International Journal of Botany

ISSN: 1811-9700

science alert

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS International Journal of Botany

ISSN 1811-9700
DOI: 10.3923/ijb.2024.99.109

Research Article
Agro-Morphological Variability of Tepi Boro Rice Landraces of Bangladesh for Effective Conservation and Safeguard from Biopiracy

[1]Mir Sharf Uddin Ahmed and [2]Shahnaz Parveen

[1]Genetic Resources and Seed Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh
[2]Training Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh

Abstract

Background and Objective: Rice (*Oryza sativa* L.) is the staple food in Asia and it is the people's livelihood. The objective of this study was to characterize the variability of Tepi Boro rice landraces in Bangladesh. **Materials and Methods:** In total 25 duplicate or similar named Tepi Boro group of rice germplasm accessions were Agro-morphologically characterized through 33 qualitative traits at Bangladesh Rice Research Institute during Boro 2020-21 season. The qualitative data were recorded by using the Rice Germplasm Descriptors and Evaluation Form of Genetic Resources and Seed Division, BRRI, Gazipur at GRSD, BRRI, Gazipur. **Results:** The frequency distributions of the study revealed that nine main characters showed no variation, nine sub-characters showed the highest dominance, 14 main characters were the most diversified and 19 sub-characters had 12 unique/rare genotypes among the studied characters. For example, all the studied Tepi Boro genotypes (100%) produced intermediate blade pubescence and consequently showed no variation among the genotypes. Similarly, the maximum number (96%) of the studied Tepi Boro genotypes showed white color ligule indicating its dominance and the most diversified traits were the lengths of the longest awn as it was clubbed into maximum five sub-characters. **Conclusion:** The study ensures the effective conservation and safeguarding of the biopiracy of Tepi Boro rice landraces in the BRRI genebank. The study will provide useful information for the breeders to choose and identify trait(s) for new improved rice varieties.

Key words: *Oryza sativa*, agro-morphological trait, Tepi Boro, rice, landrace, diversified traits

Citation: Ahmed, M.S.U. and S. Parveen, 2024. Agro-morphological variability of Tepi Boro rice landraces of Bangladesh for effective conservation and safeguard from biopiracy. Int. J. Bot., 20: 99-109.

Corresponding Author: Mir Sharf Uddin Ahmed, Genetic Resources and Seed Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh
Tel: 01792383994

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food in Asia, which is the people's livelihood because historically, abundant and diversified rice landraces were cultivated all over Bangladesh from time immemorial. Consequently, higher-yielding climate-smart varieties are needed to develop. On the other hand, any crop improvement program depends on the utilization of germplasm stock. Qualitative characters are important for plant description and are mainly influenced by the consumer's preference, socioeconomic scenario and natural selection[1]. For this, broadening the genetic base through the utilization of diverse germplasms in breeding for new rice varieties may be able to break the present yield barrier that rice breeders are currently trying to address. The plant genetic resources are reservoirs of natural genetic variation and provide raw material for crop improvement programs[2]. It is a rich reservoir of valuable genes that plant breeders can harness for crop improvement[3]. Mining elite genes within rice landraces is important for the improvement of cultivated rice[4]. Morphological descriptors were widely used and were found convenient in discriminating different genotypes[5]. Besides, the information generated from phenotyping the germplasms can be used as the basis for future collection trips to augment diversity in the genebank collections[6]. Collection and characterization of the germplasm are not only important for utilizing the appropriate attribute-based donors in breeding programmes, but are also essential in the present era for protecting the unique rice[7]. Consequently, it is very significant for any genebank to protect its conserved germplasms from bio-piracy and issues like geographical indication (GI) and intellectual property rights (IPR). A total of 12,487 names of rice germplasm were listed seasonally and Thana wise in Bangladesh. It was then identified that duplicate(s) named rice germplasm were all over the country[8]. Hence, similar and duplicate named rice germplasm need to be studied to exploit their genetic variation.

Characterization of 124 rice germplasm accessions was conducted based on 19 qualitative agro-morphological[9]. A total of 50 indigenous rice germplasm was evaluated for the agro-morphological traits[10]. Thirty-six similar named aromatic rice landraces of Bangladesh were studied on 25 qualitative characters[11]. Characterization of a core group of 100 landraces of rice (*Oryza sativa* L.), collected from different parts of Chhattisgarh, was conducted following the guidelines from the Protection of Plant Varieties and Farmers' Rights Authority, GOI. The data were recorded on 30 different agro-morphological traits (19 qualitative and 11 quantitative). Out of 30 descriptors studied, five characteristics were found monomorphic and the rest of the characters showed sufficient variations among the accessions. The genetic potential of the mentioned accessions for the desired traits could be utilized in future rice breeding programs to get promising results[12]. Consequently, more detailed studies on similar named groups of rice germplasm in Bangladesh need to be done for its more effective utilization. Therefore, the present study was carried out to characterize and evaluate the 25 similar or duplicate named Tepi Boro group of rice germplasm through qualitative traits.

MATERIALS AND METHODS

Morphological characterization: Twenty-five similar named Tepi Boro rice landrace accessions from BRRI (Bangladesh Rice Research Institute) genebank (Table 1) were characterized through 33 qualitative Agro-morphological traits by using the 'Rice Germplasm Descriptors and Evaluation Form'[8] of Genetic Resources and Seed Division (GRSD) at BRRI, Gazipur.

The unit plot comprised two rows each 5.4 m long. The thirty days old single seedling was transplanted on 25 January, 2021 in the Boro2020-21 season with a spacing of 20×20 cm between rows and plants, respectively at Genetic Resources and Seed Division of BRRI in Gazipur. Fertilizers were applied at 80:20:40 kg N, P and K per hectare, respectively. Crop management such as weeding, irrigation, etc. was done in time. Appropriate control measures were taken for insect pests, diseases and weeds when necessary. Thirty-three qualitative Agro-morphological traits like blade pubescence, blade colour, leaf sheath: Anthocyanin colour, basal leaf sheath colour, flag leaf angle, ligule colour, ligule shape, collar colour, auricle colour, culm: Anthocyanin colouration of nodes, culm angle, internode colour, culm strength, panicle type, panicle exertion, spikelet: Awns in the spikelet, spikelet: Length of the longest awn, distribution of awing, awn colour, apiculus colour, stigma colour, lemma and palea colour, lemma and palea pubescence, seed coat (bran) colour and leaf senescence[11], etc. were recorded for data analysis.

Table 1: List of similar named Tepi Boro rice germplasm for Boro 2020-21 experiment

Sl. No.	Name	Accession No.*	Upazila	District	Season
1	Tape Boro	7297	Kessorgonj	Kessorganj	Boro
2	Tepa IRRI	7855	Dashmina	Patuakhali	Aus
3	Tepakain	1532	---	Dinajpur	Aus
4	Tepi Boro	258	Trisal	Mymensingh	Boro
5	Tepi Boro	930	Nabigonj	Sylhet	Boro
6	Tepi Boro	3998	Derai	Habiganj	Boro
7	Tepi Boro	4526	Sunamganj Sadar	Sunamganj	Boro
8	Tepi Boro	4959	--	Khulna	Boro
9	Tepi Khorch	931	Nabigonj	Sylhet	Boro
10	Tepi Sail	1712	--	Faridpur	Boro
11	Tepi Sail	1724	--	Khulna	Aus
12	Tepi Boro Dhan (Kalo)	8058	Kumarkhali	Kushtia	Boro
13	Tepu	7382	Patuakhali Sadar	Patuakhali	Boro
14	Tepu	7473	Rahamgonj	Bakerganj	Aus
15	Tepu IRRI	6213	Patuakhali Sadar	Patuakhali	Aus
16	Tepu Dhan	7931	Golachipa	Patuakhali	T. Aman
17	Tepu Dhan	7986	Patuakhali Sadar	Patuakhali	Aus
18	Topa	2256	--	Kishorganj	Boro
19	Topa Boro	4373	Moulvibazar Sadar	Moulvibazar	Boro
20	Topa Boro	4981	Pabna Sadar	Pabna	Boro
21	Topa Boro	4983	Pabna Sadar	Pabna	Boro
22	Topa Boro	5041	Pabna Sadar	Pabna	Boro
23	Topa Boro	62	--	Dhaka	Boro
24	Tupa	1811	Hossainpur	Kishorganj	Boro
25	Tupa	2257	--	Kishorganj	Boro

*BRRI genebank accession number

RESULTS AND DISCUSSION

A total of 33 Agro-morphological qualitative characters of 25 genotypes of duplicate or similar named Tepi Boro group of rice germplasm accessions from the BRRI Rice genebank were studied during the Boro 2020-21 season. The results of the assessment of variability of qualitative Agro-morphological characters were described as follows.

Detailed variability of the qualitative traits: All (100%) of the germplasm had intermediate (02) type leaf blade pubescence. However, no glabrous (01) or pubescent (03) type of leaf blade was found among the germplasm (Table 2). A wide range of variability was found among the germplasm for leaf blade colour. The maximum number (36% each) of germplasm showed green (02) and dark green (03) colour leaf blades, while 24% of the germplasm had purple tips (04) and 4% had purple margins (05) leaf blades. But no pale green (01), purple blotch (06) and purple (07) colour of the leaf blade were found among the germplasm. Anthocyanin colouration in leaf sheath was absent (01) in 15 genotypes (60%) of similar or duplicate named Tepi Boro rice germplasm. The rest of the genotypes (40%) had anthocyanin colouration (09) in the leaf sheath. Out of 25 rice germplasm, 15 genotypes (60%) had green (01) nine (36%) had light purple (03) and one (4%) had purple (04) colour of basal leaf sheath. But no purple lines (02) colour of basal leaf sheath was found among the germplasm. All the 25 Tepi Boro germplasm (100%) had erect (<30°) type leaves. But no horizontal (46-90°) or drooping (>90°) type of leaf was found among the germplasm. A total of 13 genotypes of Tepi Boro germplasm (52%) had erect (<30°) type of flag leaf. Whereas nine genotypes (36%) had semi-erect (30-45°) and three genotypes (12%) had horizontal (46-90°) type of flag leaf. But no germplasm had descending (>90°) type flag leaf. A maximum number of genotypes (96%) of Tepi Boro rice germplasm had white (01) and only one genotype had purple lines (02) colour ligule in the leaf. But no purple colour (03) leaf ligule was found among the germplasm. All 25 genotypes of Tepi Boro rice germplasm showed two-cleft (02) shape ligules in the leaf. But, no acute acuminate (01) or truncate (03) shape is found among the germplasm. A total of 23 genotypes of Tepi Boro germplasm (92%) showed pale green (01) and two genotypes (8%) showed purple (03) colour collar in leaf. But a green (02) colour collar was absent in the leaf of the studied germplasm. A maximum number (23) of genotypes of Tepi Boro germplasm (92%) showed pale green (01) and two genotypes showed purple (02) colour auricle in the leaf. Out of 25 Tepi Boro germplasm, 22 genotypes (88%) were absent (01) and only three genotypes (12%) were present (09) of colour in the culm.

Table 2: Classification of 25 Tepi Boro rice based on leaf to culm colour related traits

Sl. No.	Main characters	Sub-characters/classification	No. of entry	Genotypes (1-25 Serial number as in Table 1)	Frequency (%)
1	Blade pubescence	01. Glabrous	25	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	100
		02. Intermediate		16, 17, 18, 19, 20, 21, 22, 23, 24, 25	
		03. Pubescent			
2	Blade colour	01. Pale green			
		02. Green	9	2, 3, 4, 5, 6, 9, 16, 18, 25	36
		03. Dark green	9	7, 13, 14, 15, 17, 19, 20, 21, 22	36
		04. Purple tips	6	1, 8, 10, 11, 23, 24	24
		05 Purple margins	1	12	4
		06. Purple blotch			
		07. Purple			
3	Leaf sheath: Anthocyanin colour	01. Absent	15	2, 4, 5, 7, 9, 13, 14, 15, 16, 17, 19, 20, 21, 22, 25	60
		09. Present	10	1, 3, 6, 8, 10, 11, 12, 18, 23, 24	40
4	Basal leaf sheath colour	01. Green	15	2, 4, 5, 7, 9, 13, 14, 15, 16, 17, 19, 20, 21, 22, 25	60
		02. Purple lines			
		03. Light purple	9	1, 3, 6, 8, 10, 11, 18, 23, 24	36
		04. Purple	1	12	4
5	Leaf angle	01. Erect	25	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	100
		05. Horizontal		16, 17, 18, 19, 20, 21, 22, 23, 24, 25	
		09. Drooping			
6	Flag leaf angle	01. Erect(<30°)	9	2, 5, 10, 11, 13, 17, 21, 22, 24	36
		03. Semi erect (<30-45°)	13	1, 3, 4, 6, 8, 9, 12, 14, 15, 19, 20, 23, 25	52
		05. Horizontal (<46-90°)	3	7, 16, 18	12
		07. Descending (>90°)			
7	Ligule colour	01. White	24	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	96
				16, 17, 18, 19, 20, 21, 22, 23, 24, 25	
		02. Purple lines	1	1	4
		03. Purple			
8	Ligule shape	01. Acute to acuminate			
		02. Two- cleft	25	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	100
		03. Truncate		16, 17, 18, 19, 20, 21, 22, 23, 24, 25	
9	Collar colour	01. Pale green	23	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15,	92
		02. Green		16, 17, 18, 19, 20, 21, 22, 23, 24, 25	
		03. Purple	2	1, 12,	8
10	Auricle colour	01. Pale green	23	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15,	92
				16, 17, 18, 19, 20, 21, 22, 23, 24, 25	
		02. Purple	2	1, 12	8
11	Culm anthocyanin colour	01. Absent	22	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15,	88
				16, 17, 18, 19, 20, 21, 22, 24, 25	
		09. Present	3	11, 12, 23	12

Maximum 13 Tepi Boro genotypes (52%) had intermediate (≈45°) (03) type culm angle, while one genotype (4%) had procumbent (09), five genotypes (20%) had open (≈60°) (05) and six genotypes had erect (<30°) (01) type of culm angles (Table 3). But no spreading (>60°) (07) type of culm angle was found among the germplasm. A total of 22 Tepi Boro genotypes (88%) showed green (01), two genotypes (8%) showed purple lines (03) and only one genotype showed purple (04) colour of internodes. But, no light gold (02) colour internodes were found among the studied germplasm. All the 25 studied Tepi Boro germplasm (100%) showed a strong (01) type of culm strength (lodging resistance). Moderately strong (03), intermediate (05), weak (07) and very weak (09) types of culm strength were absent among the studied germplasm. Out of 25 genotypes, 12 Tepi Boro genotypes (48%) had intermediate (05) type of panicle, seven genotypes (28%) had compact (01) and six genotypes (24%) had open (09) types of panicles. All the 25 studied Tepi Boro germplasm (100%) showed heavy (02) type of secondary branching of panicles. Absent (00), light (01) and clustered (03) types of secondary branching of panicles were absent among the studied germplasm. For panicle exsertion, 16 genotypes (64%) of the studied Tepi Boro germplasm had well exserted (09) types of panicle exsertion, while five genotypes (20%) had just exserted (05) and four genotypes (16%) had moderately well exserted (07) types. But no enclosed (01) and partly exserted (03) types of panicle exsertion were found among the studied germplasm. All the 25 studied rice germplasm (100%) showed a droopy (02) type of panicle axis. A straight (01) type of panicle axis was absent among the studied germplasm. For shattering of panicles, 23 genotypes (92%) showed low (≈3%) (03) type of panicle shattering, while two genotypes (8%)

Table 3: Classification of 25 Tepi Boro rice based on culm angle to threshability related traits

Sl. No.	Main characters	Sub-characters/classification	No. of entry	Genotypes (1-25 serial number as in Table 1)	Frequency (%)
1	Culm angle	01. Erect (<30°)	6	7, 13, 14, 15, 17, 19	24
		03. Intermediate (≈45°)	13	2, 5, 6, 8, 10, 11, 16, 20, 21, 22, 23, 24, 25	52
		05. Open (≈60°)	5	1, 3, 4, 12, 18	20
		07. Spreading (>60°)			
		09. Procumbent	1	9	4
2	Internode colour	01. Green	22	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25	88
		02. Light gold			
		03. Purple lines	2	11, 23	8
		04. Purple	1	12	4
3	Culm strength (lodging resistance)	01. Strong	25	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	100
		03. Moderately strong			
		05. Intermediate			
		07. Weak			
		09. Very weak			
4	Panicle type	01. Compact	7	8, 10, 11, 12, 17, 21, 22	28
		05. Intermediate	12	1, 2, 3, 4, 5, 6, 13, 14, 15, 20, 23, 25	48
		09. Open	6	7, 9, 16, 18, 19, 24	24
5	Secondary branching	00. Absent			
		01. Light		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	
		02. Heavy	25	16, 17, 18, 19, 20, 21, 22, 23, 24, 25	100
		03. Clustered			
6	Panicle exertion	01. Enclosed			
		03. Partly exserted			
		05. Just exserted	5	9, 13, 17, 19, 20	20
		07. Moderately well exerted	4	2, 3, 21, 22	16
		09. Well exerted	16	1, 4, 5, 6, 7, 8, 10, 11, 12, 14, 15, 16, 18, 23, 24, 25	64
7	Axis	01. Straight		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	100
		02. Droopy	25	16, 17, 18, 19, 20, 21, 22, 23, 24, 25	
8	Shattering	01. Very low (<1%)			
		03. Low (≈3%)	23	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25	92
		05. Moderate (≈15%)	2	12, 22	8
		07. High (≈35%)			
		09. Very high (>50%)			
9	Threshability	01. Difficult (<1% grains removed)			
		03. Moderately difficult (1-5%)			
		05. Intermediate (6-25%)	6	2, 10, 15, 17, 19, 25	24
		07. Loose (26-50%)	12	1, 3, 4, 6, 7, 8, 9, 13, 14, 18, 20, 21	48
		09. Easy (51-100%)	7	5, 11, 12, 16, 22, 23, 24	28

showed moderate (≈15%) (05) type of panicle shattering. But very low (<1%) (01), high (≈35%) (07) or very high (>50%) (09) types of panicle shattering were not found among the germplasm. For threshability of the panicle, 12 germplasm (48%) showed loose (51-100% grains removed) type of panicle threshability.

While seven germplasm (28%) showed easy (26-50%) and six germplasm showed intermediate (6-25%) (05) types of panicle threshability. But, difficult (<1%) (01) and moderately difficult (1-5%) (03) types of panicle threshability were absent among the germplasm. As (≈35%) (07) or very high (>50%) (09) types of panicle shattering were not found among the germplasm. For threshability of panicle, 12 germplasm (48%) showed loose (51-100% garins removed) type of panicle threshability, while seven germplasm (28%) showed easy (26-50%) and six germplasm showed intermediate (6-25%) (05) types of panicle threshability. But, difficult (<1%) (01) and moderately difficult (1-5%) (03) types of panicle threshability were absent among the germplasm.

Out of 25 Tepi Boro, awns were absent (00) in 44% germplasm (11 entries), while nine genotypes (36%) had awn at whole length (05), four genotypes (16%) had tip only (01) and one genotype had upper three-quarters only (04) (Table 4). However, awns distribution of the upper half only (03) and upper quarter only (02) of the panicle were absent among the germplasm. For the length of the longest awn, five genotypes had long (≈30 mm) (07), four had very long (>40 mm) (09), three had intermediate (≈15 mm) (05) and one each had very short (<5 mm) and short (≈8 mm) types awn. Similarly, for awns colour, 11 germplasm (44%) showed straw (01) and

Table 4: Classification of 25 Tepi Boro rice based on awn to stigma related traits

Sl. No.	Main characters	Sub-characters/classification	No. of entry	Genotypes (1-25 serial number as in Table 1)	Frequency (%)
1	Distribution of awning	0. Absent	11	2, 3, 8, 9, 10, 11, 13, 15, 16, 17, 19	44
		01. Tip only	4	14, 20, 21, 22	16
		02. Upper quarter only			
		03. Upper half only			
		04. Upper three-quarters only	1	24	4
		05. Whole length	9	1, 4, 5, 6, 7, 12, 18, 23, 25	36
2	Length of the longest awn	01. Very short (<5 mm)	1	14	4
		03. Short (≈8 mm)	1	20	4
		05. Intermediate (≈15 mm)	3	21, 22, 24	12
		07. Long (≈30 mm)	5	5, 7, 12, 18, 23	20
		09. Very long (>40 mm)	4	1, 4, 6, 25	16
3	Awn colour	01. Straw	11	4, 5, 6, 7, 14, 18, 20, 21, 22, 24, 25	44
		02. Gold			
		03. Brown (tawny)			
		04. Red			
		05. Purple	3	1, 12, 23	12
		06. Black			
4	Apiculus colour	01. White	1	22	4
		02. Straw	18	2, 3, 4, 5, 6, 7, 9, 13, 14, 15, 16, 17, 18, 19, 20, 21, 24, 25	72
		03. Brown (tawny)			
		04. Green			
		05. Red			
		06. Red apex			
		07. Purple	6	1, 8, 10, 11, 12, 23	24
		08. Purple apex			
		09. Black			
5	Stigma colour	01. White	24	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	96
		02. Light green			
		03. Yellow			
		04. Light purple			
		05. Purple	1	12	4

three germplasm showed purple (05) colour of awn. But, no gold (02), brown (tawny) (03), red (04) or black (06) colour of awns was found. Around, 72% of the germplasm (18 entries) showed straw (02) colour, while 24% of germplasm (six entries) showed purple (07) and one germplasm showed white (01) colour of apiculus in grain. However, brown (tawny) (03), green (04), red (05), red apex (06), purple apex (08) and black (09) colour of apiculus were not observed in the studied germplasm. Maximum number of Tepi Boro rice germplasm (96%) showed white (01) and only one germplasm showed purple (05) colour of stigma in rice flower. Besides, no light green (02), yellow (03) or light purple (04) colour of stigma were found in the germplasm.

For lemma and palea color, 72% of the germplasm (18 entries) showed straw (00) colour, while 24% germplasm (6 entries) showed gold and gold furrows on straw background (01) and only one showed black (09) colour of lemma and palea (Table 5). But, no brown spots on straw (02), brown furrows on straw (03), brown (tawny) (04), reddish to light purple (05), purple sports on straw (06), purple furrows on straw (07), purple (08) and white (10) colour of lemma and palea were found. All the 25 Tepi Boro germplasm (100%) had short hairs (04) on lemma and palea. But, no glabrous (01), hairs on lemma keel (02), hairs on the upper portion (03) and long hairs (05) types of pubescence on lemma and palea were found. For sterile lemma colour, 23 genotypes (92%) showed straw (01), while one entry each showed gold (02) and purple (04) colour of sterile lemma. But, no red (03) colour sterile lemma was found. Besides, 24 genotypes (96%) germplasm had medium (1.5-2.5 mm) (03) and only one genotype had a short (<1.5 mm) (01) length of sterile lemma. However, long (>2.5 mm-<lemma) (05), extra-long (≥lemma) (07) and asymmetrical (09) types of sterile lemma were not found. For seed coat (bran) colour,13 genotypes (52%) showed red (05), ten genotypes (40%) showed white (01) and one genotype each showed speckled brown (03) and brown (04) colour of the seed coat (bran) respectively. But, no light brown (02) or variable purple (06) or purple (07) colour of the seed coat (bran) was found among the studied germplasm. Maximum 20 genotypes (80%) had glutinous (02) and five genotypes (20%) had Indeterminate (03) types of endosperms. But, no non-glutinous (01) type of endosperm was found. For decorticated grain-scent (aroma), all the genotypes (100%) had non scented and no lightly scented (01) or scented (02)

Table 5: Classification of 25 Tepi Boro rice based on lemma colour to leaf senescence related traits

Sl. No.	Main characters	Sub-characters/classification	No. of entry	Genotypes (1-25 serial number as in Table 1)	Frequency (%)
1	Lemma and palea colour	00. Straw	18	2, 3, 5, 7, 8, 10, 11, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24	72
		01. Gold and gold furrows on straw background	6	1, 4, 6, 9, 15, 25	24
		02. Brown spots on straw			
		09. Black	1	12	4
		10. White			
2	Lemma and palea pubescence	01. Glabrous			
		02. Hairs on lemma keel			
		03. Hairs on upper portion			
		04. Short hairs	25	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	100
		05. Long hairs			
3	Sterile lemma colour	01. Straw	23	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24	92
		02. Gold	1	25	4
		03. Red			
		04. Purple	1	12	4
4	Sterile lemma length	01. Short (<1.5 mm)	1	16	4
		03. Medium (1.5-2.5 mm)	24	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25	96
		05. Long (>2.5 mm-<lemma)			
		07. Extra long (≥lemma)			
		09. Asymmetrical			
5	Seed coat (bran) colour	01. White	10	2, 7, 11, 13, 14, 15, 16, 17, 18, 19	40
		02. Light brown			
		03. Speckled brown	1	21	4
		04. Brown	1	20	4
		05. Red	13	1, 3, 4, 5, 6, 8, 9, 10, 12, 22, 23, 24, 25	52
		06. Variable purple			
		07. Purple			
6	Endosperm type	01. Non-glutinous			
		02. Glutinous	20	2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25	80
		03. Indeterminate	5	1, 6, 8, 18, 19	20
7	Decorticated grain: Scent (aroma)	00. Non scented	25	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	100
		01. Lightly scented			
		02. Scented			
8	Leaf senescence	01. Very early			
		03. Early			
		05. Intermediate	25	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	100
		07. Late and slow			
		09. Very late			

types of decorticated grain were found. Similarly for leaf senescence, all the Tepi Boro germplasm (100%) had intermediate (5) type of leaf senescence at the time of maturity. But there were no very early (01), early (02) late and slow (07) or very late (09) types of leaf senescence among the studied germplasm. The present study revealed sufficient genetic variability for various qualitative traits among the studied Tepi Boro germplasm. All the studied similar named genotypes were found to be distinct based on the studied traits. Finally, the studied traditional Tepi Boro rice landraces show a valuable gene pool.

Similarly, a total of 32 rice accessions of Badshah Bhog were characterized for 22 morphological characters and sufficient variations were found among the accessions for most of the studied traits[8]. Similarly, 71 aromatic landrace type cultivars were characterized for 12 morphological characters using morpho-agronomic descriptors and a wide range of variability for all the studied traits was observed[13]. Fifty-five traditional rice landraces of West Bengal mostly from the lateritic region were characterized for the quantitative and qualitative grain morphological characters and a wide variation for grain size and shape, anthocyanin colouration of lemma-palea and kernel, presence or absence of aroma and awning characteristics was found indicating a wide genetic variation among the landraces[14]. All breeders are continuously looking for morphological markers because these very important markers will enable them to identify specific parental material for specific traits[12]. Similar and comparable studies have been also reported earlier by researchers[10,11,15-20].

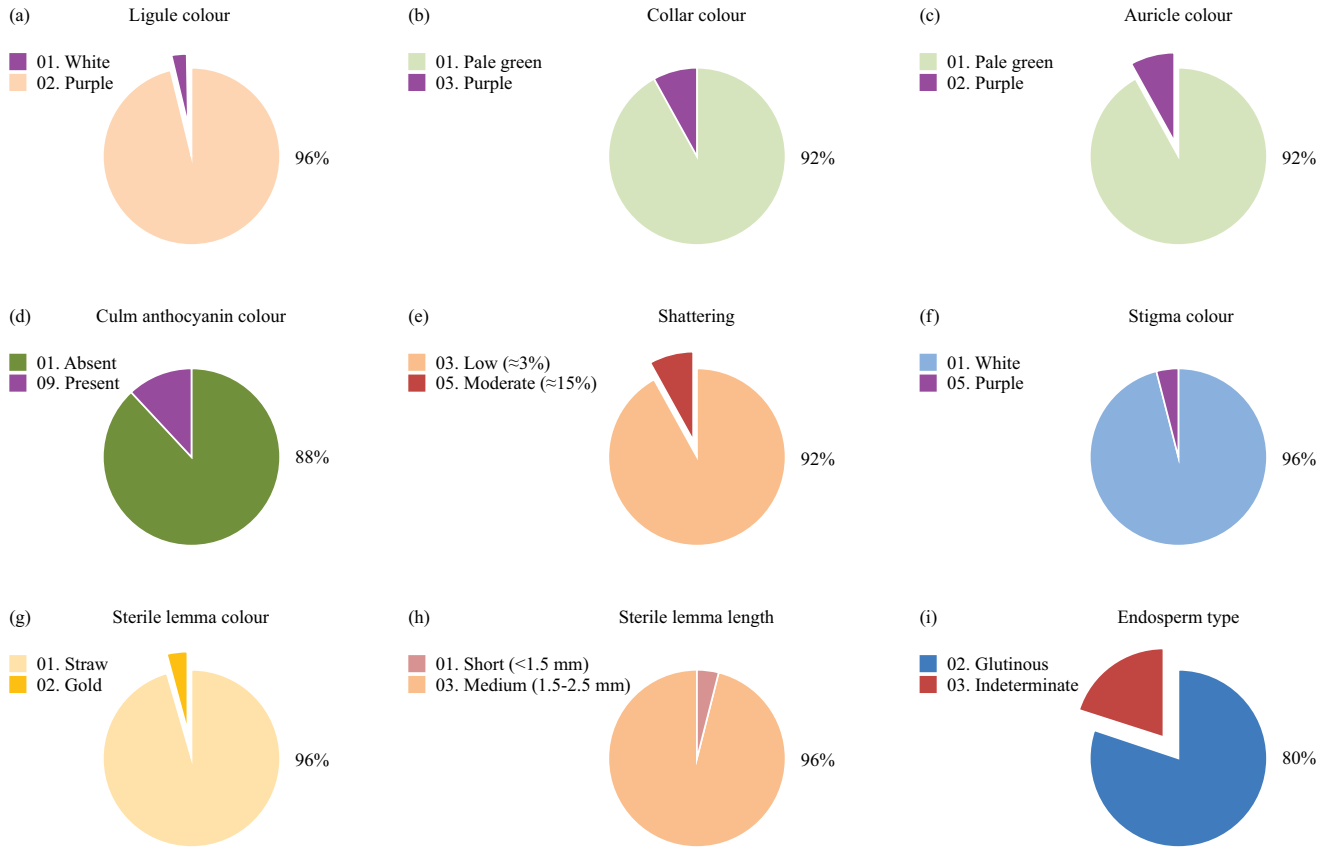

Fig. 1(a-i): Distribution pattern of nine most dominated qualitative Agro-morphological sub-characters among 25 similar or duplicate named Tepi Boro rice germplasm

Extent of the variability of the qualitative traits: The frequency distributions of 33 main qualitative Agro-morphological characters revealed that nine main qualitative characters had no variation, nine sub-characters were the most dominant (more than 80% frequency), 14 main characters were the most diversified and further divided into more than three sub-characters and 19 sub-characters had the 12 unique/rare genotypes that show those sub-characters individually (less than 8% frequency) (Table 2-5).

No variated main characters: All the studied 25 Tepi Boro genotypes (100%) produced intermediate blade pubescence, erect leaf angle, two-cleft ligule shape, strong culm strength (lodging resistance), heavy secondary branching, droopy panicle axis, lemma palea pubescence with short hairs, non-scented decorticated grain and intermediate type leaf senescence (Table 2-5) and consequently showed no variation among the genotypes.

Most dominant main characters: The maximum number of the studied Tepi Boro genotypes were showed white colour ligule (96% of the total studied genotypes) (Table 2-5 and Fig. 1), pale green colour collar (92%), pale green colour auricle (92%), no anthocyanin colour in culm (88%), low (≈3%) shattering type panicle (92%), white colour stigma (96%), straw colour sterile lemma (92%), medium (1.5-2.5 mm) length of sterile lemma (96%) and glutinous type of endosperm (80%) (Fig. 1).

Most diversified main characters: On the other hand, out of 33 agro-morphological main characters, 14 main characters were most diversified and the genotypes were clubbed into a maximum number of sub-characters/groups by showing maximum variations for these traits. For example: For leaf blade colour, out of 25 Tepi Boro genotypes, nine genotypes each showed green and dark green, six genotypes showed purple tips and one genotype showed purple margins colour and consequently four groups were produced for this main trait (Table 2-5 and Fig. 2). Similarly, the rest thirteen main characters were basal leaf sheath colour, flag leaf angle, culm angle, internode colour, panicle type, panicle exsertion, threshability, distribution of awning, length of the longest

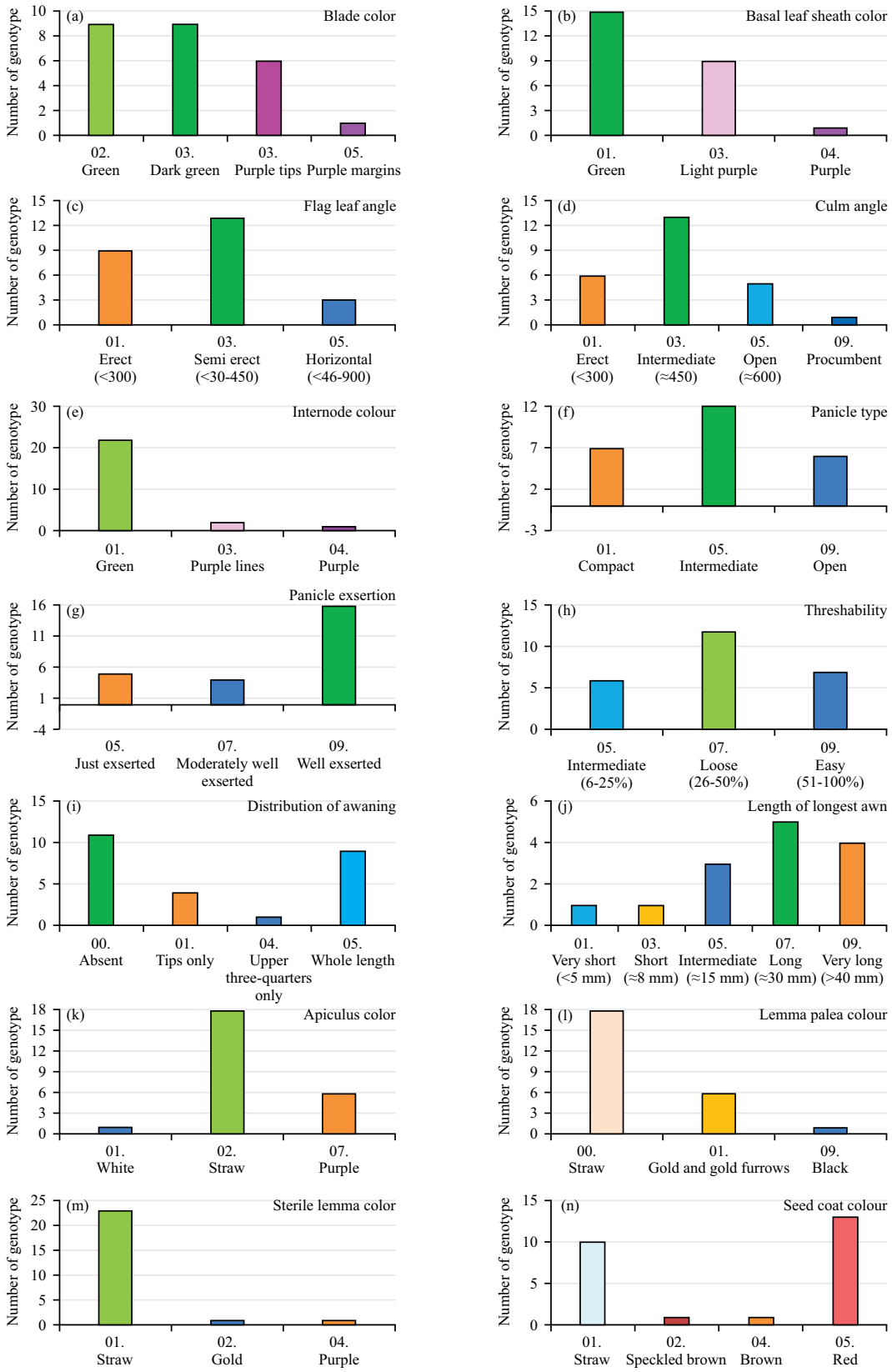

Fig. 2(a-n): Frequency distribution of 14 most diversified qualitative Agro-morphological main characters among 25 similar or duplicate named Tepi Boro rice germplasm

Table 6: List of the unique/rarest Tepi Boro rice germplasm for different qualitative traits

Combined Sl. No.	Main characters	Sub-characters/classification	No. of entry	Genotypes (serial number as in Table 1)
2	Blade colour	05. Purple margins	1	12
4	Basal leaf sheath colour	04. Purple	1	12
7	Ligule colour	02. Purple lines	1	1
9	Collar colour	03. Purple	2	1, 12
10	Auricle colour	02. Purple	2	1, 12
12	Culm angle	09. Procumbent	1	9
13	Internode colour	03. Purple lines	2	11, 23
		04. Purple	1	12
19	Shattering	05. Moderate (≈15%)	2	12, 22
21	Distribution of awning	04. Upper three-quarters only	1	24
22	Length of the longest awn	01. Very short (<5 mm)	1	14
		03. Short (≈8 mm)	1	20
24	Apiculus colour	01. White	1	22
25	Stigma colour	05. Purple	1	12
26	Lemma and palea colour	09. Black	1	12
28	Sterile lemma colour	02. Gold	1	25
		04. Purple	1	12
29	Sterile lemma length	01. Short (<1.5 mm)	1	16
30	Seed coat (bran) colour	03. Speckled brown	1	21
		04. Brown	1	20

awn, apiculus colour, lemma and palea colour, sterile lemma colour and seed coat (bran) colour. Consequently, studied 25 Tepi Boro rice germplasm clubbed into a maximum number of sub-characters or groups or clusters for these nine main characters/traits (Fig. 2).

Unique or rare characters: The unique or rarest genotype was Tepi Boro Dhan (Kalo) (Sr. No. 12) (acc. 8058) for purple margins colour leaf blade, purple colour basal leaf sheath, purple colour collar, purple colour auricle, purple colour internode, moderate (≈15%) type shattering, purple colour stigma, black colour lemma and palea and purple colour sterile lemma traits (Table 6). Similarly, Tape Boro (Sr. No. 01) (acc. 7297), Tepi Khorch (Sr. No. 09) (acc. 931), Tepi Sail (Sr. No. 11) (acc. 1724), Tepu (Sr. No. 14) (acc. 7473), Tepu Dhan (Sr. No. 16) (acc. 7931), Topa Boro (Sr. No. 20) (acc. 4981), Topa Boro (Sr. No. 21) (acc. 4983), Topa Boro (Sr. No. 22)(acc. 5041), Topa Boro (Sr. No. 23) (acc. 0062), Tupa (Sr. No. 24) (acc. 1811) and Tupa (Sr. No. 25) (acc. 2257) genotypes of Tepi Boro rice germplasm were unique/rarest for their respective sub-characters (Table 6).

They are the rarest genotype(s) because they were the only one/two genotype(s) among the studied 25 Tepi Boro group of germplasm that showed the respective different sub-characters. Similar and or comparable studies have been reported earlier[10,11,15,17,21].

CONCLUSION

Characterization based on qualitative traits is an important prerequisite to reveal the presence of substantial variability within the germplasm. It ensures effective collection, evaluation, utilization and conservation management of genebank. Considerable ranges of useful genetic variations were observed among the studied 25 Tepi Boro rice germplasm for different traits though have similar or duplicate names. It is revealed that studied germplasms offer a valuable gene pool. Besides, the information generated from DUS characterization will be supported by their registration for establishing property rights to safeguard from biopiracy. Finally, this study would be useful for breeders to choose and identify trait(s) for new improved rice varieties.

SIGNIFICANCE STATEMENT

Rice (*Oryza sativa* L.) is the staple food in Asia, which is the people's livelihood. Any crop improvement program depends on the utilization of germplasm stock. For this, twenty-five duplicate or similar named Tepi Boro group of rice germplasms were characterized through thirty-three qualitative Agro-morphological traits. The frequency distributions of studied qualitative characters revealed that nine main characters had no variation, nine sub-characters were the most dominant, fourteen main characters were the most diversified and nineteen sub-characters had twelve unique/ rare genotypes. Finally, this study would be useful for breeders to choose and identify trait(s) for Tepi Boro rice improvement.

REFERENCES

1. Das, S. and A. Ghosh, 2010. Characterization of rice germplasm of West Bengal. Oryza, 47: 201-205.

2. Sharma, S., H.D. Upadhyaya, R.K. Varshney and C.L.L. Gowda, 2013. Pre-breeding for diversification of primary gene pool and genetic enhancement of grain legumes. Front. Plant Sci., Vol. 4. 10.3389/fpls.2013.00309.
3. Yadav, S., A. Singh, M.R. Singh, N. Goel, K.K. Vinod, T. Mohapatra and A.K. Singh, 2013. Assessment of genetic diversity in Indian rice germplasm (*Oryza sativa* L.): Use of random versus trait-linked microsatellite markers. J. Genet., 92: 545-557.
4. Zhang, P., X. Liu, H. Tong, Y. Lu and J. Li, 2014. Association mapping for important agronomic traits in core collection of rice (*Oryza sativa* L.) with SSR markers. PLoS ONE, Vol. 9. 10.1371/journal.pone.0111508.
5. Akshay, M., B.S. Chandra, K.R. Devi, Y. Hari and P. Vamshi, 2022. DUS characterization of traditional varieties and advanced cultivars of rice using 29 essential characters. Oryza Int. J. Rice, 59: 157-161.
6. Rabara, R.C., M.C. Ferrer, C.L. Diaz, M.C.V. Newingham and G.O. Romero, 2014. Phenotypic diversity of farmers' traditional rice varieties in the Philippines. Agronomy, 4: 217-241.
7. Bisne, R. and A.K. Sarawgi, 2008. Agro-morphological and quality characterization of Badshah bhog group from aromatic rice germplasm of Chhattisgarh. Bangladesh J. Agric. Res., 33: 479-492.
8. Ahmed, M.S. and S. Parveen, 2024. Qualitative characterization of similar named Jirasail group of rice germplasm of Bangladesh. Int. Res. J. Modernization Eng. Technol. Sci., 6: 1706-1720.
9. Pachauri, A.K., A.K. Sarawgi, S. Bhandarkar and G.C. Ojha, 2017. Agro-morphological characterization and morphological based genetic diversity analysis of rice (*Oryza sativa* L.) germplasm. J. Pharmacogn. Phytochem., 6: 75-80.
10. Singh, M., P. Chouhan and P. Chaudhari, 2021. Agro-morphological characterization of indigenous germplasm accessions of rice (*Oryza sativa* L.). J. Pharmacogn. Phytochem., 10: 1378-1385.
11. Islam, M.Z., N. Akter, T. Chakrabarty, A. Bhuiya, M.A. Siddique and M. Khalequzzaman, 2018. Agro-morphological characterization and genetic diversity of similar named aromatic rice (*Oryza sativa* L.) landraces of Bangladesh. Bangladesh Rice J., 22: 45-56.
12. Rawte, S. and R.R. Saxena, 2018. Morphological characterization of selected rice (*Oryza sativa* L.) from core germplasm group of Chhattisgarh using DUS descriptors. Int. J. Curr. Microbiol. Appl. Sci., 7: 350-357.
13. Parikh, M., N.K. Motiramani, N.K. Rastogi and B. Sharma, 2012. Agro-morphological characterization and assessment of variability in aromatic rice germplasm. Bangladesh J. Agric. Res., 37: 1-8.
14. Sinha, A.K., G.K. Mallick and P.K. Mishra, 2015. Diversity of grain morphology on traditional rice varieties (*Oryza sativa* L.) of lateritic region of West Bengal. World J. Agric. Sci., 11: 48-54.
15. Priyanga, R.S., D. Kumaresan, K. Amudha and S. Geetha, 2020. Study of morphological diversity of rice landraces (*Oryza sativa* L.). Electron. J. Plant Breed., 11: 585-594.
16. Emi, F.R., H. Khatun, F. Yasmine, A. Khairul Hasan and M.A. Hossain, 2021. Morphological variability and genetic diversity of Aman rice germplasm of Bangladesh cultivated in Mymensingh Region. Plant Sci. Today, 8: 972-985.
17. Rao, N.N.D., V. Roja, M. Tushara, V.S. Rao and V.S. Rao, 2021. Characterization and diversity analysis of rice germplasm. Biol. Forum Int. J., 13: 170-179.
18. Lavanya, K., M. Chiranjeevi, R. Surender, P.A.S. Yadav and A.R. Fiyaz *et al*., 2021. Characterization of rice traditional varieties (*Oryza sativa* L.) based on DUS descriptors. Pharma Innovation, 10: 760-771.
19. Gupta, P., M. Parikh, S. Bhat and K. Tandekar, 2023. Morphological characterisation of rice accessions (*Oryza sativa* L.) using morphological descriptors and quality parameters. Pharma Innovation, 12: 4773-4780.
20. Remme, R.N., S. Joti and M. Zahidul Islam, 2024. Agro-morphological characterization and genetic diversity assessment of nineteen BRRI-released rice varieties. Khulna Univ. Stud., 21: 84-97.
21. Kumar, V., N.K. Rastogi, A.K. Sarawgi, P. Chandraker, P.K. Singh and B.K. Jena, 2016. Agro-morphological and quality characterization of indigenous and exotic aromatic rice (*Oryza sativa* L.) germplasm. J. Appl. Nat. Sci., 8: 314-320.