamy (1998) obtained positive effect of harvest index, days to flowering and panicles number on grain yield in rice. Maximum direct effect of growth duration and plant height on grain yield has been reported by Gomathinayagam *et al.* (1988). Highest positive indirect effects on grain yield were obtained by 1000-grain weight, flag leaf area and grains per panicle through harvest index followed by grains per panicle through spikelets per panicle and panicle length through spikelets per panicle.

The correlation coefficient of 1000-grain weight with grain yield was almost equal to its direct effect, indicating that this trait had true relationship with grain yield and direct selection through this trait will be effective for yield improvement of hybrid rice. These kinds of true relationships of grains per panicle and 1000-grain weight with grain yield have been reported by Saha *et al.* (1989). High positive indirect effect of grains per panicle on grain yield through harvest index and spikelets per panicle might be due to significant positive correlation of grains per panicle with the corresponding growth characters (Table 2). The results suggest that while using grains per panicle as a selection criterion, harvest index as well as spikelets per panicle should be given due importance. Inspite of significant positive correlation with grain yield, flag leaf area showed negative direct effect on grain yield which has been overcome by its positive and remarkable indirect effect on grain yield through harvest index, spikelets per panicle and 1000-grain weight.

The residual effect was moderate (0.475) in the present study, which was also obtained by Selvarani and Rengadamy (1998) in rice. This gives an impression that few other characters than those involved in the present study might also contribute to yield.

The genetic variability, correlation and path coefficient analysis of the present study revealed that harvest index, spikelets per panicle, days to maturity, panicles per m² and 1000-grain weight were the most important yield components in hybrid rice. The characters also showed moderate to high heritability and genetic advance in percentage of mean. Therefore, the results suggest that higher harvest index, adequate spikelets per panicle, days to maturity, more panicles per m² and larger grains are the important yield contributing traits and selection of high yielding hybrid rice based on these traits would be most effective.

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