Comparative analysis of traditional scented rice (*Oryza sativa* l.) varieties under organic cultivation based on DUS testing and yield assessment

Abstract

An agricultural field study was conducted during the kharif season of 2020 at the G.B. Pant University of Agriculture and Technology in Uttarakhand, India, to investigate the qualitative and quantitative attributes of traditionally scented rice cultivated through organic methods. The experiment, a randomized block design with three replications, evaluated ten rice varieties, labeled as V1 to V10 (KubirMamhani, Kudrat-5, etc) . The morphological variations among the varieties (registered under PPV&FR Act 2001) are based on DUS (Distinctness, Uniformity, and Stability) is required for protecting the uniqueness of traditional scented varieties of rice. It can also be the indicative of the yield. The grain, straw and harvest index were found the highest with variety Kudrat-5 followed by Kudrat-1.

Keywords: DUS, harvest index, organic agriculture, traditional scented rice

1. Introduction

More than two billion people rely on rice and rice-derived products for 60–70% of their energy needs, making rice the most widely grown crop and staple crop in Asian nations (IRRI, 2015). Global population is growing, and in order to meet the rising need for food, production must increase by 50% by the year 2050 (FAO, 2016).In India, rice cultivation spans approximately 43.7 million hectares, resulting in a production of 112.91 million tonnes and achieving a productivity of 2.578 tonnes per hectare in the 2017–18 period (DAC & FW 2019).During the six decades of the Green Revolution, India's grain production increased five times without an increase in the net cultivated land, primarily as a result of increased usage of inputs like HYVs, fertilisers, pesticides, and irrigation systems. Heavy use of synthetic fertilisers, particularly nitrogen and phosphorus, led to an imbalanced level of nutrients overall and the depletion of some nutrients in the soil.Due to their beneficial impacts on the physical, chemical, and biological characteristics of the soil, they contribute to the preservation of soil quality and the enhancement of future agricultural productivity, organic manure and biofertilizers may thus play a significant role in achieving sustainability in agricultural production among the various options available. In order to improve rather than perpetuate the agricultural system and feed the expanding population, significant changes must be made to the current practises. Organic farming is the practise of carrying out cultivation without utilising synthetic chemicals and solely relying on natural items; as a result, it is seen as environmentally beneficial and sustainable.There is no doubt that the use of chemical fertilisers has a significant impact on the increase in production, however it has been proposed that the use of organic nutrients enhances the aroma of the rice grain. Using organic fertilisers in the right amounts can help produce rice with yields that are comparable, while also maintaining the grain's quality and conserving the soil's health. A production technique known as organic farming prioritizes the use of as many organic resources as possible, including crop and animal waste, legumes, off-farm waste, growth regulators, and biopesticides. Numerous studies have demonstrated that crops grown in organic agricultural systems yields are noticeably higher than those grown in conventional agriculture during abiotic stress, such as drought circumstances (Roos*et al.*, 2018).

The choice of the ideal variety is crucial for increasing any farming system's production. Each variety's genetic makeup is typical, and this genetic makeup controls its development, DUS characterisation, and yield parameters. A variety's performance results from the interaction of its genotype and environment. The availability of nutrients to a crop is lower under organic mode than it is under inorganic or integrated systems since they are exclusively replenished from organic sources. However, because organics have a delayed rate of nutrient release, it guarantees ongoing nutritional availability. A variety that has been bred for an inorganic nutrient management system may suffer in terms of performance or growth pattern as a result of this. Organic cultivation for traditional scented rice holds significant importance in preserving agricultural heritage, promoting environmental sustainability, and ensuring high-quality, nutritious rice for consumers.

One of the key advantages of organic cultivation is the preservation of genetic diversity. Traditional scented rice varieties possess unique genetic traits that have been passed down through generations. By practicing organic methods, farmers help safeguard these traditional varieties, preventing the loss of valuable genetic resources and maintaining agricultural biodiversity. Organic cultivation for traditional scented rice helps preserve cultural and heritage values associated with these varieties. These rice varieties often hold deep significance in local traditions and cuisines. By supporting organic farming practices, communities can maintain their cultural identity and promote sustainable farming methods that align with their heritage.

As a result of alterations in the varietal range and the conversion of paddy fields for non-agricultural uses in recent times, the precious rice germplasm is rapidly vanishing (Latha et al., 2013). Hence, it is crucial to categorize and safeguard these traditional variations. Alongside ecological considerations in agriculture, consumer preferences for quality have played a noteworthy role in the development of rice and its genetic diversity, resulting in numerous classification systems for rice varieties. India's aromatic/scented rice is one of these varieties, and it sells for more money both domestically and internationally.

In order to protect agricultural varieties' intellectual property, including farmers' rights to traditional varieties, the Indian government enacted the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act in 2001. By registering them under this Act, variations' associated intellectual property rights can be protected. For variations to be registered under the PPV&FR Act, morphological classification based on DUS (Distinctness, Uniformity, and Stability) is required. Therefore, taking these factors into account, a field experiment was carried out to compare the yield of conventionally scented rice (Oryza sativa L.) cultivars grown organically and by DUS testing.

2. Materials and Methods

At the G. B. Pant University of Agriculture and Technology's Norman E. Borlaug Crop Research Centre in Pantnagar (Uttarakhand), a field trail was conducted in the kharif season of 2020.The experimental site centre is situated 243.84 metres above mean sea level at 290N latitude and 79.50E latitude. It has a subtropical climate and is located in the narrow "Tarai" belt at the base of the Himalayan "Shivalik" peaks.The experiment utilized a randomized block design and featured a net plot size of 5.75 m by 2.75 m. It encompassed ten distinct treatments: Kubir Mamhani, Kudrat-5, Chinar-20, Kesho Pohu, DRK, Kudrat-1, Pusa 1121, Type 3, Traori, and Tilak Chandan, representing different variations.Wet bed technique was used in the nursery to raise the seedlings. A seed bed measuring 3.5 metres by 1.5 metres was set up in a dry environment. The beds were saturated with water the day before sowing, and the next day they puddled. For 10 m2 plots, 500 g of sprouted seeds were disseminated. Then, beds were kept saturated with water for the first week, covered with a thin layer of water that increased in thickness until it reached 5 cm, and irrigated on alternate days in the evening. Vermicompost at a rate of 2.5 tons per hectare had also been applied 20 days after transplanting, along with the incorporation of green manure, potentially yielding a biomass of 16 tons per hectare, equivalent to 3.5 tons per hectare on a dry weight basis.Then, using nylon rope spaced 25 cm apart from 12.5 cm, seedlings were transplanted in rows, two per hill.

Statistical analysis: The Randomised Block Design's analysis of variance technique was used to examine data on various characters. For testing the significance of differences between any two treatments' means, the critical differences were estimated at a 5% level of probability (Gomez and Gomez, 1984). The following formula was used to determine critical difference (CD) when the F test showed a substantial difference between the means:

CD = SEm × $\sqrt{2}$ × t (0.05) at error degree of freedom

$$\mathbf{SEm\pm = \sqrt{\frac{Error\ mean\ sum\ of\ squre}{Number\ of\ replications}}}$$

2.1 DUS (Distinctiveness, Uniformity and Stability) characteristics

The "Guidelines for the Conduct of Test for DUS on Rice" were followed for recording observations on 10 plants of each genotype at random for all the attributes being studied at various growth stages. **(PPV & FRA, 2007)**.Observation of individual plant at booting stage were taken.

2.1.1 Basal leaf sheath color

States	Code
Green	1
Light purple	2
Purple line	3
Uniform purple	4

2.1.2 Leaf: Intensity of green color

States	Code
Light	3
Medium	5
Dark	7

2.1.3 Leaf: Anthocyanin colouration

States	Code
Absent	1

Present	9

2.1.4 Leaf: Auricle

States	Code
Absent	1
Present	9

2.1.5 Leaf: Anthocyanin colouration of auricle

States	Code
Colorless	1
Light purple	2
Purple	3

2.1.6 Leaf: Collar

States	Code
Absent	1
Present	9

2.1.7 Leaf: Anthocyanin coloration of collar

States	Code
Absent	1
Present	9

2.1.8 Leaf: Ligule

States	Code
Absent	1
Present	9

2.1.9 Leaf: Color of ligule

States	Code
White	1
Light purple	2
Purple	3

2.1.10 Flag leaf

States	Code
Erect	1
Semi-erect	3
Horizontal	5
Drooping	7

2.1.11 Panicle: Curvature of main axis

States	Code
Straight	1
Semi-straight	3
Deflexed	5
Drooping	7

2.1.12 Panicle: Secondary branching

States	Code
Absent	1
Present	9

States	Code
Weak	1
Strong	2
Clustered	3

2.1.13 Decorticated grain: shape

States	Code
Short slender	1
Short bold	2
Medium slender	3
Long bold	4
Long slender	5
Long slender (For Basmati type)	5
Extra-long slender	6

2.1.14 Decorticated grain: color

States	Code
White	1
Light brown	2
Variegated brown	3
Dark brown	4
Light red	5
Red	6
Variegated purple	7
Purple	8
Dark purple	9

2.1.15 Decorticated grain: Aroma and its extent

The aroma of decorticated grain was determined during milling by its fragrance.

States	Code
Absent	1
Present	9

2.2 Yield

2.2.1 Grain yield (kg/ha)

The Pullman thresher was used to thresh the entire harvest from the net plot. Using a grain moisture metre, the weight of cleaned grains was measured and adjusted to 14% moisture. It was translated to kg/ha of grain yield.

2.2.2 Straw yield (kg/ha)

From the total biomass, grain yield had been deducted to get the straw yield and reported on per ha basis.

2.2.3 Biological yield (kg/ha)

The biological yield, which was calculated by summing the grain and straw yields from each plot, is expressed as kg/ha.

3. Results and Discussion

3.1 DUS testing

A total of 16 characters, including both qualitative and quantitative parameters, were used to characterize 10 different rice varieties for DUS. The rice varieties displayed a wide range of distinguishing characteristics for nearly all of the morphological traits examined. Previous studies by **Manjunathaet al. (2016)**, **Mondal *et al*. (2014)**, **Manjunathaet al. (2016)**, **Kalyan *et al*. (2017)**, and**Umaraniet al. (2017)** also reported similar findings. Tables 1, 2, 3, 4, and 5 calculate the qualitative and quantitative characteristics of several agronomic and morphological criteria.

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

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

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

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

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

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

3.2 Yield

3.2.1 Grain yield

The data shown in Table 6represent that yield of grain of all the traditional short grain scented rice varieties differed significantly. The rice variety Kudrat-5 (42.46 q/ha) registered significantly the highest grain yield among all the scented rice varieties. The yield was 17.61% higher than variety Pusa-1121. It was mainly due to highest effective number of tillers per m^2 (273) and grain weight per panicle (1.89 g). Appreciable filled grains per panicle (156) and 1000- weight (15.6 g) also contributed towards its grain yield. **Davari and Sharma (2010)** also observed that organic application of vermicompost and farm yard manure led to 23-24% increase in grain yield.

Table 6. Yield and harvest index of different scented rice varieties

Variety	Yield (q/ha)			Harvest Index (%)
	Grain	Straw	Biological	
Kubri Mamhani	27.89	45.56	73.45	37.95
Kudrat-5	42.46	53.27	95.72	44.09
Chinar-20	26.53	29.14	55.66	47.57
Kesho Pohu	29.04	34.07	63.11	45.95
DRK	28.68	33.66	62.34	46.06
Kudrat-1	37.54	46.49	84.03	44.64
Pusa 1121	34.98	41.70	76.67	45.63
Type-3	26.82	37.56	64.38	41.77
Traori	25.17	42.94	68.10	37.00
Tilak Chandan	29.01	34.53	63.55	45.67
SEm±	1.03	1.43	2.28	0.01
CD at 5%	3.08	4.27	6.84	0.02
C.V.	5.780	6.19	5.59	2.11

The next highest grain yield per hectare was noted for variety Kudrat-1 (37.54 q/ha) was found to be at par with variety Pusa 1121 (34.98 q/ha). The higher grain yield of Kudrat-1 may be attributed to highest number of filled grains per panicle (198), although it has less 1000- grain weight (13.6 g), showing that it is a very fine and small grain variety. For Pusa 1121, the major attributes towards its yield are high 1000- grain weight (25.4 g) and high number of productive tillers/m^2 (253) and grain weight /panicle (1.55g). Scented rice varieties Kesho Pohu and Tilak Chandan recorded the similar yield i.e., 29.01 q/ha which was at par with variety DRK (28.68 q/ha), Kubri Mamhani (27.89 q/ha), Type-3 (26.82 q/ha) and Chinar-20 (26.53 q/ha). The minimum yield was recorded by the variety Traori (25.17 q/ha) despite having appreciable 1000- weight (21.1 g) mainly due to lesser number of filled grains per panicle. **Yadav *et al.*(2014)**observed that the green manure application and vermicomposting (organic nutrient management practices) favoured the metabolic and auxin activities in plant, andHumic acid in vermicompost increases the availability of both native and additional nutrients in soil and ultimately boosts rice crop output. **Geogre*et al.* (2005)** and **Gupta (2017)** also found variable yield response of scented rice varieties even when subjected to similar kind of management level. **Gautam *et al.* (2008)** also reported that Most of the yield-attributing characteristics have shown significant improvement, which accounts for PRH-10's greater grain production.

3.2.2Straw yield

The straw production (Table 6) exhibited considerable variation across the different varieties. The variety Kudrat-5 demonstrated the highest straw yield, which was statistically significant (53.3 quintals per hectare). The straw production for the scented rice variety Kudrat-1 was observed to be 46.5 quintals per hectare, which was comparable to the next two high straw-yielding varieties, Kubri Mamhani (45.6 quintals per hectare) and Traori (42.9 quintals per hectare). The rice variety Chinar-20, characterized by its short stature, exhibited the lowest straw yield at 29.1 quintals per hectare. The rice variety Pusa 1121 achieved a straw yield of 41.7 quintals per hectare, which was on par with the variety Type-3 (37.6 quintals per hectare). Tilak Chandan (34.5 quintals per hectare), Kesho Pohu (34.1 quintals per hectare), and DRK (33.7 quintals per hectare) also demonstrated lower straw yields. Straw yield is an output of tillers per unit area coupled with the height of the plants. In present study, varieties with high effective tillers produced higher straw yield even though they had short stature. This shows that the tiller number surpassed the contribution of plant height towards straw production.

3.2.3 Biological yield

The biological yield varied significantly where Kudrat-5 produced the significantly highest biomass (95.7 q/ha) followed by kudrat-1 (84.0 q/ha). Chinar-20 recorded the lowest biological yield (55.7 q/ha), which was also found significantly lower than all other varieties tested in the present study. The biological yield did not differ significantly among Kesho Pohu, DRK, Type 3 and Tilak Chandan. The variation total biomass may be ascribed to the capacity of a genotype to utilize the resources more efficiently and convert them into dry matter. The results were supported by **Davari and Sharma (2010)** who also observed that biological yield was significantly improved by the incorporating of FYM or vermicompost. Varieties with less height but profuse tillering resulted into more total biomass.

3.2.4 Harvest Index

Harvest Index is an important parameter of physiological significance that also indicates the transfer of a specific genotype's dry matter production to the economic portions. The harvest index for each variety of scented rice varied significantly (Table 6), andthe values of the grain yield and straw yield were highly correlated with variance. However, Chinar-20 (48%) was the variety with the highest harvest index value among the different typesfollowed by Kesho Pohu (46%), DRK (46%), Pusa 1121 (46%) and Tilak Chandan (46%). Kudrat-1 (45%), Kudrat-5 (44%) and Type-3 (42%) also recorded appreciable harvest index. The lowest value was recorded for the variety Traori (37%) followed by Kubri Mamhani (38%). Harvest index depicts the proportion of grain yield in relation to its total biomass. Therefore, varieties with good grain yield and good straw yield attained the higher harvest index. These results are also supported by **Hussain *et al.* (2014)** who noted variations in harvest index among scented rice varieties.

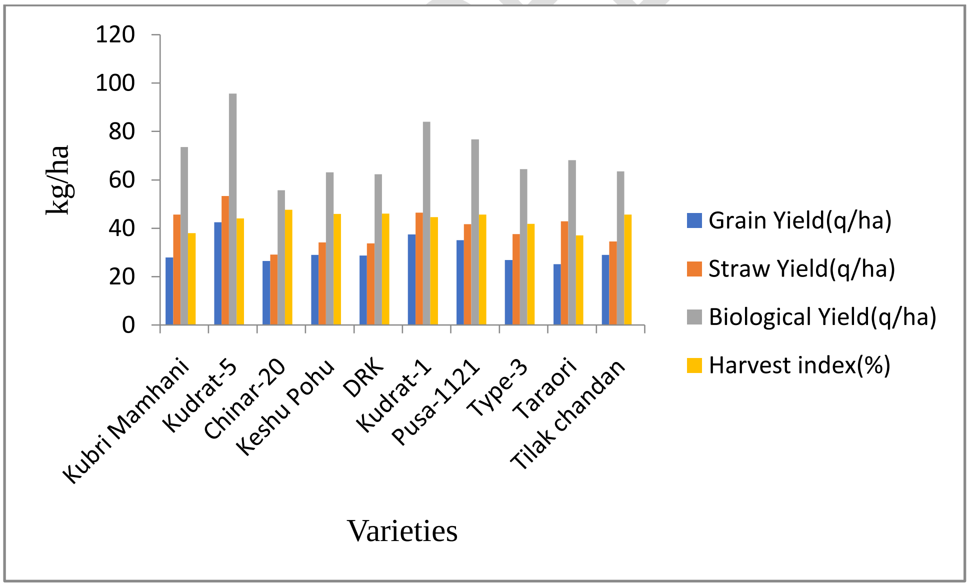

Fig. 1 Grain Yield (q/ha), Straw Yield (q/ha) and Biological Yield (q/ha) and Harvest index (%) of different scented rice varieties

4. Conclusion

The DUS characteristics are genetically determined qualities that can be identified in a genotype. As a result, the traits listed for each variety can be traced to the variety's genetics. Breeders, researchers, and farmers will find this characterisation information helpful in identifying and selecting the restoration and conservation of advantageous genes for crop improvement. The data generated on these kinds might also support their PPV&FRA registration. Also, variety Kudrat-5 was outperformed the other traditional scented rice varieties, which can be recommended in organic cultivation.

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