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Grain dimension studies in view of kernel weight development in traditional rice of West Bengal

Ashim Chakravorty*, P.D. Ghosh

Cytogenetics and Plant Breeding section, Biotechnology Research Unit, Department of Botany,University of Kalyani, Kalyani - 741235, West Bengal, India

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Abstract

Determining the genetic relationship between the species or genera is very important for genetic improvement and phylogenetic studies. Fifty one landraces of rice were evaluated for the estimation of genetic variation among the agromorphological characters. Fifty one genotypes used for the grain quality studies showed significant differences among grain quality traits. Heritability estimates were higher for morphological traits ranging from 45.8 to 99.9. Correlation analysis indicated that plant height had positive and significant association with panicle length, and grain weight. At genotypic level, kernel weight was correlated positively and significantly with maturity, grain weight, grain length, grain breadth and flag leaf angle. Path coefficient analysis indicated direct effect of grain weight followed by number of grains panicle^{-1} and grain length/breadth ratio. The grain quality studies revealed the better performance of Sarkele aman followed by Jhingasal and Annada with high values of panicle length, plant height, grain weight, number of primary branches panicle^{-1}, number of grains panicle^{-1}; Malliksal for higher values of grain length; Majhisal and Basmoti local with high values of number of primary branches panicle^{-1} and number of grains panicle^{-1}.

*Corresponding Author: Ashim Chakravorty ✉ ashimbot@gmail.com

Introduction

Rice (*Oryza sativa* L.) is one of the important cereal crops and is central to the lives of billions of people around the world. Possibly the oldest domesticated grain (~10,000 years), rice is the staple food for 2.5 billion people. Growing rice is the largest single use of land for producing food, covering 9% of the Earth's arable land. Rice is the predominant staple food for 17 countries in Asia and the Pacific, nine countries in North America and Eight Countries in Africa.

Rice provides 20 percent of the world's dietary energy supply, while wheat supplies 19 percent and maize 5 percent (FAO, 2004). India has a rich and diverse genetic wealth of rice. For the crop improvement, selection of traits is the pre requisite for further program. Wide genetic resources may be required to either increase the gene pool for germplasm improvement or to develop new cultivated varieties (Roy *et al*., 1985).

Yield of Paddy is a complex character controlled by many genes interacting with the environment and is the product of many factors called yield components. The knowledge about the relationship between yield and its contributing characters is needed for an efficient selection strategy for the plant breeders to evolve an economic variety. The information about phenotypic and genotypic interaction of various economic traits is of immense importance to a plant breeder for the selection and breeding of different genotypes with increasing yield potential (Amin, 1979). Path coefficient analysis furnishes information of both direct and indirect influence of each contributing trait on the yield and also enables breeders to rank the genetic attributes according to their contribution (Dewey and Lu, 1959).

Rice is one of the cereal crops that are consumed as whole milled and broken grain. The desired properties may vary from one ethnic group or geographical region to another and may very from country to country. The quality in rice, therefore, may be considered from viewpoint of milling quality, grain size and shape, appearance and cooking characteristics. As countries reach self sufficiency in rice production, the demand by consumers for better quality rice has increased. Traditionally, plant breeders concentrated on breeding high yields of pest resistance. Recently, the trend has changed to incorporate preferred quality characteristics that increase the total economic value of rice. Grain quality is not just dependent on the variety of rice, but quality also depends on the crop production environment, harvesting, processing and milling systems. The grain quality can be improved genetically through the improvement of grain quality components. Kernel shape and L/B ratio are important features for grain quality assessment (Rita and Sarawgi, 2008). Individual preferences varied, most of the consumers preferred imported rice but differed in their preferences for the local rice (Tomlins et al., 2005). Keeping in view these facts, the present investigation aims at finding out genetic variability of the yield attributing traits, their interrelationship, physical quality characteristics effecting the kernel weight development, which can be useful for yield improvement by grain development in future breeding program.

Materials and methods

The study comprising an experiment related to the variability, association and grain quality characters (physical) in rice was conducted at Zonal Adaptive Research Station, Krishnagar, Nadia, West Bengal, India during the kharif season of two consecutive years of 2009 and 2010. The experimental materials were collected from the three districts of West Bengal *viz*. Nadia, Murshidabad and 24 Parganas (N). The experiment was laid out in a randomized complete block design with two replications. Plant to plant and row to row distance were 20 and 15cm respectively. The recommended dose of cultural practices was done to raise the crop. At the time of maturity, the data on five competitive plants from each genotype in each replication were recorded for different characters, like, grain length, grain breadth, panicle length, grain length/ breadth ratio, grain weight, kernel weight and number of grains panicle^{-1}. The methodology given by Steel *et al.*, 1997 was used for statistical analysis. To compute variance and covariance from the data collected for the traits is to ascertain the differences among various genotypes for variability and co-variability. The genotypic and phenotypic correlation coefficient values were evaluated as suggested by Steel and Torrie (1997).The individual genotypic means were compared by Duncan's Multiple Range Test (DMRT) and the total variance was partitioned into genotypic and phenotypic components.

A comparative study of the physical quality characteristics comprising fifty one landraces of rice was completed at the Research Station of Krishnagar (Table 4). Fifty one samples were milled at 10% moisture content. After milling, the obtained brown rice was polished. Head and broken rice were separated through a rice grader. The graded samples comprising full shape grains were used to proceed for the study. The length, breadth and thickness of milled rice (50 grains per sample) were taken with the help of micrometer. Size and shape were determined according to scale of FAO standards given below. For the determination of chalkiness of endosperm, milled rice was observed under a stereo-zoom microscope. Based on the orientation of chalkiness, the rice grains were classified into white belly, white centre and white back (Anonymous 2004).

Results and discussion

Analysis of variance indicated that the difference among genotypes for all the characters under study was highly significant (α+0.01), indicating that the genotypes were highly diversified. Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, grand means and standard error of these economic traits of 51 genotypes were calculated(Table 1). GCV ranged from 8.66 to 35.28. Number of grains panicle^{-1} (40.86) had the highest GCV followed by flag leaf angle (40.39). High heritability estimates were observed for all the traits. Heritability was over 50% in the characters, like, grain weight, kernel weigh and days to maturity. So, these estimates are helpful in making selection on the basis of phenotypic performance.

The association of kernel weight with other characters was estimated by genotypic and phenotypic coefficients (Table 2). Plant height was correlated positively with the characters like, panicle length, grain breadth and grain weight. Flag leaf angle was positively associated with maturity and grain weight. Panicle length was positively and significantly correlated with grain weight. Grain length is positively correlated with grain length/breadth ratio and grain weight. Panicle length and flag leaf angle were correlated positively and significantly at genotypic and phenotypic levels. These results are in agreement with findings of Ramkrishnan *et al.* 2006. Grain yield per plant/Kernel weight was associated positively and significantly with days to maturity both at genotypic and phenotypic levels (Habib *et al*, 2005).

The estimation of correlation coefficients revealed only the relationship between kernel weight and associated characters but did not show the direct and indirect effects of different traits on kernel weight. This is because, the attributes that are in association don't exist by themselves, but are liked to other components. The path coefficient analysis suggested by Dewey and Lu (1959) specified the effective measure of direct and indirect causes of association and also depicted the relative importance of each factor involved in contributing to the final product(*i.e.* kernel weight). Out of eleven traits taken for the study, grain weight had the highest positive direct effect on kernel weight followed by number of grains panicle^{-1} and grain length/breadth ratio (Table 3).

"Duncan's Multiple Range Test" was utilized for the pair wise comparison of significantly different genotypic means (Table 4). Grain size and shape are among the first criteria of rice quality that breeders consider in developing new varieties for releasing for commercial production (Adair *et al.* 1973).

Table 1. Estimation of statistical and genetical parameters of agromorphological traits for different landraces of rice.

	Traits	Mean±S.E.	Range	GCV	PCV	h^2 (Heritability)	Genetic advance in percent of mean(%)
1	Plant height	29.46±2.14	24-43#	18.30	19.69	0.864	35.03
2	Flag leaf angle	2.37± 0.24	1°-4°	40.39	40.39	0.999	83.12
3	Panicle length	24.80±1.12	21.0-30.5#	8.66	9.77	0.785	15.80
4	Grain length	8.30±0.58	3.9-11.2@	13.78	15.47	0.794	25.30
5	Grain breadth	3.06±0.02	2.05-4.2@	18.72	18.74	0.998	38.44
6	Grain length/breadth ratio	2.85±0.51	1.73-4.96@	21.01	27.79	0.572	32.63
7	Grain weight (1000)	21.41±0.09	10.34-29.9$	19.39	19.40	0.999	39.43
8	Kernel weight (1000)	18.19±0.42	8.0-25.0$	21.16	21.28	0.988	43.32
9	Maturity (Day)	139.94±3.8	116-172.5	12.12	12.43	0.951	24.33
10	Number of primary branches panicle^{-1}	11.85±0.47	5.5-17	22.70	23.06	0.969	46.06
11	Number of grains panicle^{-1}	169.50±0.003	30-318.5	35.28	40.86	0.746	62.76

Note: # - cm, @ - mm, $ - g

Table 2 . Genotypic and Phenotypic correlation matrix. Upper diagonal genotypic correlations and lower diagonal phenotypic correlations.

Traits	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1		0.337*	0.654**	-0.053	-0.034	-0.029	0.099	0.058	-0.045	0.100	0.003
C2	0.363**		0.161	-0.058	0.062	-0.177	0.149	0.136	0.328*	-0.017	0.024
C3	0.783**	0.182		-0.143	-0.075	-0.014	0.109	0.065	-0.059	-0.032	-0.165
C4	-0.061	-0.065	-0.180		0.061	0.357**	0.437**	0.449**	0.029	-0.127	-0.132
C5	-0.038	0.062	-0.081	0.068		-0.621	0.327*	0.289*	-0.041	0.204	0.033
C6	-0.034	-0.234	-0.003	0.531**	-0.820		0.003	0.042	-0.016	-0.083	-0.056
C7	0.106	0.149	0.122	0.490**	0.328*	0.008		0.982**	0.141	0.010	-0.167
C8	0.067	0.137	0.078	0.508**	0.292*	0.043	0.988**		0.133	-0.015	-0.164
C9	-0.059	0.337*	-0.093	0.024	-0.040	-0.028	0.145	0.133		-0.188	-0.049
C10	0.079	-0.017	-0.032	-0.118	0.207	-0111	0.010	-0.015	-0.194		0.761**
C11	-0.027	0.027	-0.262	-0.105	0.042	0.014	-0.197	0.190	0.052	0.846**	

C1 :plant height C2:flag leaf angle C3:panicle length C4:grain length C5:grain breadth C6:grainL/B ratio C7:grain weight C8:kernel weight C9:maturity C 10: primary branches panicle^{-1} C11:number of grains panicle^{-1} *and**indicate significance at 5% and 1% levels, respectively. Correlation coefficient r>0.276 and r>0.351 are significant at 5% and 1% level.

Among 51 genotypes, 18 genotypes (35.3%) were slender shaped, 2 genotypes (3.92%) were bold in shape and the rest 21 genotypes (41.17%) were medium in shape. Regarding size of the grain variety, Sarkele aman (G51) was of the shortest size and the variety Kabirajsal (G26) and Manikanchan (G31) were medium in size. Rest varieties showed extra long and long shaped size of grain in them.

Table 3. Direct and indirect effect matrix.

	1	2	3	4	5	6	7	9	10	11
1	**-0.123**	0.009	-0.057	-0.001	-0.002	-0.004	0.106	0.000	-0.018	-0.006
2	-0.045	**0.026**	-0.013	-0.001	-0.003	-0.025	0.149	-0.003	0.004	0.006
3	-0.097	0.005	**-0.072**	-0.004	-0.004	0.000	0.122	0.001	0.007	-0.056
4	0.007	-0.002	0.013	**0.020**	0.003	0.057	0.490	0.000	0.027	-0.022
5	0.005	0.002	0.006	0.001	**0.052**	-0.088	0.328	0.000	-0.047	0.009
6	0.004	-0.006	0.000	0.011	-0.042	**0.108**	0.008	0.000	0.025	0.003
7	-0.013	0.004	-0.009	0.010	0.017	0.001	**1.001**	-0.001	-0.002	-0.042
9	0.007	0.009	0.007	0.000	-0.002	-0.003	0.145	**-0.008**	0.044	-0.011
10	-0.010	0.000	0.002	-0.002	0.011	-0.012	0.010	0.001	**-0.225**	0.180
11	0.003	0.001	0.019	-0.002	0.002	0.001	-0.197	0.000	-0.190	**0.212**

Residual=0.01

C1:plant height C2:flag leaf angle C3:panicle length C14:grain length C5:grain breadth C6:grainL/B ratioC7:grain weight C9:maturity C 10: primary branches panicle^{-1} C11:number of grains panicle^{-1}

Table 4. Mean Values of the physical characteristics of rice grain.

Sl. No.	Varieties	Grain length (mm)	Grain breadth(mm)	GrainL/B ratio	Grain Size	Grain Shape	Chalkiness		
							Frequency	Kernel area	Type
G1	Ranisal	9.92^{l}	2.95^{gh}	3.36^{c-k}	Extra long	Slender	OP	Medium	White belly
G2	Badhabna	8.60^{l}	3.70^{p}	2.32^{a-f}	Extra long	Medium	OP	Medium	White belly
G3	Machkata	9.34^{h-l}	3.10^{j}	3.01^{a-f}	Extra long	Slender	OP	Medium	White belly
G4	Laldhula	7.90^{d-g}	3.20^{k}	4.96^{l}	Extra long	Slender	P	Long	White belly
G5	Dhuladhan	7.90^{d-h}	3.05^{ij}	2.5^{a-g}	Extra long	Medium	VOP	Small	White belly
G6	Dhuri	8.90^{f-l}	3.05^{ij}	2.93^{a-j}	Extra long	Medium	OP	Medium	White belly
G7	Kalamkathi (white)	9.90^{kl}	2.20^{b}	4.50^{kl}	Extra long	Slender	OP	Medium	White belly
G8	Suakalma	8.30^{e-j}	3.50^{n}	2.37^{a-g}	Extra long	Medium	VOP	Small	White belly
G9	Nakrasal	7.99^{e-j}	2.50^{e}	3.10^{b-j}	Extra long	Slender	OP	Medium	White belly
G10	Asanlaya (red)	9.20^{f-l}	2.30^{e}	4.00^{h-l}	Extra long	Slender	P	Long	White belly
G11	Asanlaya (white)	9.31^{g-l}	3.20^{k}	2.90^{a-i}	Extra long	Medium	OP	Medium	White belly
G12	Pubalgara	8.82^{f-l}	3.85^{q}	2.29^{a-e}	Extra long	Medium	OP	Medium	White belly
G13	Daharnagra	8.80^{f-l}	3.50^{n}	2.51^{a-g}	Extra long	Medium	OP	Medium	White centre
G14	Kalonuia	6.24^{bc}	2.90^{g}	2.15^{a-d}	Long	Medium	OP	Medium	White belly
G15	Tulshibhog	3.90^{a}	2.40^{d}	2.25^{a-e}	Short	Medium	VOP	Small	White centre
G16	Mahisladan	9.33^{g-l}	2.40^{d}	3.38^{d-k}	Extra long	Slender	OP	Medium	White belly
G17	Dudhkalama	6.60^{b-d}	2.50^{e}	2.70^{a-g}	Long	Medium	OP	Medium	White belly
G18	Sankarsal	9.41^{i-l}	3.05^{ij}	3.08^{b-j}	Extra long	Slender	OP	Medium	White belly
G19	Badsabhog	8.90^{f-l}	2.20^{b}	4.04^{i-l}	Extra long	Slender	OP	Medium	White belly
G20	Agnisal	8.88^{f-l}	3.10^{j}	2.86^{a-i}	Extra long	Medium	OP	Medium	White belly
G21	Chandrakanta	9.00^{f-l}	4.10^{r}	2.19^{a-e}	Extra long	Medium	VOP	Small	White centre
G22	Muktasal/Suryakanta	9.00^{f-l}	2.15^{b}	4.18^{jl}	Extra long	Slender	P	Long	White belly

G23	Punjab sal	7.25^{c-e}	3.19^{k}	2.27^{a-e}	Long	Medium	OP	Medium	White belly
G24	Sita sal	8.90^{f-l}	3.00^{hi}	2.96^{a-j}	Extra long	Medium	OP	Medium	White belly
G25	Behalsal	10.0^{l}	3.00^{hi}	3.33^{c-k}	Extra long	Slender	OP	Medium	White belly
G26	Kabirajsal	6.10^{bc}	2.50^{e}	2.44^{a-g}	Medium	Medium	OP	Medium	White centre
G27	Laldhusri	7.80^{d-f}	3.60^{o}	2.16^{a-d}	Extra long	Medium	OP	Medium	White centre
G28	Malliksal	11.2^{m}	3.50^{n}	3.20^{c-j}	Extra long	Slender	OP	Medium	White centre
G29	Baid Jhulur	7.30^{c-e}	3.50^{n}	2.08^{a-c}	Long	Medium	OP	Medium	White belly
G30	Jhulur	8.20^{e-j}	3.60^{o}	2.27^{a-e}	Extra long	Medium	OP	Medium	White centre
G31	Manikanchan	5.72^{b}	3.40^{m}	2.41^{a-g}	Medium	Medium	OP	Medium	White belly
G32	Nagra	8.90^{f-l}	3.50^{n}	2.54^{a-g}	Extra long	Medium	OP	Medium	White belly
G33	Danaguri	8.90^{f-l}	4.20^{s}	2.11^{a-d}	Extra long	Medium	OP	Medium	White belly
G34	Majhisal	7.32^{c-e}	2.90^{g}	2.52^{a-g}	Long	Medium	OP	Medium	White centre
G35	Basmoti local	7.32^{c-e}	3.50^{n}	2.09^{a-c}	Long	Medium	VOP	Small	White centre
-G36	Netai sal	8.30^{e-j}	2.55^{c-j}	3.26^{c-j}	Extra long	Slender	OP	Medium	White belly
G37	Sankarkalma	9.30^{g-l}	3.20^{a-i}	2.90^{a-i}	Extra long	Medium	OP	Medium	White belly
G38	Rupsal	8.23^{e-j}	3.30^{a-g}	2.49^{a-g}	Extra long	Medium	OP	Medium	White belly
G39	Jhingasal	8.39^{e-j}	3.30^{a-g}	2.53^{a-g}	Extra long	Medium	OP	Medium	White belly
G40	Sungakalma	8.39^{e-j}	3.50^{a-g}	2.39^{a-g}	Extra long	Medium	OP	Medium	White centre
G41	Jhuli	8.15^{e-j}	3.50^{a-f}	2.32^{a-f}	Extra long	Medium	OP	Medium	White belly
G42	Raja badsha	9.45^{j-l}	3.60^{a-g}	2.62^{a-g}	Extra long	Medium	OP	Medium	White belly
G43	Kalma	8.15^{e-j}	2.05^{e-k}	3.48^{e-k}	Extra long	Slender	OP	Medium	White belly
G44	SungaNagra	8.23^{e-j}	2.05^{h-k}	4.01^{h-k}	Extra long	Slender	P	Long	White belly
G45	Kerala sundari	7.30^{c-e}	3.90^{ab}	1.86^{ab}	Long	Bold	VOP	Small	White belly
G46	Baloramasal	8.30^{e-j}	2.30^{f-k}	3.60^{f-k}	Extra long	Slender	OP	Medium	White belly
G47	Danga	9.10^{f-l}	2.50^{g-k}	3.64^{g-k}	Extra long	Slender	OP	Medium	White centre
G48	Asanlaya	7.30^{c-e}	2.60^{a-i}	2.80^{a-i}	Long	Medium	OP	Medium	White belly
G49	Lalhusri	8.33^{e-j}	2.61^{c-j}	3.19^{c-j}	Extra long	Slender	OP	Medium	White belly
G50	Annada	8.50^{e-k}	3.10^{a-h}	2.74^{a-h}	Extra long	Medium	OP	Medium	White belly
G51	Sarkele aman	7.30^{c-e}	4.20^{a}	1.73^{a}	Long	Bold	VOP	Small	White belly

Mean associated with common letters, in a column are not significantly different at 5% level of significance using DMRT

OP=Occassionally Present, VOP=Very occasionally Present, P=Present

Variety Malliksal(G28) having the maximum grain length (11.2mm) is significantly different from others. Varieties, like, Behalsal(G25), Ranisal (G1), Kalamkathi (white) (G7) and Raja Badsa (G42) are almost equal to the highest value and are statistically similar.

Sarkele aman(G51) had the maximum grain breadth followed by Danaguri (G33), Chandrakanta(G), Kerala sundari(G) and Pubalgara(G) significantly different from the remaining ones. The slender shaped variety Laldhula(G4) had the maximum length/breadth ratio (4.96) and was significantly different from others. Variety

Kalamkathi(white)(G7), Muktasal(G22), Badsabhog(G19), Sungakalma (G40) and Asanlaya(G10) are *at par* and are statistically significant. Variety Sarkele aman (G51) having minimum grain length/breadth ratio is statistically similar to Kerala sundari(G45).

The chalkiness of the rice grain was classified into white belly, white centre and white back. Among the varieties examined, the chalkiness was present very occasionally in the cultivars, like, Duladhan (G5), Suakalma (G8), Tulsibhog (G15), Chandrakanta (G21), Basmoti local (G35), Kerala sundari (G45) and in Sarkele aman(G51). In maximum cultivars, chalkiness was present occasionally while centre type of chalkiness was found in the cultivars like Pubalgara (G12), Kalonunia (G14), Chandrakanta (G21), Kabirajsal (G26), Baidjhulur (G29), Jhulur (G30), Majhisal (G34), Basmati local (G35), Jhuli (G41) and Danga (G47). The rest of the cultivars had white belly type of chalkiness. The chalky grains reduce the palatability of cooked products, thus, the presence of more than 20% of chalkiness in rice kernels is not acceptable in world markets (Cheng *et al.,* 2005).

The paper has concentrated on the physical characteristics of rice grain with consumer preference of traditionally cultivated rice varieties. Thus, it can be concluded that this study will help breeders, researchers and farmers to choose the desirable traits and the parents which are the reservoir of desired gene pool for the exploitation in future research and breeding program in developing the grain quality rice and in developing the high yielding varieties.

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