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Full Length Research Paper

Genetic studies on divergence and phenotypic characterization of indigenous and exotic indica germplasm lines in rice (*Oryza sativa* L.)

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Rice (*Oryza sativa* L.) is one of the most important staple cereal food crop and a source of calories for more than half of the world's population. Genetic diversity in the world rice germplasm is larger but only small collections have been used in breeding programs since a high genetic similarity is found within germplasms around the world. An investigation was carried out at Tamil Nadu Rice Research Institute, Aduthurai during kuruvai 2009 with 31 rice germplasm accessions of which 16 accessions were of Indian origin and remaining 15 accessions were exotics with the objective of studying genetic diversity through mahalanobis D^2 statistics. Observations recorded were related to Distinctiveness, Uniformity and stability (DUS) test and eleven yield attributing measures. Accessions were grouped into 13 clusters. The cluster I contained highest number of accessions (6) followed by cluster X, XI which had three genotypes each, where cluster XIII had only one accession. The intra cluster distance was highest in cluster X (12.11) followed by cluster XII (12.01). Highest inter cluster distance was noticed between clusters II and X (24.84) followed by clusters X and XIII (20.83), and lowest between clusters V and IX (6.14). Single plant yield contributes to 45.16% and hundred grain weight contributes to 17.20% of the total genetic divergence. Germplasm accessions namely, karthigai samba, Kodai samba, Kapula sanna BH, Yah-Zamit B 56, Vialinica Gust, Kamee No (Japan) and Tepi Dumai may be used as parents to produce highly heterotic and superior transgressive segregants upon hybridization and its conservation may be helpful for the plant breeders to design future breeding programme.

Key words: Rice (*Oryza sativa* L.), germplasm diversity, phenotypic characterization.

INTRODUCTION

Throughout the world, biodiversity is under serious threat from factors such as intensive agriculture and silviculture, increased habitat fragmentation and global warming (Hodkinson and Parnell, 2007) and activities are ongoing to conserve and characterize plant genetic resources (Spooner et al., 2005). The International Plant Genetic Resource Institute (http://www. ipgri.cgiar.org), part of the Consultative Group on International Agricultural Research (http://www. cgiar.org) helps coordinate and promote international plant genetic resource initiatives. Rice (*Oryza sativa* L.) is the principal staple cereal food crop for more than half of the world's population. It accounts for 35 to 75% of calories consumed by more than three billion Asians. Compared with other crop species, the genetic diversity present among the world rice germplasm is quite large. Three subspecies, that is, indica, japonica, and javanica compose a large reservoir of rice germplasm including a variety of local landraces and cultivars (Lu et al., 2005; Garris et al., 2005). In addition, there are a number of wild relatives that provide potentially valuable resources for the improvement of

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Table 1. Indian accessions.

S/N	Designation	Popular name or parentage	Origin
1.	T 8	Percheriyan	Travancore
2	T 18	Kapula sanna BH	Mysore
3	T 51	Sakuklathi snna batta	Mysore
4	T 186	Thattan samba	S. Arcot
5	T 469	Pasohar	Central Province
6	T 480	Vari samba	Srivaikundam
7	T 623	Tepi Dumai	Assam
8	T 920	Katta vellai	Salem
9	T 942	Dalva T 35	Cuttack
10	T 947	Jaldbara	Punjab
11	T 951	Mutali	punjab
12	T 1414	Paloellariyan	Coorg
13	T 1497	Karthigai samba	Thirunelveli
14	T 1735	Kodai samba	Udumalpet
15	T 1801	Ovar kondan	Sivaganga
16	T 1930	Manakattai (red)	Chengalpet

cultivated rice (Ren et al., 2003). Despite the richness of genetic resources, only a small proportion of the world rice germplasm collections have been used in breeding programs. Since, a high genetic similarity is found within several commercial rice germplasms around the world. Knowledge regarding the amount of genetic variation in germplasm accessions and genetic relationships between genotypes are important considerations for designing effective breeding programme.

India is a primary centre of origin of rice and has many local landraces, most of which are not cultivated today. While many are lost, a few are still cultivated by resource-poor traditional farmers in areas practicing subsistence farming. Unlike high-yielding varieties (whose variability is limited due to homozygosity), the landraces maintained by farmers are endowed with tremendous genetic variability, as they are not subjected to subtle selection over a long period of time. This aids in the adaptation of landraces to a wider agro-ecological niches and they also have unmatched qualitative traits and medicinal properties (Ganeshram et al., 2007). This rich variability of complex quantitative traits still remains unexploited. Landraces are also important genetic resources for resistance to pests and fungal diseases. The exact genetic potential, differences from commercial varieties and the magnitude of heterogeneity still present in local landraces are not well catalogued. In modern crop improvement programmes, characterization of available landraces tells their usefulness in hybridization (Frey et al., 1984). The divergence or genetic distances was studied by a biometrical technique called D^2 statistics developed by Mahalanobis (1936). It is based on multivariate analysis grouped the genotypes into various clusters as given by Tocher (Rao, 1952). This is the most effective method of quantifying the degree of genetic divergence among the genotypes taken for the study.

The present investigation was taken up with the objective of studying genetic divergence and phenotypic characterization of indigenous and exotic indica germplasm accessions of rice.

MATERIALS AND METHODS

A total of 31 rice genetic accessions formed the basic material for the present study. Among this 31 germplasm accessions, 16 accessions were Indian origin and remaining 15 accessions have exotic origin. The particulars of experimental material used in the present investigation are given in Tables 1 and 2. During Kuruvai season 2009, 31 rice genetic accessions were raised in an experimental layout in Randomized Block Design (RBD) with three replications at Tamil Nadu Rice Research Institute, Tamil Nadu Agricultural University, Aduthurai. The genotypes were planted in 10 × 15 cm spacing. Recommended agronomic practices and need based plant protection measures were followed. Three randomly selected plants were used for recording 24 observations related to distinctiveness, uniformity and stability (DUS) test and eleven yield attributing measures. DUS test were performed as per the rice plant descriptors given by Directorate of Rice Research, Hyderabad for phenotypic characterization. The genetic diversity among the 31 germplasm accessions was analyzed with respect to the following eleven yield attributing traits namely, Days to 50% flowering (DTF), plant height (PH), panicle length (PL), number of productive tillers per plant (NPT), number of primary branches per panicle (PB), number of secondary branches per panicle (SB), total number of spikelets per panicle (TNSP), number of filled grains per panicle (NFG), spikelet fertility (SF), 100 grain weight (100 GW) and single plant yield (SPY).

Table 2. Exotic accessions.

S/N	Designation	Popular name or parentage	Origin
1	T 296	Yah – Zamit B 56	Burma
2	T 337	Hand Jonta	Burma
3	T 360	Kamee No	Japan
4	T 554	Derabat	Ceylon
5	T 564	Nero Vialone	Italy
6	T 751	Vialinica Gust	Russia
7	T 757	V. Vulagariskorn	Russia
8	T 862	Kossomo (M)	West Africa
9	T 960	Chekiang Stn. 9	China
10	T 1653	Donradao	Brazil
11	T 1660	Prong – 36	Pakistan
12	T 1814	R.V. Shimba Early	Iraq
13	T 1979	Japag 3	Japan
14	T 2230	Norin 18	Japan
15	T 2371	Muga – 178	Portugal

Observations were recorded on three randomly selected plants for each trait and the genetic distance between the individual accessions were worked out using Mahalanobis D^2 statistics and the grouping of genotypes was done following the Tocher`s method as described by Rao (1952).

RESULTS AND DISCUSSION

The analysis of variance revealed the presence of significant amount of variability among the germplasm accessions for all the characters studied. D^2 statistics was performed after ascertaining the presence of significant amount of variability among the accessions. As the critical D^2 values increases, number clusters decreases and vice versa. Upon increasing the critical D^2 value, number of cluster also decreases. In the present investigation, genotype clustering was performed with the critical D^2 value of 399.42 to get optimum clusters. Based on the relative magnitude of D^2 values, all the 31 indigenous and exotic rice accessions were grouped into 13 clusters (Table 3). Among the thirteen, cluster I had six genotypes and was the largest. Clusters X and XI had three genotypes each, cluster XIII had only one genotype and all other clusters had two genotypes each. A perusal of results on cluster means (Table 4) for important yield attributing traits revealed that cluster XIII could be characterized by genotypes by having more number of primary (12.33) and secondary branches (39.78) per panicle, number of filled grains per panicle (177.44) and number of spikelets per panicle (219.00). Cluster X registered highest values for plant height (169.52) and 100 grain weight (2.77). Cluster II recorded minimum mean values for primary branches, secondary branches, number of filled grains per panicle, number of spikelets per panicle and single plant yield. Cluster VI showed the highest mean value for panicle length (39.00 cm) and lowest mean value for number of productive tillers per plant. Cluster III recorded highest mean value for days to 50% flowering (93.50). A critical appraisal of the observations indicated that none of the clusters contained genotypes with all the desirable traits which could be directly selected and utilized. Interestingly, all the maximum and minimum cluster mean values were distributed in relatively different clusters.

The similar results were reported by Bose and Pradhan (2005) and Monika et al. (2008). Based on the cluster mean, genotypes in cluster XIII may be used as a parent in breeding programme. Thereby understanding the fact that the hybridization between genotypes of different clusters is necessary for the development of desirable genotypes. Hence, depending on the per se performance of the best genotypes within the clusters may be directly used as parents in future hybridization programme. Inter and intra cluster distances were represented in Table 5. Inter cluster distance was higher than intra cluster distance indicates wider genetic diversity among the selected accessions. Intra cluster distance ranged from 0.00 to 12.11 and the maximum intra cluster distance was recorded in cluster X (D = 12.11) which was different from other clusters. The inter cluster distances was ranged from 6.14 to 24.84 as exhibited by clusters between IX and V and clusters between X and II respectively. This was followed by cluster XIII and X, cluster X and IX with cluster value of 20.83 and 9.49 respectively. Minimum inter cluster distances was recorded between IX and V followed by cluster IV and VI, cluster VII and IV which had the value of 6.49 and 6.99 respectively. Inter cluster distance of the remaining

Table 3. Clustering pattern of 31 rice genotypes based on D^2 statistics.

Cluster number	Number of genotypes	Name of genotypes
I	6	T 1414 (Paloellariyan), T 337 (Hand Jontsa), T480 (Vari samba), T 947 (Jaldbara), T 1801 (Ovar kondan), T862 (Kossomo).
II	2	T 296 (Yah – Zamit B 56), T 18 (Kapula samba BH).
III	2	T 51 (Sakulathi sanna batta), T 2371 (Muga-178).
IV	2	T 1497 (Karthigai samba), T 1735 (Kodai samba).
V	2	T 186 (Thattan samba), T 2230 (Norin 18).
VI	2	T 8 (Percheriyan), T 1979 (Japag 3).
VII	2	T 554 (Perabat), T 1653 (Donradao).
VIII	2	T 564 (Nero vialone), T 960 (Chekiang Stn. 9).
IX	2	T 360 (Kamee No), T 751 (Vialinica Gust)
X	3	T 942 (Dalva T 35), T 1814 (R.V.Shimba early), T 1930 (Manakattai red).
X I	3	T 920 (Katta Vellai), T 951 (Matali), T 1660 (Prong – 36).
X II	2	T 469 (Pasohar), T 757 (V. Vulagariskorn).
X III	1	T 623 (Tepi Dumai).

Table 4. Cluster mean for different quantitative trait among 31 rice genotypes.

	DTF	PH	PL	NPT	PB	SB	NFG	TNSP	SF	100 GW	SPY
I	90.72	148.00	28.47	8.82	9.96	31.46	118.97	135.70	87.29	2.22	18.17
II	80.17	113.06	25.75	7.61	7.67	17.89	64.00	77.06	83.32	2.07	11.64
III	93.50	130.94	27.50	8.17	9.84	26.22	95.22	113.22	84.53	2.16	17.49
IV	84.67	142.61	28.33	11.50	9.39	31.28	105.22	116.61	90.09	2.36	19.70
V	80.00	136.78	28.28	8.22	9.61	37.72	138.22	170.34	81.25	2.21	19.42
VI	84.83	136.39	39.86	6.44	9.28	28.06	84.06	103.89	81.51	2.39	14.11
VII	87.83	147.33	31.47	8.72	10.45	35.67	152.28	171.56	88.49	2.35	21.94
VIII	81.67	141.39	28.72	10.50	10.39	35.78	155.95	169.56	89.35	2.14	27.05
IX	75.17	146.92	31.03	6.75	9.78	35.33	125.28	147.50	84.61	2.24	16.66
X	96.11	169.52	30.54	9.45	10.54	34.54	137.02	150.91	88.42	2.77	24.56
XI	86.22	146.33	28.43	7.41	9.89	39.63	164.26	180.78	90.77	2.01	18.06
XII	82.33	130.05	25.20	6.89	7.95	21.50	75.11	91.39	83.54	2.71	14.42
XIII	80.33	104.89	24.83	10.67	12.33	39.78	177.44	219.00	80.98	2.47	28.05

clusters were comparatively low. The magnitude of heterosis mainly depends on the genetic distance. Greater the genetic distance between the clusters indicate wider genetic diversity between the genotypes (Arunachalam, 1981). So, the hybridization between the genotypes from the clusters X and II will result in more number of useful transgressive segregants and the high level of expression of the heterotic vigour.

Table 5. Intra and inter cluster average distance in 31 rice germplasm accessions.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I	9.65	14.03	8.45	7.77	9.89	9.14	8.35	12.03	11.55	15.66	10.77	13.01	16.55
II		4.13	10.66	11.58	11.21	10.03	15.13	15.47	12.32	24.84	14.08	13.65	17.06
III			4.48	7.45	9.54	7.36	8.65	11.68	12.30	17.17	11.07	11.91	14.00
IV				4.82	7.53	6.49	6.99	10.61	9.10	15.49	9.97	10.26	14.88
V					4.86	7.54	7.50	8.60	6.14	18.08	8.77	11.74	12.49
VI						5.44	8.76	12.35	9.03	16.97	11.37	8.82	14.65
VII							5.65	8.26	9.92	13.20	9.44	12.12	12.89
VIII								6.08	10.17	18.07	10.36	16.01	12.13
IX									6.71	19.49	10.11	13.20	15.81
X										12.11	18.87	17.32	20.83
XI											10.85	15.66	16.59
XII												12.01	15.91
XIII													0.00

Table 6. Relative contribution of 11 characters to total genetic divergence.

S/N	Character	No. of First rank	% contribution
1.	Days to 50% flowering	70	15.05
2	Plant height	67	14.41
3	Panicle length	1	0.22
4	Number of productive tillers	7	1.51
5	Primary branches	7	0.22
6	Secondary branches	4	0.86
7	Number of filled grains per panicle	21	4.52
8	Total number of spikekets per panicle	1	0.22
9	Spikelet fertility (%)	3	0.65
10	100 grain weight	80	17.20
11	Single plant yield	210	45.16
	Total	465	100

The utility of D^2 statistics as a potent tool to quantify the extent of divergence in biological populations at genetic level is further enhanced by its applicability to estimate the relative contribution of the various plant characters to total genetic divergence. The contribution of various characters towards the expression of total genetic divergence (Table 6) indicated that single plant yield contributed a maximum level (45.16%) than any other parameters. It was follow by characters like 100 grain weight (17.20%), days to 50% flowering (15.05 %), plant height (14.14%) had contributed

Table 7. Phenotypic characteristics of indigenous indica germplasm accessions.

Characters	T8	T 18	T51	T 186	T 469	T 480	T 623	T 920
Basal leaf sheath colour	Green	Green	Green	Green	Green	Purple lines	Green	Uniform purple
Leaf: Pubescence of blade surface	Medium	Medium	Weak	Medium	Strong	Medium	Strong	Medium
Leaf: Auricle	Present	Present	Present	Present	Present	Present	Present	Present
Leaf: Anthocyanin colouration of auricle	Colour less	Light Purple	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less
Leaf: Shape of Ligule	Split	Split	Split	Split	Split	Split	Split	Split
Leaf: colour of ligule	White	Light Purple	White	White	Purple	Purple	White	Purple
Time of heading	85	80	91	80	89	82	81	90
Flag leaf: Attitude of leaf blade (early)	Horizontal	Semi erect	Semi erect	Semi erect	Erect	Erect	Erect	Semi erect
0Spikelet: Density of pubescence of lemma	Strong	Medium	Strong	Strong	Strong	Strong	Strong	Strong
Lemma: Anthocyanin colouration of apex	Weak	Weak	Medium	Absent	Very strong	Very strong	Absent	Very strong
Spikelet: Colour of stigma	White	White	Purple	White	Purple	Purple	Light green	Purple
Stem: Length (excluding panicle, cm)	126	115	127	132	126	136	98	168
Stem: Anthocyanin colouration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Panicle: Length of main axis	26	26.5	27.5	29	23.5	25	25	31
Flag leaf: Attitude of blade (Late)	Semi erect	Horizontal	Semi erect	Semi erect	Erect	Semi erect	Semi erect	Horizontal
Panicle: Curvature of main axis	Drooping	Drooping	Semi straight	Drooping	Drooping	Drooping	Drooping	Drooping
Spikelet: Colour of tip of lemma	Brown	Brown	Purple	Brown	Purple	Purple	Yellowish	Purple
Panicle: Awns	Absent	Absent	Absent	Absent	Present	Present	Present	Absent
Panicle: Colour of awns					Reddish brown	Brown	Brown	-
Panicle: Distribution of awns					Whole length	Tip only	Upper half only	-
Panicle: attitude of branches	Semi erect	Semi erect	Semi erect	Semi erect	Erect to semi erect	Erect to semi erect	Erect to semi erect	Semi erect
Panicle: Exsertion	Well exscerted	Well exscerted	Well exscerted	Well exscerted	Well exsertion	Well exsertion	Well exsertion	Well exsertion
Sterile lemma colour	Straw	Straw	Straw	Straw	Straw	Straw	Straw	Straw
Decorticated grain length	6.2	6.6	5.9	6.3	6.7	6.4	6.8	6.2
Decorticated grain breadth	2.7	2.0	2.8	2.6	2.7	2.8	2.4	2.3
Decordicated grain shape	Short bold	Long slender	Short bold	Long bold	Long bold	Long bold	Long bold	Medium slender
Decorticated grain colour	White	White	White	White	Red	White	Red	White

Table 7. Phenotypic characteristics of indigenous indica germplasm accessions (cont…).

Characters	T 942	T 947	T 1414	T 1497	T 1735	T 1801	T 1930	T 951
Basal Leaf sheath colour	Green	Green	Purple	Purple	Green	Purple	Green	Green
Leaf: Pubescence of blade surface	Weak	Weak	Medium	Medium	Strong	Strong	Strong	Medium
Leaf: Auricle	Present	Present	Present	Present	Present	Present	Present	Present
Leaf: Anthocyanin colouration of auricle	Light purple	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less

Table 7. Contd.

Leaf: Shape of ligule	Truncate	Truncate	Split	Split	Split	Split	Split	Split
Leaf: Colour of ligule	White	White	White	White	White	White	White	White
Time of Heading	95	98	90	85	85	98	98	90
Flag Leaf: attitude of leaf blade (early)	Erect	Horizontal	Erect	Semi erect	Semi erect	Erect	Semi erect	Erect
0Spikelet: Density of pubescence of lemma	Medium	Strong	Medium	Strong	Medium	Medium	Strong	Strong
Lemma: Anthocyanin colouration of apex	Very strong	Absent	Very strong	Strong	Absent	Very strong	Absent	Absent
Spikelet: Colour of stigma	Purple	White	Purple	White	White	Purple	White	White
Stem: Length (excluding panicle, cm)	172	163	186	142	145	143	160	135
Stem: Anthocyanin colouration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Panicle: Length of main axis	29.5	30	30	28.5	28.5	28	31	24.5
Flag leaf: Attitude of blade (Late)	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect	Erect	Deflexed	Semi erect
Panicle: Curvature of main axis	Drooping	Drooping	Semi straight	Drooping	Semi straight	Semi erect	Semi straight	Drooping
Spikelet: Colour of tip of lemma	Purple	Brown	Purple	Brown	Yellowish	Purple	Yellowish	Yellowish
Panicle: Awns	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Panicle: Colour of awns					-	-	-	-
Panicle: Distribution of awns					-	-	-	-
Panicle: Attitude of branches	Semi erect	Semi erect	Semi erect to spreading	Semi erect	Semi erect	Semi erect	Erect to semi erect	Semi erect
Panicle: Exsertion	Well exscerted	Well exscerted	Well exscerted	Well exscerted	Well exsertion	Well exsertion	Well exsertion	Well exsertion
Sterile lemma colour	Straw	Straw	Straw	Straw	Straw	Straw	Straw	Straw
Decorticated grain length	6.4	5.9	6.4	6.2	6.2	6.3	6.4	5.9
Decorticated grain breadth	2.5	2.6	2.4	2.4	2.8	2.4	2.8	2.4
Decordicated grain shape	Long bold	Short bold	Long bold	Long bold	Long bold	Long bold	Long bold	Medium slender
Decorticated grain colour	Red	Red	Red	White	Red	White	Red	White

Table 7. Phenotypic characteristics of indigenous indica germplasm accessions (cont…).

Characters	T 296	T 337	T 360	T 554	T 564	T 751	T 757	T 862
Basal Leaf sheath colour	Purple base	Green	Green	Green	Green	Purple	Green	Green
Leaf: Pubescence of blade surface	Medium	Strong	Weak	Weak	Weak	Medium	Strong	Weak
Leaf: Auricle	Present	Present	Present	Present	Present	Present	Present	Present
Leaf: Anthocyanin colouration of auricle	Light purple	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less	Light purple
Leaf: Shape of Ligule	Split	Split	Split	Split	Split	Truncate	Split	Split
Leaf: colour of ligule	White	White	White	White	White	White	White	White
Time of Heading	81	80	80	84	78	72	76	97
Flag Leaf: attitude of leaf blade (early)	Horizontal	Semi erect	Semi erect	Erect	Semi erect	Semi erect	Erect	Semi erect

Table 7. Contd.

0Spikelet: Density of pubescence of lemma	Weak	Medium	Medium	Strong	Strong	Strong	Strong	Strong
Lemma: Anthocyanin colouration of apex	Very strong	Absent	Very strong	strong	Medium	Weak	Weak	Very strong
Spikelet: Colour of stigma	Purple	White	Purple	Purple	White	Purple	White	Purple
Stem: Length (excluding panicle, cm)	113	136	151	144	136	139	128	150
Stem: Anthocyanin colouration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Panicle: Length of main axis	25	25.5	32	31.5	28.5	28.5	26.5	30
Flag leaf: attitude of blade (Late)	Semi erect	Semi erect	Horizontal	Semi erect	Horizontal	Semi erect	Semi erect	Semi erect
Panicle: Curvature of main axis	Semi straight	Semi straight	Drooping	Semi straight	Deflexed	Semi straight	Semi straight	Drooping
Spikelet: Colour of tip of lemma	Purple	Yellowish	Purple	Purple	Yellowish	Purple	Yellowish	Purple
Panicle: Awns	Present	Absent	Absent	Present	Absent	Absent	Absent	Absent
Panicle: colour of awns	Yellowish brown			Yellowish brown	-	-	-	-
Panicle: Distribution of awns	Tip only			Tip only	-	-	-	-
Panicle: attitude of branches	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect
Panicle: exsertion	Well exscerted	Well exscerted	Well exscerted	Well exscerted	Well exsertion	Well exsertion	Well exsertion	Well exsertion
Sterile lemma colour	Straw	Straw	Dark Brown	Straw	Straw	Straw	Straw	Straw
Decorticated grain length	6.5	5.9	5.9	6.0	6.3	6.3	6.2	6.1
Decorticated grain breadth	2.3	2.4	2.5	3.0	2.5	3.0	2.6	2.8
Decordicated grain shape	Long bold	Medium slender	Medium slender	Short bold	Long bold	Long bold	Long bold	Long bold
Decorticated grain colour	White	White	White	White	White	Red	Red	White

Table 7. Phenotypic characteristics of indigenous indica germplasm accessions (cont…).

Characters	T 960	T 1653	T 1660	T 1814	T 1979	T 2230	T 2371	T 862
Basal leaf sheath colour	Green	Green	Purple	Purple	Green	Green	Green	Green
Leaf: Pubescence of blade surface	Strong	Strong	Strong	Strong	Very Strong	Medium	Strong	Weak
Leaf: Auricle	Present	Present	Present	Present	Present	Present	Present	Present
Leaf: Anthocyanin colouration of auricle	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less	Light purple
Leaf: Shape of Ligule	Split	Split	Split	Split	Split	Split	Split	Split
Leaf: Colour of ligule	White	White	White	White	White	White	White	White
Time of heading	83	91	79	97	85	80	98	97
Flag Leaf: attitude of leaf blade (early)	Semi erect	Erect	Semi erect	Erect	Erect	Semi erect	Semi erect	Semi erect
0Spikelet: Density of pubescence of lemma	Strong	Strong	Very strong	Very strong	Strong	Strong	Strong	Strong
Lemma: Anthocyanin colouration of apex	Absent	Very strong	Very strong	Very strong	Absent	Absent	Absent	Very strong
Spikelet: Colour of stigma	White	Purple	Purple	Purple	White	White	White	Purple
Stem: Length (excluding panicle, cm)	145	150	133	175	140	140	132	150

Table 7. Contd.

Stem: Anthocyanin colouration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Panicle: Length of main axis	29	31.5	30	31	27.5	28	28	30
Flag leaf: attitude of blade (Late)	Semi erect	Semi erect	Semi erect	Erect	Erect	Semi erect	Semi erect	Semi erect
Panicle: Curvature of main axis	Drooping	Semi straight	Semi straight	Drooping	Semi straight	Drooping	Drooping	Drooping
Spikelet: Colour of tip of lemma	Yellowish	Purple	Purple	Purple	Yellowish	Yellowish	Yellowish	Purple
Panicle: Awns	Absent	Absent	Present	Absent	Present	Absent	Present	Absent
Panicle: Colour of awns	-	-	-	-	Reddish brown	-	Yellowish brown	-
Panicle: Distribution of awns	-	-	Upper half only	-	Tip only	-	Upper half only	-
Panicle: Attitude of branches	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect	Erect to semi erect	Semi erect	Semi erect
Panicle: Exsertion	Well exscerted	Well exscerted	Well exscerted	Well exserted	Well exsertion	Well exsertion	Well exsertion	Well exsertion
Sterile lemma colour	Straw	Straw	Straw	Brown	Gold	Straw	Straw	Straw
Decorticated grain length	6.1	5.9	6.2	6.6	6.8	6.6	6.1	6.1
Decorticated grain breadth	2.3	2.7	2.4	2.6	2.6	2.5	2.6	2.8
Decordicated grain shape	Long bold	Short bold	Long bold	Medium slender	Medium slender	Medium slender	Long bold	Long bold
Decorticated grain colour	White	White	Red	Red	White	White	Red	White

to total genetic divergence. Panicle length (0.22%), primary branches (0.22%), total number of spikelets per panicle (0.22%) is the least contributors to the total genetic divergence. The present findings were in accordance with the findings of Subudhi et al. (2008). Phenotpyic characteristics of all 31 indian exotic germplasm accessions were given from Table 7. Cluster XIII had higher mean value for number of primary and secondary branches per panicle, number of filled grains per panicle, number of spikelets per panicle, spikelets fertility and single plant yield. Hybridization between these accessions will be useful in selecting segregants with all productive traits. Cluster IV had accessions with high number of productive tillers per plant, cluster IX lowest cluster mean value for days to 50% flowering and cluster XIII had lowest cluster mean value for plant height. Hybridization between the accessions of these clusters will be highly useful in generating useful transgressive segregants with earliness and dwarf stature.

Hence, conservation and characterization of the aforementioned germplasm accessions will be highly helpful for the plant breeders to design future breeding programme with the objective of developing varieties with high yielding ability and improved nutrition, cooking quality and resistance to biotic and abiotic stress tolerance.

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