

## Variations in morphological traits of traditional rice varieties in major rice growing regions of Tamil Nadu

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Besides therapeutic value, the traditional rice varieties have potential to compete well under changing climatic conditions viz., flood, drought, saline and sodic stress and pest and disease resistance. Recognizing the nutritional and medicinal properties of traditional varieties or landraces in rice, the consumption of these varieties is increasing nowadays. Therefore, the characterization of traditional rice varieties will be helpful in differentiating the individual varieties for further utilization in the crop improvement programme. In the present study, 32 traditional rice varieties were collected from the various places of Tamil Nadu and characterized for 62 morphological traits as per the DUS guidelines. The results of the qualitative traits indicated that the traditional rice varieties have unique characters over existing varieties in terms of basal leaf colour, leaf anthocyanin colouration, leaf sheath anthocyanin colouration, anthocyanin colouration of auricles, colour of ligule, colour of stigma and grain characters like length, width, lemma palea colour, awn type and decorticated grain colour. The study also revealed that the traditional rice varieties had extensive genetic diversity when compared to present improved types which can be used in crop improvement programme in respect to quality traits. In addition, the characterization will be useful to seek protection of the varieties under the Plant Variety Protection system.

**Keywords:** Morphological characters, Rice, Traditional varieties

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Rice (*Oryza sativa* L.) is the most extensively consumed staple food crop of major part of the world's human population, especially in Asia and it contains many nutraceutical properties because of its enriched secondary metabolites<sup>1</sup>. India ranks 12<sup>th</sup> in the world for the total number of species that have been catalogued, contributing to its genetic diversity of 1,50,170 species. Since India accounts for almost 12% of the world's biota, it has been recognized as one of the big diversity centres of the entire world<sup>2</sup>. There are vast traditional rice types in India that are often called "landraces". However, the ancient rice landraces, which were once thought to number over 1,00,000 in India alone, were swiftly replaced by modern varieties with greater yield potential and shorter growth periods<sup>3</sup>. These landraces are tolerant to adverse climatic conditions such as flood, drought, salinity and sodic conditions and resistant to pests and diseases. The varieties have medicinal values to cure asthma, atherosclerosis, diabetes and hypertension<sup>4</sup>. Also, the traditional varieties act as an excellent

detoxification for the liver. Also, the landraces are rich in iron, zinc and vitamin B1 and thus, help in reducing cholesterol in the body<sup>5</sup>.

However, the traditional varieties are harshly threatened by genetic destruction due to their replacement by present genetically reformed and improved varieties. Although locally adapted traditional varieties often yield less under ideal environmental conditions than improved varieties, subsistence farmers can rely on the greater stability of their yields over time. Landrace genetic diversity is a significant component of global agricultural biodiversity and is thought to be of utmost importance for future global output. Landraces are considered to be significantly more genetically diverse. Usually, the traditional varieties of crops show wide genetic variation with useful quantitative and qualitative characteristics and also signify a wealth of valuable genes but are still underutilized for breeding programmes<sup>6,7</sup>.

Given the difficulties brought on by climate change and the growing demand from consumers for a wholesome diet, it is crucial to preserve the existing

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landraces and identify their unique characteristics so that they can be effectively exploited in rice improvement initiatives<sup>2</sup>. Conserving traditional crop varieties is, therefore, an important issue in ecological subsistence agriculture. Preserving crop genetic resources improves the biodiversity of farmland and guarantees food security and therefore, it is an important condition for the emergence and expansion of sustainability in agriculture. Landraces can be employed to withstand biotic and abiotic stresses under future climate change because they are also known as "climate resilient varieties"<sup>8</sup>. Dwivedi *et al.*<sup>9</sup> have done the documentation of morphological traits for identification of major climate resilient traditional rice varieties for conservation and multiplication of seeds. Varietal identification by morphological characters and chemical tests in rice has been done by several workers<sup>10,11</sup>.

Therefore, conservation of the landraces or traditional varieties becomes important so as to improve the ecological diversity and they can also be used as parents in future breeding programmes for passing the specific traits to the progeny which aids in the resistance against pest and diseases. Hence, identification, conservation, multiplication and quality testing of the landraces are ecologically

important. In this regard, the genuineness of the variety is an important characteristic for the quality seed production. Hence, the characterization of important traditional rice varieties based on morphological variations in plant and seed traits has been carried out.

## Materials and Methods

### Seed materials

The experimental seed materials encompassed of 32 traditional rice varieties *viz.*, Anaikomban, Attur kichili samba, Idly, Illuppaipoo samba, Kalanamak, Kallukkar, Kallundrikar, Karukka, Karunkuruvai, Karuppukavuni, Kattanur, Kothamalli samba, Kullankar, Kuruvai kalangium, Kuzhiyadichan, Mappillai samba, Mattaikar, Milagu samba, Mottakkur, Mysore malli, Navara, Nootripathu, Norungan, Poongaar, Poovan samba, Salem sanna, Samba mosanam, Seeraga samba, Sorna, Sorna masuri, Thulasi vasanai and Vaasanai seeraga samba were collected from the farmer's holdings in different parts of Tamil Nadu. The list of landraces includes white, yellow, grey, brown and black coloured kernels of traditional cultivars were presented in the Table 1.

Table 1 — List of traditional rice varieties and their specific characteristics<sup>2,27</sup>

S. No.	Variety	Growing condition	Special features	Duration (Days)	Yield (kg/ac)
1.	Anaikomban	Lowland	Blast resistant variety and it can be cultivated in sandy soil	125	1100
2.	Attur kichili samba	Lowland	Fine table rice with rich in protein, iron, calcium, magnesium and potassium. It is preferred by South Indian and its consumption gives a body shine and which can be exploited to mitigate the effects of climate change.	130	600
3.	Idly	Lowland	-	-	-
4.	Illuppaipoo samba	Lowland	It is used for treating rheumatism and arthritis. It prevents paralysis.	120	700
5.	Kalanamak	Upland	Rich in antioxidants, protein, iron, calcium, zinc and phenolic compounds. It cures many diseases and contributes skin and bone health. It can be used by pregnant women.	120	640
6.	Kallukkar	Lowland	More than 80% germination up to 10 months under ambient storage condition.	130	900
7.	Kallundrikar	Lowland	Having strong seed dormancy of about 30-60 days.	-	-
8.	Karukka	Lowland	-	-	-
9.	Karunkuruvai	Lowland	The variety gives excellent stamina. It prevents skin disorders. It contains plant sterols that have anti-cancer effects. It contains curlone, a significant volatile molecule with strong antitumor and antioxidant properties. It can be used to alleviate the effects of climate change.	125	825
10.	Karuppukavuni	Lowland	It contains anthocyanins and antioxidants. It also contains more protein, less fat and lower levels of total soluble sugar. Emperor's rice or forbidden rice are other names for it. It lowers bad cholesterol, enhances vision, prevents cancer, manages diabetes and hypertension and is an excellent liver detoxifier.	130	800
11.	Kattanur	Lowland	-	-	-

... Contd.

Table 1 — List of traditional rice varieties and their specific characteristics<sup>2,27</sup> (Contd.)

S. No.	Variety	Growing condition	Special features	Duration (Days)	Yield (kg/ac)
12.	Kothamalli samba	Lowland	Coriander-like grains that can be grown from September to January.	135	1000
13.	Kullankar	Lowland	It is a drought-tolerant cultivar with a high zinc content. Its consumption prevents skin diseases and early ageing, controls blood pressure and revitalizes and regenerates the body. It functions as a cardiogenic and lowers the body mass index. Sandy soil is suitable for its cultivation.	120	1500
14.	Kuruvaikalanjium	Lowland	Red rice type native to Ramnad district.	140	1200
15.	Kuzhiyadichan	Lowland	The variety can withstand both salinity and drought. It has more antioxidant properties and a high phenolic content. It is a good source of eight possible natural inhibitors of SARS-CoV-2 Mpro, making it a viable functional food for managing COVID-19.	120	975
16.	Mapillai samba	Lowland	It is beneficial for treating stomach and mouth ulcers. With a low glycaemic index of 66, it improves digestive capacity and benefits diabetics. It also contains a lot of fibre, calcium and iron. In Tamil Nadu, the bridegroom is customarily given kanji made from this variety to strengthen the veins, muscles and nerves.	160	750
17.	Mattaikar	Lowland	Improved source-sink relationships, making them drought-resistant and appropriate for growing in sodic soils.	120	1450
18.	Milagu samba	Lowland	Pepper-like grains that can be grown from September to January.	-	-
19.	Mottakur	Lowland	The grain has a blunt tip.	125	600
20.	Mysore malli	Lowland	High in iron, magnesium and B vitamins for a well-rounded diet. It is a heart-healthy rice option because it is low in fat. Various foods are enhanced by their aromatic flavour and soft texture. Small farmers cultivate this heirloom cultivar following sustainable methods.	-	-
21.	Navara	Lowland	It is a good weaning food for under weight infants. It is recommended for pregnant women as it increases the weight of the fetus. It is a natural remedy for many diseases.	90	700
22.	Nootripathu	Lowland	Drought resistant variety suitable for rainfed conditions.	110	-
23.	Norungan	Lowland	Resistant to drought and suitable for cultivation under sodic soils.	124	1124
24.	Poongar	Lowland	It is a salt-tolerant variety with high levels of iron, calcium, phosphorus, zinc and protein. It strengthens the immune system and is a great rice for women's hormonal issues. It is advised for lactating mothers and pregnant women.	100	600
25.	Poovan samba	Lowland	It has very high potassium iron, calcium, magnesium, zinc and phosphorus. Table rice variety.	145	1400
26.	Salem sanna	Lowland	High fibre content in bran than normal rice. In addition to reducing the incidence of diabetes, hypercholesterolaemia and heart disease, this fibre also helps people lose weight, which helps to avoid obesity.	125	1043
27.	Samba mosanam	Lowland	Flood resistant variety can be grown in clay soils.	170	1800
28.	Seeraga samba	Lowland	Aromatic fine rice can be grown from September to January, and its seeds are similar to cumin seeds. The fragrance-producing BADH 2 gene is present in this cultivar. Other pharmacological substances, particularly antioxidants and substances that activate the central nervous system, have also been found to have anticancer effects and to enhance cognitive performance. It has a high oleic acid content. Saturated fats in the diet are substituted with oils that contain oleic acid. By reducing inflammation and cholesterol, oleic acid may help heart problems.	130	1500
29.	Sorna	Lowland	Climate resilient variety	-	-
30.	Sorna masuri	Lowland	Saline tolerant variety	125	1125
31.	Thulasi vaasanai	Lowland	This landrace was given the name Thulasi vasanai because its seeds are smaller than Seeraga samba and resemble basil seeds. Compared to Seeraga samba, it is more aromatic and superior in taste. It fills the field where it is grown with a delightful scent when it is in flower. In addition to improving digestion, this rice causes rapid weight gain.	120	-
32.	Vaasanai seeraga samba	Lowland	High fibre aroma rice improves metabolism.	120	550

The experiments for DUS characterization were conducted at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore during *Rabi* season 2020-21 and 2021-22. The crops were raised in the field by following the randomized block design with three replications. The necessary agronomic cultivation practices were followed uniformly for all the varieties. The morphological characterization of crop growth stages

was carried out in all other traditional varieties. The observations were documented on the distinguishable characters as referred in the DUS test procedures for paddy. With respect to rice DUS guidelines of PPV & FRA 2007, 17 distinguishable traits among the 62 characters have been observed for the characterization. The list of qualitative and quantitative characteristics studied for the 32 traditional rice landraces were presented in Table 2.

Table 2 — List of qualitative and quantitative characters observed

S. No.	Characteristics	States	Stage of observation	Type of assessment
Qualitative traits				
1.	Basal leaf: Sheath colour	Green Light purple Purple lines Uniform purple	40	VS
2.	Leaf: Auricles	Absent / Present	40	VS
3.	Leaf: Ligule	Absent Present	40	VS
4.	Leaf: Colour of ligule	White Light purple Purple	40	VS
5.	Spikelet: Colour of stigma	White Light green Yellow Light purple Purple	65	VS
6.	Panicle: Awns	Absent Present	90	VG
Quantitative traits				
1.	Seed Colour	Straw Gold and gold furrows on straw background Brown spots on straw Brown furrows on straw Brown (tawny) Reddish to light purple Purples pots / furrows on straw Purple Black	80-90	VG
2.	Seed Beak	Curved Slightly curved Straight	(Not specified)	
3.	Weight of 1000 fully developed grains	Very low (<15 g) Low (15-20 g) Medium (21-25 g) High (26-30 g) Very high (>30 g)	92	MG
4.	Seed Length	Very short (<6.0 mm) Short (6.1-8.5 mm) Medium (8.6-10.5 mm) Long (10.6-12.5 mm) Very long (>12.5 mm)	92	MS
5.	Seed Width	Very narrow (<2.0 mm) Narrow (2.1-2.5 mm) Medium (2.6-3.0 mm) Broad (3.1-3.5 mm) Very broad (>3.5 mm)	92	MS

... Contd.

Table 2 — List of qualitative and quantitative characters observed (Contd.)				
S. No.	Characteristics	States	Stage of observation	Type of assessment
	Quantitative traits			
6.	Decorticated grain: Length	Short Medium Long Long (For Basmati type) Extra long	92	MS
7.	Decorticated grain: Width	Narrow (<2.0 mm) Medium (2.0-2.5 mm) Broad (>2.5 mm)	92	MS
8.	Decorticated grain: Shape (in lateral view)	Short slender Short bold Medium slender Long bold Long slender Long slender (For Basmati type) Extra long slender	92	MS
9.	Decorticated grain: Colour	White Light brown Variegated brown Dark brown Light red Red Variegated purple Purple Dark purple	92	VG
10.	Silk integument colour	Yellow White Grey Black Brown Slightly reddish Red Violet	(Not specified)	
11.	Vitreous character	Translucent Pearl spot in the centre is small Pearl spot in the centre is extended Pearl spot in the centre and side slightly extended Pearl spot in the centre and side extended	(Not specified)	

### Qualitative and quantitative analysis

Some of the unique traits such as basal leaf colour, leaf anthocyanin colouration, leaf sheath anthocyanin colouration, anthocyanin colouration of auricles, colour of ligule, colour of stigma, and grain characters like length, width, lemma palea colour were assessed by visually on individual plant or parts of plants and decorticated grain colour was assessed by using the Royal Horticultural Society (RHS) colour chart among the three replications. The off-type plants present in each variety were recorded and removed to maintain the genetic purity of the variety. The phenol colour reaction was observed in the seeds of all the varieties as per the method suggested by Walls<sup>12</sup>. In this method, three replications consisting of 100 seeds each were soaked in distilled water for 24 h. The

seeds were then placed in Petri dishes having filter paper moistened with 5 mL of 1% phenol solution and placed at room temperature (28°C) for 24 h. After that, the seeds were examined and grouped into different colour classes *viz.*, no colour change, light brown, brown and dark brown. The colour reaction in the rice hulls determined the positive response of the varieties resulting from the polyphenol oxidase (PPO)<sup>13</sup>. Based on differences in each character, the qualitative traits recorded in morphological characterization were transcribed to binary characters<sup>14</sup>.

The quantitative seed characteristics such as seed length, seed width, 1000 seed weight, grain length and grain width were observed in 32 traditional rice varieties and used for clustering of varieties.

### Statistical analysis

The qualitative and quantitative traits observed during both years were pooled and subjected to cluster analysis by using the statistical analysis software Minitab. The data were analyzed using Agglomerative Hierarchical Clustering (AHC) which was performed using Ward's method. The resulting similarity matrix was subjected to cluster analysis which measures using Euclidean distance. A dendrogram depicting the number of clusters formed was generated by the Minitab software used for grouping the varieties<sup>15</sup>.

## Results and Discussion

### Morphological genetic variability

The observations revealed that the varieties differed greatly in their morphological characteristics, including the colour of the decorticated grain, ligules, stigma, lemma palea, awn characters, and basal leaf sheath. The landraces also differed significantly in the anthocyanin colouring of different plant sections. In which the following varieties *viz.*, Kullankar, Kattanur, Vasanai seeraga samba, Karunkuruvai, Mottakkur, Karuppu kavuni, Norungan, Kalanamak, Kothamalli samba, Navara and Kuzhiyadichan showed purple colouring on seedling coleoptile. Similarly, the basal leaf sheath anthocyanin colouration of landraces like Karukka, Poongar, Vasanai seeraga samba and Karuppu kavuni was purple. On the other hand, the basal leaf sheath of Kallukar, Kallundrikar, Karukka, Kattanur, Kothamalli samba, Kullankar, Kuruvai kalanjium, Kuzhiyadichan, Mottakur and Salem sanna revealed purple lines. Likewise, the colouration of internodal anthocyanins was seen in Kattanur, Karukka, Mottakkur and Karuppu kavuni (Table 3).

Varieties such as Karuppu kavuni, Kattanur and Illuppaipoo samba had stem pigmentation and Karuppu kavuni had prominent ligule pigmentation (Fig. 1). The stigma colour observed was showed wider variations among the varieties. In some varieties, the stigma colour was yellow whereas, the landraces *viz.*, Kalluntrikar, Kullankar, Kattanur, Kullankar, Karukka, Poongar, Vasanai seeraga samba, Karunkuruvai, Kuruvai Kalangium, Mottakkur, Poovan samba, Karuppu kavuni, Kalanamak, Thulasi vasanai, Illuppaipoo samba, Kothamalli samba, Milagu samba, Idly, Mysore malli, Kuzhiyadichan and Salem sanna exhibited pigmented stigma (Fig. 1).

Among the grain characters, the lemma tip colour and lemma palea colour also varied distinctly across

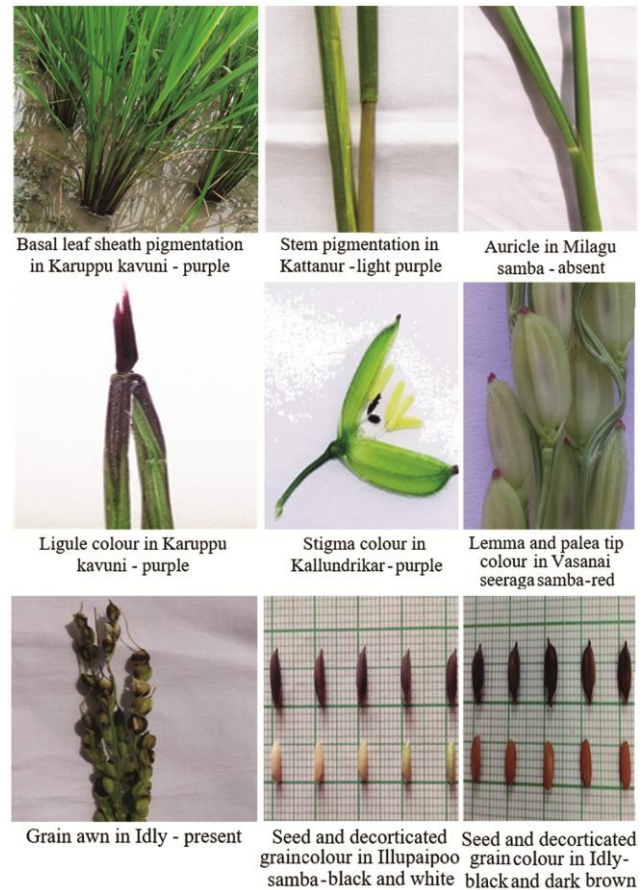


Fig. 1 — Plant, flower and seed morphological characters of traditional rice varieties

the landraces. The landrace Vasanai seeraga samba exhibited lemma tip colour and Salem sanna had lemma palea colouration. The seeds of Thulasi vasanai showed purple tip pigmentation even after maturity (Table 4). Also, the varieties Kuruvai kalangium, Norungan, Idly, Mappillai samba had a unique trait of awn on the tip of the seed.

The varieties *viz.*, Kattanur, Mattaikar, Mottakkur, Samba mosanam, Poovan samba, Norungan, Sorna, Kothamalli samba, Idly, Mysore malli and Kuzhiyadichan have showed dark brown colour on decorticated grain (Table 5) (Fig. 1). Similarly, Sridhar *et al.*<sup>16</sup> characterized the sixty-four traditional rice genotypes based on morphological characters, by following DUS test guidelines and identified the highly distinct traits *viz.*, coleoptile colour, basal leaf sheath colour, leaf colour and decorticated grain colour across the genotypes. According to Rajanna *et al.*<sup>17</sup>, the qualitative and quantitative morphological traits *viz.*, flag leaf attitude, flag leaf length, flag leaf width, days to 50% flowering, days to maturity,

Table 3 — Plant morphological traits of the traditional rice varieties

S. No.	Variety	Basal leaf sheath colour	Presence of auricle	Ligule colour	Stigma colour	Lemma palea colour at maturity	Presence of awn
1.	Anaikomban	Green	Present	White	White	Straw	Absent
2.	Attur kichili samba	Green	Present	White	White	Straw	Absent
3.	Idly	Green	Present	White	White	Brown	Present
4.	Illupaipoo samba	Green	Present	White	White	Purple	Absent
5.	Kalanamak	Green	Present	White	White	Straw	Absent
6.	Kallukar	Light Purple	Present	White	Purple	Brown furrows on straw	Absent
7.	Kallundrikar	Light Purple	Present	White	Purple	Gold and gold furrows on straw background	Absent
8.	Karukka	Light Purple	Present	White	Purple	Gold and gold furrows on straw background	Absent
9.	Karunkuruvai	Purple	Present	White	Purple	Brown	Absent
10.	Karuppu kavuni	Uniform purple	Present	Purple	Purple	Brown furrows on straw	Absent
11.	Kattanur	Light Purple	Present	White	Purple	Straw	Absent
12.	Kothamalli samba	Light Purple	Present	White	Purple	Straw	Absent
13.	Kullankar	Light Purple	Present	White	Purple	Brown	Absent
14.	Kuruvai kalanjium	Light Purple	Present	Light purple	Purple	Gold and gold furrows on straw background	Present
15.	Kuzhiyadichan	Light Purple	Present	White	Purple	Brown furrows on straw	Absent
16.	Mapillai samba	Green	Present	White	White	Brown furrows on straw	Present
17.	Mattaikar	Green	Absent	White	White	Straw	Absent
18.	Milagu samba	Green	Present	White	White	Straw	Absent
19.	Mottakur	Light Purple	Present	White	Purple	Straw	Absent
20.	Mysore malli	Green	Present	White	Purple	Gold and gold furrows on straw background	Absent
21.	Navara	Green	Present	White	White	Straw	Absent
22.	Nootripathu	Green	Present	White	Light green	Straw	Absent
23.	Norungan	Green	Present	White	White	Brown furrows on straw	Present
24.	Poongar	Uniform purple	Present	White	Purple	Straw	Absent
25.	Poovan samba	Green	Present	White	Purple	Brown furrows on straw	Absent
26.	Salem sanna	Light Purple	Present	White	Purple	Brown furrows on straw	Absent
27.	Samba mosanam	Green	Present	White	White	Brown furrows on straw	Absent
28.	Seeraga samba	Green	Present	White	White	Straw	Absent
29.	Sorna	Green	Present	White	Yellow	Straw	Absent
30.	Sorna masuri	Green	Present	White	White	Brown spots on straw	Absent
31.	Thulasi vaasanai	Green	Present	White	White	Straw	Absent
32.	Vaasanai seeraga samba	Uniform purple	Present	White	Purple	Gold and gold furrows on straw background	Absent

degree of panicle exertion, presence of awns, panicle secondary branching, days to maturity, leaf senescence and seed traits such as 1000 seed weight, grain length and width and shape of grain were found to be more useful for grouping of rice genotypes. Also, the apiculus colour, lemma and palea colour and seed coat colour showed great variability in Navara and hence, these traits can be considered as markers for the identification of Navara types<sup>18</sup>. Similarly, Sripunitha and Sivasubramaniam<sup>19</sup> identified rice varieties based on seed and seedling characters and grouped into two major clusters based on anthocyanin pigmentation. Manjunatha *et al.*<sup>20</sup> found that the characterization of rice landraces is very useful for

rice breeding towards selection, conservation and further utilization in crop improvement programme. Mondel<sup>21</sup> found that the qualitative morphological characters were relatively efficient in varietal identification and in estimating DUS testing in rice. Similarly, Gour *et al.*<sup>22</sup> characterized a total of 83 indigenous rice germplasm for testing the divergence and related qualitative differences present among the lines. In which, basal leaf sheath colour, colour of tip of lemma, lemma and palea colour were observed with highest variation. Sinha *et al.*<sup>23</sup> found wider variations in grain characters which may be utilized for the plant breeding and production of new improved variety.

Table 4 — Seed morphological traits of the traditional rice varieties

S. No.	Variety	Seed length (mm)	Seed width (mm)	Seed colour	Seed beak	1000 seed weight (g)
1.	Anaikomban	11.0	3.0	Straw (161A)	Curved	18.5
2.	Attur kichili samba	7.0	2.0	Straw (161A)	Curved	17.7
3.	Idly	7.0	3.0	Black (202A)	Slightly curved	21.5
4.	Illupaipoo samba	7.0	2.0	Black (202A)	Curved	15.6
5.	Kalanamak	7.0	3.0	Straw (161A)	Straight	18.9
6.	Kallukar	8.0	3.0	Brown furrows (165A)	Slightly curved	24.8
7.	Kallundrikar	9.0	3.0	Brown furrows (163B)	Slightly curved	31.9
8.	Karukka	6.0	3.0	Gold and gold furrows on straw background (162A)	Straight	18.9
9.	Karunkuruvai	8.0	3.0	Black (202A)	Straight	29.8
10.	Karuppu kavuni	8.0	3.0	Black (202A)	Slightly curved	24.6
11.	Kattanur	8.0	3.0	Gold and gold furrows on straw background (22A)	Slightly curved	20.6
12.	Kothamalli samba	6.0	3.0	Gold and gold furrows on straw background (162A)	Straight	19.0
13.	Kullankar	8.0	3.0	Black (N200A)	Slightly curved	23.8
14.	Kuruvai kalanjium	8.0	3.0	Brown furrows (163A)	Slightly curved	29.5
15.	Kuzhiyadichan	7.0	4.0	Brown furrows (165B)	Straight	26.8
16.	Mapillai samba	8.0	3.0	Brown furrows (N167A)	Slightly curved	29.7
17.	Mattaikar	7.0	2.0	Straw (161A)	Straight	18.6
18.	Milagu samba	7.0	3.0	Straw (161A)	Straight	17.0
19.	Mottakur	7.0	3.0	Brown furrows (163A)	Straight	24.3
20.	Mysore malli	8.0	3.0	Brown furrows (163A)	Slightly curved	22.2
21.	Navara	8.0	2.0	Straw (161A)	Slightly curved	20.0
22.	Nootripathu	8.0	3.0	Brown spots (162B)	Straight	28.8
23.	Norungan	8.0	3.0	Brown furrows (N167A)	Slightly curved	26.8
24.	Poongar	8.0	3.0	Brown furrows (N167A)	Slightly curved	25.6
25.	Poovan samba	8.0	3.0	Brown furrows (N167A)	Slightly curved	27.3
26.	Salem sanna	7.0	2.0	Brown (tawny) (163B)	Straight	14.9
27.	Samba mosanam	8.0	3.0	Straw (161A)	Slightly curved	26.9
28.	Seeraga samba	6.0	2.0	Gold and gold furrows on straw background (162A)	Curved	10.5
29.	Sorna	8.0	2.0	Straw (161B)	Slightly curved	21.4
30.	Sorna masuri	7.0	3.0	Straw (161A)	Slightly curved	20.6
31.	Thulasi vaasanai	5.0	2.0	Gold and gold furrows on straw background (162A)	Curved	10.6
32.	Vaasanai seeraga samba	8.0	3.0	Brown furrows (164 B)	Slightly curved	30.4

(Values in parenthesis indicates Royal Horticultural Society colour chart values)

Table 5 — Hulled grain traits of the traditional rice varieties

S. No.	Variety	Grain length (mm)	Grain width (mm)	Grain colour	Grain shape	Colour of silk integument	Vitreous character
1.	Anaikomban	7.0	2.0	White (158A)	Long bold	White	Pearl spot on the side is small
2.	Attur kichili samba	5.0	1.0	White (158A)	Short slender	White	Pearl spot on the side is small
3.	Idly	5.0	3.0	Dark brown (178B)	Short bold	Black	Pearl spot on the side is small
4.	Illupaipoo samba	6.0	2.0	White (159A)	Medium slender	Grey	Pearl spot on the side is small
5.	Kalanamak	5.0	2.0	White (159C)	Medium slender	White	Pearl spot on side and centre slightly extended
6.	Kallukar	6.0	2.0	White (158A)	Medium slender	White	Pearl spot on the side is small
7.	Kallundrikar	6.0	3.0	Dark brown (175B)	Short bold	White	Pearl spot on the side is small
8.	Karukka	4.0	2.0	Dark brown (183B)	Short bold	White	Translucent
9.	Karunkuruvai	5.0	2.0	Red (175C)	Short bold	Grey	Pearl spot on the side is small
10.	Karuppu kavuni	6.0	2.0	Dark brown (175A)	Medium slender	Grey	Pearl spot on the side is small
11.	Kattanur	5.0	2.0	Red (175C)	Short bold	Yellow	Pearl spot on side and centre extended

... Contd.

Table 5 — Hulled grain traits of the traditional rice varieties (Contd.)

S. No.	Variety	Grain length (mm)	Grain width (mm)	Grain colour	Grain shape	Colour of silk integument	Vitreous character
12.	Kothamalli samba	4.0	2.0	Dark brown (175A)	Short bold	White	Translucent
13.	Kullankar	5.0	3.0	Red (175C)	Short bold	Grey	Pearl spot on the side is small
14.	Kuruvai kalanjium	5.0	2.0	Red (178A)	Medium slender	Yellow	Pearl spot on the side is small
15.	Kuzhiyadichan	4.0	3.0	Dark brown (183A)	Short bold	Brown	Pearl spot on the side is small
16.	Mapillai samba	6.0	2.0	Red (183A)	Medium slender	Brown	Pearl spot on the side is small
17.	Mattaikar	5.0	2.0	White (158C)	Medium slender	Yellow	Pearl spot on the side is small
18.	Milagu samba	4.0	2.0	White (159A)	Short bold	White	Pearl spot on the side is small
19.	Mottakur	6.0	2.0	Dark brown (183B)	Medium slender	Yellow	Pearl spot on the side is small
20.	Mysore malli	6.0	2.0	Red (175C)	Medium slender	White	Pearl spot on the side is small
21.	Navara	5.0	2.0	White (156A)	Medium slender	White	Pearl spot on the side is small
22.	Nootripathu	5.0	3.0	Red (176A)	Short bold	Brown	Pearl spot on the side is small
23.	Norungan	5.0	2.0	Red (176A)	Medium slender	Brown	Pearl spot on the side is small
24.	Poongar	6.0	3.0	Red (175C)	Short bold	Brown	Pearl spot on the side is small
25.	Poovan samba	6.0	3.0	Red (175C)	Short bold	Brown	Pearl spot on the side is small
26.	Salem sanna	5.0	2.0	White (158B)	Medium slender	Yellow	Pearl spot on the side is small
27.	Samba mosanam	5.0	3.0	Red (175C)	Short bold	Brown	Pearl spot on the side is small
28.	Seeraga samba	4.0	2.0	White (158A)	Short bold	White	Pearl spot on the side is small
29.	Sorna	5.0	2.0	Dark brown (175B)	Medium slender	White	Pearl spot on the side is small
30.	Sorna masuri	5.0	2.0	White (156A)	Medium slender	White	Pearl spot on the side is small
31.	Thulasi vaasanai	4.0	1.0	White (159C)	Short slender	Yellow	Pearl spot on the side is small
32.	Vaasanai seeraga samba	6.0	2.0	Red (175C)	Medium slender	White	Pearl spot on the side is small

(Values in parenthesis indicates Royal Horticultural Society colour chart values)

**Cluster analysis**

The cluster analysis using Euclidian distance and complete linkage formed five major clusters with 11, 4, 3, 13 and 1 varieties in cluster 1, 2, 3, 4 and 5 respectively for plant morphological traits (Fig. 2a). Maximum varieties constitute cluster 4 followed by clusters 1, 2, 3 and 5. Cluster 1 and cluster 4 are grouped by green and purple basal leaf sheath colour and cluster 5 contains a single variety Mattaikar which is differentiated by the absence of auricle. In addition, the inter cluster distance indicates that the more similar varieties have less distance and dissimilar varieties have wider distance.

Seed traits formed five major clusters with 1, 4, 6, 19 and 2 varieties in clusters 1, 2, 3, 4 and 5 respectively (Fig. 2b). Maximum varieties constitute in cluster 4 followed by clusters 3, 2, 5 and 1. In which, cluster 1 contains the variety Anaikomban which constitutes the highest seed length (11 mm) and Cluster 5 contains two varieties that are similar in almost all the characters. Similarly, five major clusters with 2, 4, 3, 5 and 1 varieties in clusters 1, 2, 3, 4 and 5 respectively were formed for grain traits (Fig. 2c). In which, maximum varieties constitute Cluster 2 followed by clusters 4, 3, 5 and 1. Among the clusters, cluster 1 contains the variety Anaikomban which constitutes the highest grain

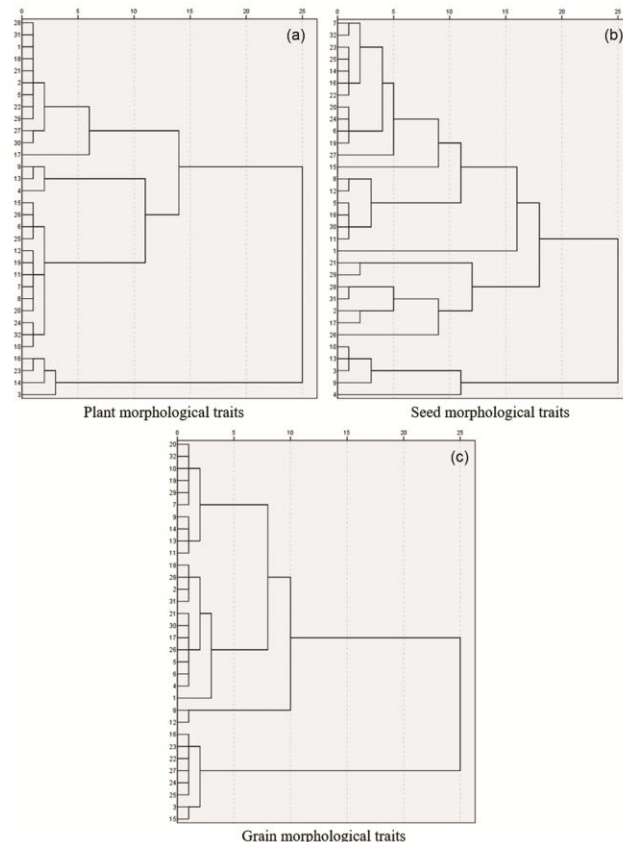


Fig. 2 — Dendrogram depicting the cluster analysis of plant, seed and grain morphological traits of traditional rice varieties

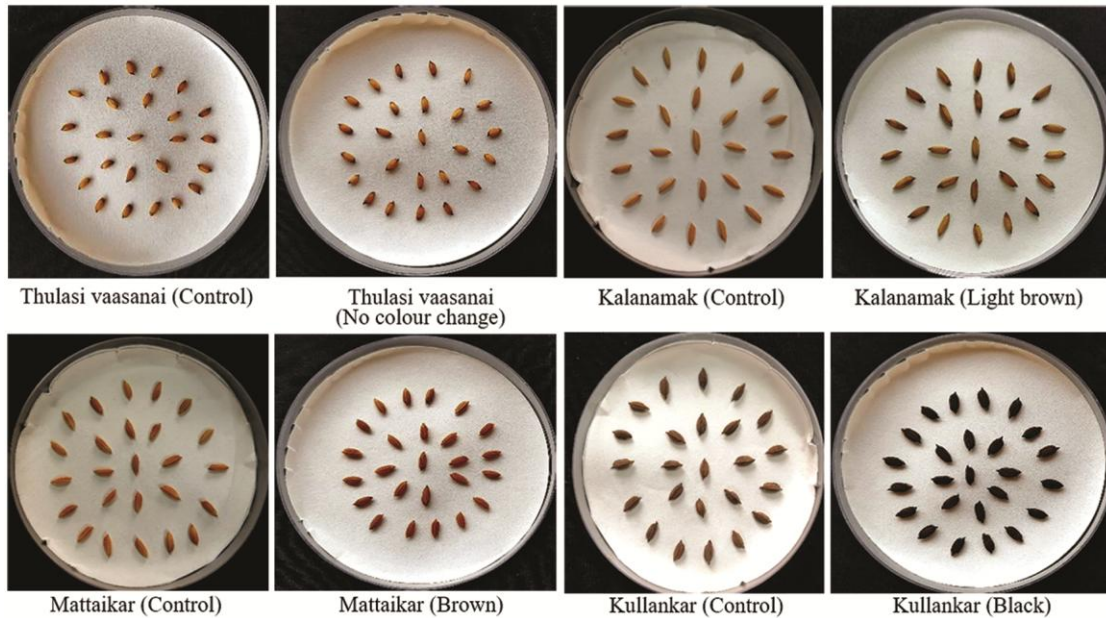


Fig. 3 — Response of the traditional rice varieties to phenol test

length (7 mm). Cluster 5 contains 2 varieties that are grouped by their similarity in translucent character, cluster 2 contains varieties that possess white grain colour while Cluster 4 contains varieties with dark brown to red grain colour and Cluster 3 contains varieties that are similar in almost all the characteristics.

#### Chemical test variability

Phenol reaction of the traditional rice varieties *viz.*, Kullankar, Nootripathu, Poongar, Vasana seeraga samba, Karunkuruvai, Mottakkur, Poovan samba, Karuppu kavuni, Sorna, Kalanamak, Thulasi vasana, Illuppaipoo samba, Kothamalli samba, Milagu samba, Idly, Navara, Kuzhiyadichan, Mappillai samba, Anaikomban and Sorna masuri have recorded with light brown to dark brown or black colour (Fig. 3). Other varieties have shown negative response to the phenol solution. The phenol test is helpful to differentiate or identify the rice germplasm accessions<sup>24</sup>. Muthu *et al.*<sup>25</sup> opined that based on the colour response of palea and lemma of seeds to phenol test the rice varieties can be efficiently distinguished. The phenol test showing a negative reaction is unable to further hydroxylate due to a lack of hydroxylating enzyme or shortage of electron donors<sup>26</sup>. Thus, the extent of variations in colour intensity among varieties might be due to differences in polyphenol oxidase enzyme activity, temperature, light, aeration and genetic background<sup>16</sup>.

Therefore, in addition to protecting plant types, DUS testing in rice is an intriguing study due to the abundance of morphological and biochemical quality parameters.

#### Conclusion

It is concluded that the traditional varieties have wide variability in plant and seed morphological characters. Particularly, some of the characteristics like seedling pigmentation, basal leaf colour, anthocyanin colouration on leaf sheath and auricles, colour of ligule, the colour of stigma and grain length, lemma palea colour, awn and decorticated grain colour are highly variant in the varieties. Particularly, the traditional varieties *viz.*, Mappillai samba, Karuppu kavuni, Kuruvai kalangium, Idly, Kattanur, Mattaikar, Illuppaipoo samba, Samba mosanam, Norungan, Salem sanna, Kothamalli samba, Mysore malli and Kuzhiyadichan showed more variations in the morphological traits. Thus, these traditional varieties can be used to develop new varieties by transferring qualitative traits such as drought tolerance, pest and disease resistance etc. However, purification of the varieties by eliminating the inadequate types under field level is essentially required. This enables the maintenance of the genetic purity of the variety and helps the farmers to produce genetically pure material. The seed production can also be easy when the varieties are genetically pure.

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### Conflict of Interest

The authors declare that they have no conflict of interest.

### Author Contributions

The author KR conducted the field experiment, collected the morphological data, compiled the data and written the manuscript. Author DTS performed cleaning of seeds and observation of seed morphological traits. Seed characterization and analysis of data were carried out by KS. The final manuscript was read and approved by the entire team.

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### Ethics Approval

Not applicable

### Data Availability

All the data are exclusively retained by the corresponding author and will be available upon reasonable request.

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