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DUS characterization of traditional scented rice (*Oryza sativa* L.) varieties under organic agriculture

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Abstract
A field experiment was conducted during *kharif* 2020 at G.B. Pant University of Agriculture and Technology, Uttarakhand, India to characterize both the qualitative and quantitative characters of traditional scented rice under organic mode of cultivation following the guidelines from the International Union for the Protection of New Varieties of Plants (UPOV) and Protection of Plant Varieties and Farmer's Rights Authority (PPV&FRA). The experiment was conducted in randomized block design with ten treatments and replicated thrice. The treatments consisted of ten rice varieties viz; V1: Kubir Mamhani, V2: Kudrat-5, V3: Chinar-20, V4: Kesho Pohu, V5: DRK, V6: Kudrat-1, V7: Pusa 1121, V8: Type 3, V9: Traori and V10: Tilak Chandan. The transplanting was done at 25cm × 12.5 cm spacing, using two seedlings per hill. Rice crop was fertilized with green manuring (*Sesbania)* and 2.5 t vermicompost ha/ha as top dressing. During the experiment, DUS characteristics for all the varieties were determined. The results revealed that the varieties were observed very highly aromatic except the Taraori variety which was recorded as medium in aroma. While the lowest aroma was recorded in Kubri Mamhani, Kesho Pohu and Tilak Chandan rice varieties.
Therefore, the characters recorded for each variety can be attributed to the genetic makeup of the variety. This detailed characterization of traditional scented rice varieties are very important from the standpoint of selection and conservation for further utilization in crop improvement programmes and also to seek protection under PPV&FR Act, 2001 of India.

Keywords: DUS, characterization, rice, PPV & FR act, organic farming

1. Introduction
Rice is the most cultivated crop and staple crop of Asian countries, more than two billion people are getting 60-70% of their energy requirement from rice and its derived products (IRRI, 2015) [3]. Globally, population is increasing day by day and to cope up with the growing demand of food there is need to produce 50% more than what is produced now by 2050 (FAO, 2016) [2]. Rice occupies an area of around 43.7 million hectares in India with production of 112.91 million tonnes and 2.578 t/ha productivity in 2017-18 (DAC & FW 2019) [1]. The grain production in India rose five times over six decades of Green Revolution without increasing the net cultivated area mainly due to increased use of inputs such as HYVs, fertilizers, pesticides along with irrigation facilities. Heavy application of synthetic fertilizers particularly nitrogen and phosphorus caused depletion of certain nutrients in soil and generally results in the nutrients imbalance in soil. Therefore, among various options available, to achieve sustainability in agricultural production, organic manure and biofertilizers may play an important role because they exert beneficial effect on the soil physical, chemical and biological properties for sustenance of soil quality and future agricultural productivity. Thus, there is a need to make necessary modifications in the ongoing practices, so that the agricultural system can be sustained rather improved to feed the burgeoning population. Organic farming is a practice of doing farming without using synthetic chemicals and exclusively depends on natural products, thus being considered as sustainable and environmental friendly. It is no doubt that the chemical fertilizers have a great impact on the yield increment, however it has been suggested that the aroma in the rice grain is improved by the use of organic nutrients**.** Use of organic fertilizers in optimum amount could help in comparable yield of rice along with preserving its quality as well as sustaining the good soil health. Organic farming is a production system which favors maximum use of organic materials (crop residues, animal residue, legumes, on and off farm wastages, growth regulators, biopesticides, etc.). A number of studies showed that under abiotic stress such as in drought conditions, crops in organic agriculture systems produce significantly higher yields than conventional agriculture (Roos

et al., 2018) [10].

To improve upon the productivity of any farming system, selection of a right variety is of utmost significance. Each variety has a typical genetic makeup which regulates its growth and yield parameters, besides the rooting pattern. Another important issue which is governed by the genetic base is the productivity and quality of the grains. The performance of a variety is an interaction between genotype and environment. Under organic mode, the nutrients are supplemented through organic sources only, therefore in comparison to inorganic or integrated system; the nutrient availability to a crop is relatively low. However, it ensures the continuous availability of nutrients as organics have slow nutrient release pattern. This is likely to affect the performance or growing pattern of a variety which have been otherwise bred for inorganic nutrient management system. Till date only limited options are available to biotic stresses and abiotic stresses. Lodging is one of the main serious issues in rice cultivation which have been observed more with the traditional type varieties, thus a variety with sturdy stems will have better stability. Other benefit expected with a suitable variety is the vigorous rooting system, which enables it to explore more soil volume both for moisture as well as nutrients.

In recent years due to change in varietal spectrum and use of paddy fields for non-agricultural purposes, valuable rice germplasm are disappearing fast (Latha *et al.* 2013) [6]. Hence, there is an urgent need for characterization and conservation of these traditional varities. In the evolution of rice and its genetic differentiation into distinct varietal groups, consumer quality preferences have played a significant role besides agro ecological factors. One such varietal group comprising the aromatic/scented rice in India which fetches higher price in domestic as well as international markets.

Government of India has introduced Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act in 2001, for the IP protection over crop varieties including farmers' rights over traditional varieties. Protection of IP rights over varieties can be accomplished by their registration under this Act. Morphological characterization based on DUS (Distinctness, Uniformity and Stability) is the requisite for registering varieties under PPV&FR Act.

Therefore, keeping these facts in consideration, the field experiment was conducted to evaluate the DUS characters of traditional scented rice (*Oryza sativa* L.) varieties under organic mode of cultivation.

2. Materials and Methods

A field experiment was conducted at Norman E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand) during *kharif* season of 2020.The experimental site centre is located at 29^0N latitude and 79.5^0E latitude, 243.84 meter above mean sea level. It falls under subtropical climate at the foot hills of "Shivalik" ranges of Himalaya a narrow belt called '*Tarai*'. During the crop season, the average weekly maximum temperature varied from from 31.4-45.2 °C. while the minimum temperature fluctuated from 6.1 °C to 17.8 °C with an average of 11.9 °C. The mean annual rainfall is about 1420 mm, of which around 75% is commences in the period of four months i.e., from June to September and the average rainy days are 58.1. The experiment was laid out in randomized block design and replicated thrice with net plot size of 5.75m × 2.75 m. The experiment consisted of 10 treatments *viz.* V1: Kubir Mamhani, V2: Kudrat-5, V3: Chinar-20, V4: Kesho Pohu, V5: DRK, V6: Kudrat-1, V7: Pusa 1121, V8: Type 3, V9: Traori and V10: Tilak Chandan. The seeds were treated with salted water prior to soaking followed by Pant Bioagent-3 (mixture of *Tricoderma* and *Pseudomonas*) @ 10 g/kg seed at the time of incubation before nursery sowing. The seedlings were raised in nursery by wet bed method. Seed beds of 3.5 m × 1.5 m size were prepared in dry condition. A day before sowing, the beds were flooded with water and puddle the following day. Sprouted seeds @ 500 g for 10 m^2 plots were broadcasted on 5th June. Beds were then kept saturated with water initially up to a week and then submerged with a thin layer of water gradually to 5 cm and irrigated on alternate days in the evening. After the harvesting of the wheat crop, the field was prepared with tractor-drawn implements. It was ploughed once by disc plough followed by two cross disc harrowing, and leveled with plank. Two days before transplanting, the layout was shaped and bunds were prepared. The individual plot was flooded with water and then puddling followed by leveling was done manually. Green manuring of *Sesbania* was done, likely biomass 16 t/ha equivalent to 3.5 t/ha on dry weight basis, along with green manuring, vermicompost @ 2.5 ton/ha had also been applied 20 days after transplanting. Seedlings were then transplanted in rows using nylon rope at 25 cm × 12.5 cm and transplanted as two seedling/hill. Observations were recorded on 10 randomly selected plants of each genotype for all the traits under study, at different stages of growth with appropriate procedures as per the "Guidelines for the Conduct of Test for DUS on Rice" (PPV & FRA, 2007) [9].

3. Results and Discussion

Total 10 rice varieties were taken for DUS characterization using 16 characters which include both qualitative and quantitative characters. The rice varieties showed wide range of distinctiveness characters for all most all the morphological traits studied and similar results has been reported earlier by Manjunatha *et al.* (2016) [7], Mondal *et al.* (2014) [8]; Manjunatha *et al.* (2016) [7]; Kalyan *et al.*, (2017) [4] and Umarani *et al.* (2017) [11]. The qualitative and quantitative characters of different agronomic and morphological parameters are computed in Table 1,2,3,4 and 5.

3.1 Basal Leaf: Sheath colour, leaf: intensity of green colour and anthocyanin coloration of different rice varieties

Data pertaining to table 1 inferred that the basal leaf: sheath colour was light purple in case of variety Kubri Mamhani, uniform purple in Chinar-20 and with purple lines in case of variety Taraori. In remaining all the varieties, the basal leaf: sheath colour was green (Table 1). The leaf intensity of green colour was darker in case of varieties Kudrat-5, Kudrat-1, Pusa 1121 and Taraori. It was light green colour of the varieties; Kubri Mamhani, Kesho Pohu and Tilak Chandan. However, the intensity of greenness was medium in case of varieties, DRK and Type 3 (Table 1). The presence of leaf: anthocyanin was found only in Chinar-20 while all the remaining all other varieties was absent in anthocyanin (Table 1).

3.2 Leaf auricle and leaf collar characteristics of different rice varieties

Table 2 showed the leaf auricles, leaf anthocyanin pigmentation of auricle, leaf collar and leaf anthocyanin colouration of collar of different rice varieties grown under organic mode of cultivation. Leaf auricles were observed or present in all the varieties. The leaf anthocyanin pigmentation of auricles was recorded as light purple in Kubri Mamhani, Pusa-1121 and Type-3. Varieties Kudrat-5, Kesho Pohu, DRK, Kudrat-1, Taraori and Tilak Chandan had colorless Leaf Anthocyanin coloration of auricles, while Chinar-20 observed as purple in anthocyanin coloration. In all the different rice varieties, leaf collar was present. Except Chinar-20, the leaf anthocyanin pigmentation of collar was absent in all the varieties.

3.3 Leaf collar and leaf ligule ratio and their colour of different scented rice varieties

Observations on presence or absence of ligules on leaf and colour of ligules are given in table 3. In all the varieties studied, the ligules were present on the leaf. Except variety Chinar-20, the ligules were white. In variety Chinar-20, the colour of ligules was purple.

3.4 Flag leaf blade and panicle characteristics of different rice varieties

Attitude of blade (flag leaf)

Table 4 shows the attitude of blade (flag leaf). The attitude of blade (flag leaf) of Kubri Mamhani, Chinar-20, Kesho Pohu, DRK, Kudrat-1 and Tilak Chandan varieties was being observed as erect while that of Kudrat-5, Pusa-1121, Type-3, and Taraori varieties, as semi erect in position (Table 4).

Panicle: curvature of main axis

Panicle: curvature of main axis of Kudrat-5, Kudrat-1, Type-3, Taraori and Tilak Chandan varieties was found as drooping, while all the other varieties i.e., Chinar-20, Kesho Pohu, DRK, Pusa-1121 had deflexed Panicle: curvature of main axis. The panicle: curvature of Kubri Mamhani was recorded as semi straight (Table 4).

Secondary branches in panicle at ripening stage

The terminal component of the rice tiller is an inflorescence called as panicle. The panicle bears rice spikelets, which develop into grains. Each node on the main panicle axis gives rise to primary branches which in turns bear secondary branches. The spikelets are borne on the primary and the secondary branches. In the table 4, the secondary branches in panicle at ripening stage were present in all the varieties. The pattern of secondary branches in Kubri Mamhani, Kudrat-5, Chinar-20, Kesho Pohu and Kudrat-1 was recorded as strong while in DRK, Pusa-1121, Type-3, Taraori and Tilak Chandan as weak (Table 4).

3.5 Decorticated grain and aroma characteristics of different scented rice varieties

Decorticated grain shape

Four distinct types were observed with respect to decorticated grain shape viz., short bold, medium bold, short slender and medium slender (Table 5). The grain shape short bold were exhibited by the varieties Kubri Mamhani, Kudrat-5, Kesho Pohu, Kudrat-1 and Tilak Chandan. The rice varieties Pusa 1121, Type-3 and Taraori exhibited medium slender shape of decorticated grain. Chinar-20 exhibited medium bold decorticated grain shape while variety DRK possessed short slender decorticated grain shape.

Decorticated grain color

The colors of decorticated grains of different short grain scented rice varieties were categorized as light green, light brown and brown (Table 5). Here, decorticated grains of varieties Kudrat-5, Chinar-20, Kesho Pohu, DRK, Kudrat-1, Taraori and Tilak Chandan were observed as light brown, while decorticated grains of Pusa 1121 and Type-3 were observed as light brown in color. Variety Kubri Mamhani exhibited light green color of decorticated grains.

Aroma and extent of aroma

All the rice varieties were tested for presence of aroma when caryopsis was intact and all varieties were found aromatic (Table 5). The extent of aroma of decorticated grains of different rice varieties were categorized as low, medium and very high. Here, Kubri Mamhani, Kesho Pohu and Tilak Chandan were found to be low in aroma, while all the other varieties were observed very highly aromatic except the Taraori variety which was recorded as medium in aroma. Similar observations had been studied by Kumar *et al.* (2016) [5].

Table 1: Basal Leaf: sheath colour, leaf: intensity of green colour and anthocyanin coloration of different rice varieties

Varieties	Basal leaf: Sheath colour	Leaf: Intensity of Green Colour	Leaf: Anthocyanin Coloration
Kubri Mamhani	Light purple	Light Green	Absent
Kudrat-5	Green	Dark Green	Absent
Chinar-20	Uniform purple	Dark Green	Present
Kesho Pohu	Green	Light Green	Absent
DRK	Green	Medium	Absent
Kudrat-1	Green	Dark Green	Absent
Pusa-1121	Green	Dark Green	Absent
Type-3	Green	Medium	Absent
Taraori	Purple line	Dark Green	Absent
Tilak Chandan	Green	Light Green	Absent

Table 2: Leaf auricle and leaf collar characteristics of different rice varieties

Variety	Leaf: Auricles	Leaf: Anthocyanin coloration of auricles	Leaf: Collar	Leaf: Anthocyanin coloration of collar
Kubri Mamhani	Present	Light purple	Present	Absent
Kudrat-5	Present	Colorless	Present	Absent
Chinar-20	Present	Purple	Present	Present
Kesho Pohu	Present	Colorless	Present	Absent
DRK	Present	Colorless	Present	Absent
Kudrat-1	Present	Colorless	Present	Absent
Pusa-1121	Present	Light purple	Present	Absent
Type-3	Present	Light purple	Present	Absent
Taraori	Present	Colorless	Present	Absent
Tilak Chandan	Present	Colorless	Present	Absent

Table 3: Leaf collar and leaf ligule ratio and their colour of different scented rice varieties

Variety	Leaf: Ligule	Colour of ligule	Attitude of blade (Flag leaf)
Kubri Mamhani	Present	White	Erect
Kudrat-5	Present	White	Semi erect
Chinar-20	Present	Purple	Erect
Kesho Pohu	Present	White	Erect
DRK	Present	White	Erect
Kudrat-1	Present	White	Erect
Pusa-1121	Present	White	Semi erect
Type-3	Present	White	Semi erect
Taraori	Present	White	Semi erect
Tilak Chandan	Present	White	Erect

Table 4: Flag leaf blade and panicle characteristics of different rice varieties

Variety	Panicle: Curvature of main axis	Secondary Branches in panicle at Ripening stage	
		Present/Absent	Pattern
Kubri Mamhani	Semi straight	Present	Strong
Kudrat-5	Drooping	Present	Strong
Chinar-20	Deflexed	Present	Strong
Kesho Pohu	Deflexed	Present	Strong
DRK	Deflexed	Present	Weak
Kudrat-1	Drooping	Present	Strong
Pusa-1121	Deflexed	Present	Weak
Type-3	Drooping	Present	Weak
Taraori	Drooping	Present	Weak
Tilak Chandan	Drooping	Present	Weak

Table 5: Decorticated grain and aroma characteristics of different scented rice varieties

Variety	Decorticated grain shape	Decorticated grain colour	Aroma	Extent of aroma
Kubri Mamhani	short bold	light green	Present	Very high
Kudrat-5	short bold	light brown	Present	Low
Chinar-20	medium bold	light brown	Present	Very high
Kesho Pohu	short bold	light brown	Present	Very high
DRK	short slender	light brown	Present	Low
Kudrat-1	short bold	light brown	Present	Very high
Pusa-1121	medium slender	Brown	Present	Very high
Type-3	medium slender	Brown	Present	Very high
Taraori	medium slender	light brown	Present	Very high
Tilak Chandan	short bold	light brown	Present	Medium

4. Conclusion

It is concluded that out of 10 evaluated scented rice varieties, Kubri Mamhani, Chinar-20 and Taraori showed purple basal leaf: sheath colour. The presence of leaf anthocyanin and purple colour ligule was found only in Chinar-20. The extent of aroma of decorticated grains of different rice varieties were categorized as low, medium and very high. Here, Kubri Mamhani, Kesho Pohu and Tilak Chandan were found to be low in aroma, while all the other varieties were observed very highly aromatic except the Taraori variety which was recorded as medium in aroma. The DUS characters are the traits found in a genotype and are governed genetically. Therefore, the characters recorded for each variety can be attributed to the genetic makeup of the variety. This information on characterization will be useful for breeders, researchers and farmers to identify and choose the restoration and conservation of beneficial genes for crop improvement. The information generated on these varieties may also support their registration with the PPV&FRA.

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