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ANALYSIS OF VARIABILITY, CORRELATION AND PATH COEFFICIENTS IN INDUCED MUTANTS OF AROMATIC NON-BASMATI RICE

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ABSTRACT

Variability, correlation and path coefficients for twelve morphological characters were studied on 18 morphologically distinct mutants in M_4 generation along with their two mother genotypes (IET 14142 and IET 14143), which were developed from Tulaipanja, an aromatic non-basmati rice cultivar of West Bengal. Genotypic and phenotypic coefficients of variation were high for flag leaf angle and panicle number; moderate for grain number per panicle, straw weight, harvest index and grain yield per plant; and low for days to flower, plant height, panicle length, spikelet number, spikelet fertility (%) and test weight. High heritability accompanied by high to moderate genetic advance for flag leaf angle, panicle number, grain number, straw weight and grain yield indicated the predominance of additive gene action for the expression of these characters. Grain yield was found to be positively and significantly correlated with plant height, panicle number per plant, straw weight and harvest index at both genotypic and phenotypic levels indicating the importance of these characters for yield improvement in this population. The results of genotypic path analysis revealed that panicle number had the highest positive direct effect followed by grain number, test weight, plant height, days to flower and straw weight. The overall results indicated that selection favouring higher panicle number per plant, test weight and straw weight and medium plant height with a reasonable balance for moderate grain number would help to achieve higher grain yield in this population of aromatic rice.

Key words**:** Aromatic non-basmati rice, induced mutant, variability, correlation, path coefficients

INTRODUCTION

Aromatic rice has a special place in world rice market. There is an increasing demand for the production of high grain quality aromatic rice in India due to its export earnings and rising standard of living. Some non-Basmati traditional aromatic rice cultivars such as Gobindabhog, Tulaipanja, *etc*. are very popular in West Bengal, an important rice growing province of India, due to their excellent grain quality and aroma. But these cultivars are handicapped by low yield potential. Therefore, there is urgent need to improve the yield potential of such rice. However, improvement in yield and its component characters through hybridization with high yielding non-aromatic rice cultivars often becomes difficult due to break-down of aroma and other cooking quality characters. Therefore, generation of variability through mutagenic treatments is of paramount importance for improvement of aromatic rice. The present investigation was undertaken to study the cause effect relationship for variation in yield in 18 advance generation gamma ray induced mutants and their two mother genotypes, derived from Tulaipanja.

MATERIALS AND METHODS

Dry bold unhusked seeds of IET 14142 (designated as T_1) and IET 14143 (designated as T_2), developed by mutagenic treatment of aromatic rice cultivar Tulaipanja (Basak 1995), were irradiated separately with three different doses of gamma rays *viz.*, 250, 350 and 450Gy (1 Gray=1 joule per kg of matter undergoing radiations = 0.1 kR) from ^{60}Co source at Central Research Institute for Jute and Allied Fibre (CRIJAF), Barrackpore, West Bengal, India. Individual plant selection in M_1, M_2 and M_3 generations was made following pedigree method. Seeds from the prospective mutant plants of M_3 generation, which were true breeding for aroma and morphologically different from each other and from their respective mother genotypes, were used for raising M_4 generation. In each dose of gamma rays three plants were selected in M_3 generation. Therefore, a total of 18 M_4 families (2 genotypes x 3 doses x 3 plants) along with their two mother genotypes were sown in the nursery bed. Thirty-day-old seedlings were transplanted during warm wet season at the Agriculture Farm, Institute of Agriculture, Visva-Bharati (23°39′N, 87°42′E, 58.9 m above sea level) in randomised block design with

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three replications. Each plot consisted of 5 rows of 3 m length with a spacing of 15 x 20 cm. Standard cultural practices were followed to raise a healthy crop. Data on twelve quantitative characters were recorded on five plants selected randomly from the middle rows of each replication. The data were subjected to analysis of phenotypic and genotypic coefficients of variability (Burton 1952), heritability and genetic advance (Johnson *et al*. 1955a) and genotypic and phenotypic correlation (Johnson *et al.*, 1955b) and path coefficients (Dewey and Lu 1959).

RESULTS AND DISCUSSION

The analysis of variance of 18 mutant families and their two mother genotypes with respect to 12 quantitative characters revealed that the mean sum of squares due to mutant genotypes were highly significant for all the characters studied indicating genetic variability among the experimental materials.

The results (Table 1) revealed that genotypic coefficient of variability (GCV) and phenotypic coefficient of variability (PCV) were high for flag leaf angle and panicle number; moderate for grain number per panicle, straw weight, harvest index and grain yield per plant; and low for days to flower, plant height, panicle length, spikelet number, spikelet fertility (%) and test weight. Similar results for high GCV and PCV values for flag leaf angle (Basak and Ganguli 1996), panicle number (Hasib *et al.* 2000; Hasib and Kole, 2004); moderate GCV and PCV for harvest index (Kole and Hasib 2003); low GCV and PCV for plant height (Hasib *et al.,* 2000) and days to flowering (Hasib *et al.* 2000; Kole and Hasib 2003; Hasib and Kole 2004) have been reported in induced mutants aromatic rice.

Difference between PCV and GCV for the studied characters was very less indicating low sensitivity to environment and consequently greater role of genetic factors influencing the expression of these characters, which led to high estimates of broad sense heritability for all the characters, except panicle length (66.7%). Almost similar results for heritability, from studies on induced mutants in aromatic rice, have been reported for plant height (Hasib and Kole 2004); days to flower, test weight and grain yield (Kole and Hasib, 2003; Hasib and Kole 2004); grain number (Hasib *et al.* 2000); and harvest index (Kole and Hasib, 2003).

The estimates of genetic advance as percent of mean were high for flag leaf angle; moderate for panicle number, grain number, straw weight, harvest index and grain yield; and low for days to flower, panicle length, plant height, spikelet number, spikelet fertility (%) and test weight. High genetic advance has been recorded by Basak and Ganguli (1996) for flag leaf angle, while low genetic advance has been recorded by Kole and Hasib (2003) for days to flower, panicle number, panicle length and test weight. High heritability accompanied by high to moderate genetic advance for flag leaf angle, panicle number, grain number, straw weight and grain yield indicated the predominance of additive gene action for the expression of these characters. Therefore, selection for the above characters would be effective.

The estimates of correlation coefficients (Table 2) revealed that, in general, the genotypic and the phenotypic correlation coefficients showed similar trend but genotypic correlation coefficients were of higher in magnitude than the corresponding phenotypic correlation coefficients, which might be due to masking or modifying effect of environment (Singh, 1980). Very close values of genotypic and phenotypic correlations were also observed between some character combinations, such as grain

Table 1. Genotypic and phenotypic coefficients of variability, heritability and genetic advance for twelve quantitative characters in induced mutants of aromatic rice

Characters	Grand mean	Range		Coefficients of variation (%)		Heritability (%)	GA % as mean
		Min.	Max.	GCV	PCV		
Days to flower	127.92	120.73	135.20	3.17	3.25	94.70	6.35
Flag leaf angle(°)	17.22	10.33	44.33	43.42	44.01	97.30	88.21
Plant height (cm)	101.64	80.50	119.47	9.81	10.62	85.30	18.65
Panicle number	13.55	11.20	19.87	19.11	20.37	88.00	36.90
Panicle length (cm)	23.42	20.63	25.17	4.52	5.54	66.70	7.60
Spikelet number	88.57	70.07	99.13	9.21	10.44	77.70	16.72
Grain number	67.28	49.87	84.20	14.25	15.44	85.20	27.10
Spikelet fertility(%)	75.80	64.00	85.00	8.06	9.11	78.40	0.15
Test weight (g)	13.12	11.90	14.09	4.26	4.88	76.00	7.62
Straw weight (g)	46.65	34.02	59.19	16.56	17.50	89.50	32.28
Harvest index (%)	19.69	17.00	25.00	11.84	13.58	76.00	20.31
Grain yield (g)	11.31	8.30	13.97	14.09	16.15	76.10	25.29

yield with panicle number, and flag leaf angle with straw weight, which might be due to reduction in error (environmental) variance to minor proportions as reported by Dewey and Lu (1959). Wide difference between genotypic and phenotypic correlations between two characters is due to dual nature of phenotypic correlation, which is determined by genotypic and environmental correlations and heritability of the characters (Falconer, 1981).

Grain yield was found to be positively and significantly correlated with plant height, panicle number per plant, straw weight and harvest index at both genotypic and phenotypic levels indicating the importance of these characters for yield improvement in this population. The results are in agreement with Nayak *et al.* (2001) and Shanthi and Singh (2001) for plant height; Nayak *et al.* (2001) and Chaudhary and Motiramani (2003) for panicle number; Balan *et al.* (2000) for straw weight; and Basak and Ganguli (1996) for harvest index.

When characters having direct bearing on yield are selected, their associations with other characters are to be considered simultaneously as this will indirectly affect yield. Significant positive correlations at both the levels were recorded for flag leaf angle with straw weight; plant height with panicle number, panicle length and straw weight; panicle number with straw weight; spikelet number with panicle length, grain number and harvest index; and grain number with spikelet fertility (%) and harvest index. Cheema *et al.* (1998) also obtained the same association between panicle length with spikelet number.

Significant negative correlations were noted for days to flower with spikelet fertility (%); flag leaf angle with spikelet and grain number, and harvest index; panicle number with spikelet number, grain number and spikelet fertility (%); spikelet number with test weight and straw weight; grain number with test weight; and straw weight with harvest index. The results are in agreement with Shanthi and Singh (2001) for test weight and grain number. Pleiotropy and / or linkage may also be the genetic reasons for this type of negative association. According to NeWall and Eberhart (1961) when two characters show negative phenotypic and genotypic correlation it would be difficult to exercise simultaneous selection for these characters in the development of a variety. Hence, under such situations, judicious selection programme might be formulated for simultaneous improvement of such important developmental and component characters.

The results of correlation coefficients implied that plant height, panicle number, straw weight and harvest index may be considered for selection for yield improvement.

Considering grain yield as effect and eight characters as causes, genotypic correlation coefficients were partitioned by using method of path analysis to find out the direct and indirect effects of

Table 2. Genotypic (G) and phenotypic (P) correlation coefficients for twelve quantitative characters in induced mutants of aromatic rice

Characters		Flag leaf angle	Plant height	Panicle number	Panicle length	Spikelet number	Grain number	Spikelet fertility(%)	Test weight	Straw weight	Harvest index	Grain yield
Days to flower	G	0.060	-0.016	0.064	0.055	0.053	-0.268*	-0.408**	-0.036	0.128	-0.270*	-0.122
	P	0.048	-0.015	0.045	0.092	-0.042	-0.236	-0.351**	-0.040	0.100	-0.225	-0.117
Flag leaf angle	G		-0.016	0.047	-0.247	-0.590**	-0.427**	-0.090	0.033	0.421**	-0.342**	0.121
	P		-0.012	0.442**	-0.208	-0.497**	-0.372**	-0.072	0.036	0.412**	-0.296*	0.123
Plant height	G			0.400**	0.486**	-0.030	-0.124	-0.192	0.066	0.666**	-0.314*	0.480**
	P			0.360**	0.360**	-0.017	-0.096	-0.153	0.024	0.558**	-0.207	0.407**
Panicle number	G				0.047	-0.657**	-0.646**	-0.425**	0.138	0.640**	-0.113	0.614**
	P				-0.015	-0.562**	-0.575**	-0.358**	0.119	0.627**	-0.034	0.627**
Panicle length	G					0.304*	0.144	-0.136	0.132	0.261*	-0.042	0.258
	P					0.261*	0.148	-0.078	0.131	0.134	0.023	0.152
Spikelet number	G						0.846**	0.367**	-0.468**	-0.476**	0.498**	-0.029
	P						0.822**	0.250	-0.329**	-0.382**	0.443**	0.053
Grain number	G							0.805**	-0.344**	-0.274*	0.429**	0.143
	P							0.755**	-0.300*	-0.251	0.432**	0.196
Spikelet fertility(%)	G								-0.080	0.034	0.185	0.252
	P								-0.134	-0.013	0.227	0.249
Test weight	G									0.090	-0.005	0.124
	P									0.094	0.037	0.147
Straw weight	G										-0.602**	0.604**
	P										-0.559**	0.546**
Harvest index	G											0.267*
	P											0.380**

*, ** Significant at P = 0.05, 0.01 respectively

Table 3. Genotypic path coefficient analysis of eight characters on grain yield in induced mutants of aromatic rice

Characters	Days to flower	Flag leaf angle	Plant height	Panicle number	Panicle length	Grain number	Test weight	Straw weight	Correlation with grain yield
Days to flower	**0.114**	-0.002	-0.002	0.078	-0.005	-0.296	-0.012	0.004	-0.122
Flag leaf angle	0.007	**-0.032**	-0.002	0.574	0.022	-0.471	0.011	0.012	0.121
Plant height	-0.002	0.001	**0.131**	0.489	-0.043	-0.136	0.022	0.018	0.480**
Panicle number	0.007	-0.015	0.053	**1.222**	-0.004	-0.713	0.047	0.018	0.614**
Panicle length	0.006	0.008	0.064	0.057	**-0.089**	0.159	0.045	0.007	0.258*
Grain number	-0.031	0.014	-0.016	-0.790	-0.013	**1.103**	-0.117	-0.008	0.143
Test weight	-0.004	-0.001	0.009	0.168	-0.012	-0.379	**0.341**	0.003	0.124
Straw weight	0.015	-0.013	0.087	0.782	-0.023	-0.302	0.031	**0.028**	0.604**

Bold figures indicates direct effect; Residual effect = 0.0111

yield contributing characters towards the grain yield. Other characters being overlapping or containing grain yield as such were excluded from path analysis. Shrivastava and Sharma (1976) suggested that only direct yield components should be used for path analysis. The results of genotypic path-analysis revealed (Table 3) that panicle number (1.222) had the highest positive direct effect followed by grain number (1.103), test weight (0.341), plant height (0.131), days to flower (0.114) and straw weight (0.028). Chaudhary and Motiramani (2003) noted greatest contribution of panicle number per plant to grain yield.

Panicle number had highest positive direct effect and very high negative indirect effect through gain number. Grain number exhibited very high direct positive effect and very low positive indirect effect only through flag leaf angle, which was counterbalanced by its indirect negative effect through rest of the characters and this resulted in non-significant association between grain number and grain yield.

Test weight had moderate positive direct effect. Its indirect effect through panicle number was positive and that of grain number was negative. This resulted in non-significant correlation of test weight with grain yield.

Plant height showed direct positive effects and its indirect effect through panicle number was relatively large and positive though that of grain number was negative. The indirect effect through the remaining characters being negligible, plant height showed significant positive correlation with grain yield.

The direct effect of days to flower was positive and its indirect effects through grain number and other characters except panicle number and straw weight were negative.

Straw weight, although exhibited very low positive direct effect on grain yield, its indirect effect through panicle number was very high and through grain number was negative. Straw weight, therefore, showed significant positive association with grain yield.

Flag leaf angle and panicle length had very low negative direct effect on grain yield. Moreover, the contributions of these two characters in the pathway of other characters were negligible and negative in majority of the cases.

The overall results indicated that selection of higher panicle number, test weight, straw weight and medium plant height with a reasonable balance for moderate grain number would particularly encourage the breeders to achieve higher grain yield. The results are in conformity with Gravois and McNew (1993) for panicle number; Mehetre *et al.* (1996) for grain number and plant height; Nayak *et al.* (2001) for panicle number, grain number and test weight; Hasib and Kole (2004) for grain number, panicle number and plant height and Khedikar *et al.* (2004) for test weight, panicle number and days to flower.

Very low residual effects (0.0111) indicated that eight characters included in this study explained high percentage of variation in grain yield. Moreover, majority of values were less than unity, which indicated that inflation due to multicolinearity was minimal (Gravois and Helms, 1992).

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