

## Varietal Characterization of Rice (*Oryza sativa* L.) based on Morphological Descriptors

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**ABSTRACT** Nineteen varieties of rice (*Oryza sativa* L.) belonging to non-basmati and basmati group were characterized based on fifty-two morphological descriptors at different stages of plant growth. The present experimental material possessed considerable variability and heritability coupled with moderate to high genetic advance for most of the morphological traits, thus signifying their utility in the varietal characterization. Although the cultivars showed overlapping of descriptor expression in various combination traits, still the identity of all the cultivars in non-basmati as well as basmati group could be established individually and could thus, be helpful for the registration/protection of these varieties.

Key words: morphological characterization, varietal characterization, rice

Intellectual Property Rights (IPR) system was internationalized in 1887 by the enactment of Paris Convention. However, agriculture was kept out of the purview of this system. Arguments specifically on Plant Breeders' Rights (PBRs) were made in the first quarter of the 20<sup>th</sup> Century from Netherlands (1919) [1] and USA (1931) [2]. First independent and complete IPR statute for plant varieties was passed in Netherlands in 1941, which came to be known as Plant Breeders' Decree (PBD). Nevertheless, this process got the required impetus through the UPOV (Union pour la Protection des Obtentions Vegetales) convention in 1961 and later through the introduction of IPRs in agriculture under TRIPs through GATT (General Agreement on Trade and Tariff) in 1991. The GATT was transformed into permanent World Trade Organization (WTO) in 1994. Under TRIPs, it was made necessary to have some form of IPRs for plants either as patent or an effective *sui-generis* system such as PBRs. India ratified the agreement on TRIPs and the Presidential Ordinance was issued in 1994 amending the Indian Patent Act of 1970 and extending it to include agriculture; and also permitting patenting of products. The Bill on IPR was passed in 2001 as "Protection of Plant

Varieties and Farmers' Rights Act" (PPV & FRA) 2001 which envisages that the new and notified/extant plant varieties will be registered and protected on the basis of their morphological characters i.e. Distinctness (D), Uniformity (U) and Stability (S) - [DUS]. Thus, it has become necessary for all the organizations to document and characterize all the notified/extant varieties that are in active commerce in their territories. Under present study, therefore, nineteen rice varieties cultivated in Punjab were characterized as per the National Test Guidelines.

### MATERIALS AND METHODS

Breeders' seed of 19 varieties of rice belonging to non-basmati (Pusa 44, Jaya, IR 8, PR 106, PR 108, PR 109, PR 110, PR 111, PR 113, PR 114, PR 115, PR 116 and PR 118) and basmati group (Basmati 370, Basmati 385, Basmati 386; Pusa Basmati-1, Pusa sugandh-2 and Superbasmati) was procured from the Breeder Seed Production unit of PAU, Ludhiana and raised at the Seed Technology Farm in plot size of five rows with each row of 5 meter length. Row to row and plant-to-plant spacing was maintained at 20 x 15 cm during *kharif* 2004 and

2005. The material was replicated twice and all the recommended agronomic practices were followed to raise a good crop. Ten competitive plants were randomly selected from each genotype in each replication to record the data. National DUS Test Guidelines [3] were followed beginning from the trial layout to recording of the last field-related observation. As per the guidelines, fifty-two morphological characters were recorded in rice material at different stages of plant growth.

Twenty days old seedlings were observed for coleoptile colour (colourless, green, purple) and plants were examined for different morphological characters during different growth stages in the field. At booting stage, leaf and leaf sheath characters like anthocyanin colouration, its distribution and intensity along with presence or absence of auricles, collar, ligule and attitude of culm were recorded. Quantitative characteristics viz. length and width of leaf blade were also measured at booting stage. Number of days taken by 50 per cent plants in each replication from sowing to flowering was recorded. The attitude of flag leaf blade and anthocyanin colouration of keel and apex along with colour of stigma was recorded at anthesis stage. The stem length i.e. length of the main stem from the ground level to the panicle node was recorded during milk stage. Furthermore, the thickness of the stem and anthocyanin colouration of nodes and internodes was also recorded at the same stage. All the panicle characters viz. exertion, presence or absence of secondary branching; awn characters like distribution, colour, length; colour of lemma and palea; and panicle number per plant were recorded after the terminal spikelets ripened. When the caryopsis became hard i.e. could no longer be dented by thumbnail, the leaf senescence and colour of sterile lemmas were recorded. The grain characters viz. weight of 1000 fully developed grains, grain length, width, shape, colour and aroma were recorded after harvest.

Besides identifying the characters helpful in grouping of varieties, the year-wise analysis followed by pooling of data was done to assess the extent of genetic variability for the 11 metric traits studied. The heritability estimates coupled with expected genetic advance indicate the mode

of gene action in the expression of a trait. Hence, the replicated mean values were used to compute genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability per cent ( $h^2_{gr}$ ) and genetic advance (GA%), following the method suggested by Johnson *et al.* [4].

## RESULTS AND DISCUSSION

In the present study, fifty-two morphological descriptors (forty-one qualitative and eleven quantitative) were used for varietal characterization. Out of qualitative characters studied, twelve characters were observed to be polymorphic in nature (Table 1), hence, indicating their potential for varietal identification.

The pooled analysis for the 11 metric traits (Table 2) revealed highly significant differences among the genotypes for all the traits under study, thus, underlining the genetic divergence of the experimental material. Furthermore, the expression of stem length and grain characters viz. 1000-grain weight, length and width was found to be stable in both the seasons in all the cultivars, thereby, emphasizing their consistency. Also, relatively low magnitude of difference between PCV and GCV for these four traits (Table 3) indicated less environmental influence in their expression. This result was in close agreement with the findings of Sharma and Dubey [5], Borbora and Hazarika [6] and Verma *et al.* [7].

High heritability and genetic advance (GA) was observed for length (99.35; 63.20) and width (97.09, 54.80) of leaf blade and stem length (99.93, 62.78) (Table 3), indicating substantial proportion of additive genetic variation in the expression. However, high heritability (98.96 to 99.98) and moderate GA (18.11 to 29.43) for days to heading, panicle length, grain characters viz. 1000 grain weight, length and width of grain as well as that of decorticated grain indicates equal importance of both additive and non-additive gene effects in the inheritance of these traits. Similar results have also been reported by Verma *et al.* [7] and Ganesan and Subramanian [8] in rice.

However, relatively higher magnitude of difference between PCV (14.47) and GCV (10.48) values for panicle number per plant indicated more

Table 1. Polymorphic characters and their state of expression

S.No.	Varieties	Characters																							
		1	2	3	4	5	6	7	8	9	10	11	12												
1	Pusa 44	Leaf: Intensity of green colour	Medium	Leaf: Pubescence of blade surface	Absent	Panicle: Curvature of main axis	Drooping	Panicle: Colour of awns	Not applicable	Panicle: Awns	Absent	Panicle: Length of longest awn	Not applicable	Panicle: Distribution of awns	Not applicable	Panicle: Attitude of branches	Semi erect	Panicle: Exsertion	Exserted	Leaf: Senescence	Late	Decorticated grain: shape	Medium medium	Decorticated grain: aroma	Absent
2	Jaya	Medium	Strong	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Late	Late	Medium medium	Absent	Absent		
3	IR 8	Medium	Absent	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Inter-mediate	Inter-mediate	Medium medium	Absent	Absent		
4	PR106	Medium	Weak	Drooping	Yellowish white	Present	Drooping	Yellowish white	Not applicable	Present	Very short	Very short	Tip only	Tip only	Semi erect	Exserted	Exserted	Late	Late	Long slender	Long slender	Absent	Absent		
5	PR 108	Medium	Absent	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Inter-mediate	Inter-mediate	Long slender	Long slender	Absent	Absent		
6	PR 109	Medium	Medium	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Inter-mediate	Inter-mediate	Long slender	Long slender	Absent	Absent		
7	PR 110	Medium	Medium	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Inter-mediate	Inter-mediate	Long slender	Long slender	Absent	Absent		
8	PR 111	Light	Absent	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Inter-mediate	Inter-mediate	Long slender	Long slender	Absent	Absent		
9	PR 113	Medium	Weak	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Inter-mediate	Inter-mediate	Long slender	Long slender	Absent	Absent		
10	PR 114	Dark	Absent	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Late	Late	Long slender	Long slender	Absent	Absent		
11	PR 115	Medium	Absent	Drooping	Yellowish white	Present	Drooping	Yellowish white	Not applicable	Present	Short	Short	Tip only	Tip only	Semi erect	Exserted	Exserted	Inter-mediate	Inter-mediate	Long slender	Long slender	Absent	Absent		
12	PR 116	Medium	Absent	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Inter-mediate	Inter-mediate	Long slender	Long slender	Absent	Absent		
13	PR 118	Medium	Absent	Drooping	Not applicable	Absent	Drooping	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Late	Late	Medium slender	Medium slender	Absent	Absent		
14	Basmati 370	Medium	Weak	Deflexed	Not applicable	Absent	Deflexed	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Spreading	Well exserted	Well exserted	Inter-mediate	Inter-mediate	Long slender	Long slender	Present	Present		
15	Basmati 385	Medium	Absent	Deflexed	Not applicable	Absent	Deflexed	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Spreading	Well exserted	Well exserted	Inter-mediate	Inter-mediate	Long slender	Long slender	Present	Present		
16	Basmati 386	Medium	Absent	Deflexed	Yellowish white	Present	Deflexed	Yellowish white	Not applicable	Present	Short	Short	Tip only	Tip only	Spreading	Exserted	Exserted	Inter-mediate	Inter-mediate	Extra long slender	Extra long slender	Present	Present		
17	Pusa Basmati 1	Dark	Absent	Deflexed	Yellowish white	Present	Deflexed	Yellowish white	Not applicable	Present	Very short	Very short	Whole length	Whole length	Spreading	Exserted	Exserted	Inter-mediate	Inter-mediate	Extra long slender	Extra long slender	Present	Present		
18	Pusa Sugandh 2	Medium	Weak	Deflexed	Not applicable	Absent	Deflexed	Not applicable	Not applicable	Absent	Not applicable	Not applicable	Not applicable	Not applicable	Semi erect	Exserted	Exserted	Inter-mediate	Inter-mediate	Extra long slender	Extra long slender	Present	Present		
19	Super Basmati	Medium	Absent	Deflexed	Yellow brown	Present	Deflexed	Yellow brown	Not applicable	Present	Very short	Very short	Tip only	Tip only	Spreading	Exserted	Exserted	Inter-mediate	Inter-mediate	Extra long slender	Extra long slender	Present	Present		

Table 2. Means of traits for the 19 rice varieties

Variety	Length of leaf blade (cm)	Width of leaf blade (cm)	Time of heading (days)	Stem: length (cm)	Panicle: length of main axis (cm)	Panicle: no./ plant	1000 grain weight (gm)	Grain length (mm)	Grain width (mm)	Decorticated grain length (mm)	Decorticated grain width (mm)
Pusa 44	29.25	0.95	130	78.00	25.50	13.0	22.5	8.3	2.3	6.5	2.2
Jaya	27.50	0.90	114	67.00	24.60	12.0	26.6	8.9	3.0	6.5	2.5
IR8	27.25	0.86	114	68.65	24.65	11.5	25.1	9.2	3.0	6.5	2.5
PR 106	27.00	0.82	114	71.85	23.90	11.0	21.9	9.0	2.4	6.8	1.9
PR 108	29.40	0.92	111	73.65	25.70	12.5	19.4	9.3	2.2	6.6	1.8
PR 109	34.70	1.60	105	64.15	26.20	13.5	22.0	8.7	2.6	6.8	2.1
PR 110	41.90	1.55	114	63.15	30.80	12.5	18.5	9.6	2.1	7.0	1.8
PR 111	29.60	0.90	105	59.00	25.60	12.5	20.8	9.2	2.1	7.3	1.7
PR 113	30.50	0.87	110	59.50	26.55	12.0	29.0	8.5	2.9	6.5	2.2
PR 114	31.20	0.88	115	68.00	24.60	11.5	21.2	9.5	2.2	7.4	1.8
PR 115	32.25	0.96	91	59.60	24.65	12.5	20.8	8.9	2.0	6.8	2.0
PR 116	32.25	0.94	114	73.70	22.45	12.5	23.7	9.2	2.3	6.8	2.0
PR 118	28.80	0.95	128	78.70	25.50	12.5	22.7	8.7	2.3	6.5	1.8
Basmati 370	57.15	1.05	105	135.01	31.45	11.0	20.6	9.5	2.1	6.9	1.7
Basmati 385	61.05	1.15	96	125.50	30.75	9.0	20.5	9.1	2.1	6.9	1.6
Basmati 386	58.90	0.97	110	137.70	31.04	10.3	24.2	10.6	2.1	7.9	1.8
Pusa Basmati 1	37.40	0.91	107	86.50	33.30	12.0	20.8	10.6	2.1	8.1	1.6
Pusa Sugandh 2	41.20	1.85	90	83.05	29.50	11.0	25.8	11.3	2.1	8.7	2.2
Superbasmati	52.10	1.25	103	97.36	32.72	12.0	21.4	11.1	2.2	7.7	1.7
CD (5%)	1.43	1.43	2.29	1.76	1.49	1.78	0.09	0.06	0.06	1.49	1.43

Table 3. Genetic parameters for 11 metric traits

Characters	PCV	GCV	h <sup>2</sup> %	GA%
Length of leaf blade	30.88	30.78	99.35	63.20
Width of leaf blade	27.40	27.00	97.09	54.80
Time of heading	09.43	09.40	99.67	19.37
Stem: length	30.50	30.49	99.93	62.78
Panicle: length	12.31	12.25	99.02	25.12
Panicle: number per plant	14.77	10.48	50.31	15.31
1000 grain weight	11.79	11.79	99.98	24.28
Grain length	09.10	09.10	99.88	18.73
Grain width	14.15	14.14	98.96	28.84
Decorticated grain length	08.81	08.76	99.83	18.11
Decorticated grain width	14.40	14.34	99.23	29.43

Where: PCV - Phenotypic coefficient of variation; GCV - Genotypic coefficient of variation; h<sup>2</sup>% - Heritability per cent; GA% - Genetic advance

environmental influence in its expression. Furthermore, moderate heritability (50.31) and low GA (15.31) indicated preponderance of non-additive gene effects, thus, revealing the inconsistent behaviour of the character and thereby limiting its scope for establishing varietal distinctness. In nutshell, the present experimental material possessed considerable variability and heritability coupled with moderate to high genetic advance for all the morphological characters except panicle number per plant, thus emphasizing their utility in the characterization of rice varieties.

A major objective of cultivar characterization is to establish the distinctness among varieties so that official regulatory bodies have a basis on which they can assign rights and protect the financial interests of plant breeders. Based on the variation observed on diagnostic characters, thirteen cultivars of non-basmati group could be categorized into three subgroups on the basis of time of heading i.e. early (<105 days), medium (105-115 days) and late (>115 days). The varieties PR 109, PR 111 and PR 113 were classified into earlier group whereas Pusa 44 and PR 118 into the late group and rest of the varieties into the medium group. Further, within the early group, PR 111 and PR 115 had shorter (~59.00 cm) stem length than PR 109 (64.15 cm). The former two could further be differentiated on the basis of length of main axis of the panicle: being longer in PR 111 than PR 115.

Within the medium group, the three varieties viz. PR 106, PR 108 and PR 116 were taller (>70 cm) than the rest. Out of these three, length of main axis of panicle was longer in PR 108 (25.90 cm) than PR 106 (23.90 cm) and PR 116 (22.45 cm). Further, PR 106 was awned as compared to awnless PR 116. The intensity of green colour of leaf and length of the decorticated grain were the other useful diagnostic characters, which could distinguish the remaining varieties. Within the late group, Pusa 44 had medium-medium grains whereas PR 118 had medium slender.

While distinguishing Basmati varieties, Pusa Sugandh 2, Basmati 385 and Superbasmati were categorized under the early flowering group (<105 days), whereas another group of Basmati 370, Basmati 386 and Pusa Basmati 1 (105-115 days)

was categorized into the medium group. Further, within the early group, Basmati 385 was taller (125.50 cm) than Pusa Sugandh 2 (83.05 cm) and Superbasmati (97.36 cm). Within the medium group, Pusa Basmati 1 was shorter (86.50 cm) than Basmati 370 (135.01 cm) and Basmati 386 (137.70 cm). Further, Basmati 370 had long slender grains as compared to extra long slender grains of Basmati 386.

Hence, the rice varieties used in the present study could be distinguished from each other and would thus, be helpful for registration and protection of these varieties. Similar attempts for establishing varietal distinctness have also been made in soybean [9], oats [10], rapeseed-mustard [11 and 12] and pearl millet [13].

In short, the cultivars in the present study showed overlapping of descriptor expression in various combination traits, but still the identity of all the cultivars in non-basmati as well as basmati group could be established individually.

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