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Qualitative agro-morphological character diversity of similar or duplicate named rice (*Oryza sativa* L.) germplasm of Bangladesh

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Abstract

Twenty-one similar or duplicate named *Kartiksail* rice of Bangladesh were studied for 21 qualitative agro-morphological characters at BRRI during T. Aman 2009-11 seasons. Only the presence and shape of ligule showed no variation. The genotypes showed strong surface pubescence on penultimate leaf blade (57%), erect type flag leaf (81%) and lateral tiller (71%), no anthocyanin color in nodes (86%) straw color of apiculus (76%) and awnless (81%) grain and late and slow type leaf senescence (71%), respectively. Again, four types of leaf blade (pale green, green, purple tip and purple margin), five types of lemma and palea (yellowish to straw, gold and or gold furrows on straw, brown spots/furrows on straw, brown and light purple on straw) and four types of apiculus (straw, gold, brown and purple) were observed among the germplasm. The studied germplasm also showed features for developing varieties with unique identification like KS14 had purple (medium) color in basal leaf sheath, KS5 had purple tip and KS14 had purple margin leaf blade, KS5 and KS6 had purple stigma and apiculus, KS5 had brown (tawny) lemma and palea. Besides, many germplasm had strong hairs on leaf blade surface for developing tolerant varieties against leaf surface infestations. Besides, the genotypes including BR4 and BR23 were grouped into two clusters by the UPGMA clustering method, where cluster II had the maximum genotypes (20). It revealed that accession no 438 and 539 were duplicated. Finally, the *Kartiksail* land races though having similar or duplicate names showed unique variability for safe conservation.

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Introduction

Rice (*Oryza sativa* L.) is the world's most important cereal crop and serves as the primary source of staple food for more than half of the global population (Emani *et al.*, 2008) especially in Asia, Africa and Latin America (Maclean *et al.*, 2002; FAO, 2004). Presently, Bangladesh is self sufficient for its rice production. But, still the productivity of rice is low in its unfavorable ecosystems in the context of its shrinking rice land and water resources. Moreover, global climate change has a negative impact on rice production in Bangladesh especially in its southern regions. Therefore, the new attributes with novel and diverse genes that govern yield structure and the quality traits with indigenous or traditional values, may be considered in parental selection for future rice variety development.

Historically, abundant diversified rice landraces were cultivated in Bangladesh from time immemorial. It is reported that the IRRI Gene Bank contains more than 8,000 traditional rice varieties collected from Bangladesh (Hossain, 2013). But, now rice diversity is threatened in Bangladesh due to extensive cultivation of Modem Varieties (MVs) all over the country and various interventions of rice habitat like cyclone, flood, soil salinity etc (Ahmed *et al.*, 2010). Therefore, rice germplasm need to be utilized for maintaining its diversity in rice field.

Rice germplasm is not only endowed with genetic diversity but also represents a wealth of valuable genes (Sarma *et al.*, 2003). The rice germplasm is a rich reservoir of valuable genes that plant breeders can harness for crop improvement (Yadav *et al.*, 2013). Different agro-morphological traits (passport data) play very important roles for their characterization and varietal identification which ultimately helps rice breeder for its improvement (Laxuman *et al.*, 2011).

Exploring diversity in a landrace collection is very important for identifying new genes and further improvement of the germplasm (Aggarwal *et al.*, 2002; Brondani *et al.*, 2006; Jayamani *et al.* 2007; and Thomson *et al.*, 2007). Knowledge of existing genetic diversity and its distribution in crop species is useful for germplasm conservation and selection of parents with diverse genetic background, thereby rendering crop improvement more efficient (Teklu *et al.*, 2006). Retention of immense genetic diversity is not only significant in terms of evolutionary potential to withstand diverse selection regimes, but also has important implications in rice breeding to furnish new genes for crop improvement, e.g. abiotic stress tolerance, or pest or disease resistance genes (Frankel and Soule, 1981).

A total of 12,487 names of rice germplasm were listed season and Thana wise in Bangladesh. It was then identified that duplicate(s) named rice germplasm were in all over the country (Hamid *et al.*, 1982). Hence, similar and duplicate named rice germplasm need to be studied weather they are duplicate or different. The identification of duplicate accessions was done exclusively on the documentation of the accessions on morphological characters (Ford-Lloyd *et al.*, 1997). Subba Rao *et al.* (2013) characterized forty three agro-morphological traits of sixty-five landraces of rice for the establishment of the distinctness among landraces during kharif season of 2011 and concluded that the study will be useful for breeders, researchers and farmers to identify and choose the restoration and conservation of beneficial genes for crop improvement and also to seek protection under Protection of Plant Varieties and Farmer's Rights Act. But, limited work has been done on characterization of local rice landraces of Bangladesh. Therefore, systematic attempts have to be made to make a total inventory of this valuable gene pool for quantifying the availability of new useful genes of this source. Besides, it is very important to protect biopiracy and geographical indications and issues related IPR. The present experiment was, therefore, undertaken to study the qualitative agro-morphological characters of 21 similar or duplicate named *Kartiksail* rice land races of Bangladesh.

Material and methods

Plant materials

A total of 21 similar or duplicate named *Kartiksail* rice accessions of Bangladesh along with two popular BRRI varieties *viz.* BR4 and BR23 were used in the experiment (Table 1).

Crop cultivation

Thirty days old single seedling was transplanted using spacing within and between rows of 20 and 25 cm, respectively in unit plot of 4 rows each 2.7 m long for each accession during T. Aman 2009 and T. Aman 2011 seasons at BRRI Gazipur. The chemical fertilizers were applied at the rate of 60-50-40-10 kg NPKS per hectare.

Method of data collection

Twenty one qualitative agro-morphological characters were studied and recorded using "Procedure of DUS tests for inbreed and hybrid Rice" (as approved by National Seed Broad, Ministry of Agriculture in Bangladesh, 2001) and "UPOV Rice Test Guidelines" (sources: TG/16/8; project 3).

Data analysis

The qualitative data were transformed to binary form as described by Sneath and Sokal (1973). The presence and absence of the different variants scored as 1 and 0, respectively were calculated by computer using Power Marker version 3.25 software (Liu and Muse, 2005). The qualitative binary data were subjected to cluster analysis using the computer package NTSYS-pc version 2.1 (Rohlf, 2002). A similarity matrix was calculated with the Simqual subprogram using the Dice coefficient, followed by cluster analysis with the SAHN subprogram using the un-weighted pair group method on arithmetic mean (UPGMA) clustering method as implemented in Numerical Taxonomy and Multivariate Analysis System (NTSYS-pc) for portrait the genotypes graphically. The similarity matrix was also used for principal coordinate analysis (PCoA) with the DCenter in NTSYS-pc.

Result and discussion

Extent of variability of the 21 qualitative characters

The 21 genotypes of similar or duplicate named *Kartiksail* rice germplasm showed wide range of variability for qualitative agro-morphological characters under studied. Out of 21 characters, the presence of penultimate leaf ligule and penultimate leaf ligule shape showed no variations among the genotypes as because all the 21 genotypes produced split or two-cleft type shape penultimate leaf ligule. Similar result was earlier reported by Hossain (2008) for green leaf color, presence of penultimate leaf ligule and two-cleft ligule shape. But no variation was observed by Nascimento *et al.* (2011) for light green inter node color and intermediate panicle type and Mahalingam *et al.* (2012) for presence of leaf auricle, absence of anthocyanin coloration of nodes and well exerted panicle exertion traits in rice.

Adair *et al.* (1966) stated that grain size and shape are the first criteria of quality that Breeders consider in developing new varieties for commercial production. In the present study, majority of the genotypes showed no anthocyanin color in leaf sheath (90%), weak and medium intensity of anthocyanin color in basal leaf sheath (each 5%), green leaf blade color (47%), strong surface pubescence of penultimate leaf blade (57%), no anthocyanin color in auricles and collar of penultimate leaf (81%), colorless ligule of penultimate leaf (81%), white color of stigma (90%), erect blade of flag leaf (81%), erect curvature of lateral tiller (71%), no anthocyanin color in nodes (86%), very weak intensity of anthocyanin color in nodes (86%), weak intensity of anthocyanin color in internodes (86%), yellowish to straw anthocyanin color of lemma and palea (below apex area) (43%), medium intensity of anthocyanin color in lemma and palea (57%), yellowish/straw color of apiculus (76%), awnless (81%), distribution of awns as whole lengths (9%), yellowish white to straw color awns (100%) and late and slow type of leaf senescence (71%), respectively among the 21 genotypes of similar or duplicate named *Kartiksail* rice germplasm. The frequency distributions of 19 qualitative agro-morphological characters are presented in Fig. 1, 2 and 3. However, Nascimento *et al.* (2011) found white color of stigma and presence of the glumella pubescence as dominant types in 146 accessions of upland rice. Parikh *et al.* (2012) also observed majority of the genotypes to possess green basal leaf sheath color (84.5%), green leaf blade color (86.8%), green tip color (57.8%), green leaf margin color (57.8%), green collar color (97.3%), white ligule color (94.7%), light green auricle color (97.3%), semi erect plant habit (44.7%), white apiculus color (53.9%), white stigma color (94.7%), awnless (72.3%) and white sterile glume color (59.2%) in 71 aromatic rice germplasm.

Table 1. Alphabetical list of the *Kartiksail* germplasm with BRRI accession number.

Common/ Local name	Code name	Accession number	Place of collection		Date of collection
			Thana	District	
Kartik Sail	KS1	3243	Balaganj	Sylhet	18/03/86
Kartik Sail	KS2	776	Raojan	Chittagong	14/01/74
Katih Shail	KS3	438	Natore	Rajshahi	12.01.74
Kartik Sail	KS4	539	Panchabibe	Rangpur	18.04.74
Kartik Sail	KS5	77	Lohaganj	Dhaka	18/07/74
Kati Shail	KS6	170	Kotowali	Tangail	08.02.74
Kartik Sail	KS7	3662	Sherpur	Sherpur	27/10/86
Kati Shail	KS8	3631	Siagra	Rajshahi	25.10.86
Kartika	KS9	4053	Jaimlapur	Sylhet	Nov.,1988
Kartik Sail	KS10	4881	Haluaghat	Tangail	Nov.,1997
Kartik Sail	KS11	76	Manikganj	Dhaka	18/07/74
Kati Shail	KS12	437	Natore	Rajshahi	10.01.74
Kartik Sail	KS13	78	Lohaganj	Dhaka	02.02.74
Kartik Sail	KS14	1882	Hossainpur	Kishorganj	21.01.76
Kartik Sail (2)	KS15	689	B.Baria	Comilla	21/03/73
Kartik Sail (2)	KS16	846	Kawaighat	Sylhet	17/12/73
Kartik Sail	KS17	664	Faridganj	Comilla	24/11/74
Kartik Sail	KS18	1887	Nandail	Kishorganj	05/02/76
Kartik Sail	KS19	844	Ch. Ghat	Sylhet	15/12/73
Katih Shail	KS20	994	Phultala	Khulna	13.12.73
Kartik Sail	KS21	845	Biswanalh	Sylhet	02/12/73

* = BRRI Rice Genebank accession number.

Detailed frequency distributions of the 21 qualitative characters

The frequency distribution of 19 qualitative agro-morphological characters showed wide range of variations among the germplasm (Table 2). The detail frequency distributions of 19 qualitative characters are given below:

1. Leaf sheath anthocyanin color

Out of 21 similar or duplicate named *Kartiksail* rice germplasm, the anthocyanin coloration in leaf sheath was present (9) only in 10% germplasm (KS6 and KS14). The rest of the genotypes (90%) had no anthocyanin coloration (1) in leaf sheath.

2. Basal leaf sheath anthocyanin color intensity

Out of 21 *Kartiksail* germplasm, intensity of anthocyanin color in basal leaf sheath was absent (1) in 90% germplasm and the rest had 5% weak (3)(KS6) and 5% medium (5)(KS14) intensity.

3. Leaf blade color

Maximum number (47%) of *Kartiksail* germplasm showed green (2) color leaf blade, while 43% had pale green (1), 5% (KS5) had purple tip (4) and 5% (KS14) had purple margin (5) color leaf blade.

4. Penultimate leaf blade surface pubescence

Maximum number (57%) of germplasm had strong (7) surface pubescence on leaf blade. On the other hand, 24% of germplasm had weak (3), 14% (KS8, KS13 and KS18) had medium (5) and 5% (KS5) had very weak or absent (1) pubescence.

Table 2. List of unique *Kartiksail* genotypes for different morphological traits.

Characteristics	index value	Unique genotypes
Leaf sheath: anthocyanin color	9 = present	KS6 and KS14
Basal leaf sheath: intensity of anthocyanin coloration	3 = weak	KS6
	5 = medium	KS14
Leaf blade: color	4 = purple tip	KS5
	5 = purple margins	KS14
Penultimate Leaf blade: pubescence of surface	1 = absent or very weak hair	KS5
	5 = medium	KS8, KS13 and KS18
Penultimate Leaf: color of ligule	3 = green with purple lines	KS5, KS6 and KS14
	4 = light purple	KS17
Stigma: color of stigma	5 = purple	KS5 and KS6
Flag leaf: attitude of blade	3 = semi-erect (30-45˚)	KS14, KS15 and KS19
	5 = horizontal (46-90˚)	KS7
Stem: intensity of anthocyanin coloration of nodes	3 = weak	KS5, KS6 and KS14
Stem: intensity of anthocyanin coloration of internodes	5 = medium	KS2 and KS5
	7 = strong	KS17
Spikelet: anthocyanin color of lemma and palea	2 = gold and or gold furrows on straw	KS2, KS10 and KS17
	4 = brown (tawny)	KS5
	6 = light purple on straw	KS6 and KS14
Spikelet: intensity of anthocyanin coloration of lemma and palea	1 = absent or very weak	KS14
	3 = weak	KS10
	9 = very strong	KS5
Spikelet: color of tip of lemma or apiculus color.	3 = gold	KS2
	4 = brown	KS17
	8 = purple apex	KS5, KS6 and KS14

5. Penultimate leaf auricles and collar anthocyanin color

Anthocyanin coloration of auricles and collar was present (9) only in 19% germplasm, while rest (81%) of the germplasm had no anthocyanin coloration in auricles and collar (1) in penultimate leaf.

6. Penultimate leaf ligule color

Around, 81% of similar or duplicate named *Kartiksail* rice germplasm had colorless (1) ligule in penultimate leaf. On the other hand, only 14% of the germplasm (KS5, KS6 and KS14) had green with purple lines (3) and 5% (KS17) had light purple (4) color ligule in penultimate leaf.

7. Stigma color

Color of stigma of 90% of the germplasm was found white (1). Besides, 10% of the germplasm had purple (5) color of stigma (KS5 and KS6).

8. Flag leaf blade attitude

Maximum number (81%) of germplasm had erect (<30⁰)(1) type of flag leaf. Whereas 14% of the germplasm (KS14, KS15 and KS19) had semi-erect (30-45⁰)(3) and 5% of the germplasm (KS7) had horizontal (46-90⁰)(5) type of flag leaf blade.

9. Stem lateral tiller curvature

The lateral tiller of 71% of the germplasm had erect (<30⁰) and 29% of the germplasm had intermediate (≈30˚) type curvature.

10. Nodes anthocyanin color

Only the 14% of the germplasm had anthocyanin coloration in nodes (9) but rest of the maximum number (86%) of the germplasm had no anthocyanin coloration (1) in nodes.

11. Nodes anthocyanin color intensity

The maximum number (86%) of the germplasm had no or very weak (1) intensity of anthocyanin coloration in nodes. On the other hand, 14% (KS5, KS6 and KS14) had weak (3) intensity of anthocyanin colorations in nodes.

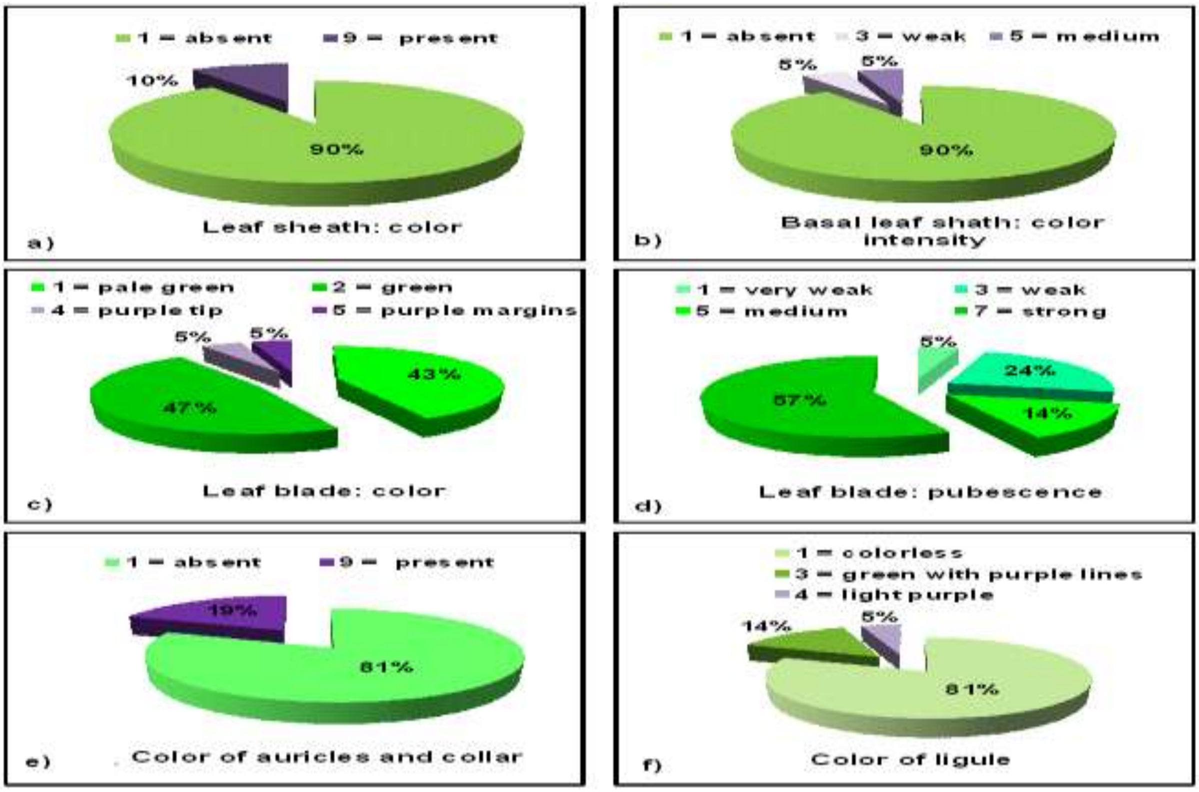

Fig. 1. Frequency distribution of basal leaf sheath color and its intensity, leaf blade color and its pubescence and color of auricles, collar and ligule of 21 *Kartiksail* rice.

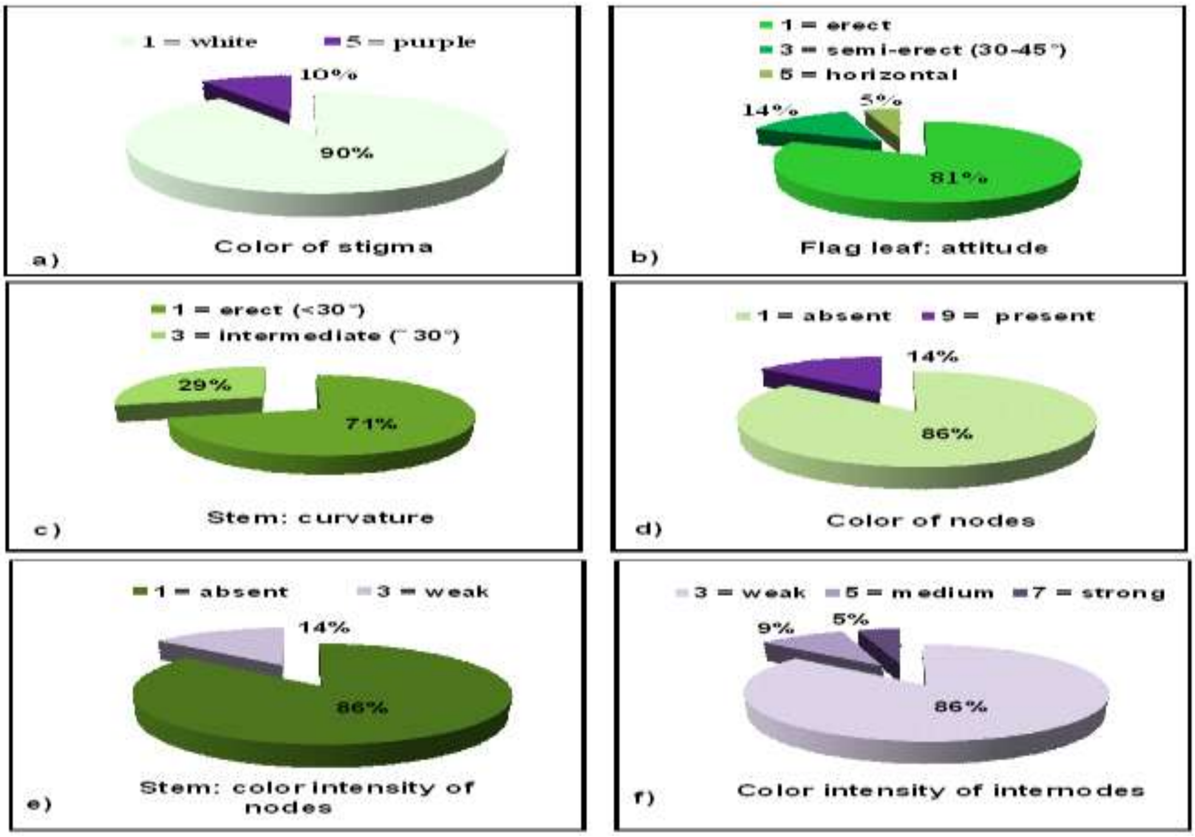

Fig. 2. Frequency distribution of stigma color, flag leaf attitude, stem curvature, color of node and color intensity of nodes and internodes of 21 *Kartiksail* rice.

12. Internodes anthocyanin color intensity

The anthocyanin coloration in internodes of 86% of the germplasm had weak intensity, while 9% (KS2 and KS5) had medium (5) and 5% (KS17) had strong (7) intensity of anthocyanin colorations in similar or duplicate named rice germplasm.

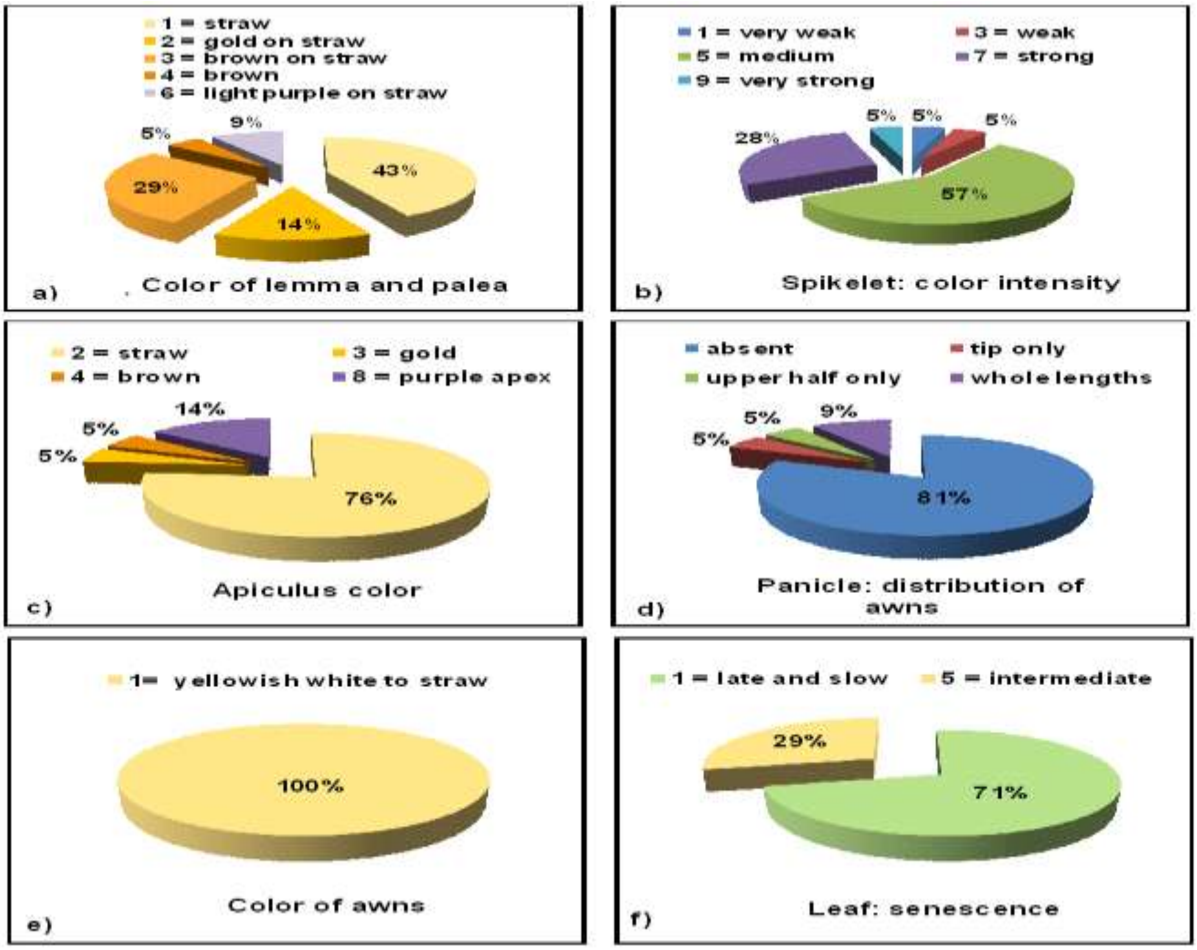

Fig. 3. Frequency distribution of lemma and palea color and its intensity, apiculus color, awns distribution and its color and leaf senescence of 21 *Kartiksail* rice.

13. Lemma and palea anthocyanin color

The anthocyanin coloration of lemma and pale showed wide range of variability among the *Kartiksail* rice germplasm. Out of 21 genotypes, 43% of the germplasm had yellowish to straw (1) color lemma and palea, while 14% (KS2, KS10 and KS17) had gold and or gold furrows on straw (2), 29% had brown spots/furrows on straw (3) and 5% had (KS5) brown (tawny)(4) and 9% (KS6 and KS14) had light purple on straw (6) color lemma and palea.

14. Lemma and palea anthocyanin color intensity

The anthocyanin color intensity of lemma and pale showed wide range of variations among the germplasm. Around 57% of the germplasm had medium (5) intensity of anthocyanin coloration on lemma and palea, while 28% had strong (7), 5% of each had very weak (1)(KS14), weak (3)(KS10) and very strong (9)(KS5) color intensity, respectively (Fig. 4).

15. Apiculus color or tip of lemma color

A wide range of apiculus color variability was found among the germplasm. Around, 76% of the germplasm showed yellowish/straw (2) color, while 14% (KS5, KS6 and KS14) had purple apex (8), 5% of each had gold (3)(KS2) and brown (4)(KS17) color of apiculus, respectively.

16. Awns in spikelet

Out of the 21 germplasm, awns were present (9) only in 19% germplasm but the rest of the genotypes (81%) were awnlesss (1).

Remarks: First row contains KS1 to KS7, second row contains KS8 to KS14 and third row contains KS15 to KS21 (all from left to right).

Fig. 4. Seed grain diversity of 21 *Kartksail* rice.

17. Awns distribution

Awns were distributed throughout the whole length of panicle (9) on 9% of the germplasm (KS8 and KS13), while distributed on the tip of panicle (1) on 5% (KS19) and upper half of panicle (5) on 5% of the germplasm (KS6).

18. Awns color

Out of the 19% of awned germplasm, all the 4 germplasm showed yellowish white to straw (1) color awns.

19. Leaf senescence

A maximum number of germplasm (71%) had late and slow (1) and 29% had intermediate (5) type of leaf senescence at the time of maturity among the 21 *Kartiksail* germplasm.

Custer analysis of Kartiksail germplasm for 19 qualitative characters

The dendrogram, constructed by using UPGMA clustering method based on Dice coefficient, distributed the 21 similar or duplicate named *Kartiksail* rice germplasm along with two popular BRRI rice varieties *viz.* BR4 and BR23 into two major clusters along with minor sub-clusters, groups and sub-groups for 19 qualitative agro-morphological traits (Fig. 5).

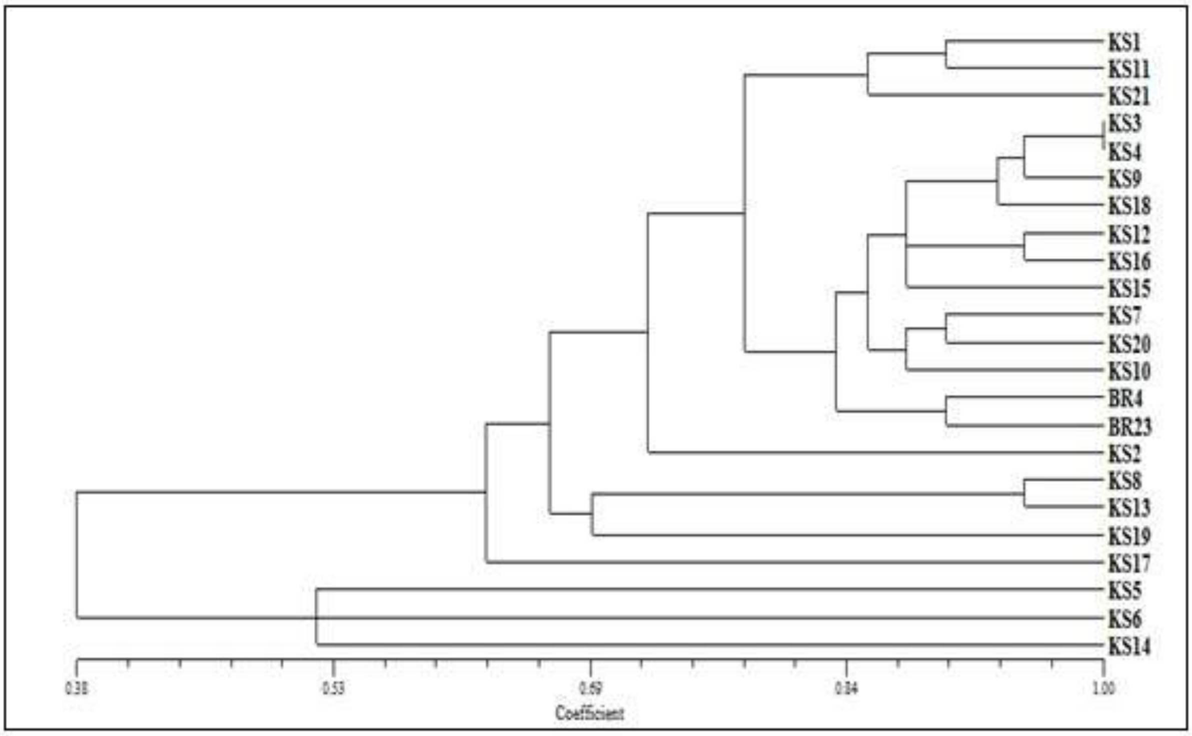

Fig. 5. Dendrogram of 21 *Kartiksail* rice for 19 qualitative agro-morphological characters.

Out of two major clusters, only one was major. Cluster II was the major cluster with maximum genotypes (20), while clusters I consisted of three genotypes (KS5, KS6 and KS14), respectively. Besides, Clusters II were consisted of three sub-clusters. The first sub-cluster of cluster II consisted with only one genotype namely KS17. The second sub-cluster consisted with three genotypes namely KS8, KS13 and KS19. The third sub-cluster of cluster II consisted with sixteen genotypes namely KS2, KS10, KS20, KS7, KS15, KS16, KS12, KS18, KS9, KS4, KS3, KS21, KS11 and KS1, respectively along with the popular BRRI varieties BR4 and BR23. Similarly, Hossain (2008) observed 10 clusters by using UPGMA clustering method in 78 aromatic and fine grain landraces of rice genotypes. Rahman *et al.* (2009) studied 110 rice varieties for evaluating genetic divergence and identified four groups for the qualitative data studied. But, Nascimento *et al.* (2011) found two major groups by using UPGMA clustering method in 146 accessions of upland rice.

It was also revealed from the result that the genotypes KS3 (accession no 438) and KS4 (accession no 539) in cluster II were identified as same which indicated that they were 100% similar for all the 21 qualitative agro-physiological characters studied. Bisne and Sarawgi (2008) and Nascimento *et al.* (2011) found 18 duplicates genotypes by evaluating 32 and 146 rice accessions, respectively and none of these duplicates included accessions with the same genotype name. But Hossain (2008) found six pairs of duplicate genotypes by evaluating 23 qualitative traits in 78 aromatic and fine grain landraces of rice and three pairs of these duplicates (Kalijira-1 & Kalijira-2, Kalijira-8 & Kalijira-10, Kalijira-12 & Kalijira-14) had accessions with the same genotype name. However, Fukuoka *et al.* (2006) in studies with aromatic rice landraces concluded that significant variation may be found among genotypes with the same name.

The genetic distance, ranging from 0.000 to 9.932, also revealed the existence of significant differences among the 21 similar or duplicate named *Kartiksail* rice land races. The highest distances (9.932) were recorded between genotypes (KS3 and KS11) and (KS4 and KS11) and the lowest (0.000) between genotype KS3 and KS4.

Conclusion

Finally, it can said that the *Kartiksail* land races though having similar or duplicate names showed exclusive variability and unique features for the studied qualitative characters which can be selected for developing varieties with unique identification, better quality and broaden genetic bases. Besides, many germplasm had strong hairs on the surface of the leaf blade, which can be utilized for developing tolerant varieties for leaf surface related insects and diseases. Besides, characterizations of the identified genotypes need to be done using SSR markers for QTL mapping and validating candidate valuable genes.

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