

SHORT COMMUNICATION

Distinctiveness, Uniformity and Stability of Quantitative Characters of Traditional Rice (*Oryza sativa* L.) Cultivars of West Bengal

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Abstract

The traditional cultivars need to be collected, conserved, and characterized to identify the desirable characters for use in rice improvement programmes. In the present study, 38 traditional rice cultivars were characterized based on 18 quantitative traits, following the guidelines of the Protection of Plant Varieties and Farmers' Rights Act (PPV&FRA) for rice. In addition to those 18 characters, the yield potential of the traditional cultivars was also recorded. Quantitative characters showed highly significant variations among the cultivars. The cultivars were classified into different categories for each quantitative character. Many cultivars were identified with desirable trait(s) along with good yield potential. KNS-2-D-3-1, KNS-2-D-5-1, KNS-2-D-11, KNS-2-D-5 and Kataribhog had high yield potential with many other advantageous traits. This study will be beneficial for breeders in the selection of desirable cultivars for a specific trait. Utilizing this data, different cultivars can be protected under PPV&FRA (2001) and for the farmers, the outcome of research will be helpful to select the appropriate traditional cultivars that possess multiple desirable characters for direct cultivation. Based on this DUS characterization, 10 traditional cultivars, namely Biru, Lal Bhog, Desi Pizam, Dhariyal, Dungru, Gujri Nunia, Kaishali, Lal Khaiyam, Lal Manshra, Loha Swarna, Mala Sundari, Nageswari, Sugandhi Dhepi, and Swet Nunia, have been submitted to PPV&FRA for registration.

Keywords: Amylose content, DUS characterization, Grain shape, Traditional rice

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Introduction

The security of the long-standing practice of cultivation of traditional cultivars, which may have enormous potential for a donor of key traits, is now being threatened by the introduction of high-yielding varieties and improved cultivation practices. The Government of India enacted the Protection of Plant Varieties and Farmers' Rights Act, 2001 (PPV&FRA), to protect plant cultivars based on the Distinctiveness, Uniformity, and Stability (DUS) test. This unique and model Act treats farmers and breeders as partners in their efforts for sustainable food security. A number of processes are involved in the process of identifying a cultivar, including verification that the cultivar is unique from all others that are known to exist, purity of the cultivar, and characterization that lists all of its characteristics. For a cultivar to be classified as a unique entity, the concepts of distinctness, uniformity, and stability are essential. Many rice researchers used this guideline for characterization of the landraces (Surje *et al.*, 2022; Akshay *et al.*, 2022; Deepika and Devaraju, 2023; Shai Prasanna *et al.*, 2024; Ivin Subakar and

Anbuselvam, 2025), conservation through registration under PPV&FRA (Surje *et al.*, 2022; Roy *et al.*, 2022) and utilization of the characterized germplasm in rice improvement (Roy *et al.*, 2022; Roy *et al.*, 2025).

The country has a diverse range of indigenous cultivars and landraces farmed throughout various states. According to Shobha Rani and Krishnaiah (2001), each state has unique aromatic rice cultivars that thrive in its region. Improving these rice cultivars is often neglected due to their low export value. Various approaches are needed to establish the identity and distinctiveness of rice cultivars produced in India, particularly in North-eastern India (Talukdar *et al.*, 2012; Chakravorty and Ghosh, 2013; Surje *et al.*, 2022). Landraces and wild species have useful traits that can be used in breeding to create high-yielding rice cultivars that are resistant to biotic and abiotic challenges (Turkey *et al.*, 2013). Notably, most of the traditional cultivars are photoperiod-sensitive.

Modern rice cultivars are historically generated through selection, hybridization, and backcrossing with regionally adapted, high-yielding genotypes. The restricted number of paternal lines results in a narrow genetic base. Crops with high genetic uniformity may be more susceptible to epidemics. The genetic diversity of rice in our country is a key source for introducing new traits or developing new plant types (Roy *et al.*, 2022).

Quantitative phenotypes are often expressed with a wide range of variation. Those characters show continuous variations among the genotypes within a species. Study of numerical variations of genotypes of a species provides exact values of the range of variations, mean of the study materials and to identify the genotypes possessing the desirable values for a particular character in a collected germplasm. A collection has limited practical value unless it is correctly appraised (Chang, 1976). This study aims to define the collected traditional cultivars of rice available at the rice repository of the university and identify key features for varietal development by breeders, and recognise the significance of local landraces. With these objectives, 18 quantitative characters have been studied for the 38 traditional cultivars of rice.

Materials and Methods

Thirty-eight traditional genotypes were used in this study. Twenty-one cultivars were earlier obtained from Shri Sumanta Misra, Pandapara Kalibari village, Jalpaiguri district, West Bengal, one from Manipur and the remaining 16 were the pure lines isolated from Kalonunia (Geographical Indication, the Registration No: 743), a popular traditional aromatic rice of the

northern part of West Bengal. All these cultivars are maintained at the Rice Repository, Department of Seed Science and Technology, Uttar Banga Krishi Viswavidyalaya. A list of the 38 genotypes is given in Table 1.

Table 1: List of the traditional rice cultivars used in the study

Sl.No.	Name of Farmers' Cultivars	Collection place/ name of the seed provider
1.	Lal Khayiam	Shri Sumanta Misra
2.	Desi Paizam	Vill & P.O. Pandapara
3.	Sweet Nunia	Kalibari
4.	Biru	Jalpaiguri district
5.	Sweet Paizam	West Bengal
6.	Dalbhog	PIN 735132
7.	Malasundari	
8.	Kaishali Binni	
9.	Simabhog	
10.	Guyri Nunia	
11.	Loha Swarna	
12.	Swarnali	
13.	Binnafuli	
14.	Dhanraaj	
15.	Paddy Queen	
16.	Dungru	
17.	Sugandhi Dhepi	
18.	Kala Khayiam	
19.	Lal Manshar	
20.	Dhariyal	
21.	Nageswari	
22.	Chakhao Amubi	Manipur
23.	KNS-2-D-3	Rice Repository
24.	KNS-2-D-11	Department of Seed
25.	KNS-2-D-12	Science and Technology
26.	KNS-2-D-15	Uttar Banga Krishi
27.	KNS-2-D-9	Viswavidyalaya
28.	KNS-2-D-10	Pundibari, Cooch Behar
29.	KNS-2-2	736165, West Bengal
30.	KNS-2-2/2-3	
31.	KNS-2-1/2-3	
32.	KNS-2-D-5	
33.	KNS-2-D-4	
34.	KNS-2-D-5-1	
35.	KNS-2-D-3-1	
36.	KNS-2-1-6	
37.	KNS 2-3	
38.	Kataribhog	

The experiment was conducted during two consecutive *khari* seasons in 2022-23. Thirty-day-old seedlings were transplanted by maintaining row-to-row and hill-to-hill distances of 30 cm and 25 cm, respectively. For each cultivar, five rows (length 5.0 m) were transplanted. The standard agronomic practices (Roy, 2023) were followed, compatible with the Terai zone, in order to achieve a good crop stand and subsequently better grain yield. Following transplanting, a 4-6 cm thin layer of water was kept in the field to prevent the growth of weeds. Hand weeding was done as and when required. Pest and disease control was also followed as per requirement.

Observations

Observations on 18 quantitative characters were taken on 10 plants of each cultivar from each replication. Data were recorded following the descriptor of PPV&FRA (2007) on rice- "Guidelines for the Conduct of Test for Distinctiveness, Uniformity, and Stability on Rice". The data were recorded at different stages of plant growth with the appropriate procedures for the following characters. In addition to 18 DUS characters, the yield data of the cultivars were also recorded.

- i. **Length of leaf blade (cm):** The length of the leaf blade was determined by measuring it from the leaf collar to the leaf's apex. Leaf length was measured during the launching phase.
- ii. **Width of leaf blade (cm):** The width was measured at the widest point of the leaf blade. The leaf breadth was observed during the booting stage.
- iii. **Stem thickness (mm):** Stem thickness was measured on some individual stems during the milky stage. Stem thickness was measured using a digital Vernier calliper.
- iv. **Days to 50% flowering:** The time of heading was observed when half of the inflorescence emerged from the booting stage, and the observation was conducted through visual appraisal of a single plant group.
- v. **Days to maturity:** The time of maturity was observed during the ripening stage, when the terminal spikelets had ripened. The observation was conducted through visual assessment of a specific group of plants.
- vi. **Stem length (excluding panicle) (cm):** The stem thickness was measured on several individual stems during the milk development stage.
- vii. **Panicle length (cm):** The panicle's length was determined by measuring it from the base to the apex during the ripening stage, when the

terminal spikelets ripened.

- viii. **Number of panicles/per plant:** The number of panicles per plant was counted during the ripening stage.
- ix. **Length of longest awn (cm):** The length of awn was measured individually by a measuring scale during the maturation stage, when the terminal spikelets had ripened.
- x. **Test weight (g):** The observation was taken by measuring the weight of 1000 fully developed grains that had been desiccated to 13% moisture content at the caryopsis hard stage, as indicated by the fact that they could no longer be dented by a thumbnail and that over 90% of the spikelets had ripened.
- xi. **Grain yield (kg/ha):** Grain yield per plant was recorded for each cultivar, and it was converted to kg/ha.
- xii. **Grain dimension:** The grain length (mm) was measured from the base of the lowermost sterile lemma to the apex of the lemma, whichever is longer, measuring the longitudinal dimension from 10 well-developed grains. The grain width (mm) was determined by the distance between the lemma and the palea at the broadest point, or dorsiventral diameter, as measured from 10 grains.
- xiii. **Kernel (decorticated grain) length (mm):** The grain length was determined by measuring the longitudinal dimension from the base to the apex of 10 well-developed decorticated grains.
- xiv. **Kernel (decorticated grain) width (mm):** The grain width was determined by the dorsiventral diameter, which was measured from 10 decorticated grains and represented the distance across the kernel at the broadest point.
- xv. **Decorticated grain shape:** According to Ramaiah (1969), grains were classified into six categories based on their length and L:B ratio: short slender, short bold (SB) (SS), medium slender (MS), long slender (LS), long bold, and extra long slender (L:B). The classification detail is as follows:

Decorticated grain types	Decorticated grain length	L:B ratio
Short slender (SS)	>6 mm	≥3
Short bold (SB)	>6 mm	<2.5
Medium slender (MS)	>6 mm	2.5 - 3.0
Long slender (LS)	≥6 mm	≥3
Long bold (L:B)	≥6 mm	<3.0
Extra-long slender	≥7.5 mm	≥3

- xvi. Presence of amylose in endosperm:** Starch is composed of two components, such as amylose and amylopectin. Amylose is a linear polymer of glucose. The glucose units are joined by α -1-4-glucoside linkages. Amylose exists in a coil for and each coil contains six glucose residues. Iodine is adsorbed within the helical coils of amylose to produce a blue-coloured complex, which is measured colourimetrically. The simplified Juliano (1971) procedure was employed to assess the amylose content.
- xvii. Decorticated grain aroma:** Aroma was assessed following the procedure as outlined by Juliano (1971). Added 15 ml of water to 5 g of rice sample in a test tube (200 mm x 35 mm) and soaked for 10 minutes. The sample was cooked in the water bath for 15 minutes. Then the cooked rice was transferred into a petri dish. The cooked rice was cooled by keeping it in the refrigerator for 20 minutes. Then the petri-plates were opened and the contents were smelled. The samples possessing the scent, as one could easily feel, produce a sharp and readily recognizable aroma and the cultivars were classified as strongly aromatic, mildly aromatic and non-aromatic.

Results and Discussion

All the characters, namely length of leaf blade, width of leaf blade, stem thickness, days to 50% flowering, days to maturity, stem length (excluding panicle), length of main axis of panicle, number of panicles per plant, test weight, grain length, decorticated grain length, amylose content and yield per plant showed high significant variation among the traditional cultivars. However, grain width exhibited non-significant variation among the cultivars, and decorticated grain width had significant variation among the cultivars at 5% level.

Length of leaf blade

Length of leaf blade varied from 25.30 cm to 59.73 cm with a mean of 37.11 cm. Four traditional cultivars were found to have long leaf blades, 30 were classified as medium, and four cultivars were categorized as short (Table 2). Significant variation in the length of the leaf blade was also reported by Subudhi *et al.* (2012), Chakravorty and Ghosh (2012, 2013), Subba Rao *et al.*, (2013), Surje *et al.*, (2022), and Shai Prasanna *et al.*, (2024).

Table 2: Classification of traditional rice cultivars based on different agronomic characters

Sl.No.	Characters	Classes	Number	Frequency (%)
1.	Length of leaf blade	Short (30 cm)	04	10.53
		Medium (30-45 cm)	30	78.95
		Long (45 cm)	04	10.53
2.	Width of leaf blade	Narrow (1.0 cm)	24	63.16
		Medium (1-2 cm)	14	36.84
3.	Stem thickness	Thin (0.40 cm)	20	52.63
		Medium (0.40-0.55 cm)	16	42.11
		Thick (0.55 cm)	02	5.26
4.	Days to 50% flowering	Late (111-130 days)	16	42.11
		Very Late (130 days)	22	57.89
5.	Days to maturity	Late (141-160 days)	26	68.42
		Very Late (160 days)	12	31.58
6.	Stem length (excluding panicle)	Very short (91 cm)	01	2.63
		Short (91-100 cm)	05	13.16
		Medium (111-130 cm)	31	81.58
		Long (131-150 cm)	01	2.63
7.	Panicle length	Medium (21-25 cm)	14	36.84
		Long (25-30 cm)	15	39.47
		Very Long (30 cm)	09	23.68
8.	Number of panicles/plant	Few (11)	03	7.89
		Medium (11-20)	20	52.63
		Many (20)	15	39.47
9.	Length of the longest awn	Very short (\leq 0.9 cm)	06	31.58
		Short (1.0-1.90 cm)	07	36.84

		Medium (2.0-2.9 cm)	03	15.79
		Very Long (3.90 cm)	03	15.79
10.	Test weight	Very low (15 g)	07	18.42
		Low (15-20 g)	18	47.37
		Medium (21-25 g)	07	18.42
		High (25-30 g)	04	10.53
		Very high (30 g)	02	5.26

Width of leaf blade

The width of the leaf blade varied from 0.30 to 1.73 cm with a mean of 0.91 cm. As per the classification of PPV&FRA (2007), none of the cultivar's leaf width fell under the 'Broad' category (Table 2). Fourteen cultivars were categorized as medium, and 24 were classified as narrow. Earlier reports furthermore confirmed the existence of significant variation among the traditional cultivars of rice in respect of the width of the leaf blade (Subba Rao *et al.*, 2013; Surje *et al.*, 2022; Shai Prasanna *et al.*, 2024).

Stem thickness

Stem thickness varied from 0.18 cm to 0.62 cm with a mean of 0.37 cm. Only two cultivars were found to have 'thick' stems, nine were classified as 'medium', and 27 cultivars were categorized as 'thin' (Table 2). Stem thickness is an important parameter of rice plants to decide the lodging status of cultivars. Taller cultivars need to have a thicker stem to provide lodging tolerance. Many rice researchers (Chakrabarty *et al.*, 2012; Chakravorty and Ghosh, 2013; Surje *et al.*, 2022) have observed significant variation among the traditional cultivars of rice.

Days to 50% flowering

Days to 50% flowering varied from 126.00 to 137.50 days with a mean of 131.21 days. None of the cultivars fell under the categories, namely 'Very Early', 'Early' and 'Medium'. Sixteen cultivars were classified as 'Late'. The majority of the cultivars used in this experiment were identified as 'very late' (Table 2). Days to 50% is an imperative trait that makes a decision on the duration of the cultivar. For intensive and extensive cultivation, early cultivars are in favorite to increase the cropping intensity. However, in this study, none of the cultivars were categorized under 'Very Early', 'Early' and 'Medium'. Most of the cultivars were 'Late' or 'very late'. These results corroborate the findings of Subba Rao *et al.*, (2013), Surje *et al.*, (2018) and Surje *et al.*, (2022).

Days to maturity

Days to maturity ranged from 148.50 to 164.50 days with a mean of 157.59 days. None of the genotypes

categorized under 'Very Early', 'Early' and 'Medium' (Table 2). Twenty-six traditional cultivars were categorized as 'Late', and 12 were found to be 'Very Late'. Our study confirmed that most of the traditional cultivars were 'Late' and 'Very Late'. A similar study was made by Subba Rao *et al.*, (2013) and Surje *et al.* (2022).

Stem length (excluding panicle)

Stem length ranged from 50.66 to 100.30 cm with a mean of 78.32 cm. Only one cultivar, Swarnali, was recorded as very short (Table 2), and five genotypes were classified as 'Short'; the majority of the cultivars were categorized under the 'Medium' category. None was categorized under 'Very Long'.

Again, the stem length in equivalence with stem thickness is an important trait that makes a decision on tolerance or susceptibility towards lodging. In general, short to medium plant height is preferred as this makes all the intercultural activities. In addition, short height rice cultivars are usually considered as lodging resistant (Anna Durai *et al.*, 2015; Zhang *et al.*, 2016; Shah *et al.*, 2019). As per the findings of many rice workers, the stem length of most of the traditional cultivars was medium and long (Chakravorty and Ghosh, 2013; Surje *et al.*, 2022). However, Subba Rao *et al.*, (2013) and Gyathri *et al.*, (2023) found that nearly all of the traditional cultivars they studied fell under very short, short and medium categories.

Panicle length

Panicle length varied from 20.43 to 40.60 cm with a mean of 27.38 cm. None of the genotypes observed under the 'Very Short' and 'Short' categories (Table 2). Fourteen cultivars were recorded under 'Medium' class, 15 cultivars were classified as 'Long' and nine cultivars fell under 'Very Long' category.

Panicle length is a desirable yield-attributing character, and a longer panicle is preferred. Many rice workers established a positive correlation of panicle length with grain yield per plant in rice (Singh *et al.*, 2006; Senapati *et al.*, 2009; Roy, 2010; Rangare *et al.*, 2012). Very long panicles were observed for Kalojeera (Subba Rao *et al.*, 2013), Tulsimukul, Maitee, and Kagey (Surje *et al.*, 2022). The length of the main axis of the panicle of most of the traditional cultivars of rice

possessed medium length (Subba Rao *et al.*, 2013; Singh *et al.*, 2015; Gyathri *et al.*, 2023).

Number of panicles/plant

The number of panicles per plant ranged from 8.50 to 32.00 cm with a mean of 18.75 cm. It is an important yield-attributing character. Fifteen cultivars were classified under 'Many' (Table 2), and the majority of the cultivars were categorized under the 'Medium' category.

Most of the traditional cultivars had more than 11 panicles per plant. It showed that the traditional cultivars of rice have high tillering potential. Similar results were also reported by Chakrabarty *et al.*, (2012); Subba Rao *et al.*, (2013); and Surje *et al.*, (2022). The traditional cultivars that possessed less than 11 panicles per plant were also reported, such as Bahurupi, Bidan Sapru (Subba Rao *et al.*, 2013); Dhuladhan, Dahamagra, Sankarsal, Behalsal, Laldhusri, Nagra, Majhisal, Kalma, Sunga Nagra, Asanlaya (Chakravorty and Ghosh, 2012, 2013); Kranti, Heera (PPV&FRA, 2007).

Length of the longest awn

Out of 38 traditional cultivars, 19 were noted to have awn (Table 2). Those 19 cultivars were classified into different classes following the guidelines of PPV&FRA (2007). Six traditional cultivars were categorized as 'Very Short', seven cultivars were categorized as 'Short', three were classified as medium, and another three cultivars were classified as 'Very Long'.

Awn length exhibited continuous variation among the cultivars. Generally, the traditional cultivars bear awns at the tip of the lemma. Variation of the length of the awn was observed by several authors (Joshi *et al.*, 2011; Surje *et al.*, 2022). Presence of awn is a primitive character of rice and well adapted to adverse environmental factors, viz., drought, salinity and low temperature (Chandraratna, 1964).

Test weight

Test weight ranged from 10.50 to 30.30 g with a mean of 19.22 g. Only two cultivars had fallen under the 'Very High' category (Table 2). There were five genotypes under the 'High' category, seven cultivars were categorized under 'Low', 17 were classified under the 'Low' category, and seven cultivars showed very low test weight.

Test weight is also an important yield-attributing character. This character had a positive and highly significant correlation with grain yield (Senapati *et al.*, 2009; Roy, 2010; Rangare *et al.*, 2012). Traditional rice cultivars are in generally possess higher test weight. The

majority of our study materials had low test weights (15-20 g). These results corroborates the report of Gyathri *et al.*, (2023).

Table No. 3: Yield of traditional cultivars

Sr. No.	Cultivars	Grain yield (kg/ha)
1.	Lal Khayiam	4650
2.	Desi Paizam	3750
3.	Sweet Nunia	4500
4.	Biru	5250
5.	Sweet Paizam	7350
6.	Dalbhog	3600
7.	Malasundari	3930
8.	Kaishali Binni	2100
9.	Simabhog	3510
10.	Guyri Nunia	1650
11.	Loha Swarna	4800
12.	Swarnali	1350
13.	Binnafuli	3000
14.	Dhanraaj	4500
15.	Paddy Queen	1350
16.	Dungru	2400
17.	Chakhao Amubi	3000
18.	Sugandhi Dhepi	3630
19.	Kala Khayiam	3900
20.	Lal Manshar	6000
21.	Dhariyal	3690
22.	KNS-2-D-3	4200
23.	KNS-2-D-11	7050
24.	KNS-2-D-12	3750
25.	KNS-2-D-15	3600
26.	KNS-2-D-9	2910
27.	KNS-2-D-10	4290
28.	KNS-2-2	3360
29.	KNS-2-2/2-3	7410
30.	KNS-2-1/2-3	4350
31.	KNS-2-D-5	7380
32.	KNS-2-D-4	4800
33.	KNS-2-D-5-1	4980
34.	KNS-2-D-3-1	5250
35.	KNS-2-1-6	3690
36.	KNS 2-3	2190
37.	Nageswari	5790
38.	Kataribhog	5250
	■ Mean	4162.11
	■ Range	1350-7410

Grain yield

Grain yield ranged from 20.00 to 60.40 g/per plant with a mean of 38.75 g/per plant. The yield per plant had been converted to yield per hectare, considering

150000/plants per hectare. Some of the cultivars showed grain yield more than 6.00 t/ha (Table 3), namely KNS-2-2/2-3 (7410 t/ha), KNS-2-D-5 (7380 t/ha), Sweet Paizam (7350 t/ha), KNS-2-D-11 (7050 t/ha) and Lal Manshar (6000 t/ha). Some of the cultivars that had desirable yield performance were Nageswari (5790 t/ha), Biru (5250 t/ha), KNS-2-D-3-1 (5250 t/ha), Kataribhog (5250 t/ha), KNS-2-D-5-1 (4980 t/ha), Loha Swarna (4800 t/ha), KNS-2-D-4 (4800 t/ha), Lal Khayiam (4650 t/ha), Sweet Nunia (4500 t/ha), Dhanraaj (4500 t/ha), KNS-2-1/2-3 (4350 t/ha), KNS-2-D-10 (4290 t/ha) and KNS-2-D-3 (4200 t/ha).

Some of the cultivars had very low grain yield (Table 3), they were Swarnali (1350 t/ha), Paddy Queen (1350 t/ha), Guyri Nunia (1650 t/ha), Kaishali Binni (2100 t/ha), KNS 2-3 (2190 t/ha), Dungru (2400 t/ha) and KNS-2-D-9 (2910 t/ha).

Grain dimension

Grain length ranged from 5.61 to 10.11 mm with a mean of 7.55 mm. None of the cultivars were found under the 'Very Long' and 'Long' categories. Five cultivars were found to be in the 'Medium' group. The majority of the genotypes were categorized under 'Short' (Table 4). Only five cultivars were found in the 'Very Short' category.

Grain width varied from 1.96 to 3.26 mm with a mean of 2.41 mm. Only one cultivar had a grain width less than 2.00 mm and fell under the 'Very Narrow' category (Table 4). The majority of the cultivars had narrow grain width. There were 26 cultivars under the 'Narrow' group. Seven cultivars fall under the 'Medium' category. Only three cultivars were found in the 'Long' grain width class.

Kernel (decorticated grain) length

Decorticated grain length varied from 3.77 to 7.07 mm with a mean of 5.34 mm. As per the classification of PPV&FRA (2007), there are five states, namely 'Short', 'Medium', 'Long', 'Long (for Basmati Type)' and 'Extra Long'. However, Gyathri *et al.*, (2023) have classified them as 'Short (6.0 mm)', 'Medium' (6.1-8.5 mm), 'Long (8.6-10.5 mm)', 'Very Long (10.6-12.5 mm)' and 'Extra Long (12.5 mm)'. Neither of the classifications was felt suitable for our study materials. Therefore, we have classified the rice cultivars as 'Short (6.0 mm)', 'Long (6.0-6.6 mm)', 'Basmati Type (6.61-7.50 mm)', and 'Extra Long (7.5 mm)', keeping parity with the classification of grain shape under Sl. No. 56 of PPV&FRA (2007). None of the cultivars fell under the 'Extra Long' category (Table 4). Only two cultivars were classified under 'Basmati Type', and four cultivars were classified as 'Long'. The

remaining 32 cultivars were classified as 'Short'. A similar study was also carried out by Surje *et al.*, (2018).

Decorticated grain width varied from 1.77 to 2.89 mm with a mean of 2.10 mm. Fifteen cultivars showed decorticated grain width less than 2.0 mm, and they were categorized as 'Narrow'. Twenty cultivars were classified as the 'Medium' category (Table 4). There were only three cultivars under the 'Broad' category. A similar result was also noted by Surje *et al.*, (2022) and Gyathri *et al.*, (2023).

Decorticated grain L:B ratio

The L:B ratio of decorticated grain wide-ranging from 1.92 to 3.45. Two cultivars were categorized under 'Broad' (Table 4), 23 were found to aggregate under 'Medium' class, and 13 cultivars had a low L:B ratio.

Decorticated grain shape

Decorticated grain dimension (decorticated grain length and decorticated grain width) plays an important role in deciding the grain shape (Harberd, 2015; Li *et al.*, 2022). Furthermore, the shape of rice grains caters to consumers' preferences. In addition, the long slender grain rice cultivars are preferred by the consumers of the United States of America, Western Europe and most of the Asian countries like India, China, Thailand and Pakistan. Whereas the short-grained rice cultivars are preferred by Japan, South Korea and Sri Lanka (Unnevehr *et al.*, 1992). Within the country, preferences differ across states and locations. Urban and suburban people prefer slender rice, while bold rice is preferred by rural people of Kerala. For any special celebration, long, slender and extra-long slender grain is preferred. Considering the preference for decorticated grain shape, the cultivars under this study were classified as short slender, short bold, medium slender, long slender, long bold, Basmati type and extra-long slender.

None of the cultivars was found under 'Extra Long Slender' and 'Basmati Type' categories (Table 4). Fifteen cultivars were medium slender; 16 cultivars were short, bold, and only one cultivar was short, slender. The largest part of the cultivars fell under 'Short Bold' and 'Medium Slender' categories. Study of Surje *et al.*, (2018) also showed a high number of cultivars had 'short bold' decorticated grains. Chakrabarty *et al.* (2012) reported predominance of 'Long Bold' and 'Extra Long' decorticated grains. However, in the study materials of Surje *et al.*, (2022), the majority of the cultivars were 'Long Bold'. In the study materials of Gyathri *et al.*, (2023), the greater part of the cultivars were under the 'Long Bold' category.

Presence of amylose in endosperm

All the cultivars were found to have amylose in their endosperm. Amylose content determines the eating quality of cooked rice. It is positively correlated with hardness and negatively correlated with stickiness (Windham *et al.*, 1997). Amylose content has long been used as a parameter for promotion of rice cultivars in AICRIP trials in India. According to PPV&FRA (2007), it has three states- low (10-19%), medium (20-25%), high (26-30%) and very high (>30%). The waxy rice contains < 5%.

In our study, the amylose content ranged from 20.81-27.89% with a mean of 23.97%. None of the cultivars fell under 'Low' and 'Very High' categories (Table 4). Most of the traditional rice cultivars in this study fell under the 'Medium' class. Thirty-four cultivars were found to have amylose content of 20-25%. This result corroborates the findings of Surje *et al.*, (2018). This is the recommended range for Indian consumers. Under this range, cooked rice will be non-sticky, which is preferred by Indian consumers. Only four cultivars (10.53%) had amylose content in the higher range (26-

30%).

Amylose content is important because firmness and stickiness are two parameters of cooked rice that influence the consumers' preferences. Waxy rice has zero or very low (< 5%) amylose content and is often referred to as sticky rice. Japonica rice tends to be low amylose, Tropical Japonica (or Javanica) tends to be intermediate or high, and Indica rice falls into all the amylose classes.

Decorticated grain aroma

The aroma of cooked rice was assessed following the method as explained by Juliano (1971). This character was found trimorphic- strong aromatic, mild aromatic and non-aromatic (Table 4), and the frequency distribution of this character was 63.16%, 21.05% and 15.79%.

Out of the 38 cultivars, 24 were recorded as having a strong aroma, eight were mildly aromatic, and six were non-aromatic. The result indicated that the majority of the cultivars were aromatic. In contrast to the collections of Akshay *et al.*, (2022) and Gayathri *et al.*,

Table 4: Classification of traditional rice cultivars based on different grain characters and presence of amylose in endosperm

Sl.No.	Characters	Classes	Number	Frequency (%)
1.	Grain length	Very short (6.0 mm)	05	13.16
		Short (6.1-8.5 mm)	28	73.68
		Medium (8.6-10.5 mm)	05	13.16
2.	Grain width	Very narrow (2.0 mm)	01	2.63
		Narrow (2.1-2.5 mm)	26	68.42
		Medium (2.6-3.0 mm)	08	21.05
		Long (3.1-3.5 mm)	03	7.89
3.	Decorticated grain length	Short (6.0 mm)	32	84.21
		Long (6.0-6.6 mm)	04	10.53
		Basmati type (6.61-7.5 mm)	02	5.26
4.	Decorticated grain width	Narrow (2.0 mm)	15	39.47
		Medium (2.0-2.5 mm)	20	52.63
		Broad (2.5 mm)	03	7.89
5.	Decorticated grain L:B ratio	2.5	13	34.21
		2.5-3.0	23	60.53
		3.0	02	5.26
6.	Decorticated grain shape	Short slender	01	2.63
		Short bold	16	42.11
		Medium slender	15	39.47
		Long slender	01	2.63
		Long bold	05	13.16
7.	Presence of amylose in endosperm	Medium (20-25%)	34	89.47
		High (26-30%)	04	10.53
8.	Aroma	Strong aromatic	24	63.16
		Mild aromatic	08	21.05
		Non-aromatic	06	15.79

(2023), the majority were non-aromatic. In another study by Surje *et al.*, (2022), they reported 25 strongly aromatic out of 132 traditional rice cultivars. Gayathri *et al.*, (2023) reported only three aromatic cultivars out of 36 genotypes they studied. Many traditional rice cultivars are grown traditionally, which do extremely well in aroma, grain quality and cooking suitability. Huge numbers of aromatic traditional cultivars are available in our country, particularly north and North-eastern states, which are at par with Basmati. Those aromatic traditional rice cultivars may be popularized to improve the farmers' income.

Promising farmers' cultivars

The traditional rice cultivars undertaken in this study registered a wide range of distinctiveness for all the quantitative characters. Similar frequencies for quantitative characters have been reported by several rice workers (Sinha and Mishra, 2013; Kalyan *et al.*, 2017; Umarani *et al.*, 2017; Manjunatha *et al.*, 2018; Gour *et al.*, 2019; Priyanga *et al.*, 2020; Singh *et al.*, 2021; Lavanya *et al.*, 2021; Surje *et al.*, 2022; Akshay *et al.*, 2022).

To find out the better performing cultivars based on yield attributing characters and a few desirable qualitative characters, 10 better performing cultivars

were listed in Table 5 for seven yield attributing characters and three quality characters. KNS-2-D-3-1 was found to be the best based on high yield potentiality (5250 t/ha), high number of panicle per plant (24.00 panicle/per plant), comparatively low days to 50% flowering (129.5 days), low days to maturity (155 days), medium amylose content (23.83%) and having medium slender grains with strong aroma.

The next better cultivar was KNS-2-D-5-1 (Table 5). It was recorded as having high yield potential (4980 t/ha), a high number of panicles per plant (29.5 panicles/plant), taking comparatively fewer days to attain 50% flowering (155.5 days), medium amylose content (22.32%) and having medium slender grains with strong aroma.

KNS-2-D-11 had recorded as a high grain yielder (7050 kg/ha), a high number of panicles per plant (23.5 panicles/plant), comparatively low days to 50% flowering (130.0 days), medium amylose content (22.92%) and having strong aroma with short bold grains.

The cultivar, KNS-2-2/2-3, had been reported as a high grain yielder (7050 kg/ha), possessing the maximum number of panicles per plant (32.0 panicles/plant) and having medium slender grains with

Table 5: Character-wise ten best performing cultivars

Characters	Cultivars
Days to 50% flowering	Desi Paizam, Malasundari, Swarnali, KNS-2-D-9, KNS-2-2, KNS 2-3, Dungru, KNS-2-D-3, KNS-2-D-5-1, KNS-2-D-3-1
Days to maturity	Chakhao Amubi, KNS-2-D-9, Desi Paizam, KNS-2-D-3, KNS 2-3, Malasundari, Swarnali, KNS-2-1-6, KNS-2-D-11, KNS-2-D-4
Plant height	Swarnali, Malasundari, Lal Manshar, KNS-2-D-15, KNS-2-D-12, KNS-2-D-10, KNS-2-2, Guyri Nunia, Dhariyal, Sweet Nunia
No. of panicles per plant	KNS-2-2/2-3, KNS-2-D-3, KNS-2-D-10, KNS-2-D-5-1, Lal Manshar, KNS-2-D-15, Biru, Sweet Nunia, KNS-2-D-3-1, KNS-2-D-11
Panicle length	Sweet Nunia, Biru, KNS-2-D-12, KNS-2-D-15, Simabhog, Guyri Nunia, Dalbhog, KNS-2-D-5, KNS-2-D-3, KNS 2-3
Test weight	Sugandhi Dhepi, Chakhao Amubi, Lal Khayiam, Loha Swarna, Dhariyal, Dungru, Swarnali, Malasundari, KNS-2-2
Grain yield	KNS-2-2/2-3, KNS-2-D-5, Sweet Paizam, KNS-2-D-11, Lal Manshar, Nageswari, Biru, KNS-2-D-3-1, Kataribhog, KNS-2-D-5-1
Grain type	Malasundari, Biru, Sweet Paizam, Dalbhog, Kala Khayiam, KNS-2-D-12, KNS-2-D-15, KNS-2-D-9, KNS-2-D-10, KNS-2-2, KNS-2-2/2-3, KNS-2-1/2-3, KNS-2-D-4, KNS-2-D-5-1, KNS-2-D-3-1, Kataribhog
Amylose content	Lal Khayiam, Sweet Nunia, Biru, Sweet Paizam, Dalbhog, Malasundari, Kaishalibinni, Simabhog, Loha Swarna, Dhanraaj, Paddy Queen, Dungru, Chakhaoamubi, Sugandhi Dhepi, Kala Khayiam, Lal Manshar, Dhariyal, KNS-2-D-3, KNS-2-D-11, KNS-2-D-12, KNS-2-D-15, KNS-2-D-9, KNS-2-D-10, KNS-2-2, KNS-2-2/2-3, KNS-2-1/2-3, KNS-2-D-5, KNS-2-D-4, KNS-2-D-5-1, KNS-2-D-3-1, KNS-2-1-6, KNS-2-3, Nageswari, Kataribhog
Aroma	Lal Khayiam, Biru, Sweet Paizam, Kaishali Binni, Sugandhi Dhepi, KNS-2-1/2-3, Nageswari, Kataribhog, Simabhog, KNS-2-D-11, KNS 2-3, Chakhao Amubi, KNS-2-D-3, KNS-2-D-12, KNS-2-D-15, KNS-2-D-9, KNS-2-D-10, KNS-2-2, KNS-2-2/2-3, KNS-2-D-5, KNS-2-D-4, KNS-2-D-5-1, KNS-2-D-3-1, KNS-2-1-6

strong aroma. KNS-2-D-5 also had high yield potential (7380 kg/ha), long panicle (30.86 cm), medium amylose content (24.73%) and short bold grains with strong aroma.

Katarybhog showed high grain yield potential (5250 kg/ha), medium amylose content (23.22%) and possessed a medium slender grain type with strong aroma. This cultivar is local to the Dakshin Dinajpur district of West Bengal. However, it can be cultivated in other northern parts of West Bengal. As documented by NBPGR, it also has a low glycemic acid index (45.72%) [IC0640647; INGR21113].

Apart from the above-mentioned cultivars, Sweet Paizam (7350 kg/ha), Lal Manshar (6000 kg/ha), Nageswari (5790 kg/ha) and Biru (5250 kg/ha) exhibited high grain yield potential and had medium amylose content. Those traditional rice cultivars can be recommended for cultivation. Sweet Pizam and Biru possessed medium slender decorticated grains.

Conclusion

All the quantitative characters, namely length of leaf blade, width of leaf blade, stem thickness, days to 50% flowering, days to maturity, stem length (excluding panicle), length of main axis of panicle, number of panicles per plant, test weight, grain length, decorticated grain length, amylose content and yield per plant showed high significant variation among the traditional cultivars except grain width that had insignificant variation. Some of the cultivars that performed at par with the released high-yielding cultivars, viz. KNS-2-D-3-1, KNS-2-D-5-1, KNS-2-D-11, KNS-2-2/2-3, KNS-2-D-5 and Kataribhog can be recommended for cultivation. Quantitative characters showed highly significant variations among the genotypes. This study will be useful for breeders, researchers and farmers to identify and restore beneficial genes for crop improvement.

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