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Genetic variability, character association and path analysis in rice under the humid sub-tropics of Terai zone of West Bengal

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SUMMARY

Fifty rice genotypes including four cultivars indigenous, 18 high yielding released varieties and 28 advanced breeding lines were evaluated to assess genetic variability, heritability (H^2) and genetic advance (GA). Efforts were made to unzip correlations among major agronomic characters like days to 50% flowering, plant height, number of panicles per plant, panicle length, number of filled grains per panicle, grain density, 100-grain weight and grain yield per plant. Determination of the mode of influence of individual characters on grain yield through path co-efficient was also attempted. Highly significant variations among the genotypes were observed for all the characters. Genotypic co-efficient of variability (GCV) and phenotype co-efficient of variability (PCV) for days to 50% flowering, plant height, and 100-grain weight were found to be very close to each other suggesting marginal influence of the environment in governing those characters. Moderate to high GCV with high H^2 and GA were discernible for days to 50% flowering, plant height, number of filled grains per plant, and grain yield per plant. Which indicates simple selection would be effective in genetic improvement of these characters. Plant height, panicle length, number of filled grains per panicle, grain density, and 100-grain weight bear significant association with grain yield per plant both at phenotypic and genotypic levels. Panicle length exerted maximum direct influence on grain yield per plant followed by 100-grain weight and plant height. IR 54447-B-B-B-10-2, IR 54313-106-2-3, IR 47554-3B-4-2B-1-2 and IR5996-3B-18-1 were found to be high yielding characterized with moderate number of panicles per plant and 100-seed weight.

Key words : Rice, correlation, Path analysis, Panicle and seed characters

The rice cultivars grown in the Terai zone of West Bengal is generally long duration. These varieties occupy the land for about 5-6 months which make delayed planting/sowing of next season crops, particularly potato. At the same time, these genotypes do not perform very well due to substantial variation in the microclimate and diversities in biotic and abiotic stress profiles prevailing in this zone. It demands varietal development *in situ* to evolve HYVs compatible for large-scale cultivation in North Bengal situation. It is mentionable that genetic improvement of rice grain yield through development of productive varieties bears immense importance. Selection of appropriate parents and identification of important component characters contributing substantially towards grain yield are considered to be key factors in it. The range and magnitude of phenotypic, genotypic and environmental variances and co-variances reflect the quantum of variability whereas H^2 and GA indicate exploitability of variance in individual characters. It is mentionable that importance of correlation and path analysis hardly require special emphasis in identifying major characters governing grain yield. They help in choosing effective selection criteria, which had considerable influence grain yield and thus governs the pace of genetic improvement. Grain yield is a complex, polygenic character influenced by the environment considerably. Effective and efficient genetic modulation largely demands in depth understanding of the biological, physiological and environmental factors and the interactions thereof. Selection of superior genotypes based on *per se* yield performance may not be effective in manipulating grain yield. It is logical to select component characters for proper articulation of their influences in manifestation of maximum grain yield. Association of grain yield and its attributes thus holds great importance in selection of desirable genotypes with high yield. Knowledge on associationship among the associated characters reveals that some of them may be used as indicator of high grain yield. In reality, correlation values between yield and its component characters are equivocal due to existing relationships among the component characters. As a result direct contribution of each component character towards grain yield and the indirect effect through its association with other component character cannot be discerned entirely from correlation. Keeping all these view, the present investigation was undertaken to quantify variability in respect of a few important agronomic characters in a set of 50 rice germplasm and assessment of character association ships through correlation and path coefficient

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analysis under the humid tropics of Terai zone of West Bengal.

MATERIALS AND METHODS

The experimental material comprised of 50 genotypes of diverse origin. The experiment was conducted at University farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar. Twenty-five days old seedlings were transplanted (singles seedling per hill) in plots measuring 3 x 1.5 m area in randomized block design with three replications. Row to row and plant to plant spacing were 15 and 10 cm, respectively. The crop was grown during *Kharif* season (June to November) of 2008 and 2009. Standard agronomic practices compatible to the humid tropic of Terai zone were followed to obtain good crop stand. Observations recorded on days to 50% flowering, plant height, number of panicles per plant, panicle length, number of filled grain per plant, grain density, 100-grain weight and grain yield per plant. The mean performance of individual genotypes over three years was pooled and employed for statistical analysis. PCV and GCV were calculated following Burton (1951). H^2 in broad sense and GA were calculated by following Lush (1940) and Jonhson *et al*. (1955), respectively. The phenotypic correlation coefficient was worked out following the method outlined by Al-Jibuori *et al*. (1958). The direct and indirect effects of individual character on grain yield were estimated as per the method suggested by Dewey and Lu *et al*. (1959).

RESULTS AND DISCUSSION

The pooled analysis of variance (Table 1) revealed significant differences among the genotypes for all the characters studied. Variations in plant height and flowering duration generally offer ample scope in developing rice varieties compatible for different agro-ecosystems. Wide range was observed in case of days to 50% flowering, plant height, number of panicles per plant, number of filled grains per panicle, grain density, and grain yield per plant (Table 2). This result is in agreement with the findings of Sukla *et al*. (1996) for days to 50% flowering, plant height panicle length in rice.

Table 2 revealed less difference, in GCV and PCV values for days to 50% flowering, plant height and 100-grain weight. It indicates marginal control of environment in governing these characters. Ramalingam *et al*. (1994) and Borbora and Hazarika (1998) also reported similar results. However, the PCV estimates were found to be higher than GCV estimates for number of panicles per plant, panicle length, number of grain per panicle, grain density, and grain yield per plant. It pinpoints the involvement of environmental influence in expression of these characters. This result abreast the findings of Sharma and Dubey (1997) and Reddy *et al*. (1997). It is mentionable that the impact of environmental influence on the genetic make up of any characters usually gets clarified by assessing GCV and PCV.

Heritability estimates were found to be high for days to 50% flowering, plant height, number of filled grains per panicle, grain density and 100-grain weight. H^2 in broad sense indicates the extent of genetic control of a character and thus the efficiency of selection to improve upon a particular character. Thus, characters endowed with high values may be used as selection criteria in genetic improvement of grain yield. Similar results were also reported by Roy and Kar (1997), Ramalingam *et al*. (1994), Yadav (1992), Reddy *et al*. (1997) for days to 50% flowering and plant height; Sarma and Roy (1993), Swant and Patil (1995) and Roy *et al*. (2001) for number of filled grains per panicle and 100-grain weight. Number of tillers per plant, panicle length, and grain yield per plant showed moderate H^2 estimates. This might be due to non-additive gene effects and their expression might be largely influenced by non-additive genetic factors Rao and Shrivastav (1994).

Johnson *et al*. (1955) and Panse (1957) opined that H estimate along with GA is more useful that H^2 alone in predicting the effectiveness of selection. The days to 50% flowering, plant height, number of filled grains per plant, grain density, 100-grain weight and grain yield per plant showed high H^2 values coupled with moderate to high GA (Table 2). Ghosh *et al*. (1981), Kaul and Kumar (1982) also reported similar results for number of filled grains per panicle, 100-grain weight and grain yield per plant.

Table 1 : Pooled analysis of variance for grain yield and yield component character in rice

Sources of variation	Days to 50% flowering	Plant height	Number of panicles/ plant	Panicle length	Number of filled grain/ panicle	Grain density	100 grain weight	Grain yield /plant
Replication	0.027	6.056	1.528	1.383	35.762	0.019	0.004	0.895
Treatment	348.204**	1210.116**	7.406**	9.508**	1951.917**	2.5500**	0.605**	11.375**
Error	0.421	4.767	1.157	0.851	37.733	0.107	0.003	0.714

** indicates significance of value at P = 0.01 level

Table 2 : Pooled estimation of range mean and genetic parameters for eight quantitative characters in rice

Characters	Range			Variance		Heritability %	GA%
	Minimum	Maximum	Mean	GCV	PCV		
Days to 50% flowering	73.667	116.333	94.38	11.408	11.428	99.640	23.458
Plant height (cm)	75.334	164.340	114.10	17.566	17.670	98.830	35.974
No of panicle/plant	5.753	12.707	8.698	16.593	20.696	64.280	27.405
Panicle length (cm)	21.737	28.243	24.763	6.820	7.876	74.990	12.167
No. of filled grain/panicle	72.810	200.463	116.731	21.639	22.270	94.420	43.314
Grain density	3.020	7.423	4.708	19.166	20.389	88.360	37.114
100-grain weight (g)	1.060	3.913	2.56	17.496	17.638	98.390	35.571
Grain yield/ plant (g)	7.903	13.400	10.763	19.296	21.147	83.270	36.273

Simple selection like mass and family selection would be effective to accumulate such additive genes, which may further improve their performance. Moderate H^2 with low GA was observed for panicle length, which indicates the involvement of operative non-additive genes where restricted selection may be followed for genetic improvement.

Correlation studies provide better insight in understanding yield components, which help in choosing proper selection criteria (Johanson *et al.*, 1955; Burton, 1951). Minimum combination of H^2 and correlation coefficient values is necessary to execute more efficient selection than direct selection for grain yield *per se*. The phenotypic and genotypic correlations among different characters were worked out by regressing phenotypic values of one character upon another (Table 3). Plant height, number of filled grains per panicle, grain density and 100-grain weight showed significant positive correlation both at genotypic and phenotypic levels, whereas, days to 50% flowering, displayed positive significant correlation at genotypic level with grain yield per plant. A positive correlation between important characters is desirable since it helps in simultaneous improvement of both the characters (Simmonds, 1979). So, they may be used as selection criteria to improve the grain yield in rice. Plant height, number of filled grains per panicle had significant positive association with grain density. Negative insignificant correlations were observed for all the characters except number of panicles per plant with 100-grain weight. A negative correlation may hinder the simultaneous expression of both the characters with high values. In such situation some economic compromise may be made (Simmonds, 1979). Days to 50% flowering showed positive significant correlation with plant height, panicle length and number of filled grains per panicle. Significant positive correlations were also found in

Table 3 : Genotypic and phenotypic correlation coefficients among yield and component characters in rice

Characters	Plant height	No. of panicle /plants	Panicle length	No. of filled grains /panicle	Grain density	100-grain weight	Grain yield/ plant
Days to 50% flowering	0.633**	-0.184	0.544**	0.301**	0.148	-0.040	0.210*
	0.628**	-0.143	0.473**	0.291**	0.136	-0.040	0.191
Plant height		-0.039	0.334**	0.387**	0.309**	-0.092	0.406**
		-0.022	0.283**	0.370**	0.286**	-0.090	0.372**
No. of panicle/plant			-0.232*	0.005	0.097	0.101	0.199
			-0.164	0.005	0.062	0.074	0.190
Panicle length				0.443**	0.135	-0.192	0.179
				0.358**	-0.003	-0.163	0.135
No. of filled grain/panicle					0.947**	-0.169	0.330**
					0.930**	-0.163	0.297**
Grain density						-0.122	0.303**
						-0.114	0.271**
100-grain weight							0.375**
							0.334**

** indicates significance of value at P=0.01 level

Table 4 : Direct and indirect effect of different characters on seed yield estimation through path analysis in rice

Characters	Days to 50% flowering	Plant height	No. of panicle/ plant	Panicle length	No. of filled grain/ panicle	Grain density	100-grain weight	Correlation coefficient of grain yield/ plant
Days to 50% flowering	-0.1833	0.2704	-0.0319	0.5150	-0.6663	0.3254	-0.0188	0.2100
Plant height	-0.1160	0.4275	-0.0067	0.3162	-0.8548	0.6823	-0.0426	0.4060
No. of panicles/plant	0.0336	-0.0166	0.1741	-0.2200	-0.0115	0.1922	0.0469	0.1990
Panicle length	-0.0996	0.1426	-0.0404	0.9475	-0.9786	0.2973	-0.0894	0.1790
No. of filled grains/panicle	-0.0552	0.1653	0.0009	0.4194	-2.2108	2.0893	-0.0787	0.3300
Grain density	-0.0270	0.1322	0.0151	0.1277	-2.0941	2.2058	-0.0566	0.3030
100-grain weight	0.0074	-0.0391	0.0175	-0.1820	0.3737	-0.2681	0.4656	0.3750

Figure underlined are the direct effect
Residual effect: 73.94

between plant height and panicle length, plant height and number of filled grains per panicle length, panicle length and number of filled grain per panicle.

Path coefficient analysis at phenotypic and genotypic levels was computed to find out the direct and indirect contribution of different characters on grain yield (Table 4). Path analysis is specifically designed to deal with variables having additive effects. It is pertinent to note that while dealing with variables having non-additive effects may lead to erroneous results (Kempthorne, 1957). Grain yield is a highly complex character heavily depends upon several other characters, which are mutually associated. True in turn impair the true association and yield is ultimately affected. Panicle length showed maximum positive direct effect followed by plant height and 100-grain weight on grain yield per plant. Direct effects of plant height, number of tillers per plant and 100-grain weight were almost equal to the correlation coefficients of grain yield per plant. This indicates that the existence of true association and direct selection in respect of this character deems to be effective. Direct effect was found to be negative for days to 50% flowering and number of filled grains per panicle, but the correlation coefficient of grain yield per plant was found to be positive. Here, the direct effect seems to be the cause of correlation. In such situations the indirect casual factors are to be considered simultaneously for efficient selection. This result is in agreement with the findings of Prashanth *et al*. (1999) for number of filled grains per panicle. High positive indirect effect was observed for panicle length and grain density through days to 50% flowering on grain yield per plant, but the direct effect of days to 50% flowering found to be reduced to negative direction due to indirect effect of number of filled grains per panicle. Correlation coefficient of grain yield per plant was low, but the direct effect was very high. Under such circumstances a restricted simultaneous selection model would be appropriate, where restricted are to be imposed to nullify the undesirable indirect effects in order to make use of the direct effects (Shing and Karar, 1977).

Residual effect indicates the involvement of other associated characters in governing grain yield, which have not been considered in this study. The residual effect was found to be 73.94%. So, independent variables could explain only 26.06% of the variability for grain yield per plant. The reason seems to be due to the presence of low and non-significant correlations of days to 50% flowering, number of panicles per plant and panicle length with grain yield. Beside the characters considered in this study, inclusion of some other additional characters would have covered the full range of variation for grain yield per plant. In conclusion days to 50% flowering, plant height, number of filled grains per panicle, grain density and 100-grain weight were emerged as important characters to improve grain yield since they posses high H^2 and GA. Plant height, number of filled grains per panicle, grain density and 100-grain weight displayed positive significant correlation with grain yield too. So these four characters may be used as selection criteria in improvising rice grain yield to augment productivity.

Taichung Sen Yu, IR 48788-4-3-4-2 and IR 55178-B-B-B-19-1 showed more number of panicles per plant. Long panicles were observed in Madhukar, IR 59968-3B-18-1 and Red Burma. CRM 644, Black Jeera, Black Burma and IR 49707-1-3-2-3 bore large number of filled grains per panicle and high grain density. The cultivars-White Burma and Black Burma along and Taipei 309, S1P1 681038 and IR 48788-4-3-4-2 had bold grains with high 100-grain weight. High grain yield was also observed in IR 54447-B-B-B-10-2, IR 54313-106-2-3, IR 47554-3B-4-2B-1-2 and IR 5996-3B-18 1, which were largely attributed to moderate number of panicles per plant, number of filled grains per panicle and 100-grain weight. These varieties may be used as parents in future breeding programmes to augment grain yield. Finally considering major agronomic characters simultaneously, IR 41996-

50-2-1-3 and IR 50404-572-2-3 were found to be early semi-dwarf high yielding varieties which may be used for large-scale cultivation in this region to boost productivity and there by production as a whole.

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