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GENETIC VARIATION, CORRELATION AND SELECTION INDICES IN ADVANCED BREEDING LINES OF RICE (*Oryza sativa* L.)

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ABSTRACT

Forty advanced breeding lines of rice were studied during T Aman season (rainfed ecosystem) for finding out selection indices, variability and character association for grain yield and its components. All the tested characters were found showing significant variation. The highest genotypic, environmental and phenotypic variances were found in filled grains/panicle followed by plant height. High heritability associated with high genetic advance were obtained in panicles/hill, plant height, filled grains/panicle, 1000-grain weight and grain yield. Genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients in most of the cases. Panicle length, panicles/hill and filled grains/panicle showed significant positive correlation with grain yield. Path analysis revealed that filled grains/panicle, panicles/hill and 1000-grain weight had positive and highest direct effects on grain yield. Moreover, panicle length had highest indirect effect on grain yield through filled grains/panicle. Discriminant function analysis revealed that a progressive increase in the efficiency of selection was observed with the inclusion of additional character in the selection index. Among the single variable indices, filled grains/panicle showed maximum relative efficiency over the straight selection for grain yield. The highest relative efficiency was observed with index involving seven characters, days to maturity + panicle length + panicles/hill + plant height + filled grains/panicle + 1000-grain weight + yield (t/ha). However, some of 3-traits, 4- traits, 5- traits, and 6- traits indices were also equally good.

Key Words: Selection indices**,** correlation, path analysis, yield, rice (*Oryza sativa* L)

INTRODUCTION

Grain yield in rice is a quantitative character and highly influenced by environment. Consequently, direct selection for grain yield is often misleading. Moreover, grain yield depends on a number of yield contributing characters. So, yield along with its contributing characters should be considered in determining the selection criteria for yield improvement. 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.

Grain yield in rice, as in other cereal crops is a complex character, and contributed by some yield contributing characters. For planning yield improvement program, knowledge

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of relationship between yield and yield contributing characters is important. Study of correlation coefficient between the characters has an importance in selection practice because it helps construction of selection indices and also permits the prediction of correlated response (Lerner, 1958). Correlation between grain yield and component characters may sometimes be misleading due to complex interrelation between the component characters, and it does not provide an exact picture of influence of one character on another. Splitting of total correlation into direct and indirect effects, therefore, would provide a more meaningful interpretation of such association. Thus, correlations in combination with path coefficient analysis are important tools to find out the association and quantity the direct and indirect influences of one character upon another. The present investigation is, therefore, carried out in rice with a view to studying the genetic variability, the relationship between yield and yield contributing characters and selection indices and their relative efficiencies, in improvement of grain yield in rice.

MATERIALS AND METHODS

The trial was set with forty advanced breeding lines of rice at Bangladesh Rice Research Institute, Joydevpur, Gazipur in a randomized complete block design with three replications during T. Aman season in 2004. Thirty-five days old seedlings grown in wet seedbed were transplanted in 1×2 m^2 plots with a spacing of 20×20 cm^2, using one seedling per hill. Fertilizers were applied @ 60:40:40 kg NPK per hectare. The fertilizers were applied at final land preparation except nitrogen. 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 done as and when become 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 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), 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 estimate 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). Selection indices were constructed using the methods developed by Smith (1936) based on the discriminant function of Fisher (1936). Selection indices and their relative efficiencies in terms of expected genetic advance in yield were calculated according to the method stated by Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

Genetic Parameters

The analysis of variance of the present study indicated highly significant variations among the varieties for all the characters studied (Table 2). In order to obtain a clear understanding of the pattern of variations, the phenotypic variance has been partitioned into genotypic and environmental variance. The highest genotypic, environmental and phenotypic variance was found in filled grains/panicle followed by plant height. The lowest magnitude of genotypic, environmental and phenotypic variance was recorded in grain yield (t/ha) followed by panicles/hill. The PCV and GCV were not very much different from each other for most of the characters except panicles/hill, filled grains/panicle and grain yield (t/ha) which indicated less influence of environment on the expression of those characters. This fact suggests that selection for yield and yield contributing characters in present population of rice would bring good response. Singh and Chaudhary (1996) also found similar result in case of grain yield in rice. 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 grain yield indicating higher degree of genetic variability in this trait but those were moderate for filled grain/panicle, 1000-grain weight, panicles/hill and plant height. The findings were mostly supported by Habib *et al.* (2005) who observed high GCV and PCV for grains/panicle and grain yield but moderate for panicles/hill and 1000-grain weight in rice. Days to maturity and panicle length exhibited low genotypic as well as phenotypic coefficients of variation in the present study, suggesting that selection for them would not be effective.

Table 1. Estimates of genetic parameters for seven characters in 40 advanced lines of rice

Character	Range	MS	σ^2g	σ^2e	σ^2p	GCV	PCV	Hb	GAM
DM	117.33-140.00	110.135**	36.39	0.96	37.35	4.61	4.67	97.43	9.37
PL	22.03-32.00	10.793**	3.32	0.76	4.09	7.13	7.91	81.31	13.24
PN	4.20-8.23	2.370**	0.67	0.37	1.04	13.11	16.38	64.11	21.63
PH	68.23-123.63	391.046**	122.13	24.66	146.79	11.56	12.67	83.20	21.72
FG	60.66-147.66	1237.408**	351.97	181.51	533.48	18.68	23.00	65.98	31.25
GW	12.81-28.44	30.241**	10.01	0.20	10.21	14.30	14.44	98.05	29.17
GY	1.18-5.48	2.223**	0.70	0.13	0.83	24.11	26.28	84.17	45.56

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

High heritability was observed in days to maturity, panicle length, plant height, 1000-grain weight and grain yield while moderate value of the parameter in filled grains/panicle and panicles/hill. Habib *et al*. (2005) reported high heritability for days to maturity, panicle length, plant height, 1000-grain weight, harvest index, chlorophyll content and grain yield while moderate value of the parameter in filled grains/panicle and panicles/hill in rice. 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 would be more useful in predicting the effect for selecting the best individual. High heritability associated with high genetic advance was obtained in panicles/hill, plant height, filled grains/panicle, 1000-grain weigh, and grain yield. 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. High heritability associated with high genetic advance was obtained for all the characters except days to maturity and panicle length which indicates that non-additive type of gene action and genotype-environment interaction plays a significant role in the expression of the later traits. Panicles/hill, plant height, filled grains/panicle, 1000-grain weight and grain yield had high heritability with high genetic advance suggesting that these five characters would be most effective in the selection of rice varieties. Grain yield showed high GCV, PCV, heritability together with high genetic advance in percentage of mean suggesting better scope for selection.

Table 2. Genotypic (G) and phenotypic (P) correlations among seven characters in advanced lines of rice

Character		PL	PN	PH	FG	TGW	GY
DM	G	0.173	0.127	0.145	-0.185	-0.011	-0.053
	P	0.149	0.095	0.128	-0.139	-0.013	-0.045
PL	G		-0.024	0.581 **	0.588 **	0.054	0.472 *
	P		0.020	0.541 **	0.448 *	0.045	0.398 *
PN	G			-0.128	0.140	-0.269	0.475 *
	P			-0.095	0.069	-0.205	0.465 *
PH	G				0.205	0.134	0.192
	P				0.178	0.133	0.178
FG	G					-0.029	0.806 **
	P					-0.018	0.763 **
TGW	G						0.336 *
	P						0.317 *

DM=Days to maturity, PL=Panicle Length, PN=Panicles/hill, PH=Plant Height, FG=Filled grains/panicle, TGW=1000-grain weight, GY=Grain yield,
* Significant at 5% level of probability, ** Significant at 1% level of probability

Correlations

Genotypic and phenotypic correlation coefficients between different pairs of characters are presented in Table 3. 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.

It appeared from the results that, grain yield was positively and significantly associated with panicle length, panicles/hill, filled grains per panicle and 1000-grain weight at both genotypic and phenotypic levels suggesting that with the increase of these traits, would bring increase in grain yield. Almost similar associations in rice were also reported by Biswas *et al.* (2000) where grain yield was found positively and significantly associated with panicle length, panicles/plant, filled grains/panicle and 1000-grain weight. Correlations at yield component level showed that panicle length was positively and significantly correlated with plant height and filled grains/panicle indicating that filled grains/panicle would increase with the increase of panicle length.

Table 3. Path coefficient analysis showing direct (bold) and indirect effects of seven characters on grain yield in advanced lines of rice

Character	Effect Through						r_g
	DM	PL	PN	PH	FG	TGW	
DM	**0.0232**	-0.0020	0.0640	0.0058	-0.1388	-0.0056	-0.0533
PL	0.0040	**-0.0116**	-0.0122	0.0233	0.4422	0.0264	0.4721*
PN	0.0030	0.0003	**0.5025**	-0.0052	0.1054	-0.1315	0.4746 *
PH	0.0034	-0.0067	-0.0646	**0.0401**	0.1541	0.0655	0.1918
FG	-0.0043	-0.0068	0.0705	0.0082	**0.7521**	-0.0140	0.8057 **
TGW	-0.0002	-0.0006	-0.1353	0.0054	-0.0215	**0.4884**	0.3360 *

* Significant at 5% level of significance; ** Significant at 1% level of significance
r_g= Genotypic correlation with yield Residual effect, R = 0.09

A negative association was found between panicles/hill and 1000-grain weight and between filled grains/panicle and 1000-grain weight in the present study indicating that with the increase of panicles/hill and filled grains/panicle simultaneous decrease of 1000-grain weight would also occur.

Path coefficient

The path coefficient analysis was performed using genotypic correlations only. From the path coefficient analysis (Table 4) it was revealed that the highest positive direct effect on grain yield was exhibited by filled grains/panicle followed by panicles/hill and 1000-grain weight. These three traits are the primary yield components in rice. Among the characters filled grains/panicle and panicles/hill had highly significant positive correlation with grain yield indicating that selection based on these characters would be effective. 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 effect on grain yield. Panicle length exhibited negative direct effect on grain yield, which had been overcome by its positive and remarkable indirect effect on grain yield through filled grains/panicle.

The residual effect of the present study was 0.09, indicating that most of the variability in grain yield was contributed by the seven characters studied in the path analysis. This gives an impression that some other characters than those involved in the present study might also contribute to yield.

The correlation and path analysis showed that panicle length, panicles/hill, filled grains/panicle and 1000-grain weight were the most important traits to be selected for the modern rice varieties. Number of filled grains/panicle showed highest direct positive effect and as a result it gave highly significant positive correlation with grain yield and it may be considered as an important yield component.

Selection indices

Selection indices for yield were constructed using different combinations of characters. Different selection indices, their expected genetic advances with relative efficiencies are presented in Table 1. It was observed that selection for individual characters like filled grains/panicle, plant height and days to maturity had higher relative efficiencies over straight selection for grain yield. Yang *et al.* (1991) reported that selection based on number of grains/spike or harvest index gave higher efficiency than for direct selection of grain yield/plant alone in wheat.

Table 4: Selection function, expected genetic advance (GA) and relative efficiency (RE%) of different selection indices of some advanced lines of rice

Lines	SN	Selection Function	GA	RE%
1	1	$0.974x_1$	10.48	777.45
2	2	$0.813x_2$	2.89	214.69
3	3	$0.641x_3$	1.15	85.31
4	4	$0.832x_4$	17.74	1316.17
5	5	$0.660x_5$	26.82	1989.61
6	6	$0.980x_6$	5.515	409.12
7	7	$0.842x_7$	1.348	100
23	8	$0.900x_4+0.656x_5$	41.54	3081.9
48	9	$3.353x_2+0.702x_4+0.580x_5$	45.24	3355.86
61	10	$0.880x_4+0.470x_5+7.025x_7$	43.39	3219.07
60	11	$0.900x_4+0.655x_5+0.905x_6$	42.28	3136.65
38	12	$0.780x_1+0.919x_4+0.643x_5$	42.23	3132.72
54	13	$1.594x_3+0.905x_4+0.654x_5$	41.71	3094.51
91	14	$3.242x_2+0.693x_4+0.409x_5+6.639x_7$	49.96	3705.93
68	15	$0.658x_1+3.634x_2+0.709x_4+0.554x_5$	46.17	3425.3
90	16	$3.38x_2+0.7x_4+0.578x_5+0.932x_6$	45.69	3389.61
84	17	$3.301x_2+1.32x_3+0.709x_4+0.582x_5$	45.35	3364.32
98	18	$0.903x_4+0.393x_5+0.108x_6+9.411x_7$	44.45	3297.4
81	19	$0.723x_1+0.904x_4+0.446x_5+7.325x_7$	44.08	3270.25
95	20	$-1.873x_3+0.844x_4+0.396x_5+9.898x_7$	43.72	3243.62
80	21	$0.78x_1+0.92x_4+0.642x_5+0.891x_6$	42.94	3185.31
74	22	$0.765x_1+1.807x_3+0.928x_4+0.641x_5$	42.48	3151.11
94	23	$1.525x_3+0.904x_4+0.654x_5+0.935x_6$	42.37	3143.4
93	24	$2.601x_2+0.353x_5+0.115x_6+8.851x_7$	37.45	2778.34
88	25	$2.459x_2-1.234x_3+0.376x_5+8.511x_7$	37.04	2747.85
97	26	$-12.658x_3-0.264x_5-2.963x_6+32.53x_7$	36.87	2735.46
72	27	$0.562x_1+2.944x_2+0.384x_5+6.741x_7$	36.79	2729.53
118	28	$3.185x_2+0.718x_4+0.341x_5+0.189x_6+8.814x_7$	47.93	3555.86
106	29	$0.607x_1+3.551x_2+0.701x_4+0.369x_5+6.98x_7$	47.9	3553.34
115	30	$3.223x_2-2.086x_3+0.656x_4+0.33x_5+9.755x_7$	47.27	3506.75
105	31	$0.657x_1+3.663x_2+0.708x_4+0.552x_5+0.911x_6$	46.87	3476.85
119	32	$-14.049x_3+0.802x_4-0.335x_5-3.249x_6+35.196x_7$	46.63	3459.35
99	33	$0.65x_1+3.58x_2+1.597x_3+0.72x_4+0.554x_5$	46.35	3483.58
114	34	$3.332x_2+1.255x_3+0.705x_4+0.58x_5+0.944x_6$	46	3412.76
113	35	$0.683x_1+0.931x_4+0.36x_5+0.037x_6+9.94x_7$	45.15	3349.18
110	36	$0.759x_1-1.67x_3+0.867x_4+0.381x_5+9.938x_7$	44.43	3296.29
109	37	$0.766x_1+1.737x_3+0.927x_4+0.64x5+0.933x_6$	43.1	3197.63
117	38	$2.063x_2-12.45x_3-0.288x_5-2.924x_6+31.904x_7$	39.63	2940.06
108	39	$0.526x_1+3.661x_2+0.298x_5+0.031x_6+9.391x_7$	37.64	2792.36
103	40	$0.59x_1+2.821x_2-0.943x_3+0.343x_5+8.543x_7$	37.21	2760.39
126	41	$2.838x_2-13.33x_3+0.644x_4-0.38x_5-3.186x_6+34.749x_7$	49.92	3702.97
124	42	$0.572x_1+3.216x_2+0.729x_4+0.291x_5+0.107x_6+9.41x_7$	48.88	3625.89
121	43	$0.647x_1+3.208x_2-1.807x_3+0.666x_4+0.302x_5+9.753x_7$	48.21	3576.19
125	44	$0.718x_1-14.186x_3+0.828x_4-0.358x_5-3.28x_6+35.423x_7$	47.3	3509.2
120	45	$0.65x_1+3.366x_2+1.529x_3+0.716x_4+0.552x_5+0.94x_6$	46.97	3484.5
123	46	$0.568x_1+2.142x_2-12.208x_3-0.327x_5-2.946x_6+32.067x_7$	39.78	2951.11
127	47	$0.625X_1+2.889X_2-13.833X_3+0.655X_4-0.413X_5-3.203X_6+34.848X_7$	50.83	3770.55

X_1=Days to maturity, X_2=Panicle length, X_3=Panicles/hill, X_4=Plant height, X_5=Fields grains/panicle, X_6=1000-Grain weight, X_7=Yield (t/ha).

When three characters were included in the selection index, maximum relative efficiency over selection for yield was obtained for the index based on panicle length + plant height + filled grains/panicle. The other combinations as plant height + filled grains/panicle + yield (t/ha) had also showed higher relative efficiencies. Martynov and Krupnov (1977) found higher efficiency when index was based on number of spikes/plant + 100-grain weight + grain yield/plant.

Considering four characters, maximum relative efficiency was obtained in combination of panicle length + plant height + filled grains/panicle + yield (t/ha). The other combinations as days to maturity + panicle length + plant height + filled grains/panicle, panicle length + plant height + filled grains/panicle + 1000-grain weight, panicle length + panicles/hill + plant height + filled grains/panicle had also higher efficiency over selection for grain yield/plant. Raut and Khorgade (1989) found the highest relative efficiency when selection index was based on number of spikes/plant + number of spikelets/spike + number of grains/spike + grain yield/plant in wheat.

Similarly, the five character combinations exhibited maximum efficiencies over straight selection for grain yield (t/ha) in combination of panicle length + plant height + filled grains/panicle + 1000-grain weight + yield (t/ha). The other combinations as days to maturity + panicle length + plant height + filled grains/panicle+ yield (t/ha), panicle length + panicles/hill + plant height + filled grains/panicle + yield (t/ha) had also higher efficiency over selection for grain yield/plant. Among the combinations involving the six characters such as panicle length + panicles/hill + plant height + filled grains/panicle + 1000-grain weight + yield (t/ha) showed maximum relative efficiency and days to maturity + panicle length + plant height + filled grains/panicle + 1000-grain weight + yield (t/ha) and days to maturity + panicle length + panicles/hill + plant height + filled grains/panicle+ yield (t/ha) had also higher efficiency than that of grain yield (t/ha). Finally, the selection index based on seven characters such as days to maturity + panicle length + panicles/hill + plant height + filled grains/panicle + 1000-grain weight + yield (t/ha) showed the highest relative efficiency among the all indices. Singh *et al.* (1982) observed in wheat 96.6% higher efficiency when selection index was based on grain yield/plant and all yield components.

So, a progressive increase in the efficiency of selection was observed with the inclusion of additional character in the selection index formula except in few cases.

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