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Variability study in seed morphology and uses of indigenous rice landraces (*Oryza sativa* L.) collected from West Bengal, India

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Abstract

Variability in seed morphology was studied in 23 rice landraces using qualitative and quantitative characters. Germplasm of these indigenous rice landraces were collected from three districts (Dakshin Dinajpur, Uttar Dinajpur and Malda) of West Bengal, India during two exploration missions undertaken in summer and winter season (2012-2013). Data were recorded for traits such as kernel husk colour, seed coat colour, aroma, kernel size, 1000 kernel weight, presence of awn and awn length. Kalonunia and Tulaipanji were the most common traditional rice landraces, accounting for 25 per cent germplasm collected from this region. Seven landraces *viz*., Dangi basful, Gauchi, Gogal sail, Gujanonia, Gujinina, Jeera sail and Lal cholis were collected for important traits such as drought and diseases tolerant for the first time from this area. A total of 18 landraces had greyed-orange and greyed-yellow husk colour while six landraces had brown - greyed brown husk colour. The seed coat colour variation in different landraces ranged from white, brown, golden yellow, light brown and red. Aroma was present in 18 landraces out of the total collection. Seventeen landraces were awnless and only six landraces were with awn. Maximum awn length (19 mm) was recorded for landrace Swarna (long grain) while minimum awn length (6 mm) was recorded for landrace Lal cholis (short grain). Maximum 1000 kernel weight (24.74 g) was recorded for landrace Lal cholis while minimum kernel weight (9.32 g) was recorded for landrace Jeera sail. Cluster analysis classified 23 accessions into two major clusters (I and II) based on similarity in quantitative parameters (kernel size, kernel breadth, awn length and kernel weight). Landraces *viz*., Binni dhan, Chini sakkar, Dangi basful, Kalonunia and Purnima (Dakshin Dinajpur), Desi mansuri, Kala mogha and Gogal sail (Uttar Dinajpur) and Tulaipanji (Malda) from geographically different districts were clustered together. Whereas others like Chini atap, Jeera sail, Kanakchur, Kartik sail, Magur sail, Radhuni tilak, Red hira sail and Tejasili (Dakshin Dinajpur) from same district fall in different clusters. Information generated through seed morphology, cluster analysis and diversity study could be efficiently used in crop improvement programme harbouring different grain quality traits.

Keywords: Cluster analysis, Diversity, Landraces, Local farmers, Rice, Seed morphological study, Tribals, West Bengal.
Abbreviations: CV_Coefficient of variation, SE_Standard error, RHS_The Royal Horticultural Society.

Introduction

Rice (*Oryza sativa* L., family Poaceae) is the leading staple food crop of India, grown in almost all the states, covering more than 30 per cent of the total cultivated area (Adhikari et al., 2012; Chakravorty et al., 2013). Its cultivation is mostly concentrated in the river valleys, deltas and low-lying coastal areas of north-eastern and southern India, mainly in the states of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Karnataka, Kerala, Maharashtra, Odisha, Tamil Nadu, Uttar Pradesh and West Bengal, which together contribute about 97 per cent of the country's rice production (Chakravorty and Ghosh, 2011). West Bengal is called as 'bowl of rice' with over 450 rice landraces (Deb, 2005; Chatterjee et al., 2008). Rice is cultivated here on over 65 per cent area under agricultural crops (Adhikari et al., 2012) in three different season's viz., Aus (autumn rice), Aman (winter rice) and Boro (summer rice). India is home to wide varieties of rice cultivars, landraces and many lesser known types that have been under cultivation since ages by indigenous farmers as well as local entrepreneurs (Vinita et al., 2013). It has more than 75,000 local cultivars/landraces of rice (Roy et al., 1985; Paroda and Malik, 1990; Khush, 1997). Rice is the principal crop of north-eastern region of India, with estimated 10,000 indigenous cultivars of rice landraces grown in this region. Rice growing areas of north-eastern region were rich in traditional landraces of which many were reported to be tolerant to biotic stresses against various pests (gall midge, stem borer, green leaf hopper) and diseases (blast, bacterial leaf blight, rice tungro virus, bacterial leaf streak) (Shastry et al., 1971; Chatterjee et al., 1977; Devadath and Rao, 1976; Jain et al., 2004). Upto 1970's systematic collection of rice germplasm especially from north-eastern region of India has been made under two major collaborative national programmes *viz*., Indian Council of Agricultural Research and PL480 of United States Departments of Agriculture. Over 1,500 collections were made from Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Tripura, including seven districts of Assam (Shastry et al., 1971). Later in over past three decades (1976-2013) the National Bureau of Plant Genetic Resources (NBPGR), New Delhi collected and conserved more than 36,000 accessions of rice. Of these nearly 600 accessions were represented from West Bengal (Plant Germplasm Reporter, 2009). Genetic divergence studies were undertaken in north-eastern India classifying 190 landraces into nine clusters (Vairavan et al., 1973) and concluded that some of the clusters occupied intermediate positions between japonica and indica types. Srivastava and Nanda

(1977) recognized five groups in the germplasm collections from northeastern India and attributed genecological differentiation identifying each group. Diversity studies in rice using morphological characters were done on improved and ancestral rice varieties of Philippines (Caldo et al., 1997; Juliano et al., 1998) and on Asian wild cultivated indigenous rice in Yunnan, China (Zeng et al., 2003). Agro-morphological traits, both qualitative and quantitative have been commonly and traditionally used to estimate relationships between genotypes (Goodman, 1972). Variation due to adaptation to specific ecosystems selection and socio-economic condition resulted in differentiation in different named landraces of a region (Bajracharya et al., 2006). Variability study for rice landraces from West Bengal was undertaken by Chakravorty et al. (2013). Introduction of high-yielding varieties of rice and low productivity of the traditional landraces were inferred to be the main reason behind erosion of landraces in the Japore tracts of Odisha (MSSRF-FAO, 2002; Chakravorty et al., 2013). Though unique diversity in landraces/ local cultivars of rice from West Bengal is well recognized for significant traits like aroma, taste and disease resistance but systematic collections are yet to be made and studied. Keeping in view the under representation of rice landrace diversity from West Bengal and threat of genetic erosion, three districts *viz*., Dakshin Dinajpur, Uttar Dinajpur and Malda were selected and studied for seed morphology, associated knowledge on local use of collected landraces was recorded to help in characterization of rice germplasm from this region.

Results

The diversity distribution pattern of diverse populations of rice landraces and germplasm accessions assembled from parts of Dakshin Dinajpur, Uttar Dinajpur and Malda districts of West Bengal region indicated mainly four regions (Islampur, Raiganj, Patiram and Gajol) having concentration of maximum landraces diversity. Table 1 and Fig. 1 depict the areas of collection (collection sites), variability in qualitative traits and diversity in rice landraces as revealed by field surveys and distribution of these landraces in different regions.

Variability in qualitative traits

Variability for qualitative and quantitative traits in landraces of rice mainly for kernel colour, kernel type, seed coat colour, presence or absence of awns and aroma type was recorded (Table 1 and 2; Fig. 2). A total of 18 accessions of landraces had greyed-orange (164 C) to greyed-yellow (162 A) husk colour and five landraces showed brown (200 B) - grey- brown (199 B) colour. Seed coat colours ranged from white (10 landraces), light brown (6 landraces), golden yellow (2 landraces) and red (5 landraces). Out of a total of 23 landraces, 16 were of coarse and bold grain type and seven were fine grain type. In 18 accessions aroma was present while five accessions were non-aromatic. 16 accessions of the landraces were awnless and only seven accessions viz. Tulaipanji, Swarna, Purnima, Red hira sail, Kanakchur, Nagra dhan and Gogal sail were with awn. Characteristics revealed by different farmers about local landraces were recorded and presented in Table 1. On the basis of feedback from identified farmers the trait- kernel taste of different landraces were recorded as very good in 13, sweet in five and good in four (Table 2). Seven landraces identified as drought and diseases tolerant were recorded for characters based on the opinion of the farmers and also validated through collection database and published literature (Chakravorty and Ghosh, 2011; Plant Germplasm Reporter, 2009). Among the landrace diversity, Gujinina, Kalonunia, Red hira sail, Kanakchur, Radhuni tilak, Dangi basful, Kala mogha and Gujanonia were aromatic types collected from this region.

Variability in quantitative traits

The landraces showed significant variability with respect to the seed morphological characters and adaptation to local environments. Variability was also measured for quantitative traits (Table 3) of rice landraces particularly for kernel length with and without husk, kernel breadth with and without husk, ratio l/b (with husk), ratio l/b (without husk) and 1000 kernel weight (g). Maximum kernel length (8.9 mm) was recorded for gogal sail while minimum kernel length was (6.0 mm) in Kalonunia, Binni dhan and Gujanonia. Maximum kernel breadth (3.5 mm) was recorded for Swarna while minimum kernel breadth (2.1 mm) was recorded for Gujinina. Maximum awn length (19 mm) was recorded for Swarna while minimum awn length (6 mm) was recorded for Lal cholis. Maximum kernel weight (24.74 g) was recorded (Table 3) for Lal cholis while minimum kernel weight (9.32 g) was recorded for Jeera sail. Rice landraces germplasm showed considerable variability for quantitative traits as indicated by coefficients of variation (CV) (Table 3). Among the traits studied the highest variability (CV per cent) was observed for 1000 kernel weight (29.31) followed by ratio of kernel length/breadth without husk (20.21), ratio of kernel length/breadth with husk (17.06) and kernel breadth without husk (16.60).

Cluster analysis

Cluster analysis based on quantitative characters and distance matrices is given in Fig. 3. Dendrogram have indicated two major cluster groups. Major cluster - I comprised 15 landraces while cluster - II comprises eight landraces. Cluster - I further grouped in two sub-clusters based on similarity in quantitative characters and aroma, taste, kernel type was of Tulaipanji, Chini sakkar, Dangi basful, Purnima, Desi mansuri, Kala mogha, Gogal sail, Kalonunia and Binni dhan (9 landraces) in sub-group (a). In sub-group (b) landraces like Gujinina, Jeera sail, Radhuni tilak, Gujanonia, Red hira sail and Chini atap (6 landraces) were grouped on the basis on similarity in quantitative characters, taste and drought resistance. Cluster II also grouped further in two sub-clusters based on similarity in characters like bold seeded type and maximum 1000 kernel weight with Lal cholis, Swarna, Tejasili, Kanakchur and Gauchi (5 landraces). In sub-group (b) landraces like Kartik sail, Magur sail and Nagra dhan (3 landraces) had similar quantitative characters and traits like kernel types, good taste and aroma. The accessions in clusters (I) and (II) are distant viz., Chini sakkar, Dangi basful, Tulaipanji and Tejasili, Lal cholis, Magur sail with traits like kernel husk colour, seed coat colour, aroma, kernel size, 1000 kernel weight, presence of awn and awn length and can be crosses successfully for distinct traits that might helpful in plant breeding programme. Different landraces collected from Dakshin Dinajpur (Binni dhan, Chini sakkar, Dangi basful, Kalonunia, Purnima), Uttar Dinajpur (Desi mansuri, Kala mogha, Gogal sail) and Malda (Tulaipanji) from diverse areas were clustered together. Also landraces collected from Dakshin Dinajpur (Chini atap, Jeera sail, Kanakchur, Kartik sail, Magur sail, Radhuni tilak, Red hira sail, Tejasili) were grouped separately.

Indigenous uses of rice landraces

In the West Bengal, rice grows in three different seasons, locally known as aus rice, aman rice and boro rice. Distinctive uses of rice landraces and their by-products of rice were recorded during household survey of different farmers. In Uttar and Dakshin

Table 1. Variability studies in 23 landraces of rice from Dakshin Dinajpur, Uttar Dinajpur and Malda districts of West Bengal, India.

S.no.	Name of the landrace	Collector no. Dist./State	Kernel colour* (code)	Seed coat colour@	Aroma	Presence of awn
1	Binni dhan	DPS/OPD-16, DD, West Bengal	Grey- brown 199 D	Light brown	Present	Awnless
2	Chini atap	DPS/OPD-29, DD, West Bengal	Greyed-yellow 161 C	White	Present	Awnless
3	Chini sakkar	DPS/OPD-22, DD, West Bengal	Greyed-yellow 161 A	White	Present	Awned
4	Dangi basful	DPS/OPD-35, DD, West Bengal	Greyed-orange 163C	White	Present	Awnless
5	Desi mansuri	DPS/OPD-39, UD, West Bengal	Greyed-orange 164 C	White	Absent	Awnless
6	Gauchi	DPS/OPD-33, MD, West Bengal	Greyed-yellow 161 A	Red	Present	Awnless
7	Gogal sail	DPS/OPD-42, UD, West Bengal	Greyed-orange 165 B	Light brown	Present	Awned
8	Gujanonia	DPS/OPD-5, UD, West Bengal	Grey- brown 199C	Light brown	Present	Awnless
9	Gujinina	DPS/OPD-3, UD, West Bengal	Greyed-yellow 161 B	Light brown	Present	Awnless
10	Jeera sail	DPS/OPD-28, DD, West Bengal	Greyed-yellow 162 A	Light brown	Present	Awnless
11	Kalonunia	DPS/OPD-17, DD, West Bengal	Brown 200 B	Golden yellow	Present	Awnless
12	Kartik sail	DPS/OPD-21, DD, West Bengal	Greyed-orange 174 A	White	Present	Awnless
13	Kala mogha	DPS/OPD-38, UD, West Bengal	Brown N 200A	White	Present	Awnless
14	Kanakchur	DPS/OPD-26, DD, West Bengal	Greyed-yellow 161 B	White	Present	Awned
15	Lal cholis	DPS/OPD-8, UD, West Bengal	Greyed-orange 165 C	Red	Absent	Awnless
16	Magur sail	DPS/OPD-23, DD, West Bengal	Greyed-orange 164 B	Red	Absent	Awnless
17	Nagra dhan	DPS/OPD-36, UD, West Bengal	Greyed-orange 164 B	Red	Present	Awnless
18	Purnima	DPS/OPD-18, DD, West Bengal	Greyed-yellow 162 C	White	Present	Awned
19	Radhuni tilak	DPS/OPD-27, DD, West Bengal	Greyed-yellow 162 A	White	Present	Awnless
20	Red hira sail	DPS/OPD-20, DD, West Bengal	Grey- brown 199 B	Light brown	Present	Awned
21	Swarna	DPS/OPD-1, UD, West Bengal	Greyed-orange 164 D	Red	Absent	Awned
22	Tejasili	DPS/OPD-24, DD, West Bengal	Greyed-orange 165 C	White	Absent	Awned
23	Tulaipanji	DPS/OPD-31, MD, West Bengal	Greyed-orange 164 C	Golden yellow	Present	Awned

DD-Dakshin Dinajpur, UD-Uttar Dinajpur, MD-Malda * RHS Chart 2001, @ Bansal et al. (2006)

Dinajpur districts local tribal people use broken rice (boiled and fermented) with *Coccinia grandis* (vern. Jungli kundri), *Clerodendrum viscosum* (vern. Ghato), *Plumbago zeylanica* (vern. Chitawar), *Vernonia cinerea* (vern. Chhepra) for the preparation of local rice beer (Jhara) or wine (Haria). Local people/tribals from Uttar Dinajpur, Dakshin Dinajpur and Malda districts, bordering to Bangladesh are using Tulaipanji (soft and digestive aromatic rice) landrace during occasions of marriage ceremony or annaprasan (ceremony when infant is offered food for the first time). A landrace Binni dhan is mainly grown in Dakshin Dinajpur was mostly used during Kalipuja (for worship of Goddess Kali in the month of October-November).

Aromatic rice landrace Magur sail was used for preparation of kheer (sweet meal) in Dakshin Dinajpur and adjoining region. A distinct landrace like Kala mogha is also used for sweet meal by local people in Uttar Dinajpur districts, particularly in Majlispur and Maldwar. Landraces Chini sakkar (taste like sugar) and Kalonunia (black textured small rice) are also used during religious ceremonies in Raiganj area of Uttar and Dakshin Dinajpur districts of West Bengal.

In Uttar Dinajpur district the local people boil atop (soaked rice) of Kalonunia in milk and sugar or molasses to prepare a delicious dish known as Payas. Seven landraces were recorded for important traits for the first time from this area. Parboiling of different rice landraces is common practice in West Bengal. Some of the important rice based products in the area of exploration were rice pudding (Payesh), rice cakes (Pithe), rice milk, rice flour, puffed rice (Khoi), parched rice (Muri) and pressed or flake rice (Chira).

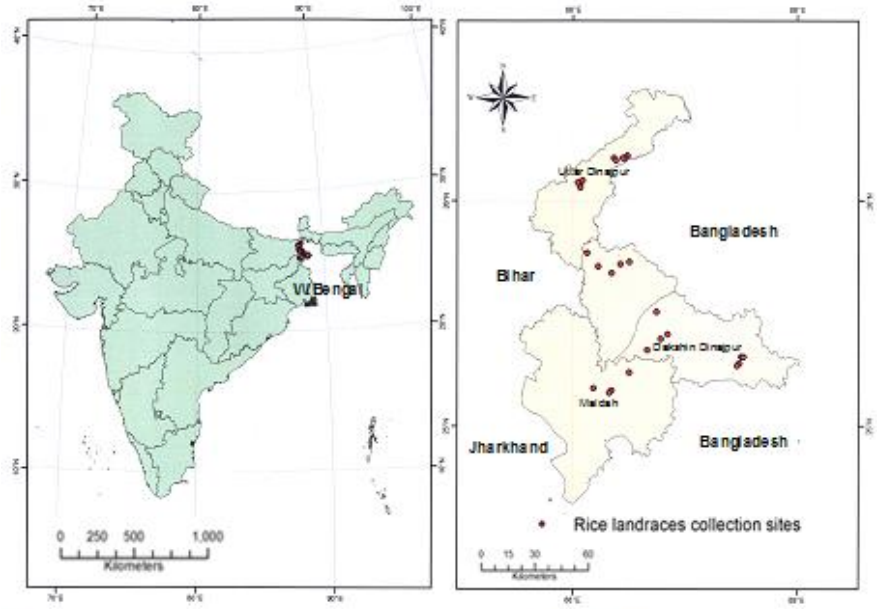

Fig 1. Germplasm sites of rice landraces collected from Dakshin Dinajpur, Uttar Dinajpur and Malda districts of West Bengal, India.

Discussion

Success of a crop improvement programme depends on the magnitude of genetic variability and the extent to which the desirable characters are heritable (Ravi et al., 2003). Analysis of genetic variability in landraces of traditional rice cultivars can help in identifying diverse parental combinations for further selection and to help introgressing desirable genes.

Morphological data

The results presented here, for landraces from West Bengal, reveal high diversity of local landraces. Maximum kernel length (8.9 mm) was recorded for Gogal sail while minimum kernel length was (6.0 mm) in Kalonunia, Binni dhan and Gujanonia. Maximum kernel breadth (3.5 mm) was recorded for Swarna while minimum kernel breadth (2.1 mm) was recorded for Gujinina. Maximum awn length (19 mm) was recorded for Swarna while minimum awn length (6 mm) was recorded for Lal cholis. During household survey it was observed that these landraces were cultivated by many farmers for over a long period of time. Similar results were also reported in rice by several workers (Patra, 2000; Deb, 2000; Singh et al., 2005; Chakravorty and Ghosh, 2011; Mishra and Sinha, 2012; Tirkey et al., 2013). The landraces are known for significant variability with respect to the seed morphological characters and adaptation to local environments (Frankel et al., 1995; Hore, 2005). Rice landraces collected from West Bengal were studied and significant variability was noted for vegetative and seed characters involving eighteen quantitative traits. All the traits except culm length, ligule length, number of grains panicle and number of primary branches/ panicle exhibited positive and significant correlation coefficients with kernel weight (Chakravorty et. al., 2013).

Areas of collection of landraces and data analysis

In the present investigation, the diversity analysis from West Bengal collections showed that 12 landraces were from Dakshin Dinajpur, eight landraces were from Uttar Dinajpur and two landraces were from Malda region mainly analysed for variability in seed morphology. Landrace like Tulaipanji is very popular indigenous aromatic rice grown in a small pocket of West Bengal. It is popular for its medium-long slender grain with high amylose content and strong aroma even after parboiling (Sen et al., 2005; Sen, 2008). Landrace Kalonunia though is relatively smaller sized kernel of golden colour and low yield but had high marketability due to its good taste as compared to other hybrid varieties (Samanta and Mallik, 2004; Dasgupta, 2013). In our study dendrogram indicated two major cluster groups. Major cluster - I comprised 15 landraces while cluster - II comprises eight landraces which are based on quantitative and qualitative characters of landraces. Similar observations were reported in landraces of West Bengal having aroma, drought and diseases tolerance (Deb, 2005; Chakravorty and Ghosh, 2011; Karmakar et al., 2012; Mishra and Sinha, 2012; Das Gupta, 2013; Mall et al., 2013). Several studies were carried out using morphological and molecular markers in different cereal species (Glaszmann, 1987; Thanh et al., 1999; Sun et al., 2001; Zhang et al., 1994). Landraces displayed variability for the trait from which they were named. Analysis of diversity with traditional landraces like Kalo, Rato, Seto, Marshi, Mehele and Darime based on traits like colour of grain, length of kernel, period of maturity etc., showed low level of morphological and molecular diversity (Chakravorty and Ghosh, 2013).

Landraces *viz*., Binni dhan, Chini sakkar, Dangi basful, Kalonunia, Purnima (Dakshin Dinajpur), Desi mansuri, Kala mogha, Gogal sail (Uttar Dinajpur) and Tulaipanji (Malda) from geographically different districts were clustered together. Others like Chini atap, Jeera sail, Kanakchur, Kartik sail, Magur sail, Radhuni tilak, Red hira sail and Tejasili (Dakshin Dinajpur), from same district fall in different clusters. Landraces *viz*., Binni dhan, Chini sakkar, Dangi basful, Kalonunia, Purnima (Dakshin Dinajpur), Desi mansuri, Kala mogha, Gogal sail (Uttar Dinajpur) and Tulaipanji (Malda) collected from diverse areas were grouped in one cluster. Likewise landraces like Chini atap, Jeera sail, Kanakchur, Kartik sail, Magur sail, Radhuni tilak, Red hira sail and Tejasili collected from same areas (Dakshin Dinajpur) were clustered separately. The reason for the former was accounted for free exchange of germplasm among farmers. For the latter, adaptation, selection and cultural variation were

Table 2. Characteristic features recorded in 23 landraces of rice based on feedback from farmers and published records.

S.no	Landrace	Specific note recorded from farmers	Remarks (references cited)
1	Binni dhan	Aromatic type, very good taste, used traditional ceremonies	Puffed rice (Adhikari et al., 2010), aromatic small seed type (Deb, 2005)
2	Chini atap	Aromatic type, sweet taste	Aromatic type (Deb, 2005)
3	Chini sakkar	Aromatic type, very good taste	Very sweet taste, used as whole grain (Deb, 2005)
4	Dangi basful	Aromatic type, very good taste	Feedback from farmers
5	Desi mansuri	Aromatic type, good taste	Aromatic type (Mishra and Sinha, 2012)
6	Gauchi	Very good taste	Feedback from farmers
7	Gogal sail	Aromatic type, sweet taste	Feedback from farmers
8	Gujanonia	Aromatic type, very good taste	Aromatic type (Deb, 2005)
9	Gujinina	Aromatic type, very good taste	Feedback from farmers
10	Jeera sail	Aromatic type, sweet taste, costly	Feedback from farmers
11	Kalonunia	Aromatic type, sweet taste, tolerance to bla stem borers and leaf folders	Protein rich (Adhikari et al., 2010), aromatic type (Das al., 2012), blast resistant (Deb, 2005; Mishra and Sinl 2012), upland, drought tolerant (Karmakar et al., 201 atop used for sweet meal (Das Gupta, 2013)
12	Kartik sail	Good taste	Aromatic, blast resistant (Deb, 2005)
13	Kala mogha	Aromatic type, very good taste	Feedback from farmers
14	Kanakchur	Very good taste	Puffed rice (Adhikari et al., 2010), aromatic type (De 2005, Mishra and Sinha, 2012)
15	Lal cholis	Very good taste	Feedback from farmers
16	Magur sail	Very good taste	Good in taste (Deb, 2005)
17	Nagra dhan	Good taste	Aromatic type (Mishra and Sinha, 2012; Chakravorty al., 2013)
18	Purnima	Aromatic type, sweet taste	Feedback from farmers
19	Radhuni tilak	Aromatic type, very good taste, insect/pes resistance for long term storage	Tolerance to blast and major insect pests such as ste borers and leaf folders (Adhikari et al., 2010), aroma type (Deb, 2005)
20	Red hira sail	Aromatic type, very good taste, tolerance blast, stem borers and leaf folders	Aromatic type (Chakravorty and Ghosh, 2011)
21	Swarna	Good yield	High yield (Das Gupta, 2013)
22	Tejasili	Good taste	Good taste (Deb, 2005)
23	Tulaipanji	Aromatic type, very good taste	Very strongly aromatic, soft kernel, digestive (Adhik et al., 2010; Das et al., 2012), medium-long kernel, hi amylose content, suitable for parboiling (Sen et al., 200

Table 3. Descriptive statistics of different rice landraces collected from Dakshin Dinajpur, Uttar Dinajpur and Malda districts of West Bengal, India.

Variables	Minimum	Maximum	Mean	SE Mean	CV
Kernel length with husk (mm)	6.00	8.90	7.64	0.19	11.94
Kernel length without husk (mm)	4.20	6.70	5.26	0.14	13.40
Kernel breadth with husk (mm)	2.20	3.50	2.65	0.07	13.08
Kernel breadth without husk (mm)	1.60	3.00	2.17	0.07	16.60
Ratio l/b (with husk)	2.00	3.86	2.86	0.10	17.06
Ratio l/b (without husk)	1.51	3.35	2.43	0.10	20.21
1000 Kernel weight (g)	9.31	24.74	15.33	0.93	29.31

probably responsible for variability among the different landraces from same region.

Materials and Methods

Collection of rice landraces

23 landraces were collected from three districts viz., Uttar Dinajpur, Dakshin Dinajpur and Malda of West Bengal during October- November 2012 and April 2013 under two exploration missions. Areas of these regions were surveyed to get information from farmers about their preference of rice landraces. A diverse collection of short and long kernel, aromatic as well as non-aromatic and local rice landraces was made (Table 1) <www.rkmp.co.in>. Only limited material was collected for landraces that were widely distributed over locations. The exploration area lies between latitude 26°11'41"N and longitude 88°10'14"E to latitude 24°52'44"N and longitude 88°2' 59"E in Gangetic alluvial zone. It is surrounded on the north by Bhutan and Sikkim, on the east by Bangladesh, northeast by Assam and on the west by Bihar.

Methodology adopted and observations recorded

Random sampling procedure was followed for collection of germplasm accessions using standard methods (Marshall and Brown, 1975; Hawkes, 1976, 1980). During collection, informal interaction was made with farmers of West Bengal. Kernel colours were recorded using code number mentioned in colour chart developed by RHS (The Royal Horticultural Society), London, United Kingdom (Royal Horticultural Society, 2001). Seed coat colours were based on descriptors developed by National Bureau of Plant Genetic Resources (Bansal et al., 2006). Some visual observations like kernel husk colour, aroma and

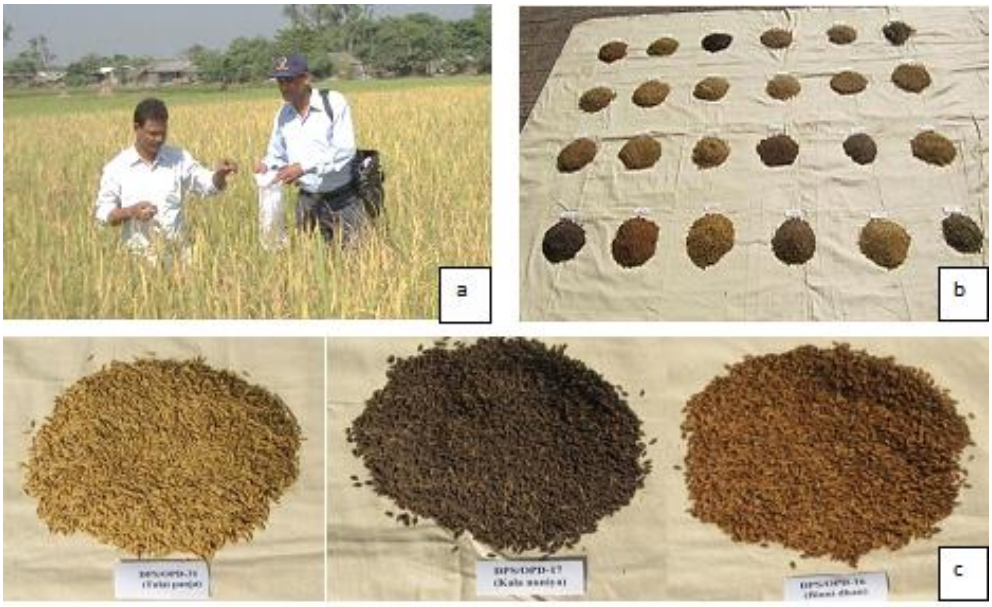

Fig 2. Variability in 23 landraces of rice collected from West Bengal: **a** Collecting landrace in farmers' field; **b** variability collected during field exploration; **c** close-up view of landraces

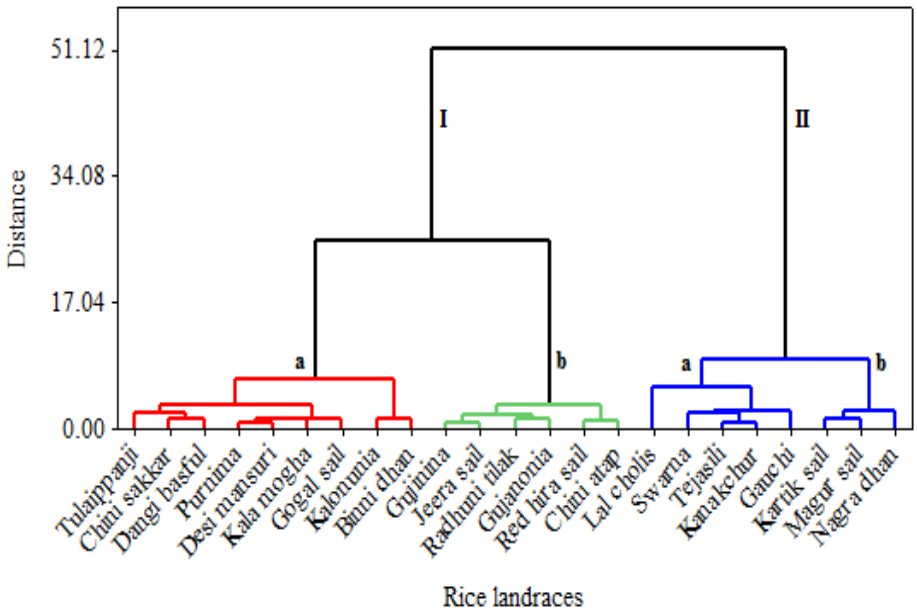

Fig 3. Dendrogram generated by Ward's method based on similarity in quantitative parameters (kernel size, kernel breadth, awn length and kernel weight) for 23 rice landraces collected from West Bengal, India.

presence of awn were recorded for 23 rice landraces. 1000 kernel weight was measured in grams by weighing 1000 seeds and kernel length, breadth was measured with the help of digital vernier calipers, length/breadth ratio was calculated and awn length was measured in millimetre (SI unit system, mm). Different qualitative and tolerance to diseases etc., traits were recorded on the basis of feedback from more than 55 farmers and further validated using published records.

Data analysis and clustering

Multivariate statistical tools have found extensive use in analysing, summarising and describing the inherent variation among crop genotypes. Descriptive statistics of different rice landraces was analysed by calculating mean, minimum, maximum, standard error and coefficient of variation. Data were analysed using MINITAB version 16.0 statistical packages (minitab.com). Cluster analysis of 23 landraces of rice was based on similarity in quantitative parameters (kernel size, kernel breadth, awn length and kernel weight).

A similarity matrix was generated based on the simple Euclidean distance across all accessions of different landraces, and this matrix was used with a hierarchical clustering technique of Ward's Minimum variance method (Ward, 1963; Rao, 1964; Kaufman and Rousseeuw, 1990).

Conclusions

Many of these landraces are poor yielder and grown only in restricted pockets in the area of collection. Special drive is desirable for their collection and conservation. Local farmers are conserving these landraces for specific traits like aroma, good taste and their regional importance. Study on agronomical evaluation of landraces especially Dangi basful, Gauchi, Gogal sail, Kalonunia and Tulaipanji that are popular but grown in small pockets, needs to be done. The traits recorded during germplasm collection are listed on the basis of feedback from farmers and present data gives preliminary observations and require further validation after characterization /evaluation. Characterization of landraces could help breeders to utilize appropriate characters in rice improvement programme. The present investigation provides the base material for the rice breeders for exploitation of landraces possessing one or more desirable characters. Some important traits like kernel husk colour, size of kernel and aroma among the collected landraces like Binni dhan, Chini atap, Chini sakkar, Gujanonia, Jeera sail, Radhuni tilak and Red hira sail are significant for exploiting the character in improvement of rice.

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