Morpho-diversity of *Oryza Sativa* L. genetic cultivars from West Bengal, India

Partha Sarathi Saha, Subhabrata Paul and Biswajit Ghosh*

Plant Biotechnology Laboratory, Department of Botany, Ramakrishna Mission Vivekananda Centenary College, Rahara, Kolkata, West Bengal (700 118), India

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Correspondence to

**E-mail*: ghosh_b2000@yahoo.co.in

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Abstract

The present study was undertaken for germplasm collection, and morphological characterization of fifty *Oryza sativa* L. cultivars from West Bengal, India. The starch-iodine test shows that the Borapaddy variety is very sticky, indicating relatively higher amylopectin content. A positive correlation (p= 0.05; two-tailed) was observed between the number of rice grains per panicle and the leaf length or leaf width, suggesting that leaf surface area is intimately linked to photosynthetic capabilities and food storage in the grains of each panicle. The odour perceived after alkaline treatment of grains, revealed that the Tulaipanji, Tulshi bhog, Bhog dhan, Khas dhan, Chini atap, Kalojire, Phulpakri, Kalanunia, Prasad bhog, Kalojoha, Katari bhog, Badsha bhog and Danaguri varieties were aromatic. The results underscore a need for conservation strategies that optimize use of rare cultivars in breeding programs.

1. Introduction

It has been estimated that half the world's population subsists wholly or partially on rice (*Oryza sativa* L.), the second most commonly consumed cereal grain after wheat (Pachauri et al., 2010). Rice belongs to the family: Gramineae (Poaceae) and tribe: Oryzae. Khush (1997) reported that ~1,20,000 varieties of rice are currently known. India is the largest rice growing country accounting for nearly one-third of the world acreage under the crop which is grown in almost all states, covering more than 30% of the total cultivated area (NBPGR-MOEF GOI, 2006). Properties of rice grains that are significant include general physical appearance in terms of grain size or shape and organoleptic qualities such as its aroma and taste because the kernel is consumed as a whole; only a small proportion is converted into flour, flakes or other products (Pachauri et al., 2010). When planted in different agro-ecological conditions rice crops naturally evolve, diversifying the number of varieties. There is a paucity of information regarding important traits in a majority of these landraces (Rana et al., 2009), which limits their use in food grain production.

In India, the state of West Bengal (23°00' N 87° 00' E) (Maps of India, 2012) is a rich reservoir of rice biodiversity (Adhikari, 2012) that derives from a legacy of indigenous farming practices. The resultant genetic variation is extensive and must therefore be conserved in order to develop new varieties that can increase yields, adapt to climatic change, resist new pests or diseases and tolerate other threats to crop production. Modern industrial agricultural practices have, however, eroded biodiversity by displacing traditional rice varieties and scant regard for the farmer's knowledge and skills necessary to cultivate and preserve such varieties (Deb, 2009).

There are several reports on agro-morphological characterization of tropical and subtropical rice varieties (Patra and Dhua, 2003; Ogunbayo et al., 2005; Bajracharya et al., 2006; Barry et al., 2007; Siddiqui et al., 2007; Sanni et al., 2008; Moukoumbi et al., 2011; Sarhadi et al., 2011), but none from West Bengal. Accordingly, the present study was undertaken for the development of rational germplasm collection, conservation and evaluation

Abbreviations

GL: Grain length; GB: Grain breadth; GL/GB: Grain shape; CLP: Colour of lemma-palea; AW: Awning; AWL: Awn length; GW: Weight of 100 grains; PC: Pericarp colour; HT: Plant height; LL: Leaf length; LW: Leaf width; LBP: Leaf blade pubescence; HD: Days to 50% heading; M: Maturity; PN: Number of panicles plant^{-1}; PL: Panicle length; PE: Panicle exsertion; NGP: Number grains unit^{-1} length of panicle.

of 50 wild-type rice varieties of West Bengal.

2. Materials and methods

2.1. Seed collection and storage

Of numerous rice landraces collected from fields of 12 different districts of West Bengal, 50 have now been studied (Table 1) in detail. Along with seed collection, relevant information like local name(s) and other unique features of each variety were also noted. For each germplasm a representative sample of seeds (~40%) collected from several individual plants of single population was labelled and stored at 4-8°C, at the Plant Biotechnology Laboratory, Department of Botany, Ramakrishna Mission Vivekananda Centenary College, Rahara, West Bengal, India.

Field evaluation was carried out in the experimental field of the college campus. About 50 to 60 seeds of each variety were imbibed in water, wrapped in moist blotting paper and laid in a dark chamber for 3-5 days at room temperature. The sprouting seeds were then spread on to the seedbed. The trial was laid out with three replications. Then seedlings of each variety were transplanted to a plot. Each plot was a single 3 m row with 30 cm between rows and 15 cm between plots. Only vermicompost was applied to each seedbed. Different agro-morphological and organoleptic characters of the germplasm were evaluated and recorded using established descriptors for rice (Chang and Bardenas, 1965; Sanni et al., 2008) with some modifications as described in IRRI-IBPGR (1980); NBPGR-MOEF GOI (2006). The time intervals during different growth stages, starting from seedling stage to post-harvest stage were also carefully recorded. Agro-morphological traits like grain length, panicle number, plant height, days to 50% heading, maturity etc. have been conventionally used to estimate relationships between genotypes IRRI-IBPGR (1980).

2.2. Grain characterization

Grain morphology is important for selection of quality marking (Siddiqui et al., 2007). A maximum of 10 grains of each

Table 1: List of different wild-type rice landraces collected from various districts of West Bengal

Sl. No.	Rice variety	District	Sl. No.	Rice variety	District
1	Tulaipanji	North Dinajpur	26	Khasdhan	Burdwan
2	Kaika dhan	Jalpaiguri	27	Lalbachhi	Coochbehar
3	Patnai-Gitanjali	East Midnapur	28	Badsha bhog	Coochbehar
4	Basmati	Murshidabad	29	Kalma	Nadia
5	Bhog dhan	Coochbehar	30	Borapaddy	Jalpaiguri
6	Kalojire	North Dinajpur	31	Lalhusri	Nadia
7	Prasad bhog	North Dinajpur	32	Jhulur	Jalpaiguri
8	Deshi borodhan	North 24 Pgs	33	Shashimohon	North Dinajpur
9	Jangli dhapa	Jalpaiguri	34	Bhadoi	North Dinajpur
10	Zonoroi	North Dinajpur	35	Manikanchan	Nadia
11	Tulshi bhog	Coochbehar	36	Gobinda bhog	Malda
12	Kalanunia	Coochbehar	37	Hajarbibi	North Dinajpur
13	Changa	North Dinajpur	38	Morishal	South 24 Pgs
14	Lokenath	South 24 Pgs	39	Jagdala	North Dinajpur
15	Barajoshoa	Jalpaiguri	40	Rajabadsha	Nadia
16	Shilkumari	North Dinajpur	41	Sungakalma	Nadia
17	Saket	Coochbehar	42	Bachhi dhan	Jalpaiguri
18	Kalajoha	Jalpaiguri	43	Roygorh	South 24 Pgs
19	Ganga-Kaberi	North 24 Pgs	44	Sabita	South 24 Pgs
20	Anjana	Coochbehar	45	Malsiraj	Jalpaiguri
21	Moul	Hoogly	46	Danaguri	Nadia
22	Chini atap	North Dinajpur	47	Deshikalam	North Dinajpur
23	Baishmuthi	Coochbehar	48	Phulpakri	Coochbehar
24	Katari bhog	South Dinajpur	49	Nayanmuni	South 24 Pgs
25	Malsira	Jalpaiguri	50	Behalshal	Nadia

cultivar were used for evaluating different morphological parameters like grain length (GL), grain breadth (GB), shape (GL/GB ratio), colour of lemma-palea (CLP), awns (AW), awn length (AWL), 100 grain weight (GW) and pericarp colour (PC) which together constitute grain quality (Chang and Bardenas, 1965; IRRI-IBPGR, 1980; NBPGR-MOEF GOI, 2006; Sanni et al., 2008).

To characterize the husked grain length (in mm), longitudinal distance from the base of the lowermost sterile lemma to the tip (apiculus) of the lemma was measured. The GL includes short (<8 mm), medium (8-10 mm) or long (>10 mm) types. Similarly, for grain breadth (GB), the dorsiventral distance (diameter) across the lemma and the palea at the widest point was measured. The GL/GB ratio can be interpreted as bold (<2.1 mm), medium (2.1-3.0 mm) or slender (>3.0 mm). The method used for observing colour of lemma-palea (CLP) and awns (AW) of the grains was only by visual inspection. The presence or absence of awns was recorded. The AWL in case of awned varieties was noted as short (<12 mm), moderately long (13-60 mm) or very long (>60 mm) (NBPGR-MOEF GOI, 2006).

Grain weight (GW) influences the choice of selecting a rice variety for consumption. For this, 100 mature dried whole grains were weighed in an electronic balance; they were classified as being light (<2 g), intermediate (2-4 g) or heavy (>4 g) (Sanni et al., 2008; IRRI-IBPGR, 1980). The PC of dehusked grains of each variety was also recorded (Sanni et al., 2008; IRRI-IBPGR, 1980).

2.3. Organoleptic or biochemical characterization

Organoleptic or biochemical properties of the grain may be used to aid in varietal classification (Chang and Bardenas, 1965). Two such properties i.e, the type of endosperm (sticky or non-sticky) and aroma of the grain were tested. The presence of amylose or amylopectin in the starchy endosperm reveals whether the variety is sticky or non-sticky, and it can be estimated by starch-iodine-blue test (Halick and Keneaster, 1956). Chang and Bardenas (1965) have reported a brownish staining reaction with 30% (w/v) iodine solution indicating that only amylopectin is present in the starch granules, whereas, a dark blue staining reaction with 30% (w/v) iodine solution indicates the presence of only amylose in the starch granules.

Another attractive characteristic of high quality rice is its distinctive grain aroma. One of several methods to estimate aroma is by smelling leaf tissue or grains after heating in water and reaction with 1.7% KOH solution for 10-12 min (Sood and Siddiq, 1978). This test was used to classify both the aromatic and non-aromatic rice cultivars.

2.4. Panicle characterization

Yield, the main agronomic trait of any crop plant, depends on different characters of panicle or inflorescence like the number of panicles plant^{-1} (PN), length of panicle (PL), panicle exsertion (PE) and number of spikelets or grains unit^{-1} length of panicle (NGP) (Chang and Bardenas, 1965). The total number of panicles individual plant^{-1} directly denotes the yield potential of that plant. The PN was characterised as low (4-6), medium (7-10) or high (11-14). The PL comprises short (<15 cm), medium (16-25 cm) or long (>25 cm) varieties and was evaluated by measuring the distance (in cm) from the panicle base to the tip. The PE was characterized as well exserted, partly exserted or enclosed on the basis of exsertion of panicle above the flag leaf sheath, after anthesis (Sanni et al., 2008). The NGP may be of lax (3-4), intermediate (5-7) or dense (8-12) types (Chang and Bardenas, 1965).

2.5. Mature plant characterization

To evaluate the diversity in different landraces, plant height (HT) at maturity, leaf length (LL), leaf width (LW), leaf blade pubescence (LBP), days to 50% heading (HD), and maturity (M) were studied as agro-morphological traits (Sanni et al., 2008). The rice plant height (HT) was measured by calculating the distance (cm) from soil surface to the tip of the tallest panicle at or following anthesis. The HT may be semi dwarf (≤110 cm), intermediate (111-130 cm) or tall (>130 cm). The leaf just below the flag leaf was used for measuring the leaf length and width (cm). The LL is short (≤40 cm), medium (41-60 cm) or long (>60 cm), whereas, LW may be narrow (<1.2 cm), medium (1.2-1.6 cm) or broad (>1.6 cm).

Leaf blade pubescence (LBP) was classified as glabrous, intermediate or pubescent, by rubbing the leaf surface from tip to the base with the fingers. Another commonly used measure is the date of 50% panicle emergence or heading (HD). The HD of each individual variety were counted and recorded as very early (<75 days), early (76-90 days), medium (91-105 days), late (106-120 days) or very late (>120 days). The period of maturity (M) for each plant was classified as being very early (<100 days), early (101-115 days), medium (116-130 days), late (131-145 days) or very late (>145 days) depending on the days from seeding to ripening of more than 85% of the grains in the panicle.

2.6. Statistical analysis

To establish correlations, if any, between agro-morphological traits studied, the Pearson's correlation coefficients (n) test was conducted on the data using SPSS v.16.0 software. Each experiment included data obtained from at least 3 replications.

3. Results and Discussion

3.1. Grain quality

Various agronomical parameters like GL, GL/GB ratio, GW and PC were investigated. Table 2 shows remarkable diversity for many of the measured grain parameters pertaining to the

Table 2: Variability in different quantitative agro-morphological characters based on the modified descriptor lists for *Oryza sativa* L. as described in Chang and Bardenas, 1965; IRRI-IBPGR, 1980; NBPGR-MOEF GOI, 2006; Sanni et al., 2008

Sl. No.	Quantitative characters	Descri-ption	Range	No. of var.	Mean±S.E.
1.	Grain length (GL) in mm	L	>10	3	11.0±0.00
		M	8-10	25	8.44±0.13
		S	<8	22	6.45±0.19
2.	Grain shape (GL / GB) in mm	B	<2.1	4	1.86±0.08
		M	2.1-3.0	30	2.71±0.03
		Sl	>3.0	16	3.75±0.13
3.	Awn length (AWL) in mm	VL	>60	-	-
		ML	13-60	5	21.26±3.01
		S	<12	6	8.27±0.81
4.	100 grain weight (GW) in g	H	>4	-	-
		I	2-4	29	2.53±0.04
		L	<2	21	1.75±0.02
5.	Plant height (HT) in cm	T	>130	35	150.11±1.44
		I	111-130	9	125.96±0.83
		SD	≤110	6	108.61±0.66
6.	Leaf length (LL) in cm	L	>60	19	66.07±0.64
		M	41-60	31	50.58±0.86
		S	≤40	-	-
7.	Leaf width (LW) in cm	B	>1.6	3	1.68±0.01
		M	1.2-1.6	31	1.44±0.01
		N	<1.2	13	1.06±0.00
8.	Days to 50% heading (HD) in days	VL	>145	-	113.53±1.37
		Lt	131-145	5	95.82±0.61
		M	116-130	27	82.40±1.44
		E	101-115	18	-
		VE	<100	-	
9.	Maturity (M) in days	VL	>145	-	-
		LT	131-145	5	142.00±0.64
		M	116-130	27	125.81±0.58
		E	101-115	18	110.31±0.7
		VE	<100	-	-
10.	No. of panicles $plant^{-1}$ (PN)	Hi	11-14	15	11.84±0.10
		M	7-10	29	8.08±0.14
		Lo	4-6	6	4.88±0.32
11.	Length of panicle (PL) in cm	L	>25	-	-
		M	16-25	16	18.64±0.52
		S	<15	34	12.58±0.27
12.	No.of grains unit $length^{-1}$ of panicle (NGP)	D	8-12	9	9.66±0.30
		I	5-7 3-4	38	6.00±0.09
		Lx		3	3.77±0.11

Abbreviations used in the Description of the Table 2

L: Long; M:Medium; S: Short; B: BOld; SL: Slender; VL: Very long; ML: Moderately long; H: Heavy; I: Intermediate; L: Light; T: Tall; SD: Semi-dwarf; B: Broad; M: Medium; N: Narrow; VL: Very late; Lt: Late; M: Medium; E: Early; VE: Very early; Hi: High; Lo: Low; D: Dense; Lx: Lax

collection. It was noted that the individual parameters differ in their patterns of geographical distribution among the 12 districts of West Bengal. Nearly 50% of rice varieties had medium grain length (8.44±0.13 mm), of which ~18% were slender in shape and the rest were of medium length. Whereas, ~ 44% of the varieties had short (6.45±0.19 mm) and ~6% had long grains (11.0±0.00 mm). It was observed that ~60% of the collected samples had medium grain shape (2.71±0.03 mm), whereas ~32% had slender (3.75±0.13 mm) and ~8% had bold grain shape (1.86±0.08 mm). The minimum and maximum GL of collected samples ranged between 5.0-13.0 mm and the range for GB was 2.0-4.0 mm, respectively.

Figure 1 depicts the diversity of AWL, CLP among all samples. Nearly 78% of the rice landraces are awnless; these varieties may therefore have been domesticated very early (Table 3; Figure 1). Awn, the extended upper part of the flowering glume plays an important role in rice seed dispersal and it also protects the rice grains from animal attack (Takahashi et al., 1986). Awn lengths vary, ranging from 6.0 mm-28.0 mm;

Figure 1: Fifty different wild-type rice landraces collected from various districts of West Bengal as detailed in Table 1

Table 3: Variability in 7 qualitative morphological characters based on the modified descriptor lists for Oryza sativa L. as described in Chang and Bardenas, 1965; IRRI-IBPGR, 1980; NBPGR-MOEF GOI, 2006; Sanni et al., 2008

Sl. No.	Quantitative characters	Description	No. of variety
1.	Colour of lemma-palea (CLP)	Pale yellow	10
		Yellow	14
		Deep yellow	3
		Light brown	3
		Brown	3
		Deep brown	5
		Blackish brown	4
		Brown furrows on yellow	3
		Brown spot on yellow	2
		Dark purple	3
2.	Awning (AW)	Present	11
		Absent	39
3.	Pericarp colour (PC)	White	32
		Cream	8
		Light brown	4
		Brown	2
		Deep brown	1
		Reddish brown	2
		Deep red	1
4.	Type of en-dosperm	Sticky	1
		Non-sticky	49
5.	Type of grain (on the basis of aroma)	Aromatic	15
		Non-Aromatic	35
6.	Leaf blade pubescence (LBP)	Pubescent	7
		Intermediate	32
		Glabrous	11
7.	Panicle ex-sertion (PE)	Well exserted	34
		Partially exserted	16
		Enclosed	-

the Tulaipanji and Kaikadhan varieties had moderately long awns (21.26±3.01 mm; Table 2), suggesting that they are more wild-type in nature. The Phulpakri and Jagdala rice varieties exhibit typical lemma and palea colour (Figure 1). Other interesting morphologies include brown furrows in Bhadoi (Figure 1) and dark purple colour in Kalajoha, Kalojire and Bhog dhan (Figure 1). An examination of the pericarps reveals that ~64% of rice varieties possess white pericarp (Table 3). Strikingly, varieties like Zonoroi, Kaika dhan, Deshi borodhan, Deshikalam, Changa, Roygorh, Bhadoi, Shilkumari, Lalhushri and Jhulur had different shades of brown or deep red coloured pericarps, which are potentially of enhanced nutritional value. It has been reported that rice varieties having red or brown pericarp are nutritionally rich due to presence of nutrients such as vitamin-B (thiamin, riboflavin, niacin), and elevated concentrations of carotenoids such as lutein (Frei and Becker, 2012). The distribution of phenotypic classes for the weight of 100 rice grains shows ~58% of varieties to be intermediate (2.53±0.04 g) and ~42% to be light weight (1.75±0.02 g), with none in the heavy weight grain category (Table 2).

3.2. *Organoleptic characteristics*

The demand for aromatic rice has been increasing in recent years not only in Asian market but also all over the world (Sarhadi et al., 2011). Grain aroma, revealed by smelling the dehusked grains of each rice variety after reaction with 1.7% KOH solution (Sood and Siddiq, 1978), indicates that 13 cultivars (Tulaipanji, Tulshi bhog, Bhog dhan, Khas dhan, Chini atap, Kalojire, Phulpakri, Kalanunia, Prasad bhog, Kalojoha, Katari bhog, Badsha bhog and Danaguri) were aromatic (Figure 2), in addition to the Basmati and Gobinda bhog varieties that have previously been reported as aromatic (Bradbury et al., 2005; Joshi and Behera 2006). This result coincides with the earlier observations, reported by our group (Saha et al., 2012). Figure 2 shows the morphology of newly identified aromatic rice grains with and without husk. Interestingly, the Tulaipanji, Prasad bhog, Kalojire, Bhog dhan, Tulshi bhog and Kalanunia aromatic varieties also possess awns (Figure 2) suggesting that these cultivars are better adapted to changes in the environment.

Amylose content or stickiness is an important character of rice grains that depends on the ratio of amylose to amylopectin present in the grain endosperm (Chang and Bardenas, 1965). Results from the starch-iodine test revealed that the Borapaddy variety collected from Jalpaiguri district of West Bengal was very sticky; starch granules from this variety gave brown

Figure 2: Identified aromatic rice landraces in the collection with and without husk. (1) Tulaipanji; (2) Prasad bhog; (3) Kalojoha; (4) Chini atap; (5) Kalojire; (6) Phulpakri; (7) Badsha bhog; (8) Katari bhog; (9) Danaguri; (10) Bhog dhan; (11) Khas dhan; (12) Tulshi bhog; (13) Kalanunia.

colouration after reacting with 30% (w/v) iodine solution (Figure 3(c);). All other varieties yielded a typical dark-purple colouration (Figure 3(b);). Thus grain aroma (Figure 2; Table 3) and stickiness (Figure 3; Table 3) both exhibit significant variation among rice samples in our collection. It was reported that sticky rice cultivars were commonly used for making soups in the food industry (Rana et al., 2009).

3.3. Mature plant characteristics

As shown in Table 2, ~70% of the landraces in the collection were found to be tall (150.11±1.44 mm), whereas ~18% were of intermediate height (125.96±0.83 mm) and ~12% were of the semi-dwarf (108.61±0.66 mm) variety. The results also showed that leaf characteristics are highly polymorphic; ~62% in the collection have leaves of medium length (50.58±0.86 mm) while ~38% have long leaves (66.07±0.64 mm). The Deshi borodhan, Moul and Roygorh varieties had long, broad leaves (1.68±0.01 mm), ~62% of the samples had leaves of medium width (1.44±0.01 mm) and ~26% had leaves of narrow width (1.06±0.00 mm) (Table 2). Leaf blade pubescence was observed throughout the collection and was ~22% glabrous; ~64% were intermediate or partially pubescent and ~14% were pubescent (Table 3).

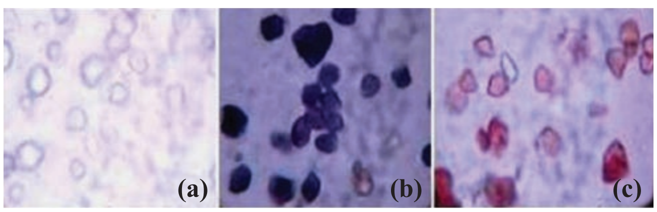

Figure 3: Reaction of iodine solution with rice starch granules. (a) Colourless rice starch granules in the absence of iodine solution (control); (b) Dark blue coloured starch granules with 30% (w/v) iodine solution; (c) Brown coloured starch granules in the presence of 30% (w/v) iodine solution.

With regard to heading, it was observed that ~54% of the samples took 95.82±0.61days to attain 50% head, while ~36% varieties were early heading (82.40±1.44 days) and ~10% were late heading varieties (113.53±1.37 days) (Table 2). Early heading varieties of rice represent a benefit of early ripening of seed and may be useful in grain production (Zafar et al., 2004). The sexual maturity also followed a similar pattern as the number of days required for 50% heading. Of all samples, early maturing (110.31±0.70 days) varieties were ~36%; medium varieties (125.81±0.58 days) were ~54% and late ones (142.00±0.64 days) were ~10% in the collection (Table 2).

The number of panicles varied among rice varieties that reflect their diverse yield potentials. Varieties having medium PN (8.08±0.14) were ~58%, while high PN (11.84±0.10) were ~30%. The remaining varieties (~12%) had low PN (4.88±0.32) (Table 2). The distribution of PE in the collection was ~32% for partially exserted and ~68% for well exserted (panicle base is clearly above the flag leave sheath) varieties (Table 3). The PL and NGP were found to be interrelated.

It was observed that ~68% of the landraces had short PL (12.58±0.27 cm), while ~32% had medium PL (18.64±0.52 cm). About 76% were intermediate (6.00±0.09), ~18% dense (9.66±0.30) and only ~6% had lax NGP (3.77±0.11) (Table 2).

The statistical significance of correlation between these traits was ascertained and is shown in Table 4 along with the matrix

Table 4: Pearson correlation coefficients (n) computed for different agro-morphological traits

Quantitative traits	GL	GB	GL/GB Ratio	AWL	GW	HT	LL	LW	HD	M	PN	PL	NGP
GL	1												
GB	0.312*	1											
GL/GB Ratio	.582**	-.543**	1										
AWL	.055	.054	.026	1									
GW	.535**	.371**	.109	-.161	1								
HT	.066	-.068	.024	.169	.157	1							
LL	.218	.222	.077	.178	.023	.172	1						
LW	.223	.198	.042	.212	.124	.254	.595**	1					
HD	-.191	-.064	-.101	-.051	.023	.171	.030	.186	1				
M	-.047	-.022	-.076	-.147	.163	.185	-.085	.099	.794**	1			
PN	.215	-.029	.229	-.090	-.026	.096	.235	.125	-.213	-.223	1		
PL	.072	.240	-.092	.080	.157	.196	.048	.121	-.208	-.257	.297*	1	
NGP	.226	.025	.191	.002	.198	.239	.283*	.284*	-.215	-.206	.240	.361**	1

*Correlation is significant at 0.05 level (2 tailed); **Correlation is significant at the 0.01 level (2 tailed) of the Pearson's correlation coefficients. Interestingly, we observed a positive correlation between NGP and LL/ LW (*p*=0.05; two-tailed; Table 4). However, the NGP does not bear correlation with either GL or GB or grain shape (GL / GB ratio; Table 4). This suggests that leaf surface area is intimately linked to photosynthetic capabilities leading to increased production of food and its ultimate storage in the grains of each panicle.

4. Conclusion

We highlight comprehensive efforts that are underway for rational germplasm collection, and preliminary agro-morpholgical characterization of fifty *Oryza sativa* L. cultivars from West Bengal, India. A positive correlation was observed between the number of rice grains panicle^{-1} and the leaf length or leaf width, suggesting that leaf surface area is intimately linked to photosynthetic capabilities and food storage in the grains of each panicle. We also identified aromatic cultivars viz. the Tulaipanji, Tulshi bhog, Bhog dhan, Khas dhan, Chini atap, Kalojire, Phulpakri, Kalanunia, Prasad bhog, Kalojoha, Katari bhog, Badsha bhog and Danaguri and this results underscore a need for conservation strategies that optimize use of rare cultivars in breeding programs.

The early heading varieties such as Tulshi bhog, Tulaipanji, Katari bhog and Danaguri are also aromatic and possess awns. These varieties may find novel commercial applications.

We identified the Zonoroi, Kaika dhan, Deshi borodhan, Deshikalam, Changa, Roygorh, Bhadoi, Shilkumari, Lalhushri, and Jhulur had different shades of brown or deep red coloured pericarps, suggesting that they are potentially of enhanced nutritional value. Rice varieties such as Borapaddy, which are sticky, find commercial use in soups and are thus in demand in the food industry.

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6. References

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