Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(6): 1363-1367
Received: 25-09-2018
Accepted: 26-10-2018

Basabdatta Das
Division of Plant Biology, Bose Institute, Main Campus, A.P.C. Road, Kolkata, West Bengal, India

Samik Sengupta
Department of Horticulture (Fruit and Fruit Technology) Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Tapas Kumar Ghose
Division of Plant Biology, Bose Institute, Main Campus, A.P.C. Road, Kolkata, West Bengal, India

Correspondence
Basabdatta Das
Division of Plant Biology, Bose Institute, Main Campus, A.P.C. Road, Kolkata, West Bengal, India

Phenotypic characters and qualitative traits of diverse rice landraces of North-East India including West Bengal

Dr. Basabdatta Das, Dr. Samik Sengupta and Tapas Kumar Ghose

Abstract
Adaptations to different habitat have shaped the rice landraces into distinct ecotypes with special characteristics. Elucidation of those differences both phenotypically and genotypically is required for the proper categorization of rice germplasms and for choosing the base population in various breeding programs. Preservation of landraces with special adaptive trait and typical end uses will help in the sustenance of the Indian agrarian system.

Keywords: Rice landrace, grain and kernel trait, qualitative trait

Introduction
As a consequence of adaptations to different habitats, extensive ecological, morphological and physiological variation exists within *O. sativa* resulting in about 120,000 different, named germplasms [1] ranging from traditional rice landraces [2] preserved by indigenous farmers to the commercially bred cultivars developed during the green revolution. Due to the influence of agro-ecological factors and consumer quality preferences of individual cultures and societies, landraces are usually more genetically and physically diverse than commercially bred cultivars [3]. India is home to many such landraces. Information generated from studies on the genetic diversity of these landraces help in the selection of parents for hybridization programs, because crop improvement depends upon the inherent variability in the base population [4]. Variations observed in the phenotypic traits are reliable measures of genetic diversity within the rice landraces. Differences in the grain and kernel morphological traits like length and breadth, length/breadth ratios, cooked kernel elongation, kernel elongation ratio and quality traits like alkali spreading value, amylose content and aroma are significant enough to segregate the landraces into various ecotypes. Improving these traits are vital milestones in rice breeding because grain size, grain shape, aroma and cooking characteristics determine the price of rice in the market [3]. Traits like grain and kernel shape and size are strongly influenced by consumer preference in the international market. A long, slender grain is preferred by consumers in India, Pakistan, Afghanistan, Iran and the USA, whereas consumers in Japan, Korea, and Northern China prefer a rice grain that is short and round [5]. Apart from the genetic make-up, traits like aroma are strongly influenced by the environment [6]. This study explores the diversity in 9 grain and kernel dimensional traits and three quality traits of a set of rice landraces collected from West Bengal and the North Eastern States.

Materials and methods
Plant Materials
A total of 89 rice germplasms including 81 rice landraces and 8 check germplasms were collected from various rice research stations in India. The landraces were divided into 4 categories; namely 25 aromatic landraces from West Bengal, 30 non-aromatic landraces from West Bengal, 26 accessions from the North Eastern States which included 6 aromatic and 6 non-aromatic landraces from Assam, 10 non-aromatic landraces from Nagaland, 3 non-aromatic landraces from Mizoram and 1 landrace from Manipur. The check germplasms included 2 basmati accessions and 6 high yielding varieties. The details of each rice accession along with the measurement of various traits are given in Table 1.

Measurement of phenotypic and qualitative traits
Twelve traits, 9 phenotypic traits (grain and kernel dimensional traits) and 3 quality traits were measured. The nine grain and kernel dimensional traits were grain length (GL), grain breadth (GB), grain length/breadth (G-L/B), 100 grain weight (100 GW), kernel length (KL),

kernel breadth (KB), kernel length/breadth (K-L/B), kernel length after cooking (KLAC) and kernel elongation ratio (KER). The three quality traits were alkali spreading value (ASV), on a scale of 1 to 7 according to the method of Little *et al*. [7] amylose percentage (AMY %) according to the method of Jennings [8] and aroma (ARO) in a scale of 0 to 3 according to the method of Sood and Siddiq [9]. Length and breadth of grains of both the uncooked and cooked kernels were measured with the help of a stage-micrometre and an eye-piece graticule under a dissecting microscope (Olympus). The average length of the cooked kernels (KLAC) was divided by the average length of uncooked kernels (KL) and to obtain kernel elongation ratio. The kernels of the rice in our collection were classified into different kernel types and shapes according to the Standard Evaluation System (SES, IRRI) [10] (Table 1). For 100 grain weight (100GW) three replications of one hundred fully developed and well-filled grains were selected, weighed, and the average weight was recorded. Alkali spreading value, an indicator of the gelatinization temperature of the rice starch, was determined according to the method of Little *et al.* [7] Apparent amylose content of the rice kernels was determined using the protocol given by Jennings *et al*. [8]

Analysis of variance (ANOVA)

The data for the 11 phenotypic traits were analyzed statistically for the difference in means through ANOVA using the software SPSS 10.0.

Results

The mean values of the grain and kernel traits and the mean values of the qualitative characters are tabulated in Table 1. The maximum and minimum values of each trait are tabulated in Table 2. From Table 2 it can be inferred that West Bengal aromatic landrace Kaminibhog have the shortest grains and Taraori Basmati have the longest grains. The West Bengal aromatic landrace Tulsibhog have the lightest grains with a 100-grain weight of 0.95 gram, and the grains of West Bengal non-aromatic landrace Bangladeshi patnai are the heaviest. Kaminibhog has the shortest kernel length whereas West Bengal non-aromatic landrace Parbol have the longest kernels. Cooked kernel length is the shortest for Kaminibhog whereas Pusa Basmati 1 has the longest cooked kernels. The alkali spreading value (ASV) of the aromatic landraces from West Bengal ranged from 2 to 3.5 whereas for the non-aromatic landraces the ASV varied between 2 to 7. The ASV for the landraces from the North East Indian states was mostly 6 or 7 with Aijong from Assam being an exception with an ASV of 1. The ASV for the high yielding varieties was 2. The amylose content of most of the West Bengal aromatic landraces was low whereas for the non-aromatic landraces this trait varied between low to high. The amylose content of the North Eastern landraces, the high yielding varieties and the Basmati varied from very low to intermediate. Among the aromatic landraces, the aroma level of the West Bengal landrace Gobindobhog was at par with the aroma level of Pusa Basmati 1. From the ANOVA table (Table 3) it can be seen that the observed values of the phenotypic traits and the qualitative characters are significantly different among the rice landraces under study, both at 5% and 1% level of significance.

Discussion

According to the observations made during this study, it was found that the aromatic rice landraces from West Bengal have smaller grain and kernel length than the basmati genotypes. The West Bengal aromatic rice are more rounded (G L/B and K L/B ratio low), have lesser kernel elongation after cooking, and except Gobindobhog, the rest have far less aroma than the evolved basmati genotypes. The basmati genotypes, on the other hand, have extra-long grain and kernel, and they are also more slender in shape (G L/B and K L/B ratio high). The alkali spreading value (ASV) is inversely proportional to the gelling temperature of rice starch, and it is also a measure of cooking time [7]. Hence more the ASV, lower the gelling temperature and lesser the cooking time. Therefore landraces with higher ASV of 6 or 7, like Marichsail or Buhrimtui, will cook faster than the other landraces like Bahurupi or Kelas which have an ASV of 2. The trait amylose content (measured in percentage) is directly proportional to the stickiness of cooked rice kernels [8]. Hence stickiness of rice kernels will increase with the increase in amylose percentage. So landraces with high amylose like Talmari will be very sticky, and landraces with low amylose like Kalo Boro Dhan will be less sticky.

Table 1: Details of the rice accessions along with mean values of grain and kernel phenotypic and quality characters and their categorization

Aromatic landraces from West Bengal																
Genotypes	**Source**	**GL**	**GB**	**G-L/B**	**100 GW**	**KL**	**K TYPE**	**KB**	**K-L/B**	**KS**	**KLAC**	**KER**	**ASV**	**AMY %**	**AMY CAT**	**ARO**	**ARO CAT**
Badshahbhog	RRS, Chinsurah	6.78	2.33	2.91	1.12	4.78	S	1.93	2.48	M	9.32	1.95	2.67	19.31	L	1.33	FS
Chinikamini 1	RRS, Chinsurah	5.87	2.7	2.17	1.22	4.07	S	2.25	1.81	R	8.17	2.01	3.67	19.5	L	2.67	MS
Chinikamini 2	RRS, Chinsurah	8.63	2.49	3.47	1.87	6.07	M	1.94	3.13	S	10.7	1.76	2.33	21.8	I	1.33	FS
Danaguri	RRS, Chinsurah	6.38	2.24	2.85	1.01	4.58	S	1.85	2.48	M	7.85	1.72	3.67	15.4	L	1	M
Gobindobhog 1	RRS, Chinsurah	6.13	2.18	2.81	1.03	4.52	S	1.85	2.45	M	8.4	1.86	2.67	15.39	L	3	S
Gobindobhog 2	RRS, Sekhampur	6.38	2.18	2.93	1.13	4.61	S	1.85	2.49	M	8.17	1.77	2.67	15.33	L	3	S
Gopalbhog	SARF, Kashipur	6.51	2.16	3.02	1.06	4.65	S	1.87	2.48	M	8.68	1.87	3	21.43	I	1.33	FS
Kalogobindobhog	ATC, Fulia	8.09	2.01	4.03	0.97	5.74	M	1.88	3.05	R	10.1	1.76	2.67	16.86	L	1	M
Kalojira	ATC, Fulia	6.66	2.97	2.24	1.35	4.37	S	2.18	2.01	B	7.17	1.64	2.33	21.2	I	2	MS
Kalonunia	SARF, Kashipur	7.55	2.26	3.34	1.33	5.23	S	1.87	2.79	M	8.54	1.63	3	20.4	I	1.67	FS
Kaminibhog	SARF, Kashipur	5.82	2.75	2.12	1.46	4.33	S	2.45	1.77	R	7.72	1.53	3	21.03	I	1.33	FS
Katarihog	RRS, Chinsurah	7.99	2.23	3.58	1.41	5.64	M	1.89	2.99	M	10.6	1.88	3	15.42	L	1.33	FS
Khasdhan	RRS, Chinsurah	6.47	2.24	2.89	0.96	4.64	S	1.88	2.46	M	8.36	1.8	3	19	L	2	MS
Lilabati	RRS, Chinsurah	7.01	2.65	2.65	1.65	5.11	S	2.2	2.32	B	8.63	1.69	2.67	16.7	L	1.67	FS
Mohanbhog	ATC, Fulia	5.86	2.25	2.6	1.11	4.18	S	1.86	2.25	B	8.17	1.96	2.67	16.62	L	1.67	FS
Narayan bhog	ATC, Fulia	8.94	2.24	4	1.4	6.88	L	1.97	3.49	S	7.76	1.65	3	17.49	L	1	M
Narayan purna	ATC, Fulia	6.69	2.3	2.91	1.35	4.14	S	2.23	1.86	R	11.3	1.62	2.33	10.9	L	1.33	FS
NC 324	RRS, Chinsurah	7.55	2.27	3.33	1.31	5.58	M	1.87	2.98	M	10.2	1.83	2.33	19.3	L	1.33	FS
NC 365	RRS, Chinsurah	9.2	2.42	3.81	1.81	6.34	M	1.95	3.25	S	7.4	1.17	2.33	18.3	L	1.67	FS
Radhunipgol 1	RRS, Chinsurah	5.94	2.33	2.55	1.06	4.44	S	1.92	2.32	B	9.04	2.04	3.33	14.6	L	1.67	FS

Radhunipgol 2	RRS, Chinsurah	5.85	2.23	2.63	1.02	4.28	S	1.96	2.18	B	8.81	2.06	3.67	13.8	L	1.67	FS
Radhatilak	RRS, Chinsurah	6.66	2.28	2.91	1.13	4.67	S	1.88	2.49	M	7.9	1.69	2.67	14.3	L	1.67	FS
Tulaipanji	RRS, Sekhampur	7.85	2.26	3.47	1.39	5.73	S	1.92	2.98	M	10.8	1.88	2.67	17.1	L	2	MS
Tulsibhog	RRS, Sekhampur	6.75	2.21	3.06	0.95	4.32	S	1.87	2.31	B	7.85	1.82	2.67	20.47	I	1	M
Tulsimanjari	ATC, Fulia	6.57	2.17	3.02	1.26	4.65	S	1.87	2.49	M	8.13	1.75	3.33	16.6	L	1	M
Non Aromatic landraces from West Bengal																	
Genotypes	**Source**	**GL**	**GB**	**G-L/B**	**100 GW**	**KL**	**K TYPE**	**KB**	**K-L/B**		**KS**	**KLAC**	**KER**	**ASV**	**AMY %**	**AMY CAT**	**ARO**	**ARO CAT**
Asitkalma	ATC, Fulia	9.52	2.15	4.44	1.75	6.71	L	2.21	3.04		S	7.21	1.07	3	20.7	I	0	N
Bangladeshi patnai	ATC Fulia	10.7	3.34	3.21	2	7.25	EL	2.23	3.26		M	8.4	1.16	3	27.4	I	0	N
Bahurupi	ATC Fulia	11.8	3.41	3.45	3.37	10.4	EL	2.81	3.69		M	11.6	1.12	2	25.1	I	0	N
Bangalakshmi	ATC Fulia	11.4	3.35	3.4	2.47	10.4	EL	2.75	3.78		S	11.1	1.07	3	28.7	I	0	N
Bhasamanik	ATC Fulia	11.6	3.38	3.44	2.3	10.7	EL	2.58	4.16		S	11.4	1.07	3	25.1	I	0	N
Chamarmani	ATC, Fulia	10.7	3.34	3.21	2	7.25	EL	2.23	3.26		M	8.4	1.16	3	27.4	I	0	N
Dudherswar	SARF, Kashipur	9.3	2.22	4.2	1.7	6.51	M	1.84	3.54		S	11.49	1.77	2.33	18.09	L	0	N
Hatipanjra	RRS, Chinsurah	8.68	2.32	3.75	1.69	6.33	M	1.92	3.3		S	11.5	1.82	2.67	16.75	L	0	N
Heerasail	RRS, Chinsurah	8.3	2.69	3.08	2.25	6.67	L	2.25	2.96		M	7.63	1.14	3	28.8	I	0	N
Kalisankar	ATC, Fulia	6.4	2.27	2.82	2.23	4.35	S	1.95	4.35		M	6.3	1.45	3	25.33	I	0	N
Kalopahar	RRS, Chinsurah	11.1	3.08	3.6	1.9	10.1	EL	2.36	4.27		S	10.6	1.06	3	30.5	H	0	N
Kelas	ATC, Fulia	8.05	3.22	2.5	2.53	6.06	M	2.7	2.25		M	7.76	1.28	2	26.1	I	0	N
Kerala sundari	ATC, Fulia	8.87	2.99	2.97	2.17	6.86	L	2.06	3.33		M	7.72	1.12	3	23.1	I	0	N
Katki	ATC, Fulia	9.32	3	3.1	1.87	6.96	L	2.62	2.66		M	7.67	1.1	3	20.1	I	0	N
Kele	ATC, Fulia	10.5	3.38	3.11	2.07	9.36	EL	2.46	3.81		S	10.1	1.08	3	24.1	I	0	N
Khandagiri	RRS, Chinsurah	8.3	3.7	2.24	3.01	5.55	M	2.91	1.91		M	5.98	1.08	2	24.3	I	0	N
Lakshmansail	RRS, Chinsurah	10.1	3.12	3.23	1.7	7.98	EL	2.01	4.05		S	8.58	1.08	3.67	38.2	H	0	N
Latasail	RRS, Chinsurah	10.7	2.43	4.4	2.23	8.29	EL	2.11	3.93		S	11.4	1.38	3	27.87	I	0	N
Madina	SARF, Kashipur	10.8	2.56	2.72	1.97	8.01	EL	2.08	2.23		M	11.3	1.97	3	23.8	I	0	N
Mahsuri	RRS, Chinsurah	11.9	2.71	4.39	2.98	8.28	EL	2.33	3.55		S	11.2	1.36	3	26.8	I	0	N
Marichsail	SARF, Kashipur	10.7	3.43	3.11	1.77	9.74	EL	2.4	4.05		S	10.7	1.1	3	33.2	H	0	N
Metedhan	SARF, Kashipur	6.54	2.58	2.77	2.03	4.83	S	2.16	2.25		M	6.53	1.35	7	19.63	L	0	N
Mugai	SARF, Kashipur	7.88	3.33	2.36	1.5	7.25	EL	2.82	2.57		M	7.58	1.05	3	28.3	I	0	N
Paizam	ATC, Fulia	7.9	2.57	3.08	1	5.54	M	2.13	2.59		M	6.3	1.67	6	16.5	L	0	N
Para	ATC, Fulia	8.28	3.36	2.47	2.61	7.67	EL	2.68	2.86		M	6.44	0.84	2	33.2	H	0	N
Parbol	ATC, Fulia	11.6	3.46	3.36	2.43	10.7	EL	2.54	4.21		S	11.3	1.06	2	32.3	H	0	N
Raghusail	RRS, Chinsurah	8.01	2.68	2.61	1.53	5.98	M	2.28	2.17		M	8.81	1.47	4	31.93	H	0	N
Raniakanda	ATC, Fulia	11.6	3.48	3.34	2.57	10.6	EL	2.58	4.11		S	11.6	1.1	2	20.2	I	0	N
Raspanjar	RRS, Chinsurah	9.49	3.31	2.87	3.3	6.93	L	2.76	2.52		M	9.95	1.44	2	23.1	I	0	N
Sadashankar	RRS, Chinsurah	11	3.39	3.25	1.9	10.1	EL	2.37	4.26		S	11.2	1.11	2.33	30.2	H	0	N
Talmari	RRS, Chinsurah	8.5	3.08	2.76	1.86	7.64	EL	2.8	2.73		M	6.99	0.91	3	34.5	H	0	N
North East Indian Genotypes																		
Genotypes	**Source**	**GL**	**GB**	**G-L/B**	**100 GW**	**KL**	**K TYPE**	**KB**	**K-L/B**		**KS**	**KLAC**	**KER**	**ASV**	**AMY %**	**AMY CAT**	**ARO**	**ARO CAT**
Aijong	AAU	9.16	2.19	4.18	1.67	6.87	L	1.96	3.5		S	11.68	1.7	1	21.5		0	N
Biroi dhan	NBPGR, Umiam	9.28	3.03	3.07	1.77	6.79	L	2.26	3.01		S	11.5	1.69	7	16.7	L	0.33	F
Bhog joha	NBPGR, Umiam	8.08	3.06	2.64	1.77	5.71	M	2.41	2.37		M	11	1.92	4	27.7	I	0.33	N
Bhu	NBPGR, Umiam	8.94	3.09	2.89	1.63	6.55	M	2.34	2.8		M	10.8	1.64	6	28.3	I	0	F
Boro Chhaiyamora	AAU	9.19	2.65	3.47	1.67	7.32	L	2.26	3		S	11.93	1.63	3	23.5	I	0	N
Buhrimtui	NBPGR, Umiam	7.93	3.01	2.63	1.87	6.02	M	2.31	2.61		M	11.5	1.91	7	17.6	L	0	N
Desi Dhan	NBPGR, Umiam	8.11	2.85	2.84	2.07	5.8	M	2.2	2.63		M	10.9	1.88	7	20.9	I	0	N
IC524502	NBPGR, Umiam	10.5	3.28	3.21	2	8.22	EL	2.94	2.79		M	12.3	1.5	5	22.4	I	0	N
IC-524507	NBPGR, Umiam	10.5	3.42	3.08	1.53	8.08	EL	3.18	2.55		M	12.5	1.55	6	20.3	I	0	N
IC-311005	NBPGR, Umiam	8.96	3.01	2.97	1.47	6.42	M	2.45	2.61		M	11.4	1.77	7	23.3	I	0	N
IC-311003	NBPGR, Umiam	13.1	2.96	4.42	1.57	9.86	EL	2.37	3.32		S	15.1	1.53	6	19	L	0	N
IC-524526	NBPGR, Umiam	8.64	3.01	2.88	2.03	6.13	M	2.52	2.43		M	10.6	1.74	6	28	I	0	N
IC-524531	NBPGR, Umiam	13.7	3.71	3.7	2.73	9.67	EL	2.92	3.31		M	15.3	1.58	7	13.7	L	0	N
IC-524528	NBPGR, Umiam	12.1	3.79	3.19	1.67	8.08	EL	3.29	2.46		M	15.5	1.92	7	21.5	I	0	N
IC-524529	NBPGR, Umiam	12.1	3.7	3.26	1.63	8.29	EL	3.34	2.48		M	14.7	1.78	6	22.3	I	0	N
IC-311028	NBPGR, Umiam	12.2	3.65	2.62	1.73	8.34	EL	3.18	2.63		M	15.3	1.83	7	26.1	I	0	N
IC-524530	NBPGR, Umiam	12.1	3.74	2.56	1.67	8.34	EL	2.97	2.81		M	14.5	1.74	7	19.6	I	0	N
IC360739	NBPGR, Umiam	12.1	3.96	3.05	1.63	9.43	EL	3.55	2.66		M	14.5	1.54	7	15	L	0	N
Joha	RRS, Chinsurah	6.51	2.16	3.02	1.06	4.65	S	1.87	2.48		M	8.68	1.87	3	21.43	I	1.33	FS
Kala Boro dhan	NBPGR, Umiam	8.34	2.96	2.82	1.67	5.78	M	2.33	2.48		M	10.9	1.88	7	4.47	VL	0.67	F
Kachalo	NBPGR, Umiam	8.82	2.84	3.11	1.93	6.52	M	2.31	2.83		M	11.5	1.76	7	24.5	I	0	N
Kalojeera	AAU	6.66	2.97	2.24	1.35	4.37	S	2.18	2.01		B	7.17	1.64	2.33	21.2	I	2	MS
Lal Binni	AAU	10.7	2.34	4.58	1.53	8.45	EL	2.02	4.18		S	12.61	1.49	5	6.23	VL	0.67	F
Malsara dhan	NBPGR, Umiam	12.2	3.21	3.81	1.63	8.65	EL	2.72	3.18		M	14	1.61	7	16	L	1	M
Morianghou	NBPGR, Umiam	8.6	3.03	2.84	1.83	6.14	M	2.55	2.41		M	10.5	1.72	6	25.7	I	0	N
Prasadbhog	AAU	9.08	2.63	3.46	1.37	6.69	L	2.01	3.33		S	11.74	1.76	7	22.1	I	1.33	FS
Check genotypes																		
Genotypes	**Source**	**GL**	**GB**	**G-L/B**	**100 GW**	**KL**	**K TYPE**	**KB**	**K-L/B**		**KS**	**KLAC**	**KER**	**ASV**	**AMY %**	**AMY CAT**	**ARO**	**ARO CAT**
IR8	RRS, Chinsurah	8.13	2.59	3.15	2.28	6.94	M	2.65	2.62		M	11.28	1.62	2	19.79	L	0	N
IR 36	RRS, Chinsurah	9.51	2.38	3.99	2.28	6.79	M	1.8	3.75		S	11.57	1.78	2	22.97	I	0	N
IR 64	RRS, Chinsurah	10.5	2.49	4.23	2.27	7.61	EL	2.11	3.61		S	10.53	2.5	2	23.3	I	0	N
Khitish	RRS, Chinsurah	11	2.18	2.84	2.17	8.14	EL	1.91	2.59		S	11.51	1.41	2	20.13	I	0	N
Lal Swarna	SARF, Kashipur	7.77	2.73	2.84	1.83	5.85	M	2.26	2.59		S	8.767	1.5	2	24.6	I	0	N
TN 1	RRS, Chinsurah	8.08	3.09	2.61	2.05	6.21	M	2.56	2.43		S	8.128	1.31	2	23.53	I	0	N

Pusa Basmati 1	RRS, Chinsurah	11.23	1.88	5.96	1.86	7.91	EL	1.59	4.978	S	16.85	2.129	7	22.27	I	3	S
Taraori Basmati	ATC, Fulia	12.45	2.12	5.86	2.03	9.09	EL	1.838	4.945	S	15.85	1.745	3	9.77	VL	1.667	FS

AAU – Assam Agriculture University, ATC – Agricultural Training Centre, RRS – Rice Research Station, NBPGR - National Bureau of Plant Genetic Resources, SARF – State Agricultural Research Farm. GL = Grain length; GB = Grain breadth; G-L/B = Grain length/breadth ratio; 100SW = 100 Seed weight; KL = Kernel length; KB = Kernel breadth; K TYPE = Kernel type; KS = Kernel shape; K-L/B = Kernel length/breadth ratio; KLAC = Kennel length after cooking; KER = Kernel elongation ratio; ASV = Alkali spreading value; Amy % = Amylose percentage; AMY CAT = Amylose category; ARO = Aroma; ARO CAT = Aroma category. With reference to Kernel type (GS), EL = Extra-long; L = Long; M = Medium; S = short. With reference to Kernel shape (KS), R = Round; M = Medium; B = Bold; S = Slender. With reference to Amylose category (AMY CAT), VL = Very low; L = Low, I = Intermediate. With reference to Aroma category (ARO CAT), N = Nil; F = Faint; M = Moderate; FS = Fairly strong; MS = Moderately strong; S = Strong.

Table 2: Minimum and maximum values of the traits and names of the corresponding rice genotypes.

Trait	Aromatic landraces from West Bengal				Non-aromatic landraces from West Bengal			
	Min	**Genotype**	**Max**	**Genotype**	**Min**	**Genotype**	**Max**	**Genotype**
GL	5.82	Kaminibhog	9.2	NC 365	6.4	Heerasail	11.9	Madina
GB	2.01	Kalogobindobhog	2.75	Kaminibhog	2.15	Asitkalma	3.7	Kele
G-L/B	2.12	Kaminibhog	4.03	Kalogobindobhog	2.24	Kele	4.44	Asitkalma
100 GW	0.95	Tulsibhog	1.82	Chinikamini 2	1.5	Metedhan	3.37	Bangladeshi patnai
KL	4.33	Kaminibhog	6.88	Narayan bhog	4.35	Heerasail	10.7	Parbol
KB	1.85	Gobindobhog	2.45	Kaminibhog	1.95	Heerasail	2.91	Kele
K-L/B	1.77	Kaminibhog	4.21	Parbol	1.91	Kele	4.35	Heerasail
KLAC	6.72	Kaminibhog	11.3	Narayanbhog	5.98	Kele	11.6	Raniakanda
KER	1.55	Kaminibhog	2.06	Radhunipgol (2)	0.84	Para	1.97	Latasail
ASV	1	Narayan purna	3.37	Danaguri	2	Bangladeshi patnai	7	Marichsail
AMY %	4.47	Narayan purna	38.2	Khandagiri	19.6	Marichsail	38.2	Khandagiri
ARO	1	Tulsibhog	3	Gobindobhog	-	-	-	-
Trait	**Landraces from North East India**				**Check genotypes**			
	Min	**Genotype**	**Max**	**Genotype**	**Min**	**Genotype**	**Max**	**Genotype**
GL	6.47	Kalo Jeera	13.7	IC-524531	7.77	Lal Swarna	12.45	Taraori Basmati
GB	2.07	Joha	3.96	IC-324094	1.88	Pusa Basmati 1	3.09	TN1
G-L/B	2.56	IC-524530	4.698	Joha	2.61	TN1	5.965	Pusa Basmati 1
100 GW	0.96	Kalo Jeera	2.73	IC-524531	1.83	Lal Swarna	2.28	IR36
KL	4.64	Kalo Jeera	9.86	IC-311003	5.85	Lal Swarna	9.087	Taraori Basmati
KB	1.85	Joha	3.55	IC-324094	1.59	Pusa Basmati 1	2.65	IR8
K-L/B	2.37	Bhog joha	4.18	Lal Binni	2.43	TN1	4.978	Pusa Basmati 1
KLAC	8.36	Kalo Jeera	15.5	IC-524528	8.13	TN1	16.85	Pusa Basmati 1
KER	1.49	Lal Binni	1.92	Bhog joha	1.31	TN1	2.129	Pusa Basmati 1
ASV	1	Aijong	7	Buhrimtui	2	IR8	7	Pusa Basmati 1
AMY %	4.47	Kala Boro dhan	28.3	Bhu	9.77	Taraori Basmati	24.6	Lal Swarna
ARO	0.67	Lal Binni	2	Kalo Jeera	1.67	Taraori Basmati	3	Pusa Basmati 1

GL = Grain length in mm; GB = Grain breadth in mm; G-L/B = Grain length/breadth ratio; 100GW = 100 grain weight in grams; KL = Kernel length in mm; KB = Kernel breadth in mm; K-L/B = Kernel length/breadth ratio; KLAC = Kennel length after cooking in mm; KER = Kernel elongation ratio; ASV = Alkali spreading value; Amy % = Amylose percentage; ARO = Aroma;

Table 3: ANOVA tables for the traits.

Traits	Genotypes				Replication			
	DF	**SS**	**MS**	**F OBS**	**DF**	**SS**	**MS**	**F OBS**
GL	90	246.37227	2.7374696	112.3673**	2	0.022095	0.011047	1.8019444
GB	90	15.659729	0.173997	33.3386**	2	0.001991	0.000995	1.5006521
GL/B	90	59.889777	0.665442	28.9992**	2	0.006531	0.003265	0.0853036
100 GW	90	11.340451	0.126005	5.13666**	2	0.0178287	0.0089143	0.3633978
KL	90	229.85431	2.5539368	138.6554**	2	0.1010568	0.0505284	1.0449859
KB	90	249330.03	2770.3337	100.6193**	2	575.42846	287.71423	2.0598127
KL/B	90	40.662179	0.451802	13.1349**	2	0.1417034	0.0708517	0.0729714
KLAC	90	283.44792	3.1494213	50.3254**	2	0.0091333	0.0045666	1.2133886
KER	90	11.950195	0.1327799	44.2868**	2	0.0072759	0.003638	0.3633978
ASV	90	661.31783	7.3479759	90.9488**	2	0.124031	0.0620155	0.7675906
AMY %	90	1774.065	197.11833	215.9875**	2	0.9548008	0.4774004	0.5230995

** Observed F value is significant at the 0.01 level. * Observed F value is significant at the 0.05 level. GL = Grain length in mm; GB = Grain breadth in mm; G-L/B = Grain length/breadth ratio; 100GW = 100 grain weight in grams; KL = Kernel length in mm; KB = Kernel breadth in mm; K-L/B = Kernel length/breadth ratio; KLAC = Kennel length after cooking in mm; KER = Kernel elongation ratio; ASV = Alkali spreading value; Amy % = Amylose percentage; df = Degrees of freedom; ss = Sum of squares; ms = Mean sum of squares; F obs = Observed F value.

Conclusions

From the observations made during this study, it can be concluded that the grains and kernels of the landraces of West Bengal and the North Eastern States are phenotypically and qualitatively diverse. The indigenous aromatic landraces of West Bengal and the North Eastern States are rather inferior to the check Basmati genotypes as far as kernel length, elongation after cooking and aroma are considered. Hence, the market demand for these aromatic landraces is lesser as compared to the Basmati genotypes. However, the traditional versatility of the aromatic landraces as religious offerings, table rice, dessert ingredient, popped rice and as a diet for the convalescent; cannot be ignored. Both the indigenous aromatic and non-aromatic landraces are well adapted to the agro-climate of their place of cultivation, and their biodiversity should be preserved to sustain the socio-economic and agrarian structure.

Acknowledgement

The authors wish to thank Prof. Swati Gupta Bhattacharya, Division of Plant Biology, Bose Institute, for her meticulous suggestions regarding improving the quality of the manuscript. The authors also acknowledge Bose Institute for providing the facilities for conducting this research.

References

1. Khush GS. Origin, dispersal, cultivation and variation of rice. Plant Mol. Biol. 1997; 35:25-34.
2. Harlan JR. Crops and Man. American Society of Agronomy, Crop Science Society of America, Madison, Wisconsin, 1975.
3. Chang TT. The origin, evolution, cultivation, dissemination and diversification of Asian and African rices. Euphytica. 1976(b); 25:425-441.
4. Garris AJ, Tai TH, Coburn J, Kresovich S, McCouch S. Genetic structure and diversity in *Oryza sativa* L. Genetics. 2005; 169:1631-1638.
5. Second G. Origin of the genic diversity of cultivated rice (*Oryza* spp.): Study of the polymorphism scored at 40 isozyme loci. Jpn. J Genet. 1982; 57:25-57.
6. Buttery RG, Lilng LC, Juliano BO. 2-Acety-1-pyrroline: An important aroma component of cooked rice. Chem Ind, 1982, 958-959.
7. Little RR, Hilder GB, Dawson EH. Differential effect of dilute alkali on 25 varieties of milled white rice. Cereal Chem. 1958; 35:111-126.
8. Jennings PR, Coffman WR, Kauffman HE. Rice Improvement. International Rice Research Institute, Manila, The Philippines, 1979.
9. Sood BC, Siddiq EA. A rapid technique for scent determination in rice. Indian. J Genet. Plant. Breed. 1978; 38:268-271.
10. SES. (Standard Evaluation System for Rice). IRRI, Manila, Philippines, 2014.