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Exploring the characteristics of traditional rice (*Oryza sativa* L.) genotypes through DUS evaluation

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Abstract

Fifty-three traditional genotypes of rice (*Oryza sativa* L.) collected from different parts of Tamil Nadu, India and characterized for different qualitative and quantitative characters by following the guidelines from the Protection of Plant Varieties and Farmer's Rights Authority (PPV & FRA). The experiment was conducted in an Randomized block design (RBD) with three replications during Kharif-2021. Out of 41 descriptors studied, three characteristics were found monomorphic, fifteen were dimorphic, ten were trimorphic, nine were tetramorphic and four were polymorphic. The traits like green coleoptiles, medium-green leaf colouration and white ligules were prevalent among the studied genotypes. Similarly, attributes like semi-erect culm attitude, presence of secondary branching and well exerted panicle had prominently observed. However, the study also highlighted the diversity of leaf characteristics, varied stem traits, heterogeneity in panicle attributes and grain variabilities.

Key words : DUS, Rice, Traditional genotypes, PPV & FRA, Characterization.

Rice (*Oryza sativa* L.) stands as a staple food crop that sustains nearly half of the global population, particularly in Asia. It is not only part of daily diet but also has cultural heritage value in rice producing regions. Over centuries rice cultivation has led to the evolution of a diverse array of traditional genotypes which have adopted to local agro-ecological condition and human preferences.

Traditional rice genotypes, commonly referred as landraces, a treasure box of genetic diversity. These genotypes, preserved by generations of farmers, have demonstrated resilience to diverse environmental challenges in a wide range of agro-climatic contexts. Importance of landraces can never be denied because improvement in existing variety depends upon desirable genes, which are possibly present in land races and wild varieties[4]. However, the modern agricultural practices and the promotion of high-yielding varieties contributed to the erosion of traditional genotypes. It is raising concerns about the loss of genetic resources that could hold the key to addressing future agricultural challenges[8,10].

The characterization and documentation of traditional rice genotypes have become paramount to preserving the wealth of genetic diversity they represent. Characterization of germplasm is important for utilizing the appropriate attribute-based donors and also essential in the present time for protecting the uniqueness of rice[9]. By systematically recording and analyzing these traits, it not only safeguards the genetic heritage of landraces but also uncovers the potential traits. It can contribute to sustainable and resilient rice production. Documented data can be readily retrieved and made available to others and help in planning breeding programmes[2,11].

Hence, using Distinctiveness, Uniformity and Stability (DUS) testing serves as a critical methodology for evaluating and protecting the uniqueness of plant varieties, including traditional genotypes. DUS testing offers a scientific foundation for identifying, cataloging and preserving the diverse attributes of traditional rice genotypes. In line with the vital need to conserve and utilize traditional rice genotypes, this study was undertaken on a comprehensive assessment of a diverse collection of traditional rice genotypes through a systematic DUS evaluation process.

The experimental material consisted of 53 traditional rice genotypes (Table-1), collected from various places were grown during Kharif-2021 at a farmer's field, Thenpathi village, Mannargudi district, Tamilnadu situated at 10.7079ºN latitude, 79.4563ºE longitude. 28 days old seedlings of each traditional genotypes were transplanted in a plot at spacing of 30cm between rows and 20cm between plants in Randomized block design (RBD) design with three replications. Cultural practices followed according to crop production guidelines of TamilNadu Agricultural University (TNAU). 10 randomly selected plants of each genotype were used for observations for all the traits under the study. As per the "Guidelines for the conduct of Test for DUS on Rice" (PPV & FRA, 2007), all the traits were recorded at different stages of growth. The traits studied were reported in Table-2.

Fifty three rice traditional genotypes used for DUS characterization using 41 descriptors which include 29 qualitative and 12 quantitative characters. The traditional genotypes undertaken for this study showed wide range of distinctiveness characters for most of the morphological traits and similar results reported by Kalyan *et al.*[5], Borah *et al.*[1], Umarani *et al.*[12], Manjunath *et al.*[7], Lavanya *et al.*[6] and Gayathri *et al.*[3]. Frequency distribution for all the characters were computed and presented in Table-2.

All of the genotypes (100%) exhibited a predominant green coleoptile colouration, whereas no instances of colourless or purple coleoptiles were observed. For basal leaf sheath colour, most of the genotypes (60.38%) represented by green sheath colour followed by light purple (28.30%), uniform purple (7.55%) and purple lines (3.77%).

Leaf descriptors showcased a diverse array of characteristics, ranging from different hues and intensities of green colouration to varying levels of anthocyanin distribution and presence in different parts of the leaf. The phenotypic observation for leaf greenness revealed 31 genotypes (58.49%) with medium intensity followed by light (24.53%) and dark (16.98%) intensities. The majority of genotypes (96.23%) exhibited an absence of anthocyanin colouration. Distribution of anthocyanin colouration on leaves observed with marginal distribution (1.89%) and uniform distribution (1.89%).

For leaf sheath anthocyanin colouration, 29 genotypes (54.72%) displayed anthocyanin colouration in leaf sheath. A continuum of anthocyanin colouration intensity in leaf sheath revealed that presence of very weak (24.53%) intensity followed by weak (20.76%), medium (5.66%), strong (1.89%) and very strong (1.89%) intensities. Pubescence manifestation on leaf blade surfaces characterized by varying intensities with notable frequencies of weak (39.62%) and medium (37.74%) pubescence.

The leaf auricles were presented in majority of genotypes (94.34%) and absent only in 3 genotypes (5.66%). Among the genotypes, 45 genotypes (84.91%) exhibited colourless auricles, 3 genotypes (5.66%) expressed light purple auricles and 2 genotypes (3.77%) with purple auricles. The evaluated genotypes uniformly displayed the presence of collars. Moreover, 49 genotypes (92.45%) exhibited an absence of anthocyanin colouration in the collar region.

The ligule was uniformly presented across all the genotypes (100%). Among these genotypes, a predominant proportion (98.11%) possessed a split ligule while minute occurrences of truncated (1.89%) ligule was observed. The colouration of ligules was predominantly white (96.23%) with marginal occurrences of purple (3.77%).

Medium length of blade was observed in 30 genotypes (56.60%) followed by long (37.73%) and short (5.66%) length of blade. Width of blade recorded predominantly as narrow (50.94%) and medium (49.06%) width, while broad width was absent in the genotypes. Semi-erect (64.15%) and erect (30.19%) culm attitudes were predominant with open (3.77%) and spreading (1.89%) attitudes occurred less frequently.

Stem related descriptors portrayed diverse attributes, such as thickness, length and anthocyanin colouration, highlighted the structural variations existing among the genotypes. Stem thickness categorized mainly into medium (45.28%) and thin (39.62%), with a smaller representation of thick (15.09%) stem. Very short stem lengths observed in 31 genotypes (58.49%) followed by short stem length (35.85%) and medium stem length (5.66%). Anthocyanin colouration was largely absent (81.13%), with a smaller presence (18.87%) in stem nodes. The intensity of anthocyanin colouration of nodes was weak (15.09%) or medium (3.77%) in some instances. Most of the stem internodes lacked anthocyanin colouration (77.36%) with a notable minority exhibited its presence (22.64%).

Length of panicle main axis was medium in 33 genotypes (62.26%), long in 13 genotypes (24.53%), short in 6 genotypes (11.32%) and very long in one genotype (1.89%). Attitude of blade of flag leaf was erect in 24 genotypes (45.28%), semi-erect in 18 genotypes (33.96%) and horizontal in 11 genotypes

(20.76%).

Panicle descriptors revealed heterogeneity in curvature, number, presence of awns and secondary branching, highlighting the diverse reproductive features within the traditional genotypes. Curvature patterns of the main panicle axis were significant with notable instances of dropping (81.13%) and deflexed (15.09%) curvatures. Panicle number per plant observed few (75.47%) to medium (24.53%) range. Only two genotypes (3.77%) were observed with awns. The colour of awns in those genotypes was yellowish brown (3.77%). Moreover, the distribution of awn noted on the tip (3.77%) of the grain.

Table-1. List of traditional genotypes of rice used for DUS characterization

Genotype code	Genotype Name	Genotype code	Genotype Name
G1	Cochin Samba	G28	Sigappu Sirumani
G2	Kottara Samba	G29	Sooran Kuruvai
G3	Mappillai Samba	G30	Kullakaar
G4	Neelan Samba	G31	Chinnar
G5	Chengalpattu Sirumani	G32	Milagu Samba
G6	Vellai Poongkaar	G33	Kuzhiyadichan
G7	Kitchili Samba	G34	Karungkuruvai
G8	Arikiravi	G35	Norungan
G9	Anaikomban	G36	Chithiraikar
G10	Pisini	G37	Seeraga Samba
G11	Kunthali	G38	Sornnamasuri
G12	Karuppu kowni	G39	Kattanur
G13	Kothamalli Samba	G40	Mattaikkar
G14	Poompalai	G41	Thooyamallee
G15	Anandanoor Sanna	G42	Garudan Samba
G16	Kattuyanam	G43	Vellai Chithiraikar
G17	Ottadai	G44	Arupatham Kuruvai
G18	Sigappu Kowni	G45	Sandikaar
G19	Kaliyan Samba	G46	Ilupaipoo Samba
G20	Kallurundai	G47	Singinikar
G21	Sanna Samba	G48	Rakthashali
G22	Soolai kuruvai	G49	Manjal Ponni
G23	Sempalai	G50	Aathur Kichali
G24	Patchai Perumal	G51	Madumuzhugi
G25	Poovan samba	G52	Gandhakasala
G26	Perum Koomvazhai	G53	Kallimadaiyan
G27	Navara		

Table-2. Frequency distribution of traditional rice genotypes for various DUS characters

S. No.	Characteristics	States	Note	Number of Genotypes	Frequency distribution (%)
1	Coleoptile: Colour	Colourless	1	0	0.00
		Green	2	53	100.00
		Purple	3	0	0.00
2	Basal leaf: Sheath colour	Green	1	32	60.38
		Light purple	2	15	28.30
		Purple lines	3	2	3.77
		Uniform purple	4	4	7.55
3	Leaf: Intensity of green colour	Light	3	13	24.53
		Medium	5	31	58.49
		Dark	7	9	16.98
4	Leaf: Anthocyanin colouration	Absent	1	51	96.23
		Present	9	2	3.77
5	Leaf: Distribution of anthocyanin colouration	Not applicable	0	51	96.23
		On tips only	1	0	0.00
		On margins only	2	1	1.89
		In blotches only	3	0	0.00
		Uniform	4	1	1.89
6	Leaf sheath: Anthocyanin colouration	Absent	1	24	45.28
		Present	9	29	54.72
7	Leaf sheath: Intensity of anthocyanin coloration	Not applicable	0	24	45.28
		Very weak	1	13	24.53
		Weak	3	11	20.76
		Medium	5	3	5.66
		Strong	7	1	1.89
		Very strong	9	1	1.89
8	Leaf: Pubescences of blade surface	Absent	1	2	3.77
		Weak	3	21	39.62
		Medium	5	20	37.74
		Strong	7	7	13.21
		Very strong	9	3	5.66
9	Leaf: Auricles	Absent	1	3	5.66
		Present	9	50	94.34

10	Leaf: Anthocyanin colouration of auricles	Not applicable	0	3	5.66
		Colourless	1	45	84.91
		Light purple	2	3	5.66
		Purple	3	2	3.77
11	Leaf: Collar	Absent	1	0	0.00
		Present	9	53	100.00
12	Leaf: Anthocyanin colouration of collar	Absent	1	49	92.45
		Present	9	4	7.55
13	Leaf: Ligule	Absent	1	0	0.00
		Present	9	53	100.00
14	Leaf: Shape of ligule	Truncate	1	1	1.89
		Acute	2	0	0.00
		Split	3	52	98.11
15	Leaf: Colour of ligule	White	1	51	96.23
		Light purple	2	0	0.00
		Purple	3	2	3.77
16	Leaf: Length of blade	Short	3	3	5.66
		Medium	5	30	56.60
		Long	7	20	37.74
17	Leaf: Width of blade	Narrow	3	27	50.94
		Medium	5	26	49.06
		Broad	7	0	0.00
18	Culm: Attitude	Erect	1	16	30.19
		Semi-erect	3	34	64.15
		Open	5	2	3.77
		Spreading	7	1	1.89
19	Stem: Thickness	Thin	3	21	39.62
		Medium	5	24	45.28
		Thick	7	8	15.09
20	Stem: Length	Very short	1	31	58.49
		Short	3	19	35.85
		Medium	5	3	5.66
		Long	7	0	0.00
		Very long	9	0	0.00

21	Stem: Anthocyanin colouration of nodes	Absent	1	43	81.13
		Present	9	10	18.87
22	Stem: Intensity of anthocyanin colouration of nodes	Not applicable	0	43	81.13
		Weak	3	8	15.09
		Medium	5	2	3.77
		Strong	7	0	0.00
23	Stem: Anthocyanin colouration of internodes	Absent	1	41	77.36
		Present	9	12	22.64
24	Panicle: Length of main axis	Very short	1	0	0.00
		Short	3	6	11.32
		Medium	5	33	62.26
		Long	7	13	24.53
		Very long	9	1	1.89
25	Flag Leaf: Attitude of blade	Erect	1	24	45.28
		Semi-erect	3	18	33.96
		Horizontal	5	11	20.76
		Deflexed	7	0	0.00
26	Panicle: Curvature of main axis	Straight	1	0	0.00
		Semi-straight	3	2	3.77
		Deflexed	5	8	15.09
		Dropping	7	43	81.13
27	Panicle: Number per plant	Few	3	40	75.47
		Medium	5	13	24.53
		Many	7	0	0.00
28	Panicle: Awns	Absent	1	51	96.23
		Present	9	2	3.77
29	Panicle: Colour of awns	Not applicable	0	51	96.23
		Yellowish white	1	0	0.00
		Yellowish brown	2	2	3.77
		Brown	3	0	0.00
		Reddish brown	4	0	0.00
		Light red	5	0	0.00
		Red	6	0	0.00
		Light purple	7	0	0.00
		Purple	8	0	0.00
		Black	9	0	0.00

30	Panicle: Distributions of awns	Not applicable	0	51	96.23
		Tip only	1	2	3.77
		Upper half only	3	0	0.00
		Whole length	5	0	0.00
31	Panicle: Presence of secondary branching	Absent	1	9	16.98
		Present	9	44	83.02
32	Panicle: Attitude of branches	Erect	1	23	43.39
		Erect to semi-erect	3	19	35.85
		Semi-erect	5	6	11.32
		Semi-erect to spreading	7	5	9.43
		Spreading	9	0	0.00
33	Panicle: Exertion	Partly exerted	3	0	0.00
		Mostly exerted	5	16	30.19
		Well exerted	7	37	69.81
34	Time maturity	Very early	1	3	5.66
		Early	3	19	35.85
		Medium	5	21	39.62
		Late	7	7	13.21
		Very late	9	3	5.66
35	Grain: Weight of 1000 fully developed grains	Very low	1	0	0.00
		Low	3	15	28.30
		Medium	5	13	24.53
		High	7	15	28.30
		Very high	9	10	18.87
36	Grain: Length	Very short	1	2	3.77
		Short	3	21	39.62
		Medium	5	29	54.72
		Long	7	1	1.89
		Very long	9	0	0.00
37	Grain: Width	Very narrow	1	1	1.89
		Narrow	3	8	15.09
		Medium	5	15	28.30
		Broad	7	27	50.94
		Very broad	9	2	3.77

38	Decorticated grain: Length	Short	1	2	3.77
		Medium	3	23	43.40
		Long	5	27	50.94
		Long (Long for basmati type)	7	0	0.00
		Extra long	9	1	1.89
39	Decorticated grain: Width	Narrow	3	4	7.55
		Medium	5	20	37.74
		Broad	7	29	54.72
40	Decorticated grain: Shape	Short slender	1	0	0.00
		Short bold	2	19	35.85
		Medium slender	3	6	11.32
		Long bold	4	2	3.77
		Long slender	5	26	49.06
		Extra-long slender	6	0	0.00
41	Decorticated grain: Colour	White	1	16	30.19
		Light brown	2	36	67.92
		Variegated brown	3	0	0.00
		Dark brown	4	1	1.89
		Light red	5	0	0.00
		Red	6	0	0.00
		Variegated purple	7	0	0.00
		Purple	8	0	0.00
		Dark purple	9	0	0.00

Forty four genotypes (83.02%) displayed the presence of secondary branching and other genotypes (16.98%) lacked this feature. Attitude of panicle branches prominently featured erect (43.39%) and erect to semi-erect (35.85%) orientations. 37 genotypes (69.81%) showcased well exerted panicles and 16 genotypes (30.19%) with most exerted panicles, while partial exertion was notably absent. Time of maturity of genotypes ranged from very early (5.66%) to very late (5.66%). Most of the genotypes were medium (39.62%) duration in nature followed by early (35.85%) and late (13.21%) durations.

Grain descriptors exposed substantial variations in weight, length, width and shape after decortication. 15 genotypes recorded low and high (28.30% in each section) weight of 1000 fully developed grains. 13 genotypes (24.53%) observed with medium weight followed by 10 genotypes (18.87%) with very high weight. Grain length ranged from very short (3.77%) to long (1.89%) with prominent presence of medium (54.72%) and short (39.62%) lengths. Grain width displayed distinct variations, predominantly encompassing broad (50.94%), medium (28.30%) and narrow (15.09%) widths with a minor representation of very broad (3.77%) and very narrow (1.89%) widths.

After decortication, grain lengths primarily manifested as long (50.94%) and medium (43.40%). Likewise decorticate grain width notably characterized by broad (54.72%) and medium (37.74%) widths. Decorticated grain shape predominantly comprised long slender (49.06%) and short bold (35.85%) shapes. Decorticated grain colour was primarily observed in light brown (67.92%) and white (30.19%) hues. Only one genotype (1.89%) observed with dark brown grain colour.

Overall, out of 53 traditional genotypes evaluated for 41 descriptors, three characters *viz.,* coleoptile colour, leaf colour and leaf ligule were monomorphic. Fifteen characters namely, leaf anthocyanin colouration, leaf sheath anthocyanin colouration, leaf auricles, anthocyanin colouration of collar, shape of ligule, colour of ligule, leaf width of blade, anthocyanin colouration of nodes, anthocyanin colouration of internodes, panicle number per plant, panicle awns, colour of awns, distribution of awns, panicle presence of secondary branching and panicle exertion were dimorphic. Ten characters *viz.,* leaf intensity of green colour, leaf distribution of anthocyanin colouration, length of leaf blade, stem thickness, stem length, intensity of anthocyanin colouration of nodes, flag leaf attitude of blade, panicle curvature of main axis, decorticated grain width and decorticated grain colour were found trimorphic.

Nine characters *viz.,* basal leaf sheath colour, anthocyanin colouration of auricles, culm attitude, panicle length of main axis, panicle attitude of branches, weight of 1000 fully developed grains, grain length, decorticated grain length and decorticated grain shape were tetramorphic. The characters like pubescence of blade surface, time maturity and grain width expressed five states. Leaf sheath intensity of anthocyanin colouration recorded six states of expression.

It was evident that certain traits such as green coleoptiles, medium-green leaf colouration and white ligules were prevalent among the studied traditional genotypes. Similarly, attributes like semi-erect culm attitude, presence of secondary branching and well exerted panicle had prominently observed. However, the study also highlighted the diversity of leaf characteristics, varied stem traits, heterogeneity in panicle attributes and grain variabilities.

The overall understanding of the morphological traits of these traditional rice genotypes can contribute breeding programs aimed at enhancing yield, stress resistance and overall adaptability. Moreover, the documentation of traditional genotypes can contribute to preservation and management of these genetic resources ensuring their availability for future generations. The exploration of both similarities and dissimilarities within these descriptors has profound implications for rice breeding programs and genetic conservation. The descriptor characteristics and frequency distribution provide a valuable reference for researchers, plant breeders and agriculturalists seeking to harness the potential of these traditional genotypes for the betterment of rice crop improvement programs.

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