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Specific Characteristics Features of Farmers' Varieties of Rice (*Oryza sativa* L.) for Testing of Distinctiveness

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Distinctiveness of a genotype is compulsory for registration under PPV & FR Act (2001). Some of the special characters of rice have been already included in the *Table of Characteristics* in the "Guidelines for Conduct of Test for Distinctiveness, Uniformity and Stability (DUS) on rice (*Oryza sativa* L.)" published by PPV & FR Authority, Government of India for rice, however some other characters which may be included in the descriptor and/or some existing trait in the descriptor may be modified. Six farmers' varieties with some special characteristics were studied for their panicle and grain characters including their special characters. Significant variability was observed for all the panicle and grain characters. In this study, we identified multiple kernel character (reference variety- *Jugal*) which may be included in the descriptors for rice as a novel trait. Occurrence of single, double and triple kernels per spikelet was 53.9, 42.2 and 3.9%, respectively. Only the colour of the sterile lemma has been included in the existing descriptor, whereas the length of the sterile lemma may also be included. The average length of the sterile lemma in *Rami Gelee* was 9.09 mm, whereas the length of fertile lemma was 8.67 mm. Apart from these two characters, in this communication we have described three more characters, namely clustered panicle, coloured kernel and dark purple coloured rice plant.

Key Words: Black kernel, Clustered panicle, Famers' varieties, Long sterile lemma, Multiple kernel, Purple plant, Rice

Introduction

Rice is one of the oldest crop domesticated and during the long period of evolution and domestication, a wide array of crop variability generated by natural and artificial selection in rice. Rice breeders have been exploiting this potential variation in many different and creative ways in crop improvement programmes. The first opportunity to take advantage of the local landraces and wild relatives' with unique characteristics was through searching of the existence of genes for important characters. As Assam and adjoining states are the part of primary centre (The Hindustan Centre of Origin, which includes Myanmar, Assam, Malaya Archipelago, Java, Borneo, Sumatra and Philippinese) of origin of rice the possibility of existence of farmer's varieties (FVs) with unique character(s) may be high. 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). India is the home for more than 75,000 local cultivars/landraces of rice (Paroda and Malik, 1990; Khush, 1997). Studies have revealed that these FVs possess useful genes for rice crop improvement programme (Roy, 2013, Roy *et al*., 2013).

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% area under agricultural crops (Adhikari *et al*., 2012) in three different seasons *viz*., *Aus* (autumn rice), *Aman* (winter rice) and *Boro* (summer rice). The ecotypes of rice, spontaneously evolved in the state, are so diverse and different that scientists at one time coined them as *Oryza sativa* var. *benghalensis* (Chatterjee *et al*., 2008). The unique diversity in landraces/local cultivars of rice from West Bengal is well recognized for significant traits like aroma, taste and disease resistance. However, there are some special characters which may or may not have much importance in respect of consumers' preference, but have immense importance for rice breeder as distinctive character during registration of variety under PPV&FR Act (2001). Considering the immense variability in FVs, some special characters of six FVs in the rice repository of Uttar Banga Krishi Viswavidyalaya have been studied.

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Materials and Methods

The experimental materials consisted of six FVs of rice namely, Rami Gelee, Thuri, Sadabhot Kalo, Kalakali, Kharadhan and Jugal (Table 1). The crop was grown during *Kharif* seasons 2013 and 2014 in randomized block design with four replications. The collected FVs were grown in the University Research Farm, Pundibari, situated at 26°19′ N latitude, 99°23′ E longitude and at a height of 43 MSL. Twenty eight days seedlings were transplanted in the main field. The spacing was maintained at 30 × 25 cm. The standard cultural practices were followed during the crop season to obtain good crop stand in the main field. Each plots consisted of fifteen rows of 5 m length. Five plants from inner rows were randomly selected for taking observation on various quantitative and qualitative characters. Observations were taken on special characters namely, colour and length of sterile lemma of Rami Gelee, clustering pattern of Thuri, presence of double and triple kernels of Jugal, purple coloured leaf and leaf sheath of Khara dhan and kernel colour of Sadabhat Kalo. Ten spikelets of Rami Gelee were taken to measure the length of sterile lemma and the average values were recorded. Ten panicles were taken to record the clustering pattern of Thuri. Digital Varner's caliper was used to measure the length of the sterile lemma and grain dimensions of all the varieties. The average values of the data were reported for various quantitative characters. For the assessment of all colour characteristics, the latest Royal Horticultural Society (RHS) colour chart was used. In addition of those special characters, grain characteristics of above mentioned varieties also have been studied. The data were subjected to standard statistical methods of analysis of variance (ANOVA) using AgRes Statistical Software, (c) 1994 Pascal Intl Software Solutions, Version 3.01 and significant differences were compared by LSD.

Results and Discussion

Analysis of variance showed highly significant differences among the FVs for all the characters studied (Table 2), namely panicle length, number of filled grains per panicle, number chaffy grains per panicle, grain density, spikelet sterility, length of sterile lemma, grain length, grain width, grain L:B ratio and 100-grains weight.

Table 1. Special features of six Farmers' Varieties of rice of West Bengal

S. No.	Genotype	Sources	Special features
1.	Thuri	Tarai Research Society, Alipurduar, W.B.	Clustered panicle
2.	Jugal	Sat Mile Satish Club, Cooch Behar, W.B.	About 60% of the spikelets bears doubled kernel
3.	Rami Gelee	Sat Mile Satish Club, Cooch Behar, W.B.	Sterile lemmas are white in colour and longer than the fertile lemma and palea
4.	Sadabhotkalo,	Tarai Research Society, Alipurduar, W.B.	Lemma and palea of are straw coloured, however, dehusked rice is dark purple to black
5.	Kalakali	Tarai Research Society, Alipurduar, W.B.	Lemma and palea of are purple spot/furrows on straw, however, dehusked rice is light brown
6.	Khara dhan	Tarai Research Society, Alipurduar, W.B.	The colour of fully opened leaves and leaf sheath is deep purple, resistant to lodging

Table 2. ANOVA for the effect of plant growth regulators on callus induction, plantlet regeneration and plantlets per responding callus

Genotypes/Characters	Sources of variation			
	Total (23)	Replication (3)	Treatment (5)	Error (15)
Panicle Length	7.240	0.657	30.768**	0.713
Number of filled grains per panicle	1600.992	156.561	7060.976**	69.884
Number chaffy grains per panicle	215.799	20.664	910.289**	23.329
Grain density	5.702	0.419	24.998**	0.327
Spikelet sterility	19.327	1.424	83.933**	1.373
Length of sterile lemma	6.142	0.011	28.238**	0.003
Grain length	0.778	0.010	3.547**	0.008
Grain width	0.141	0.008	0.633**	0.004
Grain L:B ratio	0.118	0.001	0.539**	0.001
100-grain weight	0.755	0.001	3.465**	0.003

** denote significance at P= 0.01

Clustered Panicle

In general, a pedicel bears one spikelet in a panicle. In the repository of FVs of Uttar Banga Krishi Viswavidyalaya, *Narkeldari* and *Thuri* showed clustered panicle (Figs. 2A-B). The frequency of distribution of spikelet per clusters in Thuri varied from 1 to 4 and from 1 to 6 Narkeldari (Table 3). Clustered habit appears to result mainly from reduction in pedicel length. This feature resulted high grain density in a panicle (Table 4). This result also corroborated with the findings of Chakrabarty *et al*. (2012), for the FV *Khejurchari*. Findings of Sahu *et al*. (2014) for the FVs Amajhopa, Kaudidhul, Chhindguchhi, Nariyal Phool and Amaruthi also confirmed the availability of clustered panicles in the FVs. Panicle and grain characteristic of Thuri have been given in Table 4. It showed highest grain density and reduced spikelet sterility. Its grain type is long bold, straw coloured lemma and palea, and light brown kernel colour.

Table 3. Frequency distribution of spikelet clusters in Thuri and Narkeldari with cluster spikelet

No. of spikelets occurred in cluster	Frequency of spikelet-clusters*	
	Thuri	Narkeldari
1	59.0	10.2
2	20.4	15.3
3	42.0	60.5
4	15.6	11.8
5	–	1.2
6	–	1.0

*Percentage; average of five panicles

Multiple Kernels Per Spikelet

The cultivar *Jugal* had multiple (2-3) kernels per spikelet (Figs. 1C-D). Occurrence of single, double and triple kernels per spikelet in *Jugal* was 53.9, 42.2 and 3.9%, respectively. This was also studied by Chakrabarty *et al*. (2012) and they found that the occurrence of single, double and triple kernels per spikelet were 53.7, 41.3 and 5.0 per cent, respectively. This result corroborated by the findings of Jarvis *et al*. (2008) and Kumar *et al*. (2010). Paul *et al*. (2012) also observed twin and triplet seedlings in up to 20 % of the seeds. The multiple embryos, mostly twins and triplets, and rarely quadruplets, developed through sequential cleavage from a single zygotic embryo in each ovule (Paul *et al*. 2012). As per the observation of Paul *et al*. (2012), multiple seedlings are due to sequential proliferation and cleavage of the zygotic embryos, the nucellar tissue was not involved in multiple embryo development. Grain characteristic of *Jugal* been given in Table 4. Jugal had medium bold grain, straw coloured lemma and palea, and brown kernel.

Rice is single seeded fruit and generally it bears one kernel per spikelet. Old literature on developmental anatomy concludes that rice spikelets are primitively three-grained, of which the two lateral have become vestigial (hence "sterile lemma"). It would be interesting to know if the multi-grained spikelets are a reversion to primitive type, or a new splitting of the central grain (Annonymous, 2015).

Table 4. Grain panicle characters of six farmers' varieties of rice of West Bengal

Characters/ Genotype	Thuri	Jugal	Rami Gelee	Sadabhatkalo	Kalakali	Khara dhan
Panicle length (cm)	21.76 e	24.53 d	28.22 b	24.90 cd	25.95 c	29.52 a
No. of filled grains/panicle	282.10 a	178.78 cd	169.32 d	187.80 c	179.40 cd	211.60 b
No. of chaffy grains/panicle	48.75 c	38.45 b	29.16 a	63.60 d	37.80 b	66.60 d
Grain density	12.96 a	7.25 b	6.00 c	7.54 b	6.91 b	7.17 b
Spikelet sterility (%)	14.73 a	17.70 b	14.69 a	25.29 c	17.40 b	23.93 c
Length of sterile lemma	2.54 e	2.64 d	**9.09 a**	2.79 c	2.92 b	2.17 f
Grain length (mm)	8.10 d	8.26 c	8.67 b	9.86 a	7.46 e	7.24 f
Grain breadth (mm)	2.65 c	3.12 b	3.45 a	3.14 b	2.36 d	3.16 b
L:B ratio	3.05 b	2.65 c	2.51 d	3.14 a	3.16 a	2.29 e
100-grains weight (g)	2.43 d	2.38 d	3.11 b	2.58 c	1.62 e	4.38 a
Grain type	LB	MB	LB	LB	LB	MB
Lemma and palea colour	S	S	DB	S	PS/FS	PS/FS
Kernel colour	LB	B	LB	DP	LB	P

*values bearing same letter in the row are not significantly different at P = 0.05 of LSD; LB: Long bold; MB: Medium bold; S: Straw; B: Brown; DB: Dark brown; LB: Light brown; PS: Purple spot; FS: Furrows on straw; P: Purple; DP: Dark purple

This exceptional character which is not present in the *Table of Characteristics* in the "Guidelines for Conduct of Test for Distinctiveness, Uniformity and Stability on rice (*Oryza sativa* L.)" published by PPV & FR Authority, Government of India for rice (PPV&FRA, 2007). This may be included as distinct character for varietal identification and registration under PPV & FR Act (2001).

Long Sterile Lemma

Generally the sterile lemmas are much smaller in size than the fertile lemma, and they do not bear flower, hence their name "sterile". The sterile lemmas of *Rami Gelee* most of the time exceeded fertile lemma and palea by length (Figs. 1E-F). The average length of the sterile lemma was 9.09 mm, whereas the length of fertile lemma was 8.67 mm (Table 4). *Rami Gelee* exhibited longest sterile lemma (Table 4). The sterile lemma of rest all the FVs were much shorter than the fertile lemma. The colour of the fertile lemma is dark brown, while the sterile lemmas are simple white (Fig. 1E-F). Other panicle and grain characteristics have been given in (Table 4). Grain type of *Rami Gelee* was long bold, lemma and palea colour was dark brown, and colour of the kernel was light brown.

As per description of Chang *et al*. (1965), a spikelet consists of a minute axis (rachilla) on which a single floret is borne in the axils of 2-ranked bracts. The bracts of the lower pair on the rachilla, being always sterile, are the 'sterile lemmas'. The upper bracts or the flowering glumes consist of the lemma (fertile lemma) and palea. The lemma, palea, and the included flower form the floret. The lemma and palea were seldom exceeding one-third the length of the latter (Chang *et al*., 1965). The sterile lemmas may be equal or unequal in size, the upper one generally being larger. The colour of sterile lemma has been included in the *Table of Characteristics* in the "Guidelines for Conduct of Test for Distinctiveness, Uniformity and Stability on rice (*Oryza sativa* L.)" published by PPVFR Authority, Government of India (PPV&FRA, 2007). However, white coloured sterile lemma has not also been included in the guidelines. In the guidelines only four colour have been mentioned, namely, straw, gold, red and purple. The sterile colour of *Rami Gelee* is white in colour (Fig. 1F). The length of sterile lemma also has not been included in the guidelines. So, these two special characters may be included as 'distinct character' for varietal identification and subsequently registration under PPV & FR Act (2001).

Dark Purpled Kernel

Lemma and pelea of *Sadabhot kalo* (Fig. G) and *Kalakali* were straw coloured, however, dehusked rice were dark purple to black (Fig. H) and cooked rice also black. It has a dark purple to black bran layer (inner protective layers on a rice grain), but it is notable that this colour continues through to grain itself so when the kernels are milled, they retained the purple to lavender colour, depending upon the degree of milling. Other panicle and grain characteristics have been given in the Table 4. Grain type was long bold, lemma and palea colour was purple spot or furrows on straw, and colour of the kernel was light brown.

The most common rice consumed by humans is white rice, followed by brown rice. However, rice genotypes with either red/purple or black bran layer have been cultivated for a long time in Asia (Ahuja *et al*., 2007). Coloured rice is reported to be potent sources of antioxidants and their consumption is encouraged (Yawadio *et al*., 2007; Anggraini *et al*., 2015). Black rice contains relatively high anthocyanin (primarily *cyaniding-3-O-glucoside and peonidin 3-O-glucoside*) in the pericarp layer which gives the dark purple color (Ryu *et al*., 1998; Takashi *et al*., 2001; Kristamtini *et al*., 2012). Anthocyanin is known for their bioactive properties and recognized as health-enhancing substances due to their antioxidant activities, anti-inflammatory, anticancer, anti-atherogenic, and anti-hypoglycemic effects (Wang and Stoner, 2008). Black rice is low in sugar but packed with healthy fibre and plant compounds that combat heart disease and cancer, according to scientists (Sutharut and Sudarat, 2012). When rice is processed, millers remove the outer layers of the grains to produce brown rice or more refined white rice, the kind most widely consumed in the West. Brown rice is said to be more nutritious because it has higher levels of healthy vitamin E compounds and antioxidants. But varieties of rice that are black or purple in colour are healthier still. Some scientist claimed that black rice is the new cancer-fighting rice (http://www.dailymail.co.uk/health/article-1306356/Black-rice-new-cancer-fighting-superfood-claim-scientists.html#ixzz3YKu9R4lg).

Research suggests that the dark plant antioxidants, which mop up harmful molecules, can help protect arteries and prevent the DNA damage that leads to cancer. Colored rice have important roles in reducing risk of cancer and other chronic diseases because of their free radicals scavenging capacities (Wang and Stoner,

2008; Shih *et al*., 2007; Elisia *et al*., 2007; Elisia and Kitts, 2008). Black rice also contains higher levels of proteins, vitamins and minerals than common white rice (Suzuki *et al.*, 2004).

Purpled Leaf and Leaf Sheath

The colour of fully opened leaves and leaf sheath of Khara dhan are deep purple (Fig. 1 I). Detail of its importance in photosynthesis and other activities yet to be studied. Sakamoto *et al*. (2001) studied about the purple locus of rice and they stated that the purple leaf (*Pl*) locus of rice affects regulation of anthocyanin biosynthesis in various plant tissues. It is long duration, photoperiod-sensitive cultivar. This FV is almost Registrant to major insect pests and disease pathogens prevailing in northern part of West Bengal. It was also found to be resistant to lodging. So, this FV may be used in resistant breeding as a donor against lodging, insect pests and disease pathogens. Other panicle and grain characteristics have been given in the Table 4. It possessed highest 100-grain weigh (4.38 g). Grain type was medium bold, lemma

Fig. 1. Pictorial depiction of special characters of Farmers' Varieties of rice. A) Undehusked grain of Thuri, B) Panicle of Thuri, C) Undehusked grain of Jugal, occurrence of single, double and triple kernels per spikelet in the FV *Jugal* was 53.9, 42.2 and 3.9%, respectively, D) Dehusked grain of Jugal (one kerneled grain and two kerneled grain, respectively), E) Unhusked grain of Rami Galee F). White coloured lemmas of Rami Gelee, which is generally longer than the fertile lemma and palea, G) Unhusked grain of Sadabhat Kalo, H) Dehusked grain of Sadabhat Kalo, I) Dark purpled leaf and leaf sheath of Khara dhan.

and palea colour was purple spot or furrows on straw, and colour of the kernel was purple.

Nowadays, the common people are health conscious. As per the recent finding, brown rice is said to be more nutritious than white rice (polished rice) because it has higher levels of healthy vitamin E compounds and antioxidants, but, varieties of rice that are black or purple in colour are healthier still. Thus the *Kalakali* and *Sadabhot kalo* may be popularized to improve the nutritional quality of meals of Asian and African people in particular and Latin American in general. The multiple kernel and sterile lemma colour as well as length of sterile lemma may be included in the *Table of Characteristics* in the "Guidelines for Conduct of Test for Distinctiveness, Uniformity and Stability on Rice (*Oryza sativa* L.)" published by PPVFR Authority, Government of India for Rice (PPV&FRA, 2007) for identification and subsequently registration of variety under PPV & FR Act (2001). The colour of the fertile lemma has been included in the guidelines; however the length of sterile lemma has not been included in the guidelines. So, this special character may be included as distinct character for varietal identification and subsequently registration under PPV & FR Act (2001).

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