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Morpho-physiological characterization of some indigenous rice (*Oryza sativa* L.) landraces for germplasm identification and evaluation towards drought stress under red and lateritic soil in Bankura, West Bengal

Sanjoy Shil, Sujaya Dewanjee, Ponaganti Shiva Kishore and Bhukya Rambabu

Abstract
Indigenous rice (*Oryza sativa* L.) landraces are recognized as prime treasure in agriculture due to their wider phenotypic as well as genotypic variation that evolved from their wild progenitor. Such kind of diversity empowers these landraces to resist or tolerate towards extensive range of abiotic stress like moisture stress. However, such landraces often have their lower or intermediate yield potentiality due to give downward emphasizing on their cultural management practices. Their wider adaptability and stress tolerance characters can be used in combination with conventional rice germplasm for the improvement of high yielding stress tolerance rice genotypes as several locally available rice is not yet characterized or evaluated based on their phenotypic or genotypic discrepancies.

Thus, it is utmost important to collect and conserve a large number of rice landraces followed by evaluation or characterization based on their phenotypic variation in order to widen the gene pool of the cultivated rice. Bankura district is the major producer of rice that restricts only 8 to 10 high yielding varieties and few landraces. However, so many rice landraces have been cultivated in near past but due to lack of proper identification and physio-morphic characterization for improved breeding programme to develop high yielding stress tolerance cultivars, they are not properly identified, conserved and documented for future.

In this present study, an attempt has been made to characterize 30 rice landraces during 2018 and 2019 kharif seasons at College of Agriculture, BCKV (Bankura Campus), Chhatna based on their distinct characters like Plant height, time of 50% flowering, total duration for maturity, number of effective tillers per hill, flag leaf length, panicle length, test weight (1000 grain weight in g), number of seeds per panicle etc. and grain traits *viz*. grain length & width, grain length & width ratio, kernel (Decorticated grain) length and width, kernel length & width ratio, kernel shape, colour and aroma etc. to provide fundamental information for further evaluation and future improvement programme.

Keywords: Morpho-physic characterization, traditional rice, identification, evaluation and drought stress

Introduction
Landraces in every crop are valuable and offers a treasure of genetic material for future crop improvement and prevent further gene erosion. West Bengal has rich and diverse genetic resources of traditional landraces of rice. According to Pal, 2016, West Bengal has more than 5000 region specific assemblage of folk and indigenous landraces of rice. Such landraces are greater sources of special characters like adaptation under varied soil pattern, high proportion of nutritive value, and tolerant to biotic and abiotic stresses (Das *et al*. 2013) [5]. Unfortunately, more than 90% of the rice landraces was vanished out from the rice field in West Bengal and presently 95% of rice cultivation is going on by using high yielding varieties only (Sinha and Mishra, 2012, 2013) [24] that increase the gene erosion of traditional landraces and wild rice (Fowler and Moony, 1990) [12]. Landraces are basic inputs for any crops and act as gene pool for further improvement of crops (Richharia, 1979 and Patra, 2000) [21, 19] as well as widen the gene pool of cultivated rice (Fukuoka *et al*. 2006) [13] and involved in the further improvement of existing crops by introducing desirable gene traits that present in landraces and wild varieties only (Shiva, 1991 and Holden *et al*. 1993) [22, 14], but these landraces are disappearing very fast (Durning, 1990, Holden *et al*. 1993 and Matson *et al*. 1997) [10, 14, 15]. Landraces has wide genetic diversity that helps for the development of rice varieties being tolerant towards

biotic and abiotic stresses and thus contributes higher yield and sustainable production of rice (Sano, 2000) [26]. On the contrary, some of the rice landraces often have lower or intermediate yield with low agricultural input (Ray *et al*. 2013 and Nguyen, 2002) [20, 17] and abiotic stress tolerance from such germplasm may integrate with conventional high yielding varieties for the development of high yielding abiotic stress rice varieties.

Therefore, in order to prevent gene erosion and fast disappearance of landraces, collection, identification, conservation of invaluable genetic resources in rice landraces and characterization to establish distinctiveness in varieties is utmost essential. Varietal characterization is required to identify and recording useful information that may retrieved and made available to other plant breeders for future crop improvement (Dabas *et al*. 1994) [4] and such characterization of a variety is a prerequisite to avoid duplication.

In 1961, UPOV (Convention of the Union for the Protection of New Varieties of Plants) an international body was established in Paris for protection of new varieties and grant an exclusive right on the protected varieties based on uniformity and stability of their characters (Dutefield, 2001) [11] but such models of protection were not suitable for Indian requirements and thus, GATT (General Agreement on Trade and Tarrifs) has enacted its *sui generis* system of "Protection of Plant Varieties and Farmers Act" (PPV&FRA), 2001" for providing protection to plant varieties based on Novelty (if new), Distinctiveness, Uniformity and Stability (NDUS) test (Anonymous, 2001) [2]. Article 15.3(b) of the PPV&FR Act, 2001 states that the new variety must be clearly distinguishable by one or more essential characters from any variety whose existence is a matter of common knowledge at the time of seeking protection. Establishment of a varietal uniqueness can be made through this DUS test. For rice, there are 62 (29 essential and 33 additional) morpho-physiological DUS descriptors for conducting DUS traits.

Physio-morphic identification and characterization of traditional rice landraces helps in developing new varieties with distinguished characters that would help in assessment of genetic diversity of the existing landraces and released varieties. Shobha Rani *et al*. 2004 [16] and Anonymous (2007) [3] has reported guidelines of morpho-physiological characterization of rice to conduct DUS (Distinctiveness, Uniformity and Stability) test.

Keeping view of the above facts, present investigation have been planned to characterize a set of 30 traditional rice landraces of West Bengal to understand their in-situ variability of different traits and establish their interrelationship. Such useful information facilitates the scientists to choose genitors of rice for improved breeding programme.

Materials and Methods: A field experiment was conducted at College of Agriculture, BCKV (Bankura Campus), Chhatna, Bankura to characterize agro-morphologically some diverse origin rice landraces during two consecutive kharif seasons of 2018 and 2019. Thirty indigenous rice landraces were collected from different sources and propagated in a small farm of the college for obtaining some fundamental data based on their physio-morphic characters. These landraces were given a particular code number for easily identifying them (Table I) and each landraces were laid down in completely randomized block design with three replications. The seeds of each landraces were sown in a separated seed bed (Round and raised) using vermicompost (500g in each seed bed).

A 25 days old seedling was transplanted in the 1st week of August in both the seasons study. Each plot size was 12 m2 with a spacing of 25 cm between rows and 10-15 cm between plants in a row. A random sample of 5 competitive plants from each plot was collected and used for morphological observations *viz*. Plant height, time of 50% flowering, total duration for maturity, number of effective tillers per hill, flag leaf length, panicle length, 1000 grain weight (g) and number of seeds per panicle etc. (Table II) and theses plants were also used for evaluation of their grain characters like size, shape and colour etc. (Table IV). Table III represents various grain characters of rice landraces for characterization and germplasm evaluation as per DUS test guidelines [Shobha Rani *et al.* 2004 [16] and Anonymous (2007)] [3].

Table I: List of various rice landraces utilized in the study for identification and evaluation

SL. No.	Name of the rice landraces	Code given for identification
1.	Raghusal	V1
2.	Bhootmuri	V2
3.	Jhilik Sundari	V3
4.	Banskathi	V4
5.	Bahurupi	V5
6.	Dhuapal	V6
7.	Harina Muri	V7
8.	Sanalu	V8
9.	Sada Jhul	V9
10.	Baid Jhapta	V10
11.	Dudheswar	V11
12.	Benaphool	V12
13.	Paru	V13
14.	Sono	V14
15.	Tulshi Bokul	V15
16.	Annapurna	V16
17.	Asanlaya	V17
18.	Churna Mati	V18
19.	Hijam	V19
20.	Tarari Basmoti	V20
21.	Nata	V21
22.	Roopsal	V22
23.	Shewli	V23
24.	Pakri	V24
25.	Lasal Muthi	V25
26.	Kalma	V26
27.	Kailash	V27
28.	Ranga	V28
29.	Kerala Sundari	V29
30.	Jamrul	V30

Results and Discussions: Physio-morphic characters are considered as one of the best markers for identification and evaluation of indigenous rice landraces as they are less influenced by environmental factors. Characterization of 30 rice landraces of lateritic region of West Bengal based on various qualitative and quantitative characters are represented in Table II and IV. Table II represents the characters *viz*. Plant height, time of 50% flowering, total duration for maturity, number of effective tillers per hill, flag leaf length, panicle length, test weight (1000 grain weight in g), number of seeds per panicle etc. and Table IV depicts several grain traits for quality evaluation *viz*. grain length & width, grain length & width ratio, kernel (Decorticated grain) length and width,

kernel length & width ratio, kernel shape, colour and aroma etc.

Regarding plant height, Jamrul (70-75 cm) showed least followed by Sada Jhul (70-80 cm) whereas highest observed in Ranga, Dudheswar, Lasal Muthi and Baid Japta varieties (155-160 cm) and earliest flowering was observed in Bhootmuri (63days) and late flowering in Asanlaya and Pakri (100days). Highest panicle length was recorded in Tulshi Bokul (32.66 cm) and length was less in Sanalu (19.0 cm) followed by Nata (19.33). Harina Muri contributed maximum numbers of grains per panicle (126) whereas Sanalu gave minimum number (73) grains. Variation was also studied in number of tillers per hill range from 10.3 (Ranga) to 26.2 (Raghusal). Churna Mati (42.8 cm) showed highest length of flag leaf (emerged last that provides majority of carbohydrates needed for grain filling and contributes 45% of rice grain yield) whereas Jamrul showed 17.8 cm least in length. Wide range of variation was recorded in case of 1000 grain weight (test weight) for Ranga (33.5g), Sono (14.3g) and among other varieties also that is one of the most quantitative characters for establishment (Table II).

Variation of all the grain traits were recorded for 30 landraces of rice and regarding grain dimensions, the length of the grain ranged from 7 mm (Bahurupi, Tulshi Bokul, Hijam, Kailash, Kerala Sundori, Jamrul) to 10 mm (Annapurna) whereas grain width ranged from 2.0 mm (Sada Jhul and Harina Muri) to 3.5mm (Paru, Pakri, Lasal Muthi and Ranga). Accordingly, length to width ratio of grain varied from 2.28 (Lasal Muthi and Ranga) to 4.25 (Harina Muri). Kernel (decorticated grain) length varied from 5mm (Bahurupi, Kailash and Kerala Sundori) to 7.5 mm (Banskathi) and width varied from 1.5 mm (Harina Muri, Sada Jhul, Baid Japta) to 3.0 mm (Paru, Lasal Muthi, Ranga and Jamrul). Length and width ratio of kernel ranged from 1.83 (Jamrul) to 4.66 (Baid Japta). On the basis of kernel shape, all these 30 varieties are categorized into six and out of them, 10 varieties recognized as Long and bold shaped kernel, 8 of them as long and slender shaped and 6 varieties as medium slender and 1 as medium and bold whereas 3 varieties shows as short and bold and 2 identified as short and slender shaped in lateral view (Table IV).

The kernel colour (pericarp or decorticated grain) also consist of 9 categories *viz*. white, light brown, variegated brown, dark brown, light red, red, variegated purple, purple and black. Among them, most of the kernel color was found as light brown (14 varieties), 10 varieties identified as white and 4 varieties recognized as dark brown whereas only 2 varieties (Nata, Lasal Muthi) was found as dark red. Another most economically significant grain characteristic is the presence or absence of kernel aroma and they are distinguished into 3 categories *viz*. non-scented (absence of aroma), mild scented (presence of aroma) and strong scented (highly presence of aroma) according to their intensity of aroma. Out of these 30 landraces, most of them acquired non-scented (20) and 8 identified as mild-scented (Churna Mati, Annapurna, Tulshi Bokul, Benaphool, Dudeswar, Sada Jhul, Harina Muri and Bhoot Muri) and only 2 (Tarari Bansmoti anad Kalma) found as strong scented (Table IV). Size and shape of the grains and intensity of aroma are the two significant grain characters and based on which a particular variety contributes maximum economical accrual. Mostly long slender and mild scented grain has the highest market acceptability and wider adaptability.

Results of these morpho-physiological characterizations of 30 rice landraces and their grain characters shows diverse origin as all these germplasm possesses distinct and unique traits and identification and conservation of these genes will helpful for future crop improvement.

Table II: Physio-morphic characteristics of some indigenous rice landraces grown under red and lateritic soil in Bankura district

Code No	Name of landraces	Plant height (cm)	Time of 50% flowering (days)	Duration (days)	Panicle length (cm)	No. of seeds/panicle	Number of tillers/hill	Flag leaf length (cm)	Test weight (g)
V1	Raghusal	100-105	94	125-130	24.66	117	26.2	33.38	23.1
V2	Bhootmuri	125-135	63	130-140	27.50	81	14.8	27.25	23.6
V3	Jhilik Sundari	100-105	93	120-130	26.16	78	13.4	30.8	24.4
V4	Banskathi	90-100	85	140-150	21.66	80	15.8	22.6	24.0
V5	Bahurupi	125-130	90	130-140	24.83	83	11.2	33.6	22.2
V6	Dhuapal	85-90	92	115-120	23.50	82	13.8	27.2	15.0
V7	Harina Muri	120-125	93	130-135	30.33	126	16.8	28.0	16.2
V8	Sanalu	80-85	92	120-130	19.0	73	13.0	22.8	14.6
V9	Sada Jhul	70-80	91	130-140	20.33	79	10.6	26.8	14.6
V10	Baid Jhapta	155-160	94	125-130	29.83	119	11.3	40.8	24.3
V11	Dudheswar	155-160	98	140-150	26.33	120	14.0	32.1	19.4
V12	Benaphool	120-125	90	130-140	26.0	100	15.4	26.8	20.8
V13	Paru	110-115	71	110-120	24.66	96	18.6	23.4	23.6
V14	Sono	85-90	92	130-140	23.0	74	13.0	28.6	14.3
V15	Tulshi Bokul	150-160	96	150-160	32.66	132	15.2	30.75	14.5
V16	Annapurna	145-150	93	130-140	24.5	86	19.6	32.2	17.2
V17	Asanlaya	105-110	100	130-140	25.5	85	15.6	27.8	24.9
V18	Churna Mati	150-160	91	115-120	28.16	97	17.2	42.8	21.6
V19	Hijam	125-130	88	120-130	27.0	95	11.3	28.0	17.8
V20	Tarari Basmoti	120-130	90	130-140	25.33	91	18.9	35.0	19.7
V21	Nata	110-115	85	100-110	19.33	115	11.0	26.6	26.5
V22	Roopsal	150-155	94	140-145	27.83	115	17.5	32.6	18.8
V23	Shewli	95-100	82	110-120	24.0	102	13.0	23.2	17.6
V24	Pakri	120-125	100	125-130	27.50	110	12.4	33.6	24.8
V25	Lasal Muthi	155-160	93	140-145	26.33	100	11.0	36.6	28.5
V26	Kalma	135-140	94	130-140	27.5	112	15.0	32.4	22.9

V27	Kailash	140-150	93	140-145	27.16	109	17.8	36.75	18.3
V28	Ranga	155-160	92	140-150	28.66	107	10.3	31.6	33.5
V29	Kerala Sundari	95-100	97	130-140	24.66	99	18.60	24.2	21.6
V30	Jamrul	70-75	71	120-125	24.16	90	20.2	17.8	22.6

Distinctiveness of these 30 landraces based on test weight (1000 grain weight in g) may be established as per DUS (Distinctiveness, Uniformity and Stability) guidelines on rice reported by Shobha Rani *et al.* 2004 [16] and Anonymous (2007) [3] as follows:
1. Very low (<15 gm); 2. Low (15-20 gm); 3. Medium (21-25 gm); 4. High (26-30 gm); 5. Very high (>30 gm).

Table III: Diverse grain characters of indigenous rice landraces for characterization and germplasm evaluation as per DUS test guidelines

Characters for distinctiveness	Descriptions with descriptor's code								
	1	2	3	4	5	6	7	8	9
Grain length (GL)	Very short	Short	Medium	Long	Very long	-	-	-	-
Grain width (GW)	Very narrow	Narrow	Medium	Broad	Very broad	-	-	-	-
Grain Length & Width ratio (GLW)	Very Low	Low	Medium	High	Very high	-	-	-	-
Kernel Length (KL)	Very short	Short	Medium	Long	Very long	-	-	-	-
Kernel Width (KW)	Narrow	Medium	Broad	-	-	-	-	-	-
Kernel Length & Width ratio (KLW)	Very Low	Low	Medium	High	Very high	-	-	-	-
Kernel colour	White	Light brown	Variegated brown	Dark brown	Light red	Red	Variegated purple	Purple	Black
Kernel shape	Short slender	Short bold	Medium slender	Long slender	Long bold	Basmati type	Extra-long slender	-	-
Kernel Aroma	Non scented	Mild scented	Strongly scented	-	-	-	-	-	-

Grain length (GL): 1. Very short (<6.0 mm); 2. Short (6.1-8.5 mm); 3. Medium (8.6-10.5 mm); 4. Long (10.6-12.5 mm); 5. Very long (>12.5 mm).

Grain width (GW): 1. Very narrow (<2.0 mm; 2. Narrow (2.1-2.5 mm); 3. Medium (2.6-3.0 mm); 4. Broad (3.1-3.5 mm); 5. Very broad (>3.5 mm).

Grain Length & Width ratio (GLW): 1. Very Low (<2.0); 2. Low (2.1-2.5); 3. Medium (2.6-3.0); 4. High (3.1-3.5); 5. Very high (>3.5).

Kernel (Decorticated grain) Length (KL): 1. Short (<6.0 mm); 2. Medium (6.1-8.5 mm), 3. Long (8.6-10.5 mm), 4. Basmati type (10.6-12.5 mm), 5. Extra-long (>12.5 mm).

Kernel (Decorticated grain) Width (KW): 1. Narrow (<2.5 mm); 2. Medium (2.0-2.5 mm); 3. Broad (>2.5 mm)

Kernel Length & Width ratio (KLW): 1. Very Low (<2.0); 2. Low (2.1-2.5); 3. Medium (2.6-3.0); 4. High (3.1-3.5); 5. Very high (>3.5).

Kernel (decorticated grain) colour: 1. White, 2. Light brown, 3. Variegated brown, 4. Dark brown, 5. Light red, 6. Red, 7. Variegated purple, 8. Purple, 9-Black.

Kernel shape: 1. Short slender, 2. Short bold, 3. Medium slender, 4. Long slender, 5. Long bold 6. Basmati type, 7. Extra-long slender.

Kernel Aroma: 1. Non-Scented/Absent; 2. Mild Scented/Present; 3. Strongly scented/Present.

Table IV: Some essential grain characterization of indigenous rice landraces grown under red and lateritic soil in Bankura district as per DUS test guidelines

Code No	Name of landraces	GL (mm)	GW (mm)	GLW	KL (mm)	KW (mm)	KLW	Kernel colour	Kernel shape	Kernel Aroma
V1	Raghusal	8.5	2.9	2.93	6	2	3	White	Long and slender	Non-scented
V2	Bhootmuri	8	3	2.66	6	2.5	2.4	Light brown	Medium and bold	Mild-scented
V3	Jhilik Sundari	9	3	3	7	2.5	2.8	White	Long and slender	Non-scented
V4	Banskathi	9	2.5	3.6	7.5	2	3.75	White	Long and bold	Non-scented
V5	Bahurupi	7	3	2.33	5	2.5	2	Light brown	Medium and slender	Non-scented
V6	Dhuapal	8.5	2.5	3.4	6	2	3	White	Medium and slender	Non-scented
V7	Harina Muri	8.5	2	4.25	6	1.5	4	Light brown	Long and slender	Mild scented
V8	Sanalu	7.5	2.5	3	5.5	2	2.75	Light brown	Short and slender	Non-scented
V9	Sada Jhul	8	2	4	6	1.5	4	Light brown	Short and slender	Mild scented
V10	Baid Jhapta	9	3	3	7	1.5	4.66	Light brown	Medium and slender	Non-scented
V11	Dudheswar	8	2.5	3.2	6.5	2	3.25	White	Long and slender	Mild scented
V12	Benaphool	8	3	2.66	6.5	2	3.25	Dark brown	Medium and slender	Mild scented
V13	Paru	8.5	3.5	2.43	6.5	3	2.16	White	Medium and slender	Non-scented
V14	Sono	8	2.5	3.2	6	2	3	Light brown	Long and slender	Non-scented
V15	Tulshi Bokul	7	3	2.33	5	2.5	2	White	Short and bold	Mild scented
V16	Annapurna	10	3	3.33	6.5	2	3.25	White	Long and bold	Mild scented
V17	Asanlaya	8	3	2.66	6	2.5	2.4	Light brown	Long and bold	Non-scented
V18	Churna Mati	9	2.5	3.6	7	2	3.5	White	Long and slender	Mild scented

V19	Hijam	7	2.5	2.8	6	2	3	Light brown	Long and slender	Non-scented
V20	Tarari Basmoti	8	2.5	3.2	6	2	3	Dark brown	Long and slender	Strong-scented
V21	Nata	8.5	3	2.83	6.5	2.5	2.6	Dark red	Long and bold	Non-scented
V22	Roopsal	9	2.5	3.6	6.5	2	3.25	White	Long and slender	Non-scented
V23	Shewli	9	2.5	3.6	6	2	3	Light brown	Long and slender	Non-scented
V24	Pakri	8	3.5	2.28	6.5	3	2.16	Light brown	Long and bold	Non-scented
V25	Lasal Muthi	8	3.5	2.28	6	3	2	Dark red	Long and bold	Non-scented
V26	Kalma	8	3	2.66	6	2.5	2.4	Dark brown	Long and bold	Strong-scented
V27	Kailash	7	3	2.33	5	2	2.5	Dark brown	Medium and slender	Non-scented
V28	Ranga	8	3.5	2.28	6	3	2	Light brown	Long and bold	Non-scented
V29	Kerala Sundari	7	3	2.33	5	2.5	2	Light brown	Short and bold	Non-scented
V30	Jamrul	7	3	2.33	5.5	3	1.83	Light brown	Short and bold	Non-scented

Legends: GL= Grain Length (mm); GW=Grain Width (mm); GLW=Grain Length & Width ratio; KL=Kernel (decorticated grain) Length; KW=Kernel (decorticated grain) Width; KLW=Kernel Length & Width ratio.

Conclusion and future recommendation: Characterization of a variety based on their physio- morphology and grain traits are pre-criterion for the selection of a suitable variety to improve variety towards abiotic stress like drought. Some of the distinguishable characters like plant height, length of the panicle and flag leaf, number of seeds per panicle and number of tillers per hill, days to 50% flowering and maturity period, seed traits like 1000 grain weight, grain and kernel dimensions and their ratio, shape of the grain and color, presence of aroma etc. has been found to be more useful for identification and grouping these landraces to maintain genetic purity during seed production.

Grain characteristics (Presence of aroma, shape of grain) play an important role regarding the market value and acceptability of this rice variety. Churna Mati, Benaphool, Dudheswar, Tulshi Bokul, Annapurna, Sada Jhul, Harina Muri and Bhoot Muri etc. are some of potential varieties may have higher market value and marginal farmers of red and lateritic region welcome or reintroduce these varieties into their agricultural fields again inspite of having lower productivity. However, some these varieties also exhibited the presence of awns and can thus withstand under stress conditions also. They are found to be superior in panicle length, number of productive tillers, test weight etc. and hence they are the source of valuable germplasm for breeding of high yielding as well as stress tolerance rice varieties due to their distinct and diverse characters. Such qualitative characters are considers as markers as they are less influenced by environmental changes. During 2001, Agnihotri has reported the ecophysiology study on local rice varieties of Kumaun district and Singh and Singh (1997) [23] also have been studied about the local varieties of aromatic rice. Deb (1995, 1996, 2000a and 2002) also studied prevalent landraces of rice in West Bengal and gave emphasized on their identification and conservation. This study must have to be helpful for breeders, researchers and farmers to conserve, identify and characterize of such landraces of rice genes for future crop improvement. These varieties have immense importance keeping their gene pool for sustainability towards climate change and undoubtedly such traditional landraces may sustained under adverse climatic condition particularly under erratic rainfall situation as they are better suited as compared to current high yielding varieties.

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