Electronic Journal of Plant Breeding, 1(2) : 114-123 (March 2010)

Research Article

Physico-chemical and cooking characteristics of rice genotypes

Umadevi, M, P. Veerabadhiran, S. Manonmani and P. Shanmugasundaram

Abstract

Studies were conducted on 110 rice genotypes to assess the genetic variability, heritability and correlation among the genotypes for sixteen grain quality characters and grain yield. The genotype ASD 06-4 recorded maximum mean value for hulling per cent and milling per cent. CRMS 32 A recorded intermediate value for gelatinization temperature, gel consistency, amylose content and superior performance for volume expansion ratio. Higher magnitude of genotypic variability in terms of GCV of more than 20 per cent was recorded for gel consistency, volume expansion ratio, alkali spreading value, single plant yield, and amylose content. The single plant yield had highly significant and positive association with L/B ratio, water uptake, breadth-wise expansion ratio, gel consistency and amylose content. The traits *viz.,* single plant yield, volume expansion ratio, gel consistency, alkali spreading value and amylose content possessing high GCV, heritability and genetic advance could be effectively used in selection.

Key words: Rice, quality characters, variability, amylose content.

Introduction

Rice is consumed principally as a whole grain and the texture of the whole grain is a matter of primary importance. Rice quality is of great importance for all people involved in producing, processing and consuming rice, because it affects the nutritional and commercial value of grains. Grain quality is based upon objective and subjective criteria, the relative importance of which depends upon the particular end-use. The most important quality components, common to all users, include appearance, milling, cooking, processing and nutritional quality. Further grain quality has become an important issue affecting domestic consumption and international trade of rice (Lodh, 2002). The utilization of rice (*Oryza sativa* L.) as a food involves the milling of rough rice or paddy to remove the hull and bran. Milled products include whole kernel rice (head rice) and partial kernels (broken rice). Head rice is grain that remains intact, completely or at least in 3/4 of the whole grain, after the milling process. Milling quality is determined by the quantity of total milled rice and the percentage head rice that can be produced from a unit of rough rice. Head rice is a major determinant of price in the paddy markets of many countries, including the United States. Therefore, the value of rough rice is directly related to its milling quality and the prevailing market demands. Different cultivars of waxy and non-waxy rice are usually classified according to their grain dimensions, amylose content, amylograph consistency, gelatinisation properties of the extracted starches and the texture of cooked rice (Juliano, 1985). Texture is an important attribute of food acceptance by consumers and as such, a critical step in quality assessment. Texture is defined as "the sensory manifestation of the structure of food and the manner in which that structure reacts to applied force". Rice texture is affected by a number of factors such as rice variety, amylose content, gelatinisation temperature and processing factor. Conventionally, sensory and processing qualities of rice have been assessed by a contribution of preference sensory and physicochemical properties evaluations. Breeders in the tropics thus have to develop rice hybrids with grain quality specific to that target area. According to Khush *et al.* (1988) the cooking characteristics of hybrid bulk grains are intermediate between those of parents. Hence it is possible to develop rice hybrids of acceptable grain quality. Keeping this in view, 110 rice genotypes

Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore – 641 003.
Email: keerthitnau@yahoo.com

were used in the present study to find out the extent of genetic variability and correlation among the genotypes for grain quality characters.

Material and Methods

One hundred and ten rice genotypes selected from the germplasm material received from Barwale Foundation, Hyderabad, Directorate of Rice Research, Hyderabad and different research stations of Tamil Nadu Agricultural University *viz.,* Bhavanisagar, Coimbatore, Aduthurai, Ambasamudram and Tirurkuppam were raised in randomized block design (RBD) with three replications during September 2007. A spacing of 20 x 20 cm was adopted. The recommended package of practices were followed. Grains were harvested and sun dried for three days. Observations were recorded on sixteen qualitative characters as per the "Standard Evaluation System for rice" (SES, 1996) descriptors suggested by IRRI. The mean data for each character were subjected to statistical analysis. Genetic parameters like variability, GCV, PCV, heritability and genetic advance were calculated by Johnson *et al.* (1955). The association between yield and component characters and among themselves was computed based on genotypic and phenotypic correlation coefficients (Goulden, 1952).

Measurement of quality traits

Milling quality

The rough rice (Paddy) was cleaned, dried to 12 to 14 per cent moisture and dehulled with a McGill laboratory Sheller. After hulling, the brown rice was milled and polished in a Kett polisher for a standard time to find out the milling percentage and head rice recovery.

Kernel length, Kernel breadth and Kernel length/breadth ratio

Ten unbroken brown rice in three sets were measured using Vernier Calipers and the mean length, breadth was expressed in millimeter (mm).

Kernel length, Kernel breadth and Kernel length/breadth ratio after cooking

Thirty unbroken milled kernels were measured for their length and breadth before cooking. The kernels were kept in porous cloth bags, tied and pre-soaked in water for 20 minutes. The cooked rice was taken out from the bags and placed on a blotting paper to drain the excess water. Length and breadth of five cooked rice grains were measured in millimeters in three replications.

Alkali spreading value (ASV) /Gelatinization temperature (GT)

Gelatinization temperature (GT) was estimated based on alkali spreading value (ASV) of milled rice. The method developed by Little *et al*. (1958) was used to score alkali-spreading value. Two sets of seven whole milled kernels of each entry were placed in petriplates containing 10 ml of 1.7 per cent potassium hydroxide solution. The kernels were arranged in such a way to provide space between kernels for spreading. The plates were covered and incubated at room temperature for 23 hours. The appearance and disintegration of kernels were rated visually.

Volume expansion ratio and water uptake (VER and WU)

Volume of milled rice was measured in a graduated measuring cylinder and weighed the sample and then the milled rice was cooked in boiling water bath in a cloth bag up to its optimum cooking time. The cooked rice was blotted free of water and final volume was measured again by water displacement method and weighed the final weight. The ratio of the volume of cooked rice to the volume of milled rice and weight of the cooked rice and weight of the milled rice were expressed as volume expansion and water uptake (Verghese, 1960) and the scale for volume expansion ratio and water uptake are as follows.

Volume expansion ratio and water uptake =

$$\frac{\text{Increase in volume after cooking}}{\text{Increase in volume before cooking}}$$

Gel consistency (GC-mm)

Gel consistency (GC) was analyzed based on the method described by Cagampang *et al*. (1973). Two sets of milled rice flour (100 mg) were taken in test tubes. To this, 0.2 ml of 95 per cent ethanol containing 0.025 per cent thymol blue and 2.0 ml of 0.2 N KOH were added. Contents were mixed using a Vortex Genie mixer. The test tubes were covered with glass marbles in order to prevent steam loss and to reflux the samples. The samples were cooked in a vigorously boiling water bath for eight minutes to make the contents reach two third the height of the tube. The test tubes were removed from the water bath and kept at room temperature for five minutes. The tubes were kept in an ice water bath for twenty minutes and laid horizontally on a table, lined with millimeter graphing paper.

Amylose content (AC - %)

The simplified procedure of Juliano (1979) was used for estimating the amylose content. Two samples of milled rice flour (50 mg) were taken in 50 ml volumetric flask. To this, 0.5 ml of 95 per cent ethanol was added to wash the sample adhering to the flask followed by 5 ml of 1 N NaOH. The material was left undisturbed overnight to gelatinize

the starch. The solution was made up to 50 ml. Sample extract of 2.5 ml was pippetted out into another 50 ml volumetric flask. To this, 20 ml of distilled water was added followed by three drops of phenolphthalein to develop pink colour. Then 0.1 N HCl was added drop by drop until the colour disappeared. The volume was made up to 50 ml after the addition of 1 ml of iodine reagent and the blue colour developed was read at 590 nm. Amylose concentration (0-600) was obtained by plotting the absorbance in the standard curve. Amylose content of each genotype was expressed as percentage of total quantity of sample taken for analysis.

Results and Discussion

The analysis of variance revealed highly significant differences among the genotypes for all the seventeen characters indicating the existence of significant amount of variability among the values for the characters studied. Selection of parents is an important criterion for the successful breeding programme. Many breeders practically use the *per se* performance of genotypes for choosing parents. The genotype ASD 06-4 recorded maximum mean value for hulling per cent and milling per cent. Short and medium type grains which are more round, thick and hard than long grains produce high head rice recovery (http://www.knowledgebank.irri.org). In the present study, the following genotypes *viz.,* IR 73328 A, IR 75596 A, IR 75601 A, IR 80154 A, IR 80559 A, CRMS 32 A, APMS 6 A, IR 72081 A, ACK 99017, AD 01260, TP 1021, RR 363-1, RR 361-1, ASD 06-1, ASD 06-2 , ASD 06-3, ASD 06-4, ASD 06-5, ASD 06 -6, ASD 06 -7 and ASD 06 -8 are medium grain type and they recorded 50-60 per cent head rice recovery. These results are consistent with Asif B. Shikari *et al.* (2008). The genotype IR 58025 showed maximum mean value for L/B ratio, alkali spreading value and lowest mean for kernel breadth. CRMS 32 A recorded intermediate value for alkali spreading value, gel consistency, amylose content and superior performance for volume expansion ratio (Table 1). Linear elongation ratio less than 1.32 is undesirable (Dipti *et al.,* 2003). In the present study, only one genotype (IR 72081) recorded highest (1.94) linear elongation ratio and twenty seven genotypes registered in the ratio of 1.60-1.80 and ten genotypes recorded low value (<1.32) for linear elongation ratio. Kulkarni *et al.* (2000) reported maximum mean value for linear elongation ratio.

Among PCV and GCV estimates comparison of characters based on GCV is more appropriate as it represents the heritable portion of total variability. PCV estimates include environmental effect also. Higher magnitude of genotypic variability in terms of GCV of more than 20 per cent was recorded for gel consistency, volume expansion ratio, alkali spreading value, single plant yield, and amylose content (Table 2). Vanaja and Babu (2006) reported high GCV values with respect to gel consistency. These traits showing high genotypic variability offer greater scope for genetic improvement through selection. L/B ratio after cooking, kernel length after cooking, head rice recovery, breadth-wise expansion ratio, , linear elongation ratio, L/B ratio, kernel breadth after cooking, milling per cent recorded moderate level of GCV indicating considerable amount of variability expressed for these characters. Low GCV estimates were noticed in the present study for kernel length, kernel breadth and hulling per cent. Vanaja and Babu (2006) reported low GCV for hulling per cent.

In the present study, all the grain quality traits recorded high heritable estimates. Besides showing heritability estimates the characters, single plant yield, volume expansion ratio, gel consistency, alkali spreading value and amylose content also showed high GCV estimates, there by pointing to the improvement of these characters through simple phenotypic selection. Similar results were recorded by Krishnaveni and Shobha Rani (2008) for the traits linear elongation ratio, volume expansion ratio, water uptake, gel consistency, alkali spreading value and amylose content.

The genetic advance as per cent of mean was found to be high for gel consistency, alkali spreading value, single plant yield, volume expansion ratio, amylose content, water uptake, L/B ratio after cooking, kernel length after cooking, head rice recovery, breadth-wise expansion ratio, milling per cent, linear elongation ratio, after cooking. These characters also showed high heritability estimates.

While considering heritability and genetic advance as per cent of mean together, characters like gel consistency, alkali spreading value, single plant yield, volume expiation ratio, amylose content, water uptake, L/B ratio after cooking, kernel length after cooking, head rice recovery, breadth-wise expansion ratio, milling per cent, linear elongation ratio, L/B ratio and kernel breadth after cooking had recorded high heritability and high genetic advance. These results indicate the existence of greater scope for improvement of these characters through direct phenotypic selection by fixing additive gene effects. This is in accordance with Kundu *et al.* (2008) for number of grains per panicle and single plant yield.

The studies on correlation of characters indicate the intensity and direction of character association in a crop. The inter relationship of component characters of yield provide the information about the consequences of selection for simultaneous improvement of desirable characters under selection. The single plant yield had highly significant and

positive genotypic association with hulling percent, milling per cent, head rice recovery, L/B ratio, L/B ratio after cooking and volume expansion ratio. (Table 3). This agreed with the report of Vivekanandan (1993) that the kernel traits were independent of yield. Hence it may be possible to combine grain yield and quality by specific breeding programme. The information on the inter-correlation among the yield components shows the nature and extent of relationship with each other. This will help in the simultaneous improvement of different characters along with grain yield in the breeding programmes. Milling per cent also recorded highly significant positive genotypic correlation with head rice recovery, L/B ratio after cooking, linear elongation ratio and volume expansion ratio.

From the foregoing discussion, it can be concluded that the traits, single plant yield, volume expansion ratio, gel consistency, alkali spreading value and amylose content possessing high GCV, heritability and genetic advance could be effectively used in selection.

References

Asif B. Shikari, Syed Zameer Hussain, G.A. Parray, A.G. Rather and Shafiq A.Wani. 2008. Physico-chemical and cooking properties of non-basmati temperate rice (*Oryza sativa* L.). *Crop Improv.,* **35**(2): 109-114.

Cagampang, G.B., C.M. Perez and B.O. Juliano. 1973. A gel consistency test for eating quality of rice. *J. Sci. Food Agri.,* **24**(8-9): 1589-1594.

Dipti, S.S., Bari M.N and Kabir K.A. 2003. Grain quality characteristics of some Beruin Rice varieties of Bangaladesh. *Pakistan J. Nutri.,* **2**(4): 242-245.

Goulden, C.H. 1952. Methods of Statistical Analysis. John Wiley and Son. Inc., New York.

Johnson, H.W., H.F. Robinson and R.E. Comstock. 1955. Estimation of genteic and environmental variability in soyabean (*Glycine max* (L.) Merril.). *Agron. J.,* **47**(4): 314-318.

Juliano, B.O. 1979. Amylose analysis in rice – A review. In: Proc. Workshop on chemical aspects of rice grain quality. *IRRI, Los Banos, Philippines:* 251-260.

Juliano, B.O.1985. A simplified assay for milled rice amylose. *Cereal Sci.Today,* **16**: 334-338.

Khush, G.S., I. Kumar and S.S. Virmani. 1988. Grain quality of hybrid rice. In*: Hybrid Rice. IRRI***,** Manila, Philippines: 201-215.

Krishnaveni, B. and N. Shobha Rani. 2008. Inheritance of grain size and shape in rice. 2008. *Oryza,* **45**(3): 242-44.

Kulkarni, N., G.N. Devi and G. Sarojini. 2000. Genotype x environment interactions for quality traits in mutants of Samba Mashuri. *Oryza,* **37**(1): 72-74.

Kundu, A., B.K. Senapati, A. Bakshi and G.S. Mandal. 2008. Genetic variability of panicle characters in tall indica aman rice. *Oryza,* **45**(4): 320-323.

Little, R.R., G.B. Hilder and E.H. Dawson. 1958. Differential effect of dilute alkali on 25 varieties of milled white rice. *Cereal Chemistry***, 35**(2): 111-126.

Lodh, S.B. 2002. Quality evaluation of rice for domestic and international consumers. In: *Genetic evaluation and utilization (GEU) in rice improvement,* CRRI, Cuttack: 135-140.

Standard Evaluation System for Rice. 1996. *IRRI* (International Rice Research Institute).

Vanaja, T and Babu L.C. 2006. Variability in grain quality attributes of high yielding rice varieties (*Oryza sativa* L.) of diverse origin. *J. Trop. Agriculture,* **44**(1-2): 61-63.

Verghese, D.D. 1960. A standard process for cooking rice for experimental purpose. *Madras Agric. J.,* **36**: 217.

Vivekanandan, P. 1993. Genetic analysis of grain quality traits in rice (*Oryza sativa* L.). *Ph.D. Thesis,* Tamil Nadu Agricultural University, Coimbatore (unpubl.)

Table 1. Mean performance of genotypes for grain quality traits

Sl.No	Genotypes	H %	M %	HRR %	KL (mm)	KB (mm)	L/B	KLAC (mm)	KBAC (mm)	L/B AC	LER	BWER	ASV	WU (gms)	VER	GC (mm)	AC %
1	IR 58025	67.30	57.89	48.72	6.14**	**1.62**	**3.79****	10.50**	2.48	4.23**	1.71**	1.53**	**6.25****	2.50	2.77	141.35**	17.90
2	IR 64608	73.67	58.00	55.49**	6.57**	1.81	3.63**	10.18**	2.47	4.13**	1.55**	1.36**	5.35**	2.51	3.10	77.00	27.50
3	IR 68275	76.73**	68.66**	53.59**	5.67	1.91	2.97	8.48	2.66**	3.19	1.50	1.39**	4.65**	2.37	2.67	112.50**	21.65
4	IR 68886	72.22	66.09	51.33**	6.28**	1.71	3.67**	9.97**	2.84**	3.52	1.59**	1.66**	**1.65**	2.40	3.60	86.50	18.00
5	IR 68888	74.22**	66.30**	57.39**	6.05**	1.63	3.71**	10.70**	2.56	4.19**	1.77**	1.58**	2.00	2.51	3.18	109.25**	15.25
6	IR 68897	73.28	65.79**	53.81**	6.56**	1.84	3.57**	10.50**	2.48	4.24**	1.60**	1.35**	5.25**	2.79	2.98	59.00	20.90
7	IR 69624	73.14	67.94**	40.65	6.37**	1.96	3.25**	9.91**	2.58**	3.85**	1.56**	1.32**	5.65**	2.13	3.50	64.50	31.60**
8	IR 69628	71.13	67.07**	49.43**	5.76	1.74	3.32**	8.38	2.18	3.84**	1.46	1.26	5.50**	2.31	3.42	139.50**	23.25
9	IR 70362	78.73**	71.43**	57.50**	6.16**	1.96	3.15**	8.73	2.65**	3.29	1.42	1.36**	3.75	**2.00**	3.64	127.00**	30.80**
10	IR 70369	70.98	60.00	53.07**	5.86	1.75	3.35**	8.96	2.60**	3.45	1.53**	1.49**	4.75**	2.28	3.03	133.50**	25.67**
11	IR 70372	77.05**	66.93**	50.78**	6.07**	1.65	3.68**	9.71**	2.95**	3.30	1.60**	**1.79****	3.25	2.47	2.89	131.00**	25.75**
12	IR 72078	68.68	60.03	40.81	6.23**	1.85	3.37**	10.20**	2.78**	3.68**	1.64**	1.50**	5.25**	2.49	3.60	76.60	29.40**
13	IR 72080	70.99	61.57	56.95**	5.96	1.83	3.27**	9.79**	3.01**	3.25	1.65**	1.65**	2.25	2.42	2.79	57.50	30.70**
14	IR 72081	79.22**	71.00**	60.06**	6.03**	2.03**	2.98	**11.68****	2.57	4.55**	**1.94****	1.27	4.25	2.55	4.63**	61.00	21.75
15	IR 73318	72.92	67.69**	44.42	6.28**	1.83	3.44**	10.40**	2.97**	3.50	1.66**	1.63**	4.25	3.09	3.67	**179.00****	27.70**
16	IR 73320	71.22	65.34**	**61.24****	5.81	1.81	3.21**	8.49	2.43	3.50	1.46	1.34**	2.25	2.60	3.58	127.50**	14.05
17	IR 73321	71.59	62.98	54.41**	6.15**	1.76	3.51**	9.79**	2.28	4.29**	1.59**	1.30	2.75	2.55	3.02	87.00	21.80
18	IR 73327	70.35	61.45	52.02**	5.76	1.85	3.12**	8.39	2.35	3.57	1.46	1.27	5.25**	2.39	3.12	132.50**	24.25
19	IR 73328	71.66	70.98**	50.84**	5.67	1.95	2.91	8.49	2.97**	2.86	1.50	1.53**	4.50**	2.86	3.15	122.00**	30.85**
20	IR 75596	78.18**	68.19**	59.42**	5.35	1.95	2.75	8.22	2.33	3.53	1.54**	1.20	3.25	2.55	4.78**	79.00	25.10**
21	IR 75601	79.56**	67.47**	60.24**	6.15**	2.05**	2.97	9.88**	2.51	3.95**	1.61**	1.23	4.50**	2.60	4.89**	63.50	25.10**
22	IR 75603	63.21	50.26	50.15**	6.50**	1.85	3.52**	10.66**	2.89**	3.70**	1.64**	1.56**	4.75**	3.52	3.39	**39.00**	21.60
23	IR 75608	79.69**	69.68**	57.82**	6.26**	2.21**	2.84	10.30**	2.82**	3.66**	1.65**	1.28	4.90**	2.65	4.90**	63.50	24.80**
24	IR 79156	61.44	53.56	44.36	6.56**	1.84	3.57**	8.49	2.86**	2.97	1.30	1.56**	4.25	2.40	3.81	157.00**	18.10
25	IR 80151	75.21**	68.41**	50.58**	6.16**	1.73	3.57**	9.28**	2.30	4.04**	1.51	1.33**	3.25	2.52	2.99	133.60**	27.40**
26	IR 80154	78.71**	69.24**	57.78**	6.02**	1.99**	3.02	10.29**	2.31	4.46**	1.71**	1.16	4.00	2.60	4.78**	124.75**	17.15
27	IR 80559	79.52**	69.75**	57.68**	5.69	1.93	2.95	8.98	2.45	3.67**	1.58**	1.27	2.25	2.67	4.82**	79.30	24.90**
28	CRMS 32	84.96**	77.50**	59.87**	5.84	1.93	3.03	8.89	2.51	3.54	1.52**	1.30	4.25	2.67	**4.92****	67.15	22.15
29	APMS 6	87.54**	77.27**	58.64**	5.69	1.89	3.02	8.28	2.39	3.47	1.46	1.27	3.25	2.50	4.75**	93.75	21.00
30	Pusa 5	79.84**	71.93**	53.54**	6.30**	1.92	3.29**	9.31**	2.98**	3.13	1.48	1.56**	4.25	2.12	3.60	94.00	19.60

Sl.No	Genotypes	H %	M %	HRR %	KL	KB	L/B	KLAC	KBAC	L/B AC	LER	BWER	ASV	WU	VER	GC	AC %
31	IR 3883-41-3-2-2-2	65.39	57.42	37.54	6.51**	2.01**	3.24**	9.53**	2.94**	3.25	1.46	1.47**	2.50	2.47	2.96	52.00	20.75
32	IR 62161-180-3-1-3-2	79.50**	61.18	41.74	6.70**	2.10**	3.19**	10.56**	3.26**	3.25	1.58**	1.55**	3.00	2.28	2.78	97.60**	22.25
33	IR 62124-83-3-2-1	80.38**	75.75**	46.80	5.91	2.06**	2.88	9.68**	2.64**	3.68**	1.64**	1.28	4.50**	3.06	4.91**	72.50	23.75
34	IR 63874-187-2-2-1-2	74.14**	67.31**	41.06	6.31**	1.93	3.28**	9.81**	2.84**	3.46	1.56**	1.48**	2.00	2.37	3.09	40.00	11.80
35	IR 21567-18-3	71.26	64.75	39.15	6.61**	2.25**	2.95	10.62**	**3.41****	3.12	1.61**	1.52**	3.00	2.63	3.19	58.50	13.70
36	IR 65489-11-2	69.61	60.58	42.89	6.62**	2.06**	3.22**	9.83**	3.07**	3.21	1.49	1.49**	3.50	2.74	3.19	171.50**	23.80
37	IR 63079-195-2-2-3-2	65.94	54.88	41.46	6.40**	1.91	3.36**	10.26**	2.65**	3.88**	1.60**	1.39**	2.50	2.83	3.16	115.00**	14.70
38	IR 62036-222-3-3-1-2	77.32**	67.93**	51.50**	6.14**	1.93	3.19**	10.17**	2.46	4.14**	1.66**	1.28	3.00	2.86	4.60**	54.00	25.60**
39	IR 62037-93-1-3-1-1	74.99**	68.25**	57.49**	6.61**	2.12**	3.12**	10.21**	2.51	4.07**	1.55**	1.19	4.50**	3.15**	4.49**	57.50	24.00
40	IR 63881-49-2-1-3-2	78.77**	69.58**	49.25	6.35**	2.01**	3.17**	10.44**	2.45	4.26**	1.65**	1.23	3.50	2.65	4.61**	87.50	25.20**
41	IR 65597-143-2-3-1	69.19	59.10	41.36	6.41**	2.33**	2.76	9.97**	2.63**	3.80**	1.56**	1.13	3.50	3.32**	2.59	110.00**	21.80
42	IR 65483-14-1-4-13	65.66	60.50	41.02	6.23**	1.93	3.24**	10.44**	2.76**	3.79**	1.68**	1.43**	5.50**	2.51	2.43	132.50**	34.50**
43	W 216	64.71	54.83	38.04	6.82**	2.16**	3.17**	9.93**	2.34	4.24**	1.46	1.09	3.50	2.57	2.74	45.00	24.90**
44	IR 61614-38-19-3-2	66.81	57.81	37.57	7.15**	2.12**	3.38**	10.62**	2.46	4.33**	1.49	1.16	4.50**	2.59	3.03	71.50	24.20
45	IR 72865-94-3-3-2	75.94**	65.05**	50.11**	6.07**	2.09**	2.91	10.85**	2.35	4.62**	1.79**	1.13	3.50	2.74	4.76**	57.50	25.20**
46	WCR 21	69.11	60.57	41.22	6.24**	2.35**	2.66	9.86**	2.91**	3.39	1.58**	1.24	4.50**	2.86	2.90	110.00**	29.60**
47	IR 62037-129-2-3-3-3	69.79	59.84	44.39	**7.16****	2.21**	3.25**	8.48	2.70**	3.15	1.18	1.22	2.50	2.77	2.93	130.00**	24.70**
48	IR 62030-83-1-3-2	77.59**	70.13**	49.08	6.35**	2.19**	2.90	10.82**	2.41	4.49**	1.71**	1.11	2.00	2.91	4.77**	60.00	24.90**
49	IR 10198-66-2	67.24	52.96	39.39	5.91	1.95	3.04	9.25**	2.66**	3.48	1.57**	1.37**	4.00	3.27**	2.46	120.00**	23.80
50	IR 62171-122-3-3-3-3	77.22**	70.96**	43.30	6.81**	2.15**	3.17**	9.64**	2.39	4.03**	1.42	1.12	3.00	3.07	2.85	100.00**	23.20
51	IR 59673-93-2-3-3	75.05**	68.09**	45.65	5.72	1.96	2.92	9.15**	2.48	3.70**	1.60**	1.27	3.50	2.77	4.86**	40.50	18.85
52	IR 68427-8-3-3-2	79.11**	70.81**	52.35**	5.64	1.83	3.09**	10.44**	2.21	4.73**	1.86**	1.21	4.50**	3.32**	4.80**	50.00	21.00
53	IR 68926-61-2	74.77**	68.05**	49.94**	6.85**	1.96	3.50**	8.85	2.04	4.35**	1.29	1.04	4.00	3.09	4.55**	57.50	**11.20**
54	ADT 36	71.83	59.49	41.23	6.24**	2.09**	2.99	9.25**	3.03**	3.05	1.48	1.46**	2.00	2.96	2.82	127.50**	20.20
55	ADT 39	64.72	55.86	49.50**	5.96	2.35**	2.54	8.65	3.14**	2.76	1.45	1.34**	5.00**	3.17**	2.99	76.00	23.80
56	ADT 43	69.59	58.28	43.44	6.45**	2.21**	2.92	9.56**	2.78**	3.45	1.48	1.26	3.00	2.86	3.09	80.50	24.70**
57	ACK 03002	69.59	61.29	43.62	5.62	1.85	3.04	7.87	2.22	3.55	1.40	1.21	5.50**	3.17**	2.95	81.50	25.59**
58	CO 43	71.42	61.26	38.14	6.72**	1.98	3.40**	8.64	2.21	3.92**	1.29	1.12	4.00	3.25**	3.31	71.75	24.55**
59	TKM 11	68.00	59.19	41.55	5.94	1.75	3.40**	10.57**	2.12	**4.99****	1.78**	1.22	4.50**	3.27**	2.88	105.00**	25.30**
60	MDU 5	79.28**	71.27**	52.27**	6.45**	2.15**	3.01	9.21**	2.62**	3.52	1.43	1.22	4.50**	3.37**	4.77**	73.50	21.80

Sl.No	Genotypes	H %	M %	HRR %	KL	KB	L/B	KLAC	KBAC	L/B AC	LER	BWER	ASV	WU	VER	GC	AC %
61	I.W.Ponni	73.68	59.10	47.84	5.41	1.92	2.83	7.82	2.33	3.36	1.45	1.22	5.00**	2.94	2.78	76.00	23.75
62	ACK 99017	75.95**	71.21**	50.48**	6.64**	2.36**	2.82	8.65	2.82**	3.07	1.32	1.20	3.00	3.44**	4.68**	63.00	17.80
63	AD 01259	75.73**	69.44**	46.94	6.09**	1.93	3.17**	8.69	2.60**	3.34	1.43	1.35**	3.50	3.62**	4.10**	69.00	25.80**
64	AD 01260	74.93**	68.16**	52.23**	6.05**	2.00**	3.04	9.47**	2.30	4.12**	1.57**	1.16	2.50	**4.86****	4.47**	69.00	23.65
65	TP 1021	76.43**	67.91**	50.54**	5.72	1.96	2.93	9.29**	2.62**	3.55	1.63**	1.34**	4.00	4.30**	4.58**	62.50	25.80**
66	CB 99019	67.03	50.87	36.92	5.25	1.99**	2.65	8.86	2.61**	3.40	1.69**	1.32**	4.50**	2.94	3.09	48.50	18.75
67	CB 2001105	67.14	54.85	38.14	6.36**	2.09**	3.05	9.43**	2.50	3.77**	1.48	1.20	3.00	3.07	2.48	142.50**	23.50
68	RR 363-1	74.71**	67.87**	50.92**	5.86	1.99**	2.95	8.44	2.33	3.63**	1.44	1.17	4.00	4.14**	4.79**	74.00	20.60
69	RR 361-1	76.30**	71.37**	50.11**	6.11**	2.06**	2.98	9.21**	2.61**	3.53	1.51	1.27	5.00**	3.96**	4.61**	61.50	23.75
70	RR 354-1	74.75**	68.15**	49.43**	5.81	2.01**	2.90	8.28	2.52	3.30	1.43	1.26	3.00	4.25**	4.69**	73.50	20.40
71	RR 347-1	74.92**	65.81**	49.93**	6.04**	1.96	3.09**	9.08	2.42	3.75**	1.51	1.24	4.50**	3.96**	4.80**	47.50	23.25
72	RR 348-6	74.17**	66.11**	49.93**	5.96	2.05**	2.91	8.70	2.62**	3.33	1.47	1.28	4.00	4.19**	4.51**	67.50	23.80
73	RR 286-1	73.51	67.95**	49.44**	5.41	1.96	2.77	6.97	2.40	2.91	1.29	1.23	3.50	4.80**	4.86**	69.00	20.75
74	IR 61608-213	64.61	54.00	40.04	6.24**	1.83	3.42**	9.26**	2.31	4.01**	1.49	1.27	5.50**	2.59	2.90	101.00**	23.70
75	RR 166-645	74.79**	67.19**	49.17	6.18**	2.05**	3.02	9.49**	2.25	4.23**	1.54**	1.10	4.50**	3.53**	4.38**	60.00	24.80**
76	RR433-1	70.85	64.18	50.95**	5.92	1.96	3.03	9.37**	2.45	3.83**	1.58**	1.26	4.50**	3.83**	4.64**	81.50	22.70
77	RR 434-3	74.53**	66.47**	51.30**	5.81	1.86	3.13**	8.11	2.40	3.38	1.40	1.30	4.50**	3.78**	4.73**	77.50	23.70
78	IET 17392	71.28	61.73	49.24	**4.12**	1.66	2.49	**5.50**	2.04	2.70	1.34	1.23	5.50**	3.59**	3.01	132.50**	16.70
79	IET 19307	67.11	55.10	47.85	4.61	1.66	2.79	5.74	**1.96**	2.94	1.25	1.18	2.50	3.26**	2.74	131.00**	20.80
80	IET 19419	65.80	55.89	41.28	4.34	1.92	**2.27**	5.96	2.32	2.58	1.37	1.21	2.50	3.23**	3.11	89.00	22.50
81	IET 19390	71.16	59.33	45.01	5.15	1.82	2.83	8.26	2.47	3.35	1.61**	1.36**	3.50	3.39**	3.15	63.00	20.50
82	IET 19394	69.61	59.84	41.15	5.61	1.94	2.90	6.81	2.52	2.71	1.21	1.30	4.50**	3.09	3.38	51.00	23.50
83	T 196	64.83	59.24	44.29	5.75	1.86	3.10**	8.04	2.64**	3.05	1.40	1.43**	4.00	3.64**	3.32	61.50	17.75
84	T 226	61.12	54.41	41.25	6.26**	2.17**	2.89	8.04	2.67**	3.02	1.29	1.24	2.50	3.64**	3.11	97.00	21.80
85	T 341	65.83	51.43	43.17	5.43	2.09**	2.61	7.10	2.74**	2.60	1.31	1.32**	2.00	3.37**	3.35	104.00**	20.90
86	T 965	69.25	61.31	39.35	5.63	1.65	3.42**	8.53	2.12	4.03**	1.52**	1.29	3.00	3.21**	2.58	76.00	40.80**
87	T 1032	69.72	55.95	43.81	6.19**	1.96	3.16**	8.59	2.31	3.72**	1.39	1.18	3.50	3.39**	2.47	90.50	19.45
88	T 1400	67.96	55.93	42.11	6.25**	1.98	3.16**	9.19**	2.41	3.81**	1.47	1.22	2.50	2.97	3.11	102.50**	19.60
89	T 1406	69.39	64.45	45.15	5.73	2.25**	2.55	8.59	2.36	3.65**	1.50	1.05	3.00	3.28**	2.46	87.50	29.20**
90	T 1408	69.17	54.82	**30.70**	5.85	2.36**	2.48	6.22	2.49	2.50	1.06	1.06	4.50**	3.16**	3.36	133.50**	**43.60****

Sl.No	Genotypes	H %	M %	HRR %	KL	KB	L/B	KLAC	KBAC	L/B AC
91	T 1446	69.35	59.77	41.04	6.21**	2.12**	2.93	8.26	2.86**	2.89
92	PR 106	69.27	61.72	40.95	6.65**	2.09**	3.19**	8.33	2.40	3.48
93	BPT 5204	67.47	53.73	40.62	4.92	1.96	2.52	6.82	2.46	2.78
94	Jeeraga Samba	71.36	55.07	39.75	4.82	1.65	2.92	7.06	2.32	3.05
95	CB 20035	67.23	56.12	45.16	4.80	2.12**	2.27	6.47	2.52	2.57
96	Swarna	**59.21**	**48.02**	36.18	5.71	2.14**	2.68	6.36	2.73**	**2.33**
97	WGL 14	70.14	59.31	41.77	6.52**	2.06**	3.18**	6.72	2.40	2.80
98	IR 64	61.29	50.88	41.23	6.61**	1.83	3.63**	9.24**	2.49	3.72**
99	DE 2	74.93**	55.02	40.80	5.76	1.93	2.99	6.94	2.36	2.95
100	WGL 32100	69.43	64.39	38.95	5.11	1.86	2.76	7.50	2.51	2.99
101	GEB 24	65.50	60.15	42.07	5.32	1.92	2.78	7.34	2.46	2.99
102	Tulasi Manjari	65.32	59.04	43.22	5.26	1.65	3.20**	7.30	2.19	3.33
103	ASD 06 -1	71.23	67.44**	52.28**	6.15**	2.06**	2.99	8.84	2.60**	3.41
104	ASD 06 -2	79.91**	69.56**	49.97**	5.71	2.08**	2.75	8.29	2.61**	3.18
105	ASD 06 -3	79.28**	70.84**	49.44**	5.52	1.95	2.84	9.25**	2.39	3.87**
106	ASD 06 -4	**87.61****	**79.21****	54.07**	5.62	2.06**	2.74	8.42	2.42	3.48
107	ASD 06 -5	79.31**	69.55**	51.32**	5.43	1.80	3.02	8.80	2.36	3.74**
108	ASD 06 -6	78.75**	69.14**	49.62**	6.34**	2.14**	2.97	8.94**	2.50	3.57
109	ASD 06 -7	81.72**	69.23**	49.28	6.52**	2.21**	2.96	9.40**	2.61**	3.60
110	ASD 06 -8	79.42**	70.78**	50.62**	5.75	**2.54****	2.27	9.25**	2.61**	3.55
	GM	**72.46**	**63.38**	**47.29**	**5.99**	**1.97**	**3.05**	**8.94**	**2.54**	**3.54**
	CD	**1.66**	**1.47**	**2.09**	**0.03**	**0.02**	**0.03**	**0.16**	**0.04**	**0.09**

Significant at 1 % level (GM +CD)

H % - Hulling per cent, M % - Milling percent, HRR % - Head rice recovery per cent, KL - Kernel length, KB - Kernel breadth, L/B - Kernel length/breadth ratio, KLAC - Kernel length after cooking, KBAC - Kernel breadth after cooking, L/B AC - Kernel length/breadth ratio after cooking, LER - Linear elongation ratio, BWER - Breadth wise expansion ratio, (ASV) Alkali spreading value, WU - Water uptake VER- Volume expansion ratio, GC – Gel consistency, AC – Amylose content.

Table 2. Estimates of parameters of variability for quality traits

Characters	Range	Mean	PV	GV	PCV %	GCV %	h^2	GA	GA (%)
Hulling per cent (H %)	59.21-87.61	72.46	31.54	30.84	7.75	7.66	97.77	11.31	15.61
Milling per cent (M %)	48.02-79.21	63.39	44.19	43.64	10.49	10.42	98.75	13.52	21.33
Head rice recovery (HRR %)	30.70-61.24	47.29	42.60	41.47	13.80	13.62	97.36	13.09	27.68
Kernel length (KL-mm)	4.12-7.16	5.99	0.29	0.29	9.03	9.03	99.90	1.11	18.58
Kernel breadth (KB-mm)	1.62-2.54	1.97	0.03	0.03	9.02	8.99	99.58	0.36	18.50
L/B ratio (L/B)	2.27-3.79	3.06	0.09	0.09	10.28	10.27	99.72	0.65	21.12
Kernel length after cooking (KLAC-mm)	5.50-11.68	8.94	1.55	1.54	13.91	13.88	99.57	2.55	28.54
Kernel breadth after cooking (KBAC-mm)	1.96-3.41	2.54	0.07	0.07	10.25	10.22	99.30	0.53	20.97
L/B ratio after cooking (L/B AC)	2.33-4.99	3.54	0.27	0.27	14.81	14.75	99.28	1.07	30.28
Linear elongation ratio (LER)	1.04-1.94	1.49	0.02	0.02	10.46	10.41	99.01	0.32	21.33
Breadth-wise expansion ratio (BWER)	1.03-1.79	1.30	0.02	0.02	11.09	11.04	99.27	0.29	22.75
Alkali spreading value (GT)	1.65-6.25	3.79	1.06	0.97	27.12	26.03	92.14	1.95	51.47
Water uptake (WU gms)	2.00-4.86	3.06	0.30	0.30	18.06	18.04	99.86	1.14	37.14
Volume expansion ratio (VER)	2.31-4.92	3.60	0.71	0.70	23.43	23.21	98.13	1.70	47.37
Gel consistency (GC-mm)	39.00-179.00	88.24	1033.01	1011.27	36.42	36.04	97.90	64.82	73.45
Amylose content % (AC %)	11.20-43.60	23.26	23.11	22.76	20.67	20.51	98.48	9.75	41.93
Single plant yield (SPY-g)	10.72-33.63	23.20	31.41	30.38	24.16	23.76	96.72	11.17	48.14

Table 3. Genotypic and phenotypic correlation coefficient among yield and quality traits of 110 rice genotypes

Traits		H %	M %	HRR%	L/B	L/B AC	LER	BWER	ASV	WU	VER	GC	AC %	SPY
H %	**G**	**1.000**	0.899	0.663**	-0.073	0.284**	0.329**	-0.139	-0.010	0.007	0.686**	-0.259**	-0.025	0.564**
	P	**1.000**	0.884	0.648	-0.072	0.282	0.324	-0.139	-0.012	0.006	0.669	-0.250	-0.025	0.548**
M %	**G**		**1.000**	0.671**	-0.010	0.307**	0.333**	-0.102	0.028	0.033	0.688**	-0.254**	0.001	0.604**
	P		**1.000**	0.660	-0.010	0.303**	0.328**	-0.101	0.027	0.033	0.677	-0.250	0.003	0.591**
HRR %	**G**			**1.000**	0.109	0.304**	0.388**	0.059	0.042	-0.089	0.596**	-0.143	-0.149	0.662**
	P			**1.000**	0.106	0.299	0.381	0.056	0.041	-0.087	0.583	-0.137	-0.147	0.642**
L/B	**G**				**1.000**	0.499**	0.231**	0.489**	0.038	-0.398**	-0.169*	0.088	-0.084	0.099**
	P				**1.000**	0.498	0.230	0.488	0.038	-0.397	-0.168	0.086	-0.084	0.097
L/B AC	**G**					**1.000**	0.682**	-0.211*	0.122	-0.160	0.252**	-0.250**	-0.009	0.297**
	P					**1.000**	0.682	-0.213	0.117	-0.160	0.244	-0.245	-0.009	0.292**
LER	**G**						**1.000**	0.265**	0.149	-0.238**	0.238**	-0.176*	-0.017	0.411
	P						**1.000**	0.264	0.143	-0.237	0.230	-0.174	-0.017	0.402**
BWER	**G**							**1.000**	0.009	-0.389**	-0.272**	0.255**	-0.081	0.085
	P							**1.000**	0.002	-0.387	-0.266	0.249	-0.080	0.081
GT	**G**								**1.000**	-0.035	0.030	0.014	0.242**	0.173*
	P								**1.000**	-0.035	0.029	0.009	0.229	0.165*
WU	**G**									**1.000**	0.306**	-0.255**	-0.028	-0.108
	P									**1.000**	0.304	-0.251	-0.028	-0.106
VER	**G**										**1.000**	-0.405**	-0.112	0.611**
	P										**1.000**	-0.396	-0.112	0.596**
GC	**G**											**1.000**	0.117	-0.122
	P											**1.000**	0.114	-0.117
AC %	**G**												**1.000**	0.029
	P												**1.000**	0.029
SPY	**G**													1.000
	P													1.000

**** Significant at 1 % level** *** Significant at 5% level**