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Research Article

Characterization of Some Cultivated Rice (*Oryza sativa* L.) Based on Phenotypic, Physicochemical and Cooking Properties

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Abstract

Evaluation of rice genetic diversity is an important step for character specific varietal development program. The present study characterizes 15 rice germplasm of Indian accessions on the basis of agro morphological, physicochemical and cooking parameters. The cultivars showed high degree of variations on their traits. Mean plant height of 88.96 cm, flag leaf length (26.48 cm), flag leaf width (1.17 cm), grain per panicle (130), panicle length (20.97 cm), days to 50% flowering (112.06 days), kernel length breadth ratio (2.65), cooked kernel length breadth ratio (3.25), linear elongation ratio (1.65). Out of 15 rice cultivars, only Sada nunia and Das nunia are aromatic rice and Sada nunia also contain awn. Plant height showed significant positive correlation with PnL and DF and significant negative correlation with GB. GL positively significantly correlates with FLL, GrWt with GL and GB, DF with MT. The cluster analysis grouped the 15 cultivars into 4 clusters with 37.5 dissimilarity coefficient. The high variability with promising traits among the cultivars expected to be significance for future rice breeding programmes.

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Keywords: Agro-morphology, Genetic diversity, Germplasm, Cultivars, Variability, Cluster analysis

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Introduction

Rice (*Oryza sativa* L.) is one of the leading food crops of the world that feeds as a staple food nearly one half of the world's population (Singh et al., 2005). Rice is a cereal crop and belongs to the family Poaceae. Rice grain contains 7% protein, 12% water and 75 to 80% starch (Oko et al., 2012; Hossain et al., 2015). India is the major rice growing country and produces about 20% of all world rice. In India, out of total cropped land rice is cultivated in 44.7% area and produces 70.3% of the total food grain (DAC&FW 2018).

Rice is grown in more than 100 countries across all habitable continents. In South East Asian countries, India traditionally rich in the diversity of cultivated rice also in the wild progenitors of cultivated rice (Singh et al., 2001). Genetic diversity maybe provides as an insurance against crop failure (Subba Rao et al., 2001). Landraces contain many valuable traits such as production, quality, biotic and abiotic stress tolerance etc. Assessment of genetic diversity is extremely important in rice breeding for selection and conservation of different landraces for their further utilization in crop improvement programmes (Patra, 2000). The successful crop improvement programme is extremely dependent on the efficient exploitation of the genetic variability within germplasm and selection of the genotypes which contains quality contributing and desirable yield traits (Acquaah, 2012).

Hence, characterization of rice cultivars and their identification are important for the genetic improvement, seed production programs and release. Thus, assessment of these varieties will further donate towards creating a genetic database and will help in planning breeding programmes in that region.

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Materials and methods

Plant material

The experimental material consisted of 15 cultivated rices. The genotypes were grown in the pots as well as field at Experimental Rice Field, Plant Genetics & Molecular Breeding Laboratory, Department of Botany, University of North Bengal, West Bengal, India.

Agro-morphological traits

The data were collected on 10 randomly selected plants from each germplasm. Agro-morphological traits were measured according to DUS (Distinctiveness, Uniformity and Stability) test protocol (PPV&FR Acts 2001, Govt. of India) for characterizing the diverse genotypes. The 21 days old seedlings of each genotype were transplanted with spacing 20 cm × 20 cm in randomized complete block design (RCBD) with 3 replications. Observations like Plant height (PH), flag leaf length (FLL), flag leaf breadth (FLB), panicle length (PnL), grain per panicle (Gr/Pn), days to 50% flowering (DF), maturity date (MT), Tillering (Till), 1000 grain weight (GrWt), grain length (GL), and grain breadth (GB) were recorded.

Grain physico-chemical and cooking parameters

Based on Alkali Spreading Value (ASV), Gelatinization Temperature was measured. For Alkali Spreading Value, six kernels were taken and removed their aleurone layer manually with the help of blade. The polish kernels were kept in petriplate containing freshly prepared 1.7% KOH solution and covered them with lid. After 10 mins., lids were opened and smelt, graded them for aroma by sensory evaluation protocol by Sood and Siddiq (1978). After 23 hours of incubation at room temperature, data was recorded visually based on the appearance and disintegration of kernels and scored them according to Little et al. (1958). A low ASV score indicates to a high GT. Conversely, a high ASV score indicates a low GT.

Elongation ratio was measured according to Oko et al. (2012). The linear elongation ratio was calculated by the average length of cooked kernel divided by the average length of uncooked kernel and breadth wise elongation ratio was calculated by average breadth of cooked kernel divided by the average breadth of uncooked kernel. Cooked kernel length breadth ratio was calculated by length of cooked rice divided by breadth of cooked rice.

Statistical Analysis.

The experiment was conducted with three replications under laboratory condition. The experimental data were recorded in Microsoft Excel. The descriptive statistics were done in Microsoft Excel 2007. Pearson correlation coefficients (r) were calculated by using IBM SPSS 23 statistical software. Pair Group Method with Arithmetic Mean (UPGMA) hierarchical clustering in Past4.03 software based on dissimilarity matrix for phenotypic diversity among the rice cultivars.

Results and Discussion

Variability of morphological traits

Significant genetic variation was seen in the germplasm for the agro-morphological traits. Among the 15 germplasm, the traits under study showed wide range of variations (Table 1). Plant height (PH) ranges from 67.11 cm to 128.00 cm with a mean of 88.96 cm and 17.22 CV%. Flag leaf length (FLL) ranges from 19.09 cm to 36.01 cm with a mean of 26.48 cm (%CV = 19.29) and flag leaf breadth ranges from 0.61 cm to 1.59 cm with a mean of 1.17 cm (%CV=20.76). Panicle length ranges from 15.36 cm to 25.59 cm with a mean of 20.97 (%CV=11.94). Grain per panicle ranges from 85 to 176.33 with a mean of 130 (%CV=18.56) Grain length and breadth ranges from 7.28 mm and 2.04mm to 9.40 mm and 3.08 mm with a mean of 8.22 mm and 2.52 mm (%CV=7.99 and 11.78). Grain weight ranges from 16.40 g to 25.64 g with a mean of 20.85 (%CV=14.61). Tillering ranges from 3 to 7 with a mean of 4.13 (%CV=1.15). Days to 50% flowering and maturity time ranges from 98 days and 133 days to 128 days and 158 days with a mean of 112.06 days and 144.33 days (%CV= 7.39 and 5.05). Awns recorded mean of 2.33mm (%CV=313.61) respectively.

Physico-chemical and cooking parameter analysis

It was observed that rice grain quality was showed a huge genetic variability. Out of 15 rice cultivars only Sada nunia and Das nunia are aromatic and rest are non-aromatic. Alkali spreading value (ASV) was showed a wide range of genetic variability among the cultivars. Ranjana cultivar showed lowest Alkali spreading value (ASV)(1), so gelatinization temperature (GT) is highest (6) and Sada nunia showed highest ASV (6) and lowest GT (1) (**Fig. 1.**) (**Table 2**).

Table. 1 Agro-morphological variation of rice cultivars

Traits	Range	Minimum	Maximum	Mean	SEM (±)	Std. Deviation	CV (%)
PH	60.89	67.11	128.00	88.96	3.95	15.32	17.22
FLL	16.92	19.09	36.01	26.48	1.31	5.11	19.29
FLB	0.98	0.61	1.59	1.17	0.06	0.24	20.76
PnL	10.23	15.36	25.59	20.97	0.64	2.50	11.94
Gr/Pn	91.33	85.00	176.33	130.00	6.23	24.13	18.56
GL	2.12	7.28	9.40	8.22	0.16	0.65	7.99
GB	1.04	2.04	3.08	2.52	0.07	0.29	11.78
GrWt	9.24	16.40	25.64	20.85	0.78	3.04	14.61
Till	4.00	3.00	7.00	4.13	0.29	1.15	27.89
DF	30.00	98.00	128.00	112.06	2.13	8.28	7.39
MT	25.00	133.00	158.00	144.33	1.88	7.29	5.05
Awn	28.30	0.00	28.30	2.33	1.90	7.38	316.61

Plant height (PH cm), Flag leaf length (FLL cm), Flag leag breadth (FLB cm), Panicle length (PnL cm), Grain per panicle (Gr/Pn), Grain length (GL mm), Grain breadth (GB mm), Grain weight (GrWt g), Tillering (Till), Days to 50% flowering (DF days) and Maturity time (MT days), Awn (mm).

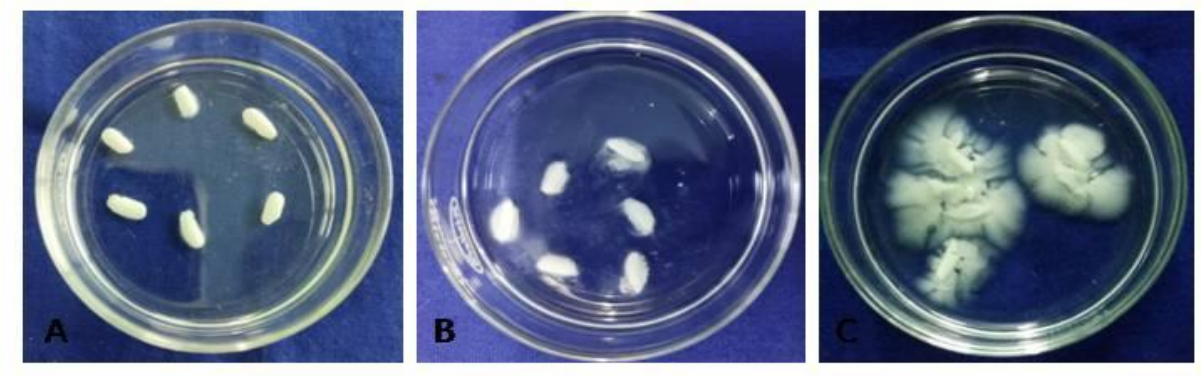

Fig. 1 Representative photo of ASV and GT experiment. Figure showing: A- Low ASV (1-2), B- Medium ASV (3-5), C- High ASV (6-7)

Table. 2 Physicochemical properties (ASV, GT, and Aroma) in rice cultivars.

Cultivar name	Aroma	ASV	GT
Mala	0	2	7
Das nunia	3	5	3
Swarno	0	2	7
China	0	2	7
IR-28	0	2	7
Sada nunia	3	6	1
Suruchi	0	3	5
Banni	0	4	3
Paras	0	3	5
Pioneer	0	3	5
Yamuna	0	3	5
Pratik	0	6	1
Nironjana	0	6	1
Ranjana	0	1	7
Paijam	0	6	1

Kernel length (KL) and Kernel breadth (KB) varied from 5.18 mm to 6.94 mm and 1.86 mm to 2.65 mm with a mean of 5.94 mm (CV% = 9.36) and 2.22 mm (CV%=8.88). Kernel length –kernel breadth ratio (KL/KB) is very important attribute of rice grain and it varied from 2.07 to 3.30 with a mean of 2.65 (CV%=14.91). Cooked kernel length (CKL) and breadth (CKB) varied from 8.00 mm to 11.16 mm and 2.40 mm to 3.80 mm with a mean of 9.78 mm (CV%=12.23) and 3.06 mm (CV%=11.27). Cooked kernel length-breath ratio (CKL/CKB) varied from 2.15 to 4.47 with a mean of 3.25 (CV%=20.78). Linear elongation ratio (LER) varied from 1.22 to 1.94 with a mean of 1.65 (CV%= 11.83) and breadth wise elongation ratio (BER) varied from 1.17 to 1.68 with a mean of 1.38 (CV%=10.67) (**Table. 3**).

Table. 3 Cooking properties of rice

Traits	Range	Minimum	Maximum	Mean	SEM (±)	Std. Deviation	CV (%)
KL	1.76	5.18	6.94	5.94	0.14	0.55	9.36
KB	0.79	1.86	2.65	2.22	0.05	0.19	8.88
KL/KB	1.23	2.07	3.30	2.65	0.10	0.39	14.91
CKL	3.26	8.00	11.26	9.78	0.30	1.19	12.23
CKB	1.40	2.40	3.80	3.06	0.08	0.34	11.27
CKL/CKB	2.32	2.15	4.47	3.25	0.17	0.67	20.78
LER	0.72	1.22	1.94	1.65	0.05	0.19	11.83
BER	0.51	1.17	1.68	1.38	0.03	0.14	10.67

Kernel length (KL mm), Kernel breadth (KB mm), Kernel length breadth ratio (KL/KB), Cooked kernel length (CKL mm), Cooked kernel breadth (CKB mm), Cooked kennel length breadth ratio (CKL/CKB), Linear elongation ratio (LER), Breadth wise elongation ratio (BER).

Correlation among the Traits

Pearson's correlation (r) measured the potency of the association between two characters. In the present study, the correlations among the characters showed significant positive relations among the traits (**Table. 4**). Plant height showed (PH) positive correlation with PnL, DF, MT, Awn and significant negative correlation with GB. Flag leaf length (FLL) showed positive correlation with GL. Grain weight (GrWt) positively correlates with FLB, GL and GB. Days to 50% flowering (DF) showed significant positive correlation with MT.

Table. 4 Correlation among agromorphological traits of 15 cultivars

	PH	FLL	FLB	PnL	Gr/Pn	GL	GB	GrWt	Till	DF	MT	Awn
PH	1											
FLL	.199	1										
FLB	-.155	.200	1									
PnL	.584*	.132	.055	1								
Gr/Pn	-.310	-.061	.183	-.145	1							
GL	.103	.565*	.408	.312	-.034	1						
GB	-.664**	-.109	.440	-.430	.173	.062	1					
GrWt	-.352	.111	.657**	-.136	.247	.563*	.606*	1				
Till	-.122	-.209	.090	.355	.129	-.118	.158	.143	1			
DF	.650**	.047	-.288	.192	-.207	.096	-.413	-.216	-.202	1		
MT	.562*	.277	-.334	.046	-.191	.188	-.362	-.279	-.370	.901**	1	
Awn	.453	.106	-.402	.503	-.125	.130	-.353	-.289	.265	.354	.368	1

*****Correlation is significant at the 0.05 level (2-tailed). ******Correlation is significant at the 0.01 level (2-tailed).

Plant height (PH cm), Flag leaf length (FLL cm), Flag leag breadth (FLB cm), Panicle length (PnL cm), Grain per panicle (Gr/Pn), Grain length (GL mm), Grain breadth (GB mm), Grain weight (GrWt g), Tillering (Till), Days to 50% flowering (DF days) and Maturity time (MT days), Awn (mm).

Diversity Analysis by Clustering

Based on 15 agro-morphological and physicochemical traits, a dendrogram was constructed by UPGMA hierarchical clustering methods and grouped the 15 rice cultivars into four clusters (**Fig. 2**) on the basis of average linkage and Euclidean distance. Cluster I consist Sada nunia and Das nunia. Cluster II consists five cultivars, Paijam Nironjana, Mala, Paras, Banni. Cluster III consist only Ranjana. Cluster IV consists seven cultivars namely Yamuna, Pioneer, Suruchi, Pratik, IR-28, China and Swarno.

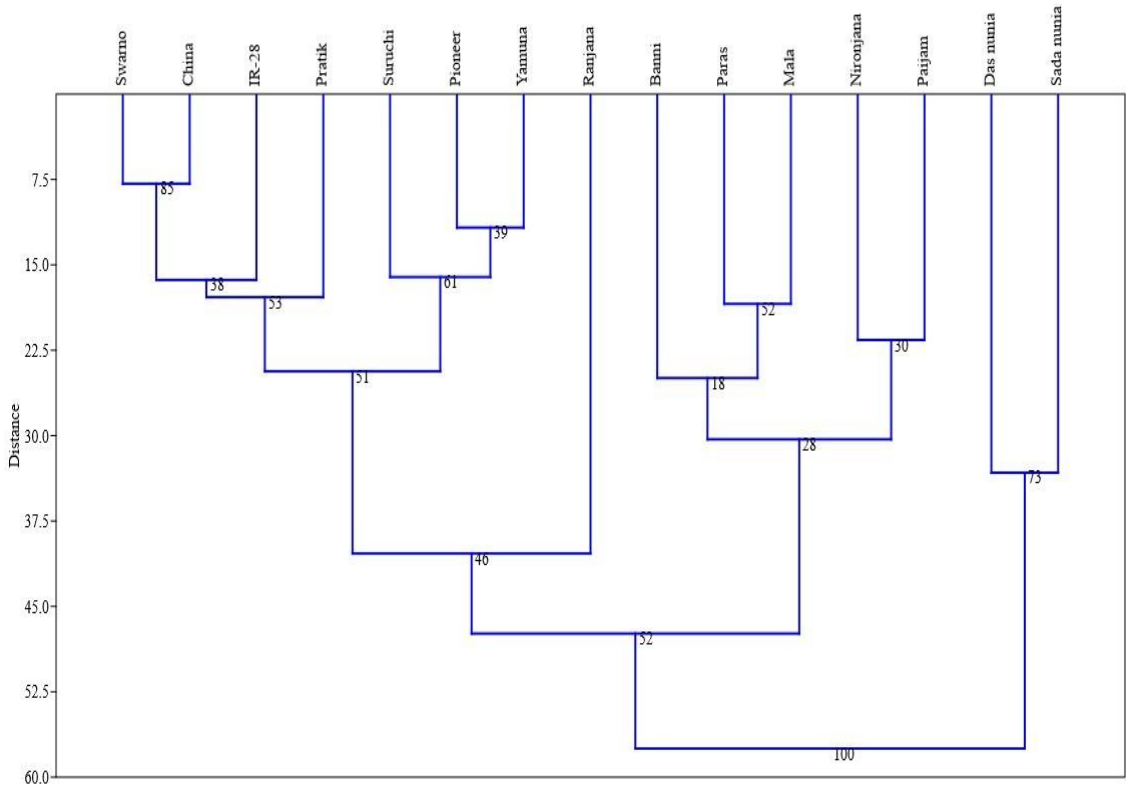

Fig. 2 Grouping of 15 rice cultivars based on unweighted pair-group method with arithmetic means (UPGMA) hierarchical clustering method.

Discussion

The characterization of germplasms on the basis of agro-morphological traits is fundamental for plant breeding programmes which provide the basic information. (Lin.,1991). The genetic analysis of quantitative characters is one of the main prerequisites for planning a plant breeding programme (Khatun et al., 2015). Among the 15 rice cultivars, all the traits show significant variations. Different phenotypic variations have been reported by many rice researchers in different rice accessions (Ullah et al., 2011; Pandey et al., 2011). The coefficient of variation (CV%) of phenotypic traits ranges widely (5.4% to 23.45%) and small variation on qualitative traits.

Gelatinization temperature (GT) is a temperature when rice starch started to bulge and lose its crystallinity in an irreversible manner. According to Surek 2002, gelatinization temperature is a physicochemical trait of the starch. Rice starch usually gelatinizes at 65 - 85 °C temperatures (Bakshi and Singh, 2019). During cooking, high gelatinization temperatures shows softening of rice. Grain size and shape mostly determine the purchaser acceptance and market value of rice, while cooking quality is controlled by the properties of starch. During cooking some rice varieties expand more in size than others. Length-wise elongation without a corresponding expansion in girth is considered a greatly desirable grain quality trait (Sood and Sadiq.,

1979). Cooked grain length is governed by genetic as well as environmental factors (Şişman, 2016).

Correlations assist the breeder to understand the interrelated characters in the time of selection for genetic improvement (Chakravorty et al., 2013). Plant height showed a significant positive correlation with PnL, supported by (Roy et al., 2014; and Saha et al., 2019). The negative correlation of the plant height with flag leaf area was also reported (Saha et al., 2019). The significant positive correlation of grain yield with 100-grain weight in the present study was supported by (Efendi et al., 2015; Ibrahim et al., 2019). Thus, the altering of these characters would have a positive impact on yield improvement. Days to maturity showed significant positive correlation with plant height reported in this study was supported by Krishna Naik et al. (2005). Grains per panicle showed negative correlation with plant height supported by Chakraborty and Chakraborty (2010).

The UPGMA dendrogram generally clustered the rice cultivars in to four major groups at 37.5 dissimilarity coefficient, which suggest a high level of phenotypic diversity in the rice genotypes.

Genotypes of distant clusters showed wide spectrum of variability in the segregation and to perform maximum heterosis in crossing (Hosan et al., 2010). Variability assessment of rice genotypes on the basis of cluster analysis is reported by several workers (Ghalain (2006), Hien et al. (2007), Naik et al. (2006), Sarawgi and Bhisne (2007) and Ratho (1984). Ratho (1984) reported that the pattern of clustering did not go after the geographical origin of a variety. For higher variability in breeding, parent plant selection on the basis of wider inter-cluster distances was recommended by Mishra et al. (2003), Chaturvedi and Mourya (2005). The present study provides strategy for selection of parents on the basis of agro-morphological traits with special reference to yield and quality characters for further improvement.

Conclusion

All the valuable rice cultivars possess huge genetic variability, which can be utilized in broadening the genetic base or varietal improvement program in future. Characterization of genotypes is the basic fundamental tool for breeding which helps to select the right parent plant. This study provides the basic information for rice variety improvement as well as breeding programs.

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