

Short Communication

Structural features of central aerenchyma for establishing varietal distinctiveness in rice

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Rice is the world's most important food crop and a primary food source for more than one third of the world's population [1]. It is rich in carbohydrate and protein as well as vitamins, minerals and fibre. It is a major ingredient in cuisines world over, in the form of breakfast, cereals, staple carbohydrates, snacks, alcoholic beverages and desserts. Rice is consumed as a grain most exclusively by humans, supplying 20 % of daily calories for the world population. Production of rice, the world's most important staple food crop, is threatened worldwide by drought. The rice plant require large amounts of mineral nutrients, including nitrogen for their growth, development and grain production. Plants are aerobic organisms and lack of oxygen presents a severe stress. Low oxygen conditions in plants can be brought about by high metabolic activity, soil water logging or flooding [2]. Soil water logging and flooding are environmental conditions that are frequently encountered by plants growing in aquatic or semi-aquatic habitats. However, when plant shoots become flooded, they also experience oxygen shortage. Plants, such as rice (*Oryza sativa* L.), endure frequent flooding by adaptations found not only in roots, but also in stems and leaves. Gas-filled spaces known as aerenchyma are constitutively found in aquatic and semi-aquatic plants, and are considered to be an efficient mechanism to ameliorate low oxygen stress. Because most agricultural fields are at least occasionally flooded, the development of crops capable of tolerating flooding by rapidly developing

efficient networks of aerenchyma would have important benefits for farmers. Aerenchyma facilitates gas exchange between aerial and submerged plant parts by reducing the diffusion resistance to gas exchange imposed by cells. Hence, it is of great importance in crop survival in water logging. Thus, the present study aimed to analyse basic structure of aerenchyma in the rice stem, with an attempt to distinguish the varieties on the basis of these structural differences.

Anatomical studies of the aerenchyma system of rice plants was carried out with 25 rice varieties of *Oryza sativa* L. during kharif 2014 in the Division of Seed Science and Technology, IARI, New Delhi. The structure of aerechyma was studied with the aid of a binocular microscope. During binocular studies, resolution was so adjusted so as to critically examine the morphological structures of the aerenchyma. The aerenchyma of rice plants was investigated using plants in the reproductive stage. The cross-sections of rice stem were stained with saffranin to observe the detailed structure under microscopy. The images were captured and stored for further study.

Rice is one of the few crops able to withstand periods of partial or even complete submergence [3-5]. One of the adaptive traits of rice is the constitutive presence of aerenchyma which enables oxygen to be transported to the submerged organs [6-7]. Aerenchyma formation is one of the plant's morphological adaptations that help to

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increase gas circulation inside the underwater organs [8].

The oval shaped vascular bundles were observed to be numerous and scattered irregularly in the ground tissues. Peripheral bundles were small and closely arranged. The central bundles were large and widely arranged. In the rice stem, aerenchyma was formed in between the vascular bundles, which were located in an outer ring below the epidermis. The conserved number of aerenchyma may be a result of the conserved anatomy of rice with a defined number of vascular bundles in the stem. The number of aerenchyma formed increased from bottom to top in a recurrent pattern that was observed in each internode.

A detailed analysis of the cells that were lysed to form a gas space in the rice stem revealed that these cells possess characteristic features. They were larger, as also observed for cortex cells in rice roots that form aerenchyma [9]. They contained a large vacuole, were lighter in colour and appeared to be devoid of chloroplasts. Unlike the surrounding parenchymal cells, pre-aerenchyma cells contained little or no starch, and had a thin cell wall.

The nodes of mature stems were observed to be hollow and additional

aerenchyma channels with diameters of 0.1-0.2 mm embedded in parenchymatous cells were found between vascular bundles of the stem walls. The vast aerenchyma system was detectable within the nodes. Compared to the leaf sheaths enveloping the stem, the extent of the aerenchyma of the stem was much smaller. Differences between the aerenchyma of 25 rice varieties were studied at both vegetative and reproductive stage and the aerenchyma was observed to be well established. The aerenchyma of 25 rice varieties was studied intensively and investigations focused on differences between the varieties (Fig. 1, i to xxv). Significant differences were found in the anatomy of the aerenchyma.

An attempt was made to visualise the clustering pattern using shape and size features of central aerenchyma. Six clusters were formed on the basis of similarities in structural features (Table 1). Cluster I consisted of three genotypes, namely, PS 2, PS 3 and PS 5 having elliptical shaped central aerenchyma. Cluster II contained three genotypes-Jyothi, Kranthi and NDR 359 having smaller sized aerenchyma with somewhat elliptical shape as compared to cluster I. Five genotypes- PB 6, PS 4, Improved PB 1, Kasturi and Makom constituted cluster III with circular central aerenchyma of bigger

Table 1. Clusters on the basis of structural features of aerenchyma.

Cluster	No. of Genotypes	Varieties
I	3	PS 2, PS 5, PS 3
II	3	JYOTHI, KRANTHI, NDR 359
III	5	PB 6, PS 4, IMP. PB 1, KASTURI, MAKOM
IV	4	PB 1, VASUMATI, PHALGUNA, BASMATI 370
V	7	MANDYA VIJAYA, CSR 27, PANT DHAN 4, VIJETHA, PR 113, VIKRAMARYA
VI	3	VL DHAN 81, JAYA, PANT DHAN 12

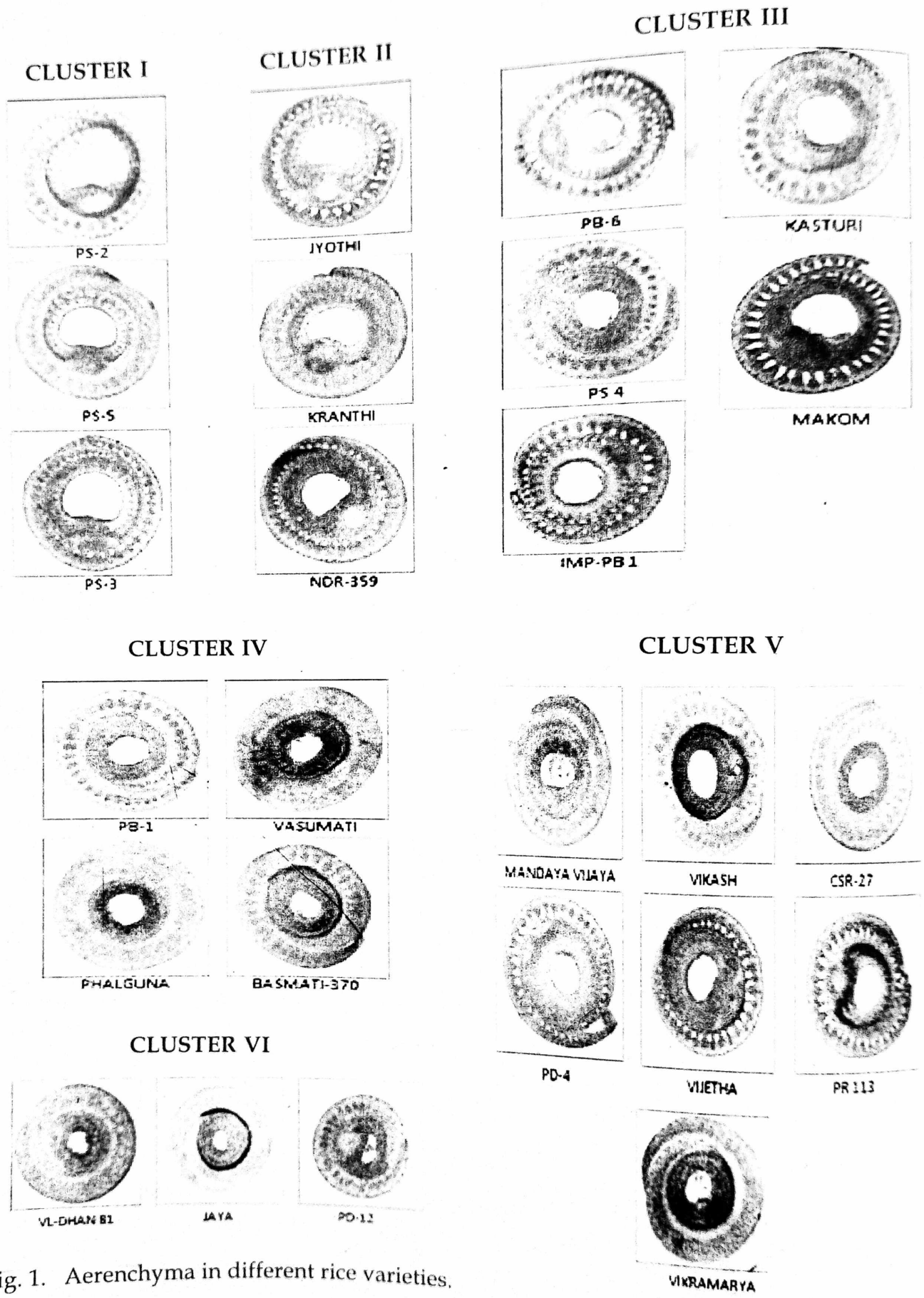


Fig. 1. Aerenchyma in different rice varieties.

size. Cluster IV included four genotypes namely PB1, Vasumati, Phalguna and Basmati 370 with small and round central aerenchyma. Cluster V included maximum number of genotypes (seven) having varieties Mandaya Vijaya, Vikash, CSR 27, Pant Dhan 4, Vijetha, PR 113 and Vikramarya with clear cut distinguished central aerenchyma. Cluster VI consisted of three genotypes namely VL Dhan 81, Jaya and PD 12 with smaller sized central aerenchyma.

Thus, the study revealed that by using basic structural differences between aerenchyma, the varieties could be successfully grouped into various clusters.

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