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Agro-morphological and quality characterization of indigenous and exotic aromatic rice (*Oryza sativa* L.) germplasm

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Abstract: For establishment of the distinctness among 64 aromatic rice germplasm, 35 agro-morphological and quality traits were used. Most of the studied traits showed wide variation among the germplasm. Purple colour of auricles and ligule was found in only one genotype, while light purple colour of auricles was recorded in four genotypes. White colour of stigma was recorded in 57 accessions, whereas purple stigma was observed in six accessions. Awns present in 31 accessions. The weight of 1000 grains, which is one of the most important yield attributing traits showed wide variation among accessions, and ranges from very low to very high weight. Grain: length and decorticated grain: length showed high variation and ranges from very short to long type, while grain: width and decorticated grain: width showed somewhat little variation among the genotypes. Extra long slender type grain shape was observed in 27 accessions. White type of decorticated grain colour was found in 55 genotypes, while light red and red colour was observed in only three genotypes. The present study concluded that all sixty four accessions were found to be distinct on the basis of thirty one agro-morphological and quality traits. Accessions having short stem length, very long panicle length, more number of panicle per plant, and extra long slender grain may be used as potential donor in hybridization programmes. This study will be useful for breeders, researchers and farmers to identify and choose the restoration and conservation of beneficial genes for crop improvement.

Keywords: Agro-morphological, Aromatic rice, Characterization, Quality

INTRODUCTION

Aromatic rice constitutes small but a special group of rice, and highly priced due to their pleasant aroma and excessive kernel elongation after cooking. Thousands of locally adapted aromatic rice genotypes have evolved over several decades as a result of natural and human selection (Mathure *et al*., 2011). These genotypes are endowed with tremendous genetic variability and the reservoirs of useful genes, and can be used to enrich the commercial rice cultivars with desired genes for useful traits (Zeng *et al*., 2003). Despite the richness of genetic resources, only a small proportion of the world rice germplasm collections have been used in breeding programmes. The exact genetic potential, differences from commercial varieties and the magnitude of variability still present in local landraces are not well catalogued. Some of these genotypes are being gradually eroded from their respective places of origin and are on the verge of becoming extinct due to competition from high yielding varieties (Ram *et al*., 2007; Maxted and Kell, 2009).

Various agro-morphological and quality traits of rice play very important roles for their characterization and varietal identification which ultimately helps rice breeder for its improvement (Laxuman *et al*., 2011). Agro-morphological parameters of rice cultivars determine their yield potential, local agronomic suitability and ability to escape from or to tolerate biotic and abiotic stresses. So, systematic study and characterization of such germplasm is an important step for utilizing the appropriate attribute based donors and protecting the unique rice in present era (Parikh *et al*., 2012). Hence, there is an urgent need to catalogue, characterize and conserve the non-basmati and basmati rice genotypes which are inextricably integrated with culture and traditional knowledge of the nation. In this context, an attempt was made to characterize a set of aromatic rice germplasm for various agro-morphological and quality traits to identify the variability available in the germplasm collection and their conservation before further extinction.

MATERIALS AND METHODS

Sixty four indigenous and exotic aromatic rice (*Oryza sativa* L.) germplasm (Table 1) were grown in a ran-

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domized complete block design at Research cum Instructional Farm, IGKV, Raipur during *Kharif* 2014. Each entry was sown in four rows of 2m length at spacing of 20 cm between rows and 15 cm between plants. Crop was raised following recommended package of practices. Observations were recorded on five randomly chosen plants of each genotype per replication for quantitative traits. The qualitative traits were visually assessed according to the National Test Guidelines for DUS test in rice which was developed by Directorate of Rice Research Rajendranagar, Hyderabad (Shobha Rani *et al*., 2006). The observation of various characteristics was recorded at different stages of growth with appropriate procedures as per the DUS test guidelines of PPV & FR Act, 2001.

The traits studied were Basal leaf: sheath colour, Leaf: pubescence of blade surface, Leaf: auricles, Leaf: anthocyanin colouration of auricles, Leaf: ligule, Leaf: shape of ligule, Leaf: colour of ligule, Days to 50% flowering (days), Flag leaf: attitude of blade (early observation), Spikelet: density of pubescence of lemma, Lemma: anthocyanin colouration of apex, Spikelet: colour of stigma, Stem: length (excluding panicle), Stem: anthocyanin colouration of nodes, Stem: anthocyanin colouration of internodes, Panicle: length of main axis, Flag leaf: attitude of blade (late observation), Panicle: curvature of main axis, Panicle: number per plant, Spikelet: colour of tip of lemma, Panicle: awns, Panicle: colour of awns, Panicle: distribution of awn, Panicle: secondary branching, Panicle: attitude of branches, Panicle: exertion, Sterile lemma: colour, Grain: weight of 1000 fully developed grains, Grain: length, Grain: width, Decorticated grain: length, Decorticated grain: width, Decorticated grain: shape, Decorticated grain: colour and Decorticated grain: aroma. The list of characters along with descriptor is mentioned in Table 2.

RESULTS AND DISCUSSION

To establish distinctness among aromatic rice germplasm, 35 quantitative and qualitative characters have been used. Qualitative characters are considered as morphological markers in the identification of landraces of rice, because they are less influenced by environmental changes (Raut, 2003). The results of agro-morphological and quality characterization as observed in studied aromatic rice accessions are presented in Table 3. Regarding basal leaf: sheath colour, green colour was observed in most of the accessions, whereas light purple, purple lines and uniform purples was recorded in 3 (Kanak Jeer, Hung-mi-hsiang-ma-tsan and Niaw Hawm Mali), 3 (Chimbalate Basmati, IR 62873-227-1-16 and IR 62873-238-2-3) and 1 accession (Hawm Jan), respectively that made it distinct from others. Purple colour of auricles and ligule was found in only one genotype (Hawm Jan), while light purple colour of auricles was recorded in four genotypes (Hung-mi-hsiang-ma-tsan, Niaw Hawm Mali, IR 62873-227-1-16 and IR 62873-238-2-3). IR 62873-227 -1-16 also exhibited light purple colour of ligule. Genotype “Bong Cay” showed very late type days to 50% flowering, however no genotype was found very early type, and rest of the genotypes fall under early (28), medium (21) and late (14) group. In early observation, erect type of flag leaf was observed for 30 genotypes but remaining was of semi-erect type. For spikelet: density of pubescence of lemma, 6 were of very strong, 18 were of strong, 23 were of medium and 19 were of weak type of pubescence. White colour of stigma was recorded in most of the accessions, whereas purple stigma was observed in only six accessions. Very short stem: length was recorded in 19 accessions, while long in 12 accessions. Sixty one genotypes were observed for absence of anthocyanin colouration of nodes and only three genotypes (Hung-mi-hsiang-ma-tsan, Niaw Hawm Mali and IR 62873-227-1-16) found presence for the character. Similarly, for anthocyanin colouration of internodes 60 accessions were recorded absence and 4 accessions (Hawm Jan, Niaw Hawm Mali, IR 62873-227-1-16 and Bas 867) were recorded presence for the character. Panicle length for 14 cultivars was of very long, 39 were of long and 11 were of long, and no accessions were observed for short and very short type panicle.

Flag leaf attitude of blade in late observation was recorded deflexed type in only two genotypes (Neelabati and Niaw Hawn Mali), while rest of the genotypes were of erect, semi-erect and horizontal type. For the character, panicle curvature of main axis, 28 were of deflexed, 19 were of dropping and 17 were of semi-straight. With respect to panicle number per plant, 40 accessions exhibited few number and 24 were of medium number. Colour of tip of lemma observed white in 25 accessions, yellow in 16, purple in 11, red in 4, brown in 4 and black in 4 accessions. Awns present in 31 accessions only, and yellowish white and yellowish brown colour of awns observed in most of the accessions. Reddish brown colour of awns was exhibited by genotype Bindli, black colour of awns by Kanak Jeer, and purple colour of awns by RAU 3043, Banspatri and Dhanaprasad. The distribution of awns on tip only was recorded in five genotypes only. However, awns distributed on whole length of the panicle were observed in 26 accessions. All the 64 genotypes exhibited presence of secondary branching. Forty seven genotypes were of strong branching and remaining was of weak in nature. Erect to semi-erect type attitude of branches was observed for 23 accessions. However, semi-erect and semi-erect to spreading type was observed for 20 accessions each. Only one genotype was spreading in nature. Mostly that is 59 genotypes were of well exerted panicle exertion while five genotypes were of mostly exerted types. The weight of 1000 fully developed grains, which is one of the most important yield attributing traits showed wide variation among accessions and ranges from very low to very high

Table 1. List of the aromatic rice germplasm.

S. N.	Germplasm	Source/Contribution	S. N.	Germplasm	Source/Contribution
1.	RAU 3043	BI/ DRR	33.	Ranbir Basmati	J & K/ IARI
2.	Maguraphulla	OD/ DRR	34.	Basmati 564	J & K/ IARI
3.	Kanikabhog	OD/ DRR	35.	Chimbalate Basmati	J & K/ IARI
4.	Kapoor Kranti	RPR/ DRR	36.	Basmati 217	PU/ DRR
5.	Adam Chini B	UP/ DRR	37.	Taroari Basmati	PU/ DRR
6.	Kanak Jeer	UP/DRR	38.	Basmati Bahar	PU/ DRR
7.	Bhanta Phool A	UP/DRR	39.	Karnal Local	PU/ DRR
8.	Kamini Joha	AS/ DRR	40.	Basmati Type 3	PU/ DRR
9.	Bindli	NAGINA	41.	Basmati 370	PU/ DRR
10.	Banspatri	RPR	42.	Basmati 6141	PU/ DRR
11.	Shyamjeera	RPR	43.	Basmati Mahan	DRR
12.	Lectimachi	OD/DRR	44.	Basmati 5874	PU/ DRR
13.	Tarunbhog	RPR/ DRR	45.	Basmati 11	PU/ DRR
14.	Neelabati	OD/DRR	46.	HBC 46	HA/ DRR
15.	Kalikhasa	AS/ DRR	47.	Haryana Basmati 1	HA/ NAGINA
16.	PDKV Shriram	MH/ DRR	48.	Mahisugandha	KOTA/ DRR
17.	Dhanaprasad	DRR	49.	Pusa Basmati 1	IARI/ DRR
18.	Kalimooch	RPR/ DRR	50.	Pusa Basmati 1121	IARI/ DRR
19.	Ayepyaung	MYANMAR/ DRR	51.	Yamini	CSSRI/ DRR
20.	Binirhen	PHILIPPINES/ DRR	52.	Vasumati	DRR
21.	Bong Cay	VIETNAM/ DRR	53.	Improved Pusa Basmati 1	IARI/ DRR
22.	Daw Leuang	THAILAND/ DRR	54.	Kasturi	DRR
23.	Guinata	PHILIPPINES/ DRR	55.	UPR 3565-10-1-1	PANTNAGAR
24.	Hung-mi-hsiang-ma-tsan	CHINA/ DRR	56.	UPR 2828-7-2-1	PANTNAGAR
25.	Hawm Jan	THAILAND/ DRR	57.	IET 18033	DRR
26.	Lua Nhe Den	VIETNAM/ DRR	58.	KDML 105	THAILAND
27.	Longku Labat	INDONESIA/ DRR	59.	Domsaih	IRAN/ DRR
28.	Niaw Hawn Mali	THAILAND/ DRR	60.	IR 62873-227-1-16	IRRI/ DRR
29.	Popot	INDONESIA/ DRR	61.	IR 62873-238-2-3	IRRI/ DRR
30.	Improved Sarbati	PANTNAGAR	62.	Hasan Serai	IRAN/ DRR
31.	Laldhan	PANTNAGAR	63.	IR 75428-6-3	IRRI/ DRR
32.	Basmati 386	LUDHIANA	64.	Bas 867	US PATENTED LINE

Abbreviations: AS- Andhrapradesh, BI- Bihar, CSSRI- Central Soil Salinity Research Institute, DRR- Directorate of Rice Research, HA- Haryana, IARI- Indian Agriculture Research Institute, IRRI- International Rice Research Institute, J & K- Jammu & Kashmir, MH- Maharashtra, OD- Odisha, RPR- Raipur, UP- Uttar Pradesh

weight. Grain length showed high variation and ranges from very short to long type, while grain width showed somewhat little variation among the genotypes. Similarly, decorticated grain length exhibited wide range of variation from short type to extra long type whereas decorticated grain width showed only narrow and medium type. Grain shape also showed highest variation among genotypes and vary from short slender to extra long slender. Extra long slender type grain shape was observed in 27 accessions. White type of decorticated grain colour was found in 55 genotypes, while light red and red colour was observed in only three genotypes (Hung-mi-hsiang-ma-tsan, Laldhan and Basmati 5874).

Out of 35 characters observed, days to 50% flowering, spikelet: density of pubescence of lemma, lemma: anthocyanin colouration of apex, stem: length, flag leaf: attitude of blade, spikelet: colour of tip of lemma, panicle: colour of awns, grain: weight of 1000 fully developed grains, grain: length, decorticated grain: length, decorticated grain: shape and decorticated grain: colour recorded highest variation among accessions. After that, basal leaf: sheath colour, leaf: pubescence of blade surface, leaf: anthocyanin colouration of auricles, leaf: colour of ligule, spikelet: colour of stigma, panicle length of main axis, panicle: attitude of branches, sterile: lemma colour and grain: width showed variation in different accessions. All the 64 accessions exhibited presence of leaf: auricles, leaf: ligule, decorticated grain: aroma and shape of ligule and marked no differences among germplasm. However, rest of the characters found each of two classes among different accessions. Our results are in close agreement with those of Bisne and Sarawgi (2008), who characterized thirty two aromatic rice accessions of Badshah Bhog group for twenty two morphological traits and found sufficient variation among the accessions for most of the traits studied. Out of twenty two morphological traits, leaf blade colour, lemma and palea colour, apiculus colour, and lemma and palea pubescence found the highest variation in different accessions. After that leaf blade pubescence, flag leaf angle, culm angle, panicle type and panicle threshability showed moderate variation, and seven traits found each of two classes among different accessions. The remaining six morphological traits *viz.*, basal leaf

Table 2. List of characters along with descriptor.

S. N.	Characters	States and Note					
1.	Basal leaf: sheath colour	Green-1	Light purple- 2	Purple lines- 3	Uniform purple- 4		
2.	Leaf: pubescence of blade surface	Absent- 1	Weak- 3	Medium- 5	Strong- 7	Very strong- 9	
3.	Leaf: auricles	Absent- 1	Present- 9				
4.	Leaf: anthocyanin colouration of auricles	Colourless- 1	Light purple- 2	Purple- 3			
5.	Leaf: ligule	Absent- 1	Present- 9				
6.	Leaf: shape of ligule	Truncate-1	Acute- 2	Split- 3			
7.	Leaf: colour of ligule	White- 1	Light purple- 2	Purple- 3			
8.	Days to 50% flowering (days)	Very early (<71)- 1	Early (71-90)- 3	Medium (91-110)- 5	Late (111-130)- 7	Very late (>131)- 9	
9.	Flag leaf: attitude of blade (early observation)	Erect- 1	Semi-erect- 3	Horizontal- 5	Drooping- 7		
10.	Spikelet: density of pubescence of lemma	Absent- 1	Weak- 3	Medium- 5	Strong- 7	Very strong- 9	
11.	Lemma: anthocyanin colouration of apex	Absent- 1	Weak- 3	Medium- 5	Strong- 7	Very strong- 9	
12.	Spikelet: colour of stigma	White- 1	Light green- 2	Yellow- 3	Light purple- 4	Purple- 5	
13.	Stem: length (excluding panicle)	Very short (<91 cm)- 1	Short (91-110 cm)- 3	Medium (111-130 cm)- 5	Long (131-150 cm)- 7	Very long (>150 cm)- 9	
14.	Stem: anthocyanin colouration of nodes	Absent- 1	Present- 9				
15.	Stem: anthocyanin colouration of internodes	Absent- 1	Present- 9				
16.	Panicle: length of main axis	Very short (<16 cm)- 1	Short (16-20 cm) - 3	Medium (21-25 cm)- 5	Long (26-30 cm)- 7	Very long (>30cm)- 9	
17.	Flag leaf: attitude of blade (late observation)	Erect- 1	Semi-erect- 3	Horizontal- 5	Deflexed- 7		
18.	Panicle: curvature of main axis	Straight- 1	Semi-straight- 3	Deflexed- 5	Dropping- 7		
19.	Panicle: number per plant	Few (<11)- 3	Medium (11-20)- 5	Many (>20)- 7			
20.	Spikelet: colour of tip of lemma	White- 1	Yellowish- 2	Brown- 3	Red- 4	Purple- 5	Black- 6
21.	Panicle: awns	Absent- 1	Present- 9				

S. N.	Characters	States and Note								
22.	Panicle: colour of awns	Yellowish white-1	Yellowish brown- 2	Brown- 3	Reddish brown- 4	Light red- 5	Red- 6	Light purple- 7	Purple- 8	Black- 9
23.	Panicle: distribution of awns	Tip only- 1	Upper half only- 3	Whole length- 5						
24.	Panicle: secondary branching	Weak- 1	Strong- 2	Clustered- 3						
25.	Panicle: attitude of branches	Erect- 1	Erect to semi-erect- 3	Semi-erect- 5	Semi-erect to spreading- 7	Spreading- 9				
26.	Panicle: exertion	Partly exerted- 3	Mostly exerted- 5	Well exerted- 7						
27.	Sterile lemma: colour	Straw- 1	Gold- 2	Red- 3	Purple- 4					
28.	Grain: weight of 1000 fully developed grains	Very low (<15g)- 1	Low (15-20 g)- 3	Medium (21-25 g)- 5	High (26-30 g)- 7	Very high (>30 g)- 9				
29.	Grain: length	Very short (<6.0 mm)- 1	Short (6.0-8.5 mm)- 3	Medium (8.6- 10.5 mm)- 5	Long (10.6 - 12.5 mm) - 7	Very long (>12.5 mm)- 9				
30.	Grain: width	Very narrow (<2.0 mm)- 1	Narrow (2.1 -2.5 mm)- 3	Medium (2.6 3.0 mm)- 5	Broad (3.1 -3.5 mm)- 7	Very broad (>3.5 mm)- 9				
31.	Decorticated grain: length	Short (<5.51mm)- 1	Medium (5.51- 6.60 mm)- 3	Long (6.61- 7.50 mm)- 5	Extra long (>7.51mm)- 9					
32.	Decorticated grain: width	Narrow (<2.0 mm)- 3	Medium (2.0-2.5 mm)- 5	Broad (>2.5 mm)- 7						
33.	Decorticated grain: shape	Short slender- 1	Short bold- 2	Medium slender- 3	Long bold- 4	Long slender - 5	Extra long slender- 6			
34.	Decorticated grain: colour	White- 1	Light brown - 2	Variegated brown- 3	Dark brown- 4	Light red- 5	Red- 6	Variegated purple- 7	Purple- 8	Dark purple- 9
35.	Decorticated grain: aroma	Absent- 1	Present- 9							

Table 3. Characterization of the aromatic rice germplasm as per DUS guidelines.

S. N.	Germplasm	Characters/ Descriptors a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	Y	z	aa	ab	ac	ad	ae	af	ag	ah	ai
1.	RAU 3043	1	7	9	1	9	3	1	5	3	3	9	1	5	1	1	9	5	3	3	5	9	8	5	2	5	7	4	3	3	3	1	3	3	1	9
2.	Maguraphulla	1	5	9	1	9	3	1	7	1	9	3	5	7	1	1	9	3	7	3	3	1	-	-	2	5	7	1	3	3	3	1	5	2	1	9
3.	Kanikabhog	1	5	9	1	9	3	1	7	3	3	3	1	7	1	1	7	5	5	5	2	1	-	-	2	5	7	1	5	1	3	1	3	3	1	9
4.	Kapoor Kranti	1	5	9	1	9	3	1	5	3	5	9	1	7	1	1	7	5	5	3	5	1	-	-	2	7	7	4	5	1	3	1	5	2	1	9
5.	Adam Chini B	1	5	9	1	9	3	1	7	3	3	9	1	7	1	1	5	3	5	5	5	1	-	-	2	3	7	4	3	1	3	1	3	3	1	9
6.	Kanak Jeer	2	7	9	1	9	3	1	3	3	7	9	1	7	1	1	9	5	7	3	6	9	9	5	1	7	7	4	3	3	3	1	5	3	1	9
7.	Bhanta Phool A	1	5	9	1	9	3	1	5	3	3	9	1	7	1	1	9	5	3	3	6	1	-	-	2	3	7	4	3	3	3	1	5	2	1	9
8.	Kamini Joha	1	3	9	1	9	3	1	7	3	5	1	1	5	1	1	7	3	7	5	2	1	-	-	2	3	7	1	1	3	3	1	3	2	1	9
9.	Bindli	1	5	9	1	9	3	1	5	3	5	1	1	5	1	1	7	3	5	3	4	9	4	5	1	7	7	2	5	3	5	1	5	2	1	9
10.	Banspatri	1	7	9	1	9	3	1	5	1	5	9	1	1	1	1	5	3	7	5	5	9	8	5	2	5	7	4	3	3	3	1	3	1	1	9
11.	Shyamjeera	1	7	9	1	9	3	1	7	1	3	1	1	3	1	1	5	1	5	3	1	9	1	5	2	7	7	1	3	3	5	3	5	3	2	9
12.	Lectimachi	1	3	9	1	9	3	1	7	3	5	5	5	1	1	1	7	3	3	5	5	1	-	-	2	3	5	1	1	1	3	1	5	2	1	9
13.	Tarunbhog	1	3	9	1	9	3	1	7	1	7	1	1	3	1	1	5	1	5	3	2	1	-	-	2	3	7	1	3	3	5	1	5	2	1	9
14.	Neelabati	1	7	9	1	9	3	1	7	3	3	9	1	7	1	1	9	7	5	5	6	1	-	-	2	5	7	4	1	1	3	1	3	2	1	9
15.	Kalikhasa	1	3	9	1	9	3	1	7	3	3	9	1	3	1	1	7	3	7	5	6	1	-	-	2	5	7	4	3	1	3	1	5	2	1	9
16.	PDKV Shriram	1	7	9	1	9	3	1	7	1	3	1	1	5	1	1	5	1	5	3	2	1	-	-	2	7	7	1	1	3	3	1	3	1	2	9
17.	Dhanaprasad	1	7	9	1	9	3	1	5	3	1	1	1	5	1	1	9	5	7	3	5	9	8	1	2	3	7	1	3	3	3	1	3	3	1	9
18.	Kalimooch	1	3	9	1	9	3	1	5	1	7	1	1	5	1	1	9	3	7	3	2	9	1	5	1	5	7	1	5	3	3	1	3	3	1	9
19.	Ayepyaung	1	7	9	1	9	3	1	7	1	5	1	1	1	1	1	7	3	5	3	2	1	-	-	2	7	7	1	5	3	3	3	5	3	1	9
20.	Binirhen	1	3	9	1	9	3	1	3	3	7	1	1	1	1	1	7	3	3	3	1	1	-	-	2	3	5	1	5	3	3	1	5	3	2	9
21.	Bong Cay	1	5	9	1	9	3	1	9	1	5	1	1	7	1	1	5	3	3	3	1	1	-	-	2	3	5	1	3	3	3	1	5	3	1	9
22.	Daw Leuang	1	5	9	1	9	3	1	7	1	5	3	1	7	1	1	5	1	3	3	2	1	-	-	2	3	7	1	5	3	3	3	5	3	1	9
23.	Guinata	1	7	9	1	9	3	1	5	3	3	7	1	3	1	1	7	3	3	3	5	1	-	-	2	5	7	3	5	3	3	1	3	1	1	9
24.	Hung-mi-hsiang-ma-tsan	2	5	9	2	9	3	1	7	3	9	1	5	3	9	1	5	5	3	5	4	1	-	-	1	5	7	1	5	3	5	1	5	2	6	9
25.	Hawm Jan	4	7	9	3	9	3	3	3	1	3	5	5	1	1	9	5	1	7	3	4	1	-	-	2	3	7	3	5	3	3	1	3	3	1	9
26.	Lua Nhe Den	1	5	9	1	9	3	1	5	1	7	1	1	5	1	1	9	5	5	3	1	9	1	5	2	5	7	1	5	3	3	1	5	2	1	9
27.	Longku Labat	1	3	9	1	9	3	1	5	3	5	1	1	7	1	1	7	5	3	5	1	1	-	-	1	5	7	1	5	3	5	1	3	3	2	9
28.	Niaw Hawn Mali	2	3	9	2	9	3	1	5	1	5	7	1	5	9	9	7	7	5	3	5	1	-	-	2	3	7	3	5	3	5	1	5	2	1	9
29.	Popot	1	7	9	1	9	3	1	5	3	5	7	1	1	1	1	7	5	5	3	5	1	-	-	2	7	7	3	5	3	3	1	5	2	1	9
30.	Improved Sarbati	1	7	9	1	9	3	1	3	3	7	1	1	1	1	1	7	5	3	5	1	1	-	-	1	5	7	1	5	5	3	9	3	6	1	9
31.	Laldhan	1	3	9	1	9	3	1	3	3	7	7	1	3	1	1	7	3	7	3	4	1	-	-	2	3	7	3	5	5	3	9	3	6	5	9
32.	Basmati 386	1	5	9	1	9	3	1	5	3	5	1	1	5	1	1	7	3	7	5	2	1	-	-	1	3	7	1	5	5	3	9	3	6	1	9
33.	Ranbir Basmati	1	5	9	1	9	3	1	3	3	3	1	1	3	1	1	7	5	5	3	2	9	2	5	1	7	7	1	5	5	3	5	3	5	1	9
34.	Basmati 564	1	3	9	1	9	3	1	3	3	5	1	1	3	1	1	7	5	5	5	2	9	1	5	1	5	7	1	5	7	3	9	3	6	1	9
35.	Chimbalate Basmati	3	7	9	1	9	3	2	3	3	7	1	1	3	1	1	7	5	7	5	5	9	2	5	1	5	7	1	5	5	3	5	3	5	1	9
36.	Basmati 217	1	7	9	1	9	3	1	5	3	5	1	1	5	1	1	9	3	5	3	2	9	2	5	2	5	7	1	5	7	3	9	3	6	1	9
37.	Taroari Basmati	1	7	9	1	9	3	1	5	3	7	1	1	5	1	1	9	3	7	5	1	9	2	5	1	5	7	1	7	7	3	9	3	6	1	9
38.	Basmati Bahar	1	5	9	1	9	3	1	3	3	7	1	1	3	1	1	7	5	5	5	1	9	1	5	2	7	7	1	5	5	3	9	3	6	1	9
39.	Karnal Local	1	5	9	1	9	3	1	5	3	5	1	1	5	1	1	7	5	5	5	3	9	1	5	1	5	7	1	5	7	3	9	3	6	1	9
40.	Basmati Type 3	1	5	9	1	9	3	1	3	1	3	1	1	5	1	1	7	3	3	5	2	9	2	5	1	3	7	1	5	5	3	5	3	5	1	9
41.	Basmati 370	1	7	9	1	9	3	1	3	3	3	5	1	5	1	1	9	5	5	3	3	9	2	5	2	7	7	1	5	5	3	5	3	5	1	9
42.	Basmati 6141	1	7	9	1	9	3	1	3	3	5	1	1	5	1	1	9	5	7	3	2	9	2	5	1	3	7	1	5	5	3	5	3	5	1	9
43.	Basmati Mahan	1	5	9	1	9	3	1	3	1	7	1	1	5	1	1	7	3	3	3	1	1	-	-	2	3	7	1	3	5	3	5	3	6	1	9
44.	Basmati 5874	1	7	9	1	9	3	1	3	1	7	3	1	3	1	1	7	1	5	3	2	1	-	-	2	5	7	1	5	5	3	9	3	6	6	9

Contd.

45.	Basmati 11	1	5	9	1	9	3	1	5	1	3	1	1	1	1	1	5	3	3	3	2	9	1	1	2	3	5	1	7	5	3	9	3	6	1	9
46.	HBC 46	1	7	9	1	9	3	1	3	3	5	1	1	7	1	1	9	5	5	3	1	9	2	5	1	7	7	1	5	5	3	9	3	6	1	9
47.	Haryana Basmati 1	1	3	9	1	9	3	1	5	1	5	1	1	1	1	1	7	1	7	5	1	9	1	5	2	3	5	1	5	7	3	9	3	6	1	9
48.	Mahisugandha	1	7	9	1	9	3	1	3	1	5	1	3	1	1	1	7	1	7	3	1	1	-	-	2	3	7	1	5	5	3	5	3	5	1	9
49.	Pusa Basmati 1	1	7	9	1	9	3	1	3	1	3	1	1	1	1	1	7	1	5	3	1	9	1	5	2	3	7	1	5	7	3	9	3	6	1	9
50.	Pusa Basmati 1121	1	5	9	1	9	3	1	5	1	5	1	1	1	1	1	7	3	5	5	1	9	1	1	1	7	7	1	5	7	3	9	3	6	2	9
51.	Yamini	1	5	9	1	9	3	1	5	1	3	1	1	3	1	1	7	3	3	5	1	9	1	5	1	3	7	1	7	7	3	9	3	6	1	9
52.	Vasumati	1	3	9	1	9	3	1	3	1	7	1	1	1	1	1	7	1	5	3	1	9	1	5	2	7	7	1	5	5	3	9	3	6	1	9
53.	Improved Pusa Basmati 1	1	7	9	1	9	3	1	5	1	5	1	1	1	1	1	7	1	3	3	1	9	1	5	2	5	7	1	5	7	3	9	3	6	1	9
54.	Kasturi	1	7	9	1	9	3	1	3	1	7	1	1	1	1	1	9	1	5	3	1	9	1	5	2	7	7	1	5	5	3	5	3	5	1	9
55.	UPR 3565-10-1-1	1	5	9	1	9	3	1	3	1	9	1	1	1	1	1	7	3	5	3	1	1	-	-	2	7	7	1	5	7	3	9	3	6	2	9
56.	UPR 2828-7-2-1	1	5	9	1	9	3	1	3	1	1	1	1	3	1	1	7	3	7	3	1	9	1	1	2	7	7	1	5	7	3	9	3	6	1	9
57.	IET 18033	1	3	9	1	9	3	1	3	1	7	1	1	3	1	1	7	3	5	5	1	9	1	1	2	7	7	1	5	7	3	9	3	6	1	9
58.	KDML 105	1	7	9	1	9	3	1	7	3	7	1	1	7	1	1	7	3	3	5	1	1	-	-	2	3	7	1	5	7	3	9	3	6	1	9
59.	Domsaih	1	5	9	1	9	3	1	3	1	5	1	1	3	1	1	7	3	7	3	1	1	-	-	2	5	7	1	7	7	3	9	3	6	1	9
60.	IR 62873-227-1-16	3	7	9	2	9	3	2	3	1	9	1	5	1	9	9	5	3	5	5	3	9	2	5	2	7	7	1	3	5	1	9	3	6	1	9
61.	IR 62873-238-2-3	3	7	9	2	9	3	1	3	3	3	5	5	1	1	1	7	5	7	3	5	1	-	-	2	9	7	1	5	7	3	9	3	6	1	9
62.	Hasan Serai	1	5	9	1	9	3	1	3	3	9	1	1	5	1	1	7	3	7	3	1	9	1	5	2	7	7	1	5	5	3	9	3	6	1	9
63.	IR 75428-6-3	1	5	9	1	9	3	1	3	3	7	1	1	5	1	1	7	5	3	3	1	1	-	-	2	7	7	1	3	5	3	9	3	6	1	9
64.	Bas 867	1	3	9	1	9	3	1	3	1	3	1	1	1	1	9	7	3	5	5	2	1	-	-	2	3	7	1	5	5	3	5	3	5	1	9

Basal leaf: sheath colour- a, Leaf: pubescence of blade surface- b, Leaf: auricles- c, Leaf: anthocyanin colouration of auricles- d, Leaf: ligule- e, Leaf: shape of ligule- f, Leaf: colour of ligule- g, Days to 50% flowering (days)- h, Flag leaf: attitude of blade (early observation)- i, Spikelet: density of pubescence of lemma-j, Lemma: anthocyanin colouration of apex- k, Spikelet: colour of stigma- l, Stem: length (excluding panicle)- m, Stem: anthocyanin colouration of nodes- n, Stem: anthocyanin colouration of internodes- o, Panicle: length of main axis- p, Flag leaf: attitude of blade (late observation)- q, Panicle: curvature of main axis- r, Panicle: number per plant- s, Spikelet: colour of tip of lemma- t, Panicle: awns- u, Panicle: colour of awns- v, Panicle: distribution of awns- w, Panicle: secondary branching- x, Panicle: attitude of branches- y, Panicle: exertion- z, Sterile lemma: colour- aa, Grain: weight of 1000 fully developed grains- ab, Grain: length- ac, Grain: width- ad, Decorticated grain: length- ae, Decorticated grain: width- af, Decorticated grain: shape- ag, Decorticated grain: colour- ah, Decorticated grain: aroma- ai

sheath colour, ligule colour, auricle colour, awning, awn colour and stigma colour showed no difference among accessions. The current results are also supported by the findings of Parikh *et al.* (2012) who characterized seventy one aromatic rice accessions for twelve morphological characters and found a wide range of variability for all the morphological traits studied. Out of twelve morphological characters, basal leaf sheath colour, leaf blade colour, ligule colour, plant habit, apiculus colour and awning showed high variation among the accessions and the rest of the six characters found in each of two classes among different accessions. The findings of Subba Rao *et al.* (2013) further strengthen current results. They characterized sixty five landraces of rice for forty three characters and found thirty two distinct landraces on the basis of twenty two essential and twenty four additional characters. Similarly, the findings of Sinha *et al.* (2015) also give support to our results. Sinha *et al.* (2015) characterized fifty five traditional rice varieties for the grain morphological traits and reported a wide variation for grain size and shape, anthocyanin colouration of lemma-palea and kernel, presence or absence of aroma and awning characteristics.

Thus, characterization is an important prerequisite to evaluate phenotypic diversity within germplasm collection. It creates the basis to ensure effective utilization of the crop germplasm by both farmers and breeders otherwise unevaluated germplasm remain mere curiosities to the breeding programmes.

Conclusion

The present study concluded that all sixty four accessions were found to be distinct on the basis of thirty one agro-morphological and quality traits. Majority of the accessions had green basal leaf: sheath colour, colourless leaf: anthocyanin colouration of auricles, white leaf: colour of ligule, semi-erect flag leaf: attitude of blade in early and late observation, white colour of stigma, absence of stem: anthocyanin colouration of nodes and internodes, few panicle: number per plant, white spikelet: colour of tip of lemma, yellowish white panicle: colour of awns, whole length distribution of awns, strong panicle: secondary branching, well exerted panicle: exertion, straw sterile lemma: colour, medium thousand grain weight, extra long slender decorticated grain: shape and white decorticated grain: colour. Improvement of commercial status and preservation of biodiversity present among such indigenous and exotic aromatic rice is also linked to the conservation of the long heritage associated with it. Accessions having short stem length, very long panicle length, more number of panicle per plant, and extra long slender grain may be used as potential donor in hybridization programmes. Therefore, this study will be useful for breeders, researchers and farmers to identify and choose the restoration and conservation of beneficial genes for crop improvement.

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