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GENETIC VARIABILITY FOR GRAIN QUALITY TRAITS IN INDIGENOUS RICE LANDRACES OF CHHATTISGARH, INDIA

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ABSTRACT

The investigation was carried out to estimate the components of genetic variability and associated statistical parameters for grain quality traits of 215 indigenous rice landraces of Chhattisgarh, India. Substantial genetic variability among the all genotypes was observed for the characteristics under study. All the genotypes were showed highly significant differences for all the studied grain quality traits. Coefficient of variation ranges from 8.61% for hulling percentage to 45.01% for alkali spreading value. Negligible difference between genotypic coefficient of variation and phenotypic coefficient of variation was observed for all the traits. High heritability with high genetic advance as percent mean was observed for all the grain quality traits except for hulling percent and milling percent. These results indicated that direct selection based on phenotypic performance could be rewarding for all quality traits because they are less influenced by environment and mostly governed by additive gene action. It has been observed that sixty nine genotypes had short slender type grain characteristics whereas; forty seven genotypes have short bold type grains. Thirty genotypes showed more than 80% hulling percent, fifty six genotypes showed more than 70% milling percent and fourteen genotypes showed more than 65%

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head rice recovery percent. Total sixty nine genotypes have intermediate type alkali spreading value which has 70-74°C gelatinization temperature and total hundred genotypes has intermediate amylose content (20-25%). Tulsimanjari, Luchai, BaiganiDhan, Kapri, and Badshahbhog have been identified superior genotypes for all of the quality traits. Superior genotypes identified for various quality traits could be utilized for future breeding programme.

1 Introduction

Rice landraces, local varieties, indigenous lines play a pivotal role for food nutritional and health security besides resistance to diseases and pests and resilience to climate changes which is needed for the survival of human civilization on earth. Rice is food grain crop of global importance with special preference in Asian countries. Grain yield improvement is the prime objective of plant breeders for several decades but demand for good quality rice is also increased in current decade as living standard of people are being gradually improved (Rathi et al., 2010). Therefore, improvement of grain quality features of rice becomes the utmost objective next to yield enhancement and has become major concern in rice breeding programs to meet the consumer preference and market demand. Rice varieties having good milling parameters, good appearance quality, good cooking and eating parameters, can be considered as superior grain quality rice variety which increases the total economic value of rice. Consumer preferences for good quality rice varied from one geographical region to another (Juliano & Perez CM, 1984; Rathi et al., 2010). In India, long grain specially Basmati varieties and fine or short slender grain varieties with intermediate amylose and alkali spreading value, intermediate gel consistency and high volume expansion of cooked rice is preferred. Whereas, low amylose and short grain is preferred in China and Japan (Hossain et al., 2009). Chhattisgarh state is popular as Rice Bowl of India, where tribal peoples grown traditional rice varieties since past hundreds of years. These varieties have special dominating character in terms of wide adoptability and tolerant to climate change. More than 23250 rice germplasm were recorded in Chhattisgarh state which showed vast diversity for specific quality traits viz. aroma, good cooking quality, grain type and shape, kernel colour etc. Short grain aromatic rice of Chhattisgarh is very popular due to its premium grain quality. Rice is consumed principally as a whole grain therefore; the texture of the whole grain is a matter of primary importance (Kumar, 1989; Hossain et al., 2009). Several studies on genetic variability parameters and descriptive statistics for grain quality traits have been previously conducted. In spite of that unexploited genetic variability is still exist in rice landraces which are of equally important in selecting the superior parents. These superior parents can give extreme heterosis and superior recombinants for better grain quality

components (Karupaiyan et al., 2013). Genetic parameters such as genotypic coefficient of variation and phenotypic coefficient of variation are the important genetical parameters for mining the amount of variability present in the germplasm. Role of environmental attributes on the expression any genotype and reliability of characters can be determined precisely by high broad sense heritability united with high genetic advance (Babu et al., 2012).

Descriptive statistical measures viz., mean, median, range, quartiles, standard deviation, standard error, skewness and kurtosis, can reveal a great deal of information about any variable of interest. Rice genetic resources are a key component to breeding programs and farmers have long played an important role, contributing to rice diversity by developing and nurturing thousands of rice varieties (Bellon et al., 1997). This vast wealth of rice germplasm including landraces and traditional varieties is a good source of important alleles to develop new rice varieties (Rabara et al., 2014)

Despite abundant genetic resources, only a small proportion of the total rice germplasm collection has been used in breeding programs. This discrepancy has narrowed the genetic base in most improved varieties and advance breeding lines (Kumbhar et al., 2015). Hence, appropriate conservation of landraces and broadening the gene pool of rice varieties has become necessary for breeding rice varieties with high yields and superior grain qualities in India. Germplasm/land races constitute the foundation for genetic improvement of crops. Therefore, the present experiment was conducted to assess nature and magnitude of variability parameters and descriptive statistics for grain quality traits in 215 indigenous rice landraces of Chhattisgarh, India.

2 Materials and Methods

2.1 Plant materials

The experimental material comprises total of 215 genotypes including 213 traditional landraces and two local varieties (Mahamaya and Rajeshwari) of rice of Chhattisgarh, India (Table 1). A total of 600 rice landraces and local varieties were collected from different parts of Chhattisgarh and were grown at research field, IGKV, Raipur during *Kharif* 2015 by following the

Table 1 List of rice genotypes used for the study

S. No.	Name	S. No.	Name	S. No.	Name	S. No.	Name
1	Luchai	31	Chhindmauri	61	Badshabhog-2	91	NariyalJhoba
2	Sonagathi	32	Karhani	62	Lajini Super	92	Sindursal
3	Kherkakuchi	33	Sihar	63	Gangabaru	93	Chhindmauri
4	Dadbanko	34	JhimiprasSamlayi	64	GudkamalDhan	94	Sugandha
5	Danighoda	35	Nandel	65	TulsiManjari	95	Dandrice
6	Anjani	36	Kapri	66	Kanakbhog	96	BansveeraDhan
7	Bathrash	37	Bhusi	67	DRRH-3	97	Jhingapuchhi
8	Saraitoliha	38	DhauraMundariya	68	Mahamaya	98	BeedelaDhan
9	Jonyaphool	39	Gangachur	69	Rajeshwari	99	Sonagathi-2
10	Pratiksha	40	Karhani	70	HR 14-1 Heera	100	PhalodDhan
11	Bhadvel	41	Byalo	71	MatkoDhan	101	LalmaDhan
12	Ranikajal	42	Bhusu	72	NimaliyaBanki	102	BaiganiDhan
13	Bhajna	43	Safri-2	73	Jonyaphool	103	MaranDhan
14	Ratajhinga	44	Sanchorma	74	Kadamphool	104	LoktiMusi
15	Pataniyajhuli	45	SatraSafri	75	Indjopa	105	AsamChudi
16	Laxmibhog	46	Barhani	76	Ramigauri	106	Jana Dhan
17	Sawani	47	Kanakbans	77	Brown Rice-1	107	RelaDhan
18	Jhilli	48	Jhimipras-2	78	Arokhutu	108	Jhunuprash
19	Tulsimongra	49	Dhaniyaphool	79	Brown Rice-2	109	OdhaDhanBanarsi
20	DhauraMundariya	50	Lalbarhasal	80	Dubraj	110	B.D. Safri
21	Jhimipras	51	Alsenga	81	HathiPanjra	111	Lochai
22	PangudiGoindi	52	Barhasal-2	82	Modipeera	112	GadurSela
23	Safri	53	RuchiDhan	83	Petgadi	113	KareniDhan
24	Barhasal	54	Rudra	84	Ramlaxman	114	PivriLochai
25	Dubraj	55	Bhunduluchai	85	Raja Banga	115	Govardhan Kali Kamod 2
26	Agyasal	56	Barhasal-3	86	Kari Gilash	116	Loindi
27	Jauphool	57	Khetganga	87	Muni Bhog	117	Santio
28	Kalajeera	58	Bashabhog	88	SuaPankhi	118	Parra Dhan
29	Byalo	59	Tulsibhog	89	Mala Gauri	119	Godadani
30	Badshabhog	60	Nariyalphool	90	DokraDokri	120	Ramshri

S. No.	Name	S. No.	Name	S. No.	Name	S. No.	Name
121	Danwar	135	Kumhdayin	149	BaktiChudi	163	Kalinga
122	ChatiyaNakhi	136	BhejrimaiDhan	150	JhilliSafri	164	Bhusu
123	BhathaMasri	137	RatanChudi	151	Nanded	165	Kabeli
124	Kanchan	138	Panwar	152	TuriyaKhudig	166	Gatuvan
125	BaigaSeeng	139	Chhindmauri	153	Antarved	167	Baikoni
126	Mota Safri-2	140	Rani Parewa	154	Rang Chudi	168	ChinniParas
127	MohlaiBanko	141	Ramlichonch	155	MotaChudi	169	Jalsinga
128	SutaiDhan	142	Mejhri	156	B.D. Safri-2	170	Agni Fag
129	Haripanti	143	Bodibaja	157	KharikhaKuchi	171	Lalapana
130	Bhujnin	144	Jela	158	MemriKhed	172	BahalBinjo
131	Manki	145	Badshabhog Selection-1	159	Ankapalli	173	Kari Grass
132	Sadachar	146	Kari Alcha	160	Samarlengda	174	Asam Chudi-2
133	Mahabaikoni	147	DeshiSurmatiya	161	Mayath	175	Tulsi Mala
134	Khajoor	148	Anjaniya	162	MotaSafri	176	Surmatiya

Note: Source of all the collected landraces is IGKV, Raipur (CG), India

augmented design. A core set of 215 rice landraces was constructed by selecting superior genotypes based on their grain yield and attributing traits from these 600 genotypes. All 215 landraces were cleaned properly, dried in hot air oven up to 12-14% moisture content and kept at room temperature for four months then used for grain quality parameter estimation at R.H. Richharia Rice Research Laboratory, Department of Genetics and Plant Breeding, IGKV, Raipur (CG), India. In this investigation, grain quality parameters of each rice samples were analysed in duplicates.

2.2 Physical parameters of rice grains:

All the standard protocol according to Indian Institute of Rice Research, Hyderabad, India (formerly, Directorate of Rice Research) was followed for estimating the grain quality parameters (DRR, 2014).

2.2.1 Brown rice length and breadth (L/B) ratio

Brown rice length and breadth of 10 random samples of whole rice grains from each genotype were measured manually by using millimetre scale and graph. Average length and breadth of 10 samples were used for L/B ratio calculation and further analysis.

2.2.2 Brown rice recovery percent (hulling percent)

About 100 gram of rough rice samples were hulled by a single pass through a standard rubber roll huller (Satake Engineering Co. Ltd. Tokyo, Japan) to produce brown rice (decorticated rice). The brown rice was then weighed and used for calculation of hulling percentage based on initial weight of rough rice as; hulling percent = (weight of hulled rice/ weight of rough rice) X100 (DRR, 2014).

2.2.3 Milled rice recovery percent (milling percent)

Hulled brown rice was then used for milling up to 5% by using a McGill No. 2 miller (Rapsilver Supply Co. Inc., Brookshire, TX). The generated milled rice was weighed and used for milling percent calculation based on initial weight of rough rice as; milling percent = (weight of milled rice/ weight of rough rice) X100 (DRR, 2014).

2.2.4 Head rice recovery percent (HRR percent)

Milled rice kernels were separated into head rice and broken kernel fractions with different sized separator/ sieves. Full kernel

and $\frac{3}{4}$ size kernels were considered as head rice and weighed for calculating HRR percentage. Head rice recovery percentage was calculated as; head rice recovery percent = (weight of full kernel and $\frac{3}{4}$ sized kernel/ weight of rough rice) X 100 (DRR, 2014).

2.3 Grain physico-chemical and cooking parameters

2.3.1 Elongation Ratio

Elongation ratio of cooked kernels was determined by dividing the length of cooked kernel to length of uncooked kernel.

2.3.2 Alkali Spreading Value and Gelatinization temperature (GT)

Alkali Spreading Value and gelatinization temperature was assessed using standard alkali digestion and spreading scores (Little et al., 1958). Six whole grains from each of the genotypes were placed in plastic Petridish containing 10 ml 1.7% KOH. The arrangements of grains were in such a way that they were not in contact with each other. All the petri dishes were properly covered and incubated at 30 °C for 23 hours. Scoring was based on visual appearance and disintegration of all the six endosperm of each genotype.

2.3.3 Gel consistency (GC)

Polished rice of each genotype was powdered by using mortar and pestle followed by sieved with 1 mm sieve. In long test tube (2×19.5 cm), 100 mg of rice flour was taken followed by adding of 0.2 ml of ethanol containing 0.25% thymol blue. Thereafter, 2.0 ml of 2.8 g KOH in 250 ml distilled water was added into each tube and mixed properly by using vortexer. All the samples were kept in hot water bath for 8 min then cooled for 5 minutes. All the samples were vortexed again and kept in ice bath for 20 min. Later on, all the tubes were taken out and laid horizontally on laminated graph paper for one hour to take the measurement (DRR, 2014).

2.3.4 Amylose content (AC)

Amylose content of each landrace was estimated by following the method of Juliano (1971). 100mg rice flour was taken into volumetric flask and added 1ml ethanol (95%) with 9ml of sodium hydroxide (1N). The samples were kept on a boiling water bath followed by cooling for 10 minutes at room temperature. Final volume of 100 ml was made by adding distil water. Thereafter, 5ml solution was pipetted out from 100ml stock solution and added 1ml of acetic acid (1N) and 2 ml of freshly prepared iodine solution. Solutions were shaken properly and kept at dark place for 20 minutes and determine the absorbance at 620 nm using a UV-Vis spectrophotometer (Jasco, Cambridge, UK).

2.4 Statistical analysis:

Descriptive statistics for all the traits and histogram were made by using XLSTAT v18.07. Analysis of variance (One way ANOVA) was calculated by using OPSTAT software following the suggested formula of Panse & Sukhatme (1967). Method suggested by Burton (1952) was followed for calculation of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV). Broad sense heritability (h^2) was calculated as per method suggested by Hanson et al. (1956). Similarly, method suggested by Johnson et al. (1955) was used for the calculation of genetic advance (GA). GCV, PCV, heritability and genetic advance were analyzed manually by MS-Excel-2007 by following the above mentioned methods.

3 Results and Discussion

3.1 Analysis of Variance (ANOVA)

The analysis of variance (ANOVA) revealed the presence of highly significant differences among all rice landraces for all the grain quality traits (Table 2). This indicates the existence of ample

Table 2 Analysis of Variance (ANOVA) for grain quality traits in indigenous rice landraces

Source of variation	Df	Mean sum of squares															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Treatment	214	1.11**	0.18**	0.42**	0.75**	0.16**	0.35**	2.25**	0.59**	0.38**	0.07**	82.25**	73.87**	75.31**	6.68**	545.95**	32.44**
Error	215	0.022	0.02	0.061	0.017	0.026	0.073	0.018	0.013	0.021	0.003	5.395	3.64	1.73	0.002	4.61	0.156
Total	429																
Coefficient of variation (%)		12.70	15.60	14.97	11.63	14.97	14.66	13.97	17.44	15.82	12.58	8.61	9.26	10.69	45.01	26.98	17.11
SEd		0.15	0.14	0.25	0.13	0.16	0.27	0.13	0.11	0.14	0.05	2.32	1.91	1.32	0.04	2.15	0.39
CD at 1%		0.39	0.37	0.64	0.34	0.42	0.70	0.35	0.30	0.38	0.14	6.04	4.96	3.42	0.12	5.58	1.03
1. Brown rice Length				4. Kernel rice Length				7. Kernel length after cooking				10. Elongation Ratio				13. HRR%	
2. Brown rice Breadth				5. Kernel rice Breadth				8. Kernel breadth after cooking				11. Hulling %				14. ASV/GT	
3. Brown rice L/B ratio				6. Kernel rice L/B ratio				9. Kernel L/B ratio after cooking				12. Milling %				15. GC (mm)	
																16. Amylose Content	

** Significant at 1% level of significance; * Significant at 5% level of significance

amount of variability among rice landraces for studied traits. Coefficient of variation is simply a measure of dispersion of the variable. In present investigation, CV ranges from 8.61% for hulling percentage to 45.01% for alkali spreading value. Coefficient of variation was observed higher for gel consistency (26.98%) followed by kernel breadth after cooking (17.44 %) and amylose content (17.11 %). Results indicated that overall high coefficient of variation was present for all the traits under study. The presence of a wide range of variability might be due to diverse sources of the materials having high natural recombination and mutations that has accumulated over decades in these landraces. Thus, there is a good opportunity to select better parental types improving the rice grain quality traits. The results were in consonance with the finding of Dhanwani et al. (2013); Devi et al. (2015) and Devi et al. (2016).

3.2 Genetic Variability Parameters:

3.2.1 Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV):

Genetic variability parameters for all the grain quality traits are given in Table 3. Results in table exhibited wide range of variation for different traits. The maximum genotypic and

phenotypic variations were obtained for gel consistency (270.67 and 275.28 respectively) followed by hulling percent (38.43 and 43.82 respectively), HRR percent (36.79 and 38.52 respectively) and milling percent (35.12 and 38.76 respectively). The higher GV and PV values indicated that environment influence is negligible for these traits. All the grain physical parameters were showed slightly low genotypic and phenotypic variations which are the indicative of quite stable nature of these traits. Coefficients of variation studies indicated that the estimates of phenotypic coefficient of variation (PCV) were slightly higher than the corresponding genotypic coefficient of variation (GCV) estimates for all traits indicating that phenotypic variation was determined by and large by genotype with negligible influence of extraneous factors and therefore, selection for such traits on the basis of phenotype only could also be rewarding as suggested by Babu et al. (2012) and Karupaiyan et al. (2013).

The magnitude of coefficient of variation was categorized as high (> 20%), moderate (10- 20%) and low (< 10%). The high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was observed for alkali spreading value (45.09% and 45.08%) and gel consistency (27.16% and 26.93%) while the brown rice length (12.85% and 12.60%), brown rice breadth (16.44% and 14.78%), brown rice L/B ratio

Table 3 Variability parameters for grain quality traits in indigenous rice landraces

S. N.	Name of Trait	Grand Mean	Genetic variance (Vg)	Phenotypic variance (Vp)	PCV %	GCV%	Heritability (bs)	Genetic advance (GA)	GA as % of mean
1	Brown rice length	5.84	0.54	0.56	12.85	12.60	96.10	1.49	25.44
2	Brown rice Breadth	1.96	0.08	0.10	16.44	14.78	80.77	0.54	27.36
3	Brown rice L/B ratio	3.03	0.18	0.24	16.10	13.89	74.42	0.75	24.68
4	Kernel length	5.24	0.36	0.38	11.80	11.53	95.54	1.22	23.22
5	Kernel Breadth	1.88	0.07	0.09	16.18	13.72	71.89	0.45	23.97
6	Kernel L/B ratio	2.84	0.14	0.21	16.23	13.15	65.65	0.62	21.95
7	Kernel length after cooking	7.58	1.12	1.14	14.06	13.95	98.42	2.16	28.51
8	Kernel breadth after cooking	2.80	0.29	0.30	19.69	19.26	95.73	1.09	38.83
9	Kernel L/B ratio after cooking	2.76	0.18	0.20	16.31	15.44	89.66	0.83	30.12
10	Elongation Ratio	1.45	0.03	0.04	12.95	12.39	91.55	0.36	24.42
11	Hulling %	74.29	38.43	43.82	8.91	8.34	87.69	11.96	16.10
12	Milling %	65.51	35.12	38.76	9.50	9.05	90.61	11.62	17.74
13	HRR%	57.25	36.79	38.52	10.84	10.59	95.51	12.21	21.33
14	Alkali Spreading Value	4.05	3.34	3.34	45.09	45.08	99.94	3.76	92.84
15	Gel Consistency	61.09	270.67	275.28	27.16	26.93	98.33	33.61	55.01
16	Amylose Content	23.48	16.14	16.30	17.20	17.11	99.04	8.24	35.08

(16.10% and 13.89%), kernel length (11.80% and 11.53%), kernel breadth (16.18% and 13.72%), kernel L/B ratio (16.23% and 13.15%), kernel length after cooking (14.06% and 13.95%), kernel breadth after cooking (19.69% and 19.26%), kernel L/B ratio after cooking (16.31% and 15.44%), elongation ratio (12.95% and 12.39%), head rice recovery percent (10.84% and 10.59%) and amylose content (17.20% and 17.11%) were showed intermediate PCV and GCV. Hulling percent (8.91% and 8.34%) and milling percent (9.50% and 9.05%) were showed slightly lower PCV and GCV based on the scale. Higher and intermediate value of GCV gives idea for selection of trait with significant improvement. However estimation of total heritable variation based on GCV only could not give significant output (Roychowdhury & Tah, 2011). Further, Burton & Devane (1952) suggested that the genetic coefficient of variation together with heritability estimates gave a better picture of the extent of heritable variation. Similar results were observed by Maneerattanarungroj et al., (2015); Rath et al., (2010); Babu et al. (2012); Chaudhary & Singh (1994); Shivani & Reddy (2000), Pathak & Sharma (1996).

3.2.2: Broad sense heritability:

Heritability (h^2) estimates were interpreted as low (<30%), medium (31% - 70%) and high (>70%) as per the classification of Johnson et al. (1955). In the present investigation all the grain quality traits showed high heritability (broad sense) except for kernel L/B ratio (65.65%) which showed moderate heritability. Highest broad sense heritability exhibited for alkali spreading value (99.94%) followed by amylose content (99.04%), kernel length after cooking (98.42) and gel consistency (98.33). High heritability values indicate that the characters under study are less influenced by environment in their expression. The plant breeder, therefore adopt simple selection method on the basis of the phenotype of the characters which ultimately improves the genetic background of these traits. Similar results have been reported by Rath et al. (2010); Babu et al. (2012); Sarawgi et al. (2000), Gannamani (2001) and Sao (2002).

3.2.3 Genetic advance as percent of mean:

The estimates of genetic advance as percent of mean provide more reliable information regarding the effectiveness of selection in improving the traits. Genetic advance denotes the improvement in the genotypic value of the new population over the original population. Johnson et al. (1955) categorized the genetic advance as percent of mean as high (>20%), moderate (10-20%) and low (<10%). All the studied grain quality traits were exhibited high estimate of genetic advance as percent of mean except for hulling percent (16.10%) and milling percent (17.74%) which showed moderate GA as percent mean. Highest GA as percent mean was exhibited alkali spreading value (92.84%) followed by gel

consistency (55.01%) kernel breadth after cooking (38.83%) and amylose content (35.08%). Similar findings were also reported by Shivani & Reddy (2000), Iftikharuddaula et al. (2001), Gannamani (2001), Sao (2002), Rath et al., (2010) and Babu et al. (2012). High heritability with high genetic advance as percent mean was observed for all the grain quality traits except for hulling percent and milling percent which indicated that expression of these traits are less influenced by environment and controlled by additive gene action (Panse, 1957). Therefore, these traits could be improved through direct selection or progeny selections. High heritability with moderate GA as percent mean was observed for trait hulling percent and milling percent which indicate that these trait are also governed by additive gene action and can be improved by selection methods with proper care (Roychowdhury & Tah, 2011). None of the trait exhibited high heritability with low GA as percent mean which indicate the absence of non-additive gene action among the studied traits.

3.3 Descriptive Statistics for various grain quality parameters:

Descriptive statistical measures can reveal a great deal of information about any variable of interest. Descriptive statistics, presenting the measures of central tendency and measure of variations for all the traits are given in table 4. Brown rice length ranges from 3.65mm (Tulsimongra) to 9.10mm (DokraDokri) with an average of 5.84mm (Figure 1). Brown rice breadth ranges from 1.45 mm (Chinniparas) to 2.90 mm (Ranikajar) with an average of 1.96 mm. Brown rice L/B ratio ranges from 1.87 mm (Manki) to 4.21 mm (Chinniparas) with an average of 3.03 mm. Kernel length ranges from 3.10 mm (Tulsimongra) to 7.50 mm (Hathipanjra) with an average of 5.24 mm (Figure 2). Kernel breadth ranges from 1.40 mm (Chinniparas) to 2.65 mm (Bhujanin) with an average of 1.88 mm. Kernel L/B ratio ranges from 1.72 mm (BhejrimaiDhan) to 3.83 mm (Jhilli) with an average of 2.84 mm.

Standard evaluation system (SES), IRRI (1996) based grain shape classification of all genotypes are given in table 5. Sixty nine genotypes have short slender type grain characteristics whereas 47 genotypes have short bold type grains (Table 5). Eighty four land races have medium slender type grain characteristics. Out of 215 rice genotypes, 7 genotypes has long slender type grain feature whereas 4 genotypes has long bold type grain characteristics.

Kernel length after cooking ranges from 4.70 mm (Loktimachi) to 11.25 mm (Kapri) with an average of 7.58 mm. Kernel breadth after cooking ranges from 1.75 mm (Bhajna) to 4.32 mm (Lalbarhasal) with an average of 2.79 mm. Kernel L/B ratio after cooking ranges from 1.09 mm (Lalbarhasal) to 4.67 mm (Kabeli) with an average of 2.76 mm. Elongation ratio ranges from 1.14 (Karhani) to 2.18 (Kapri) with an average of 1.45. Kapri showed almost doubled elongation ration which is the basic feature of

Table 4 Descriptive statistics for grain quality traits in indigenous rice landraces

Statistic	Sum	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Variance (n-1)	Standard deviation (n-1)	Skewness (Pearson)	Kurtosis (Pearson)
Brown rice length (mm)	1255.75	5.84	3.65	9.10	5.45	5.50	5.75	6.15	0.55	0.74	0.81	3.03
Brown rice breadth (mm)	421.65	1.96	1.45	2.90	1.45	1.70	1.90	2.10	0.09	0.31	0.66	0.01
Brown rice L/B ratio	652.26	3.03	1.87	4.21	2.34	2.74	3.08	3.34	0.21	0.46	-0.19	-0.04
Kernel length (mm)	1125.85	5.24	3.10	7.50	4.40	4.95	5.25	5.50	0.37	0.61	0.16	2.17
Kernel breadth (mm)	404.05	1.88	1.40	2.65	1.25	1.65	1.85	2.05	0.08	0.28	0.56	-0.13
Kernel L/B ratio	610.60	2.84	1.72	3.83	2.11	2.54	2.85	3.12	0.17	0.42	-0.12	-0.35
Kernel length after cooking (mm)	1629.75	7.58	4.70	11.25	6.55	6.90	7.50	8.10	1.13	1.06	0.51	0.93
Kernel breadth after cooking (mm)	602.55	2.80	1.75	4.32	2.57	2.40	2.70	3.10	0.30	0.55	1.92	10.74
Kernel L/B ratio after cooking	593.98	2.76	1.09	4.67	3.58	2.47	2.76	3.02	0.19	0.44	0.21	1.48
Elongation ratio	312.79	1.45	1.14	2.18	1.05	1.33	1.41	1.54	0.03	0.18	1.22	1.80
Hulling %	15971.48	74.29	44.07	88.27	44.20	71.05	75.06	78.25	41.12	6.41	-0.71	1.93
Milling %	14084.04	65.51	43.62	77.46	33.84	62.04	66.10	70.28	36.94	6.08	-0.59	0.33
HRR%	12309.76	57.25	37.78	69.79	32.01	52.48	59.30	61.74	37.66	6.14	-0.57	-0.31
Alkali Spreading Value	871.50	4.05	1.00	7.00	6.00	2.00	4.00	6.00	3.34	1.83	0.11	-1.23
Gel Consistency	13134.00	61.09	29.50	98.50	69.00	46.50	61.50	69.50	272.90	16.52	0.50	-0.20
Amylose content (%)	5047.69	23.48	11.84	33.82	21.98	20.48	23.88	25.71	16.22	4.03	-0.09	0.23

Figure 1 Lengthwise arrangement of hulled rice of identified superior genotypes

Table 5 Classification of 215 indigenous rice landraces based on grain shape (SES, IRRI 1996)

Grain Type	Kernel length (mm)	Kernel L/B ratio	Genotypes	Total
Short slender	< 6.0	> 3.0	Jhilli, Hajan, Kosawari, HarunaMasri, ChatiyaNakhi, ChinniParas, B.D. Safri-2, Sonagathi-2, Mota Safri-2, JhimiprasSamlayi, Sonkharcha, MotaChudi, Bashabhog, Bhajna, MotaSafri, Safri, Khetganga, Bhusu, Antarved, Ratajhing, Bhadvel, Sawani, KharikhaKuchi, Pancho, Kherkakuchi, Indjopa, Brown Rice-2, MatkoDhan, Badshabhog Selection-1, BhataNakhi, Ikkopatla, DeshiSurmatiya, Ramshri, Pataniyajhuli, DhauraMundariya, Anjaniya, Ankapalli, Dubraj, MohlaiBanko, Agyasal, Ramjhilli, SatraSafri, Ikkomota, Safri-2, Sichar, Dowana, Nanded, NimaliyaBanki, Brown Rice-1, Pratiksha, BaktiChudi, SutaDhan, Lajini Super, Jhimipras, Katrani-4, Badshabhog-2, RuchiDhan, Dubraj, Jhimipras-2, Jela, Kalinga, Bhata Masri-2, Dhaniyaphool, Bhusu, Sanchorma, Hardigathi, Danwar, Rang Chudi, Jonyaphool	69
Short bold	< 6.0	< 2.5	LalmaDhan, Ramlaxman, Haripanti, Kanakbans, Korma, DRRH-3, Barhasal, Sugandha, Dandrice, Petgadi, Barhasal-2, Anjani, Nariyalphool, Surmatiya, DhauraMundariya, Dadbanko, Sadachar, SuaPankhi, Kalajeera, NariyalJhoba, Loindi, Barhani, Bhaisapuchhi, Lochai, PivriLochai, Sindursal, KareniDhan, Santio, RatanChudi, LoktiMusli, Agni Fag, Mahabaikoni, Ramlichonch, HathiPinjara, Tulsimongra, Rani Kajar, Panwar, Govardhan Kali Kamod 2, Jana Dhan, Sonagathi, Bhujnin, Modipeera, Chhindmauri, Mala Gauri, Manki, Muni Bhog, BhejrimaiDhan	47
Medium slender	< 6.0	2.5-3.0	BahalBinjo, PhalodDhan, Ramigauri, KondhaKoya, Kanchan, GudkamalDhan, Kapri, Byalo, Chhindmauri, Ramlaxman, Masri, Gaurimala, Jalkeshar, Gatuvan, Majori, Katrani-7, Laxmibhog, Byalo, Bhusi, Gangabaru, Arokhutu, Kadamphool, Kumhdayin, Danighoda, Barhasal-3, Bhunduluchai, Kabeli, Rajabangla, Safri-17, BaigaSeeng, Badshabhog, Bodibaja, Rudra, Parra Dhan, Godadani, Baikoni, Mayath, Alsenga, RelaDhan, Tulsibhog, Tulsimanjari, Jonyaphool, Asam Chudi-3, BhathaMasri, B.D. Safri, GadurSela, BeedelaDhan, TuriyaKhudig, PangudiGoindi, Jhingapuchhi, BaiganiDhan, BansveeraDhan, Ranikajal, MemriKhedhi, Bansgathi, Khajoor, Maidubraj, Kari Alcha, Sihar, Jalsinga, Kari Grass, Asam Chudi-2, Luchai, Nandel, Jhunuprash, Chhindmauri, Jauphool, Sudama, Karhani, Manmohan, Kanakbhog, AsamChudi, OdhaDhanBanarsi, Tulsu Mala, Katrani-9, Samarlengda, Lalapana, ParwatKal, HR 14-1 Heera, Bathrash, ChurlaiBanko, MaranDhan, Luchai- 2, Gomti, Lalbarhasal, Karhani, Mejhri, Saraitoliha	88
Long slender	> 6.0	> 3.0	HathiPanjra, Raja Banga, Mahamaya, DokraDokri, Rajeshwari, Gangachur, JhilliSafri	7
Long bold	> 6.0	< 3.0	Kari Gilash, Rani Parewa, Jhoomar, Jalgundi	4
Total				215

basmati rice. So it can be said that Kapri rice landrace has basmati type feature (Figure 3).

Hulling percent ranges from 44.07 % (Reladhan) to 88.27 % (Luchai) with an average of 74.29 %. Total 30 genotypes showed >80% hulling percent among the all genotypes. Milling percent ranges from 43.62 % (Reladhan) to 77.46 % (BaigniDhan) with an average of 65.51 %. Total 56 genotypes showed >70% milling percent out of 215 genotypes. High head rice yield is one of the most important criteria for measuring milled rice quality. Head rice recovery percent ranges from 37.78 % (Reladhan) to 69.79 % (Badshabhog 2) with an average of 57.25 %. Total 14 genotypes showed >65% head rice recovery percent among all the genotypes. Genotypes having high hulling percent, milling percent and HRR percent could be utilized for

development of good quality rice variety.

Gelatinization temperature (GT) is a measure of temperature and time required for cooking of rice grains which is estimated based on alkali spreading value (ASV). The ASV varied over a wide range from 1 to 7 (Figure 4). Total 69 genotypes have intermediate type alkali spreading value (4-5 scale) which has 70-74°C gelatinization temperature. Total 55 genotypes showed high ASV (6-7) which had low gelatinization temperature. Remaining 91 genotype showed high (>74 °C gelatinization temperature).

Landrace Luchai (29.25 mm) had lowest gel consistency whereas landraces Odhadhan had highest (98.50 mm) gel consistency with an average of 61.09 mm (Figure 5). Gel consistency determines the softness or hardness of cooked rice. Soft and medium gel

Figure 2 Lengthwise arrangement of milled rice of identified superior genotypes

Figure 3 Basmati property of landrace Kapri

Figure 4 Representation of alkali spreading value (ASV) in rice landraces

Figure 5 Representation of gel consistency scales in rice

Symbols: ----- Median + Mean ♦ Minimum/ Maximum ○ Outliers 1 ✖ Outliers 2

Symbols: + Mean ♦ Minimum/ Maximum ○ Outliers 1 ✖ Outliers 2

Figure 6 Boxplots showing descriptive statistics of various grain quality traits in indigenous rice landraces

Figure 6 Boxplots showing descriptive statistics of various grain quality traits in indigenous rice landraces

Figure 7 Histogram showing frequency distribution of various grain quality traits in indigenous rice landraces

consistency types are generally preferred by consumers at different regions. In present investigation, total 81 genotypes had intermediate type (40mm – 60mm) gel consistency. Amylose content is considered as a prime determinant of cooking quality with GT and GC in rice. The amount of amylose determines how sticky the rice grain will be when cooked. Amylose content ranges from 11.84 % (Dadbanko) to 33.82 % (Bhatamasri) with an average of 23.48 %. Total 100 genotypes has intermediate amylose content (20-25%). Varieties with intermediate amylose content are generally most preferred in Indian conditions because they look dry and fluffy retaining their soft texture even after cooling.

Among the traits, highest standard deviation was found for gel consistency followed by hulling percent, milling percent and head rice recovery percent. Standard deviation provides a reliable estimate of the degree to which the numbers in the variable deviate from the mean. Thus, the standard deviation is truly a standard measure of variability that applies to any distribution, regardless of the unit of measure used (Larson & Farber, 2002). If the standard deviation is very small, scores are not scattered far from the mean. The larger the standard deviation, the more widely scattered are values in the distribution (McHugh, 2003).

3.4 Box plots profile based on descriptive statistics

Descriptive statistics based box plots for each trait has been given in Figure 6 which showed graphical summary of the distribution of a trait. Median value of each trait is almost similar or nearer to their respective mean value which indicated the proper distribution of genotypes for corresponding traits. Box plot showed that among the 218 genotypes, 75% individuals have equal to or less than 78.25 % (Third quartile) hulling percent while 25% genotypes have equal to or less than 71.05 % (First quartile) hulling percent. In the same way, 75% genotypes have equal to or less than 70.28 % milling percent while 25% genotypes have equal to or less than 62.04 % milling percent. Similarly, 75% genotypes have equal to or less than 61.74 % (Third quartile) head rice recovery percent while 25% genotypes have equal to or less than 52.48 % (First quartile) head rice recovery percent. This showed that higher hulling percent, milling percent and HRR % were observed in more than or equal to 75% genotypes. For amylose content, 75% genotypes have equal to or less than 25.71% (Third quartile) amylose whereas 25% genotypes have equal to or less than 20.48 (First quartile). Upper and lower outliers of each trait are the indicative of maximum and minimum values for the corresponding trait which are presented in corresponding box plots.

3.5 Frequency distribution based histogram of grain quality traits

Histogram showing frequency distribution for various grain quality traits on 215 rice genotypes revealed different patterns of distribution as shown in Figure 7. Histogram showed that none of the trait follows the exact normal distribution pattern but brown rice length, kernel length, kernel L/B ratio, kernel L/B ratio after cooking and amylose content showed somehow similar to normal distribution. The study on frequency distribution of traits using skewness and kurtosis helps to extract the available information on nature of gene action (Fisher et al., 1932) and number of genes controlling the traits (Robson, 1956), respectively. Skewness and kurtosis for all studied traits are given in Table 4. Skewness values and histogram for brown rice L/B ratio (-0.19), kernel L/B ratio (-0.12), hulling percent (-0.71), milling percent (-0.59), head rice recovery percent (-0.57) and amylose content (-0.09) showed that these traits were negatively skewed. Whereas, brown rice length (0.81), brown rice breadth (0.66), kernel length (0.16), kernel breadth (0.56), kernel length after cooking (0.51), kernel breadth after cooking (0.52), elongation ratio (1.22), alkali spreading value (0.11) and gel consistency (0.50) were positively skewed.

The skewed distribution of a trait in general suggests that the trait is under the control of non-additive gene action and is influenced by environmental variables. Positive skewness is associated with complementary gene interactions while negative skewness is associated with duplicate (additive x additive) gene interactions. The genes controlling the trait with skewed distribution tend to be predominantly dominant irrespective of whether they have increasing or decreasing effect on the trait (Pooni et al., 1977). In this study, all the grain quality traits showed minor skewness as the value of skewness for all the traits were close to zero (Table 1). So it can be said that non-additive gene action is absent in studied traits which is also confirmed by variability parameter studies.

Kurtosis values for brown rice L/B ratio (-0.04), kernel breadth (-0.13), kernel L/B ratio (-0.35), kernel breadth after cooking (-0.06), head rice recovery percent (-0.31), ASV (-1.23) and gel consistency (-0.20) showed that these traits were negatively skewed. Whereas, brown rice length (3.03), brown rice breadth (0.01), kernel length (2.17), kernel length after cooking (0.93), kernel L/B ratio after cooking (1.48), elongation ratio (1.80), hulling percent (1.93), milling percent (0.33) and amylose content (0.23) were positively skewed. Histogram showed that kernel L/B ratio, kernel breadth after cooking, kernel L/B ratio after cooking, hulling percent, milling percent and amylose content showed similar to mesokurtic configuration whereas rest of the trait showed leptokurtic configurations. None of the trait showed platykurtic configuration. The traits with leptokurtic and

platykurtic distribution are controlled by fewer and more number of genes, respectively. Kurtosis is negative or close to zero in the absence of gene interaction and is positive in the presence of gene interactions (Nachimuthu et al., 2014).

Conclusion

The study revealed that there was significant genetic variability among the genotypes for all the grain quality characters examined in the landraces and genotypes of rice. Several land races were identified for good grain quality features which could be used in rice breeding strategy and biotechnological research for further yield and quality characters improvement. Land races viz. Tulsimanjari, Luchai, BaiganiDhan, Kapri, and Badshahbhog have been identified superior and desirable from this study. Tulsimongra has shortest kernel length whereas HathiPanjra and DokraDokra have longest kernel length. Other land races viz. Luchai, BaiganiDhan and Badshahbhog were identified superior for good milling parameters. Kapri, Bhajna and Kabeli were identified superior for cooking quality parameters in which Kapri showed Basmati type quality (2.18 length wise elongation after cooking). All the genetic parameters for studied traits showed less influence of environment which is good for further selection of these traits. It can be concluded that indigenous rice landraces enriched in cooking and eating quality features hold enormous potential to be utilized as value added products. The present investigation provided the breeding materials to the rice breeders for exploitation of landraces in future breeding programme. Some important traits like hulling percent, milling percent, head rice recovery, amylose content, gelatinization temperature and elongation ratio can be significantly improved by exploiting the landraces of rice

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Conflict of Interest

Authors declare that there is no conflict of interests arising from this study.

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