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Validation of essential and grouping characters of rice (*Oryza sativa* L.) extant varieties to select the most similar groups

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Abstract
Rice is the world's most important food crop and provides 21% of the human per capita energy, and 15% of protein globally (FAO). India is the world's second largest producer (105.4 mt) of rice on an area of 44.7 mha with productivity of 24.6 qt/ha. In the system of commercial seed production, detailed characterization of the varieties play the critical role in the maintenance of genetic purity. Diversity analysis provides information on the genetic distances among farmers' varieties and genetic similarity/distinctness among populations of the same named landrace(s) grown by different farmers in different niche environments. The present study was carried out to characterize the twenty-eight extant rice varieties for plant and grain morphological traits and assessment the extent of similarity and variability in these varieties. The field experiment was conducted during *kharif* season of 2014-15 in the field of Seed Science and Technology Division, ICAR-Indian Agricultural Research Institute, New Delhi. The complete DUS database of plant morphological characters for all the rice varieties were generated as per DUS guidelines (Rice) no. SG/01/2007. Out of twenty seven morphological descriptors studied, three were monomorphic, two were dimorphic and rest twenty two were polymorphic. The study grouped the 28 varieties into five different clusters based on these DUS parameters. The present experimental material thus revealed considerable variability for most of the morphological characters, indicating their utility in the characterization and use in rice variety improvement programme.

Keywords: Extant variety, DUS test, genetic variability

Introduction
Cultivated rice (*Oryza sativa* L.) belongs to family Poaceae and, at present sustains two thirds of the world's population. It provides 35–60% of the calories of total requirement consumed by almost half of humanity. Rice (*Oryza sativa* L.) has chromosome number 2n =2x =24. There are 24 recognized species including Asian and African cultivated rice grown all over the world. South East Asia is considered as its center of origin. At global level, rice is the second most important crop after wheat worldwide, and occupies 153 million ha area with a production of 656 mt annually (IRRI, 2013). India is the world's second largest producer (105.4 mt) of rice on an area of 44.7 mha with productivity of 24.6 qt/ha.

While the introduction and development of high yielding, fertilizer responsive, short statured rice varieties ushered in the green Revolution in the country and helped attaining food security subsequently, a growing concern is being raised about the rapid loss of the conventional farmers' varieties. It is believed that many of these varieties assumed greater significance in the context of climate change, which renewed the interaction in evaluation, conservation and seed multiplication of such varieties. In the system of commercial seed production, detailed characterization of the varieties play the critical role in the maintenance of genetic purity (Chakrabarty *et al.* 2012) [1].

Apart from that there are number of rice varieties which are the result of systematic breeding and high skilled knowledge and experience of breeders which give high yield and provide resistance against biotic and abiotic stresses. These high yielding varieties are the basic tools for food security in developing countries including India. Variety development is time consuming process; therefore breeder of the variety should get some reward for that such effort in terms of royalty and protection. The minimum requirement of an effective sui generis system for the protection of plant varieties under the GATT agreement establishing the WTO points towards the available system under the UPOV. The UPOV convention provides a system based on DUS testing of crop varieties, accepted and in operation in a large number of countries Mauria, S. (2000) [2]. Hence, India has developed its *sui generis* system for Plant

Variety Protection of new varieties for granting Plant Breeder's Rights (PBR) to the breeder/farmers/Institution known as Protection of Plant Variety & Farmer's Right Act 2001 (PPV&FRA). This Act is considered as a landmark development in the agriculture in the country. The implementation of this Act is expected to accelerate agricultural development and protect plant breeders' rights for creating new plant varieties through higher investments in research and development both by the public and private plant breeding institutions. However, to protect the rights of the breeders/breeding institutions against misappropriation and plagiarism, it is desirable that there should be a comprehensive characterization of such varieties. Therefore, it is important to characterize all varieties of common knowledge and to prepare and maintain a comprehensive data base for reference and comparison.

Diversity analysis provides information on the genetic distances among farmers' varieties and genetic similarity/distinctness among populations of the same named landrace(s) grown by different farmers in different niche environments. The present study was carried out to characterize the extant rice varieties for plant and grain morphological traits and to assess the extent of similarity and variability in these varieties.

Materials and methods

The field experiment was conducted during *kharif* season of 2014-15 in the field of Seed Science and Technology Division, ICAR- Indian Agricultural Research Institute, New Delhi comprising of twenty eight extant rice varieties. The experiment was conducted in Randomized Block Design (RBD) with two replications during *kharif* season of 2014. The test plot details were as follows: All the 28 rice varieties were sown as per layout below: Replication = 2, Row length = 4 m, Number of rows per variety = 4 Distance of R-R = 30 cm and P-P= 20 cm is followed.

Sampling procedure: The observations were made on twenty plant or plant parts, which were equally divided in two replications as per PPV&FR guidelines. (Anonymous, 2007).

Characters used for observation: The complete DUS database of plant morphological characters for all the rice varieties were generated as per DUS guidelines (Rice) no. SG/ 01/ 2007.

Result and discussion: The present study was initiated with an attempt to group the most similar varieties together and to resolve differentiation among them. To achieve the same, the varieties of the present study were singled out using a combination of grouping characters and essential characters as listed in DUS guidelines. A total of three grouping characters and twenty four essential characters as per the DUS guidelines (Rice) no. SG / 01 / 2007; were recorded for the research material at various growth stages starting from basal leaf sheath colour (at seedling stage) upto grain length and width (after harvesting). Out of twenty seven morphological descriptors studied, three were found monomorphic, two were dimorphic and rests twenty two were found polymorphic in state of expression. Therefore, the following seven important quantitative DUS traits were used for grouping the varieties:

1. Leaf: Length of blade
2. Leaf: Width of blade
3. Stem: Length excluding panicle
4. Panicle: Length of main axis
5. Grain length
6. Grain width
7. Time of heading: since this trait is one of the important traits used universally for grouping of varieties; hence used for clustering.

Similar outcome was confirmed by Manjunatha, G. A *et al.* (2018) [3] and found that Out of 25 descriptors studied, three characteristics were found monomorphic, seven were dimorphic, six were of trimorphic, seven were tetramorphic and decorticated grain shape showed five states of expression, and lemma and palea colour recorded six states of expression. Similarly in another study a total of three characters viz., leaf auricles, leaf ligules and leaf shape of ligule were found to be monomorphic. The characters namely leaf anthocyanin colouration, leaf sheath anthocyanin colouration, panicle awns, panicle distribution of awns and leaf pubescence of blade surface were recorded as dimorphic. Seven traits viz., coleoptile colour, leaf intensity of green colour, ligule colour, leaf anthocyanin colouration of auricles, panicle exertion, leaf length of blade and leaf width of blade were of trimorphic. Five traits namely basal leaf sheath colour, culm attitude, flag leaf attitude of blade (early and late observation), panicle curvature of main axis were recorded four states of expression. The traits viz., spikelet colour of stigma, stem length, days to 50% flowering and time to maturity were showed five states of expression (Priyanga, R. S *et al.* 2020) [4].

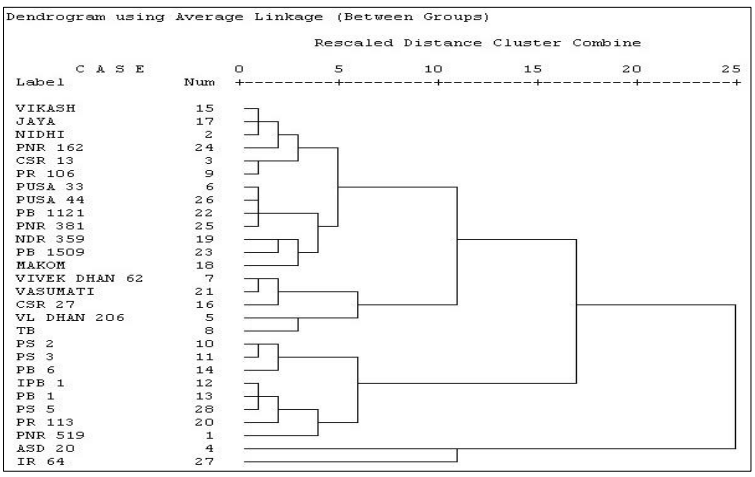

Fig 1: Dendrogram based on DUS parameters

Table 1: Clustering pattern of varieties based on DUS parameters

Cluster	Number of Varieties	Name
I	06	VIKASH, JAYA, NIDHI, PNR-162, CSR-13, PR-106
II	07	PUSA-33,PUSA-44,PB-1121,PNR-381,NDR-359,PB-1509, MAKOM
III	05	VIVEKDHAN-62, VASUMATI, CSR-27, V L DHAN-206, TARAORI BASMATI
IV	08	PS-2, PS-3, PS-5, PB-6, IMPROVED PB-1, PB-1, PR-113, PNR-519
V	02	ASD-20, IR-64

The varieties of the present study were singled out using a combination of grouping characters and essential characters as per the DUS guidelines (Rice) no. SG / 01 / 2007. The study grouped the 28 varieties into five different clusters (Fig. 1 and Table 1) based on these DUS parameters.

A total of eight grouping characters and nineteen essential characters as per the DUS guidelines (Rice) no. SG / 01 / 2007 were recorded for the research material at various growth stages starting from basal leaf sheath colour (at seedling stage) upto grain length and width (after harvesting). The study grouped the 28 varieties into five different clusters based on these DUS parameters. The present experimental material thus revealed considerable variability for most of the morphological characters, indicating their utility in the characterization and use in rice variety improvement programme. The varieties with distinct and distinguishable characteristics and economic and genetic values can be registered for its protection under the PPV&FR Act, 2001 and the prominent characters can be employed in the commercial production of genetically pure seeds of such varieties. Similar result were found by Pourabed, E *et al.* (2015) [5] who experimented DUS testing of rice varieties through microsatellite markers for the identification and distinction of 40 rice varieties consisting of local varieties of Iran, improved varieties, and IRRI varieties. The results of cluster analysis based on DUS testing showed the complete discrimination of varieties from each other except for IR58025A and IR58025B. Moreover, cluster analysis could detect the most of the improved varieties from local varieties.

Raghuvanshi *et al.* (2014) [6] studied morphogenetic characterization based on DUS testing, to distinguish seventeen varieties of forage sorghum on the basis of twenty six essential morphogenetic characteristics, of seedling, plant (vegetative stage and at maturity) and matured seeds, as per the National Guideline for DUS test of Sorghum. Begum and Kumar (2011) [7] characterized thirty two jute (*Corchorus olitorius* and *C. capsularis*) varieties, including 25 released/notified and seven of common knowledge through distinctness, uniformity and stability (DUS) testing trials for two consecutive years using 17 heritable morphological traits to enable identification of these varieties and for unambiguous ascertainment of distinctness. Joshi *et al.* (2007) [8] evaluated ninety one farmers' grown rice varieties, collected from southern part of West Bengal for 52 plant morphological and grain characteristics for two years at IARI, New Delhi farm. Of the 44 qualitative traits studied, maximum variability was recorded with respect to density of pubescence of lemma, curvature of main axis of panicle, attitude of branches of panicle, anthocyanin colour of keel in lemma, colour of tip of lemma and lemma and palea colour.

Data were recorded for 60 DUS descriptors (46 qualitative and 14 quantitative) following guidelines from the International Union for the Protection of New Varieties of Plants (UPOV) and the Protection of Plant Varieties and Farmer's Rights Authority (PPV & FRA). Data on quantitative traits were subjected to Combined over Years Distinctness (COYD) and Combined over Years Uniformity (COYU) analyses. The descriptors offering the most discrimination were time to 50% heading, decorticated grain shape, and the colour of lemma and palea. (Mondal, B *et al.* 2014) [9]

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