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Morphological traits and yield performance of Purple rice under varying plant densities

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ABSTRACT

An experiment was conducted at the Field Laboratory, Department of Crop Botany, Bangladesh Agricultural University during Aman season 2018 primarily to describe agro-morphological descriptors of a purple rice cultivar and to evaluate the effect of spacing on morphological traits, yield contributing characters and yield. The experiment comprised four rice cultivars; Purple rice and three other check cultivars *viz.* BR22, BRRI dhan34 and BRRI dhan46, and three spacing *viz.* 15 cm × 15 cm, 20 cm × 15 cm and 25 cm × 15 cm. The experiment was laid out in randomized complete block design with three replications. All the studied morphological traits, yield contributing characters and yield were significantly differed among the cultivars and planting densities. Purple rice cultivar was 101.8 cm in height; the number of total tillers hill^{-1} 12.88, number of non-effective tiller hill^{-1} 1.37; leaf vertical and straight, purple in colour; panicle length 23.63 cm, number of primary and secondary branches panicle^{-1}13.28 and 15.56, length of primary and secondary branch 8.91 cm and 2.26 cm, number of total and unfilled grains panicle^{-1} 140.5 and 57.95, respectively; 1000-grains weight 21.92 g, grain yield 3.55 tha^{-1}, harvest index 51.03% and lifespan 115 days. The spacing 25 cm × 15 cm was found to be better for both growth and grain yield of Purple rice. Purple rice could be used as potential breeding material for its exceptional morphological characteristics.

Keywords: Morphological attributes, population density, short duration cultivar, Purple rice, monsoon rice

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1 Introduction

Rice (*Oryza sativa* L.), belongs to the family Poaceae, is one of the most important cereal crops in the globe, which was the staple food for 650 million hungry and 80% of world undernourished people (IRRI, 2016). It is the staple food of Bangladesh and contributes to about 92% of the total food grains produced in the country. Up to 75% of required calories and 55% of protein are met from rice in the average daily diet of the people (HIES, 2016). Bangladesh ranks fourth following China, India and Indonesia in respect of rice growing area and production (FAO, 2019); at present, rice occupies 11.62 m ha of land and overall production is about 36.28 m t (BBS, 2019). In Bangladesh, rice is grown year-round in three growing periods *viz.* Aus (summer rice), Aman (monsoon rice) and Boro (winter rice). Aman rice occupies 49% of total rice area and contributes 39% of total rice production in the country, stands at about 14 million tons. The country is now on the threshold of attaining self-sufficiency in food grain production (BBS, 2019). However, the population of Bangladesh is growing at the rate of 1.36 per cent every year i.e., another 30 m people may be added over the next 20 years; that adds new demand of grain crops and agricultural commodities. Therefore, agricultural scientists are working hard and soul to increase the grain yield of rice by releasing (new) modern cultivars, with high yield potential and added values e.g., taste, aroma, nutritional quality, etc., along with technologies for adoption in the field.

Commonly two types *viz.* traditional/local and modern including inbred and hybrid, of rice cultivars are grown in Bangladesh. The modern cultivars are short and stout stature lodging resistant, high tillering capacity, leaves dark green in colour, broad, straight and vertical posed leaves, high photosynthesis rate, most of the cultivars disease and insect resistant; more fertilizer responsive; higher number of grains panicle^{-1} and high yielder; and the grain-straw ratio of 1:1.25; but less tasteful to eat (Janoria, 1989). On the hand, the traditional cultivars are characterized by long and weak stature, susceptible to lodging, low tillering capacity; leaves light green in colour, long, remain horizontal, low photosynthesis rate; low fertilizer responsive and low yielder, well adapted to the local environment, lower number of grains panicle^{-1}, the grain-straw ratio of 1:2 or more, more tasteful to eat (Saito and Futakuchi, 2009). Recently, Purple rice, a rare cultivar, gets the attraction of progressive farmers as well as media personnel for its exceptional stem and leaf colour (Anonymous, 2018; Ahmed, 2019), although purple rice cultivar has been cultivated in China since long ago. This rice is rich in anthocyanins, antioxidants, vitamins and fibres, which possesses various health benefits including preventing cancer, diabetes and heart disease (Jang and Xu, 2009). The purple rice may contain more antioxidant compounds, which help to protect the body's cells from harmful free radicals, than the white ones (Anonymous, 2018).

Agro-morphological characterization is a process of evaluation of all phenotypic descriptors that could identify cultivars or accessions in a collection. The proper morphological characterization helps – farmers to take proper cultivation strategies for higher yield; breeders to include desirable characters in the breeding programme and/or to identify traits for further improvement. Hitherto, we don't have any comprehensive scientific information on agro-morphological descriptors of purple rice in Bangladesh (Hoque, 2018). Suitable plant density is an effective factor for yield maximization (Rahman, 2015). The optimum plant spacing ensures plants to grow properly both in their above and below-ground parts through efficient utilization of solar radiation and nutrients. On contrary, the inter-specific competition among the plants is high in a densely populated rice field, which sometimes results in gradual shading and lodging and thus produces straw instead of grain (Islam et al., 2013). The present investigation, therefore, was undertaken primarily to describe agro-morphological descriptors of purple rice and to find out the optimum plant density for maximizing grain yield.

2 Materials and Methods

2.1 Study location

The experiment was conducted at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University during the period of May to December (Aman season) 2018. The experimental field was located at 24°43′9.6″N, 90°25′29.7″E and an altitude of 18 m above the sea level. The experimental area belongs to the non-calcareous dark grey soil under Old Brahmaputra Floodplain Agro-ecological Zone (AEZ 9) of Bangladesh. The region covers a large area of the Brahmaputra river-borne sediments which were laid down before the river-shifted into its Jamuna Channel about 200 years ago (UNDP/FAO, 1988). The initial soil of the field was analyzed and had the following characters: pH 6.8, organic matter 1.65%, total nitrogen 0.18%, phosphorus 3.5 ppm, potassium 0.18 meq 100g^{-1}, Sulfur 4.0 ppm. The agro-climatic conditions i.e. monthly values of maximum, minimum and average temperature (°C), relative humidity (%), monthly total rainfall (mm) and sunshine (h) received at the experimental site during the study period have been presented Table 1.

2.2 Experimental treatment

Purple rice and three check cultivars with different lifespan and yield potential *viz.* BR22 (145–150 days; 5.0 t ha^{-1}), BRRI dhan34 (135–145 days; 3.5 t ha^{-1}) and BRRI dhan46 (120–130 days; 4.7 t ha^{-1}), were used as experimental materials (BRRI, 2017). Seeds of the Purple rice cultivar were collected from Dulali Begum, a progressive farmer of Sundarganj Upazila, Gaibandha; and other cultivars were from local market (Certified seed). Three spacing *viz.* 15 cm × 15 cm, 20 cm × 15 cm and 25 cm × 15 cm, were used as experimental treatments.

2.3 Field experiment

The experiment was laid out in two factorial randomized complete block design (RCBD) with three replications. The unit plot size was 10 m^2 (4 m × 2.5 m). The recommended dose (Urea-Triple Super Phosphate-Muriate of Potash-Gypsum @ 150-52.2-82.5-60 kg ha^{-1}, respectively) of TSP, MoP and gypsum fertilizers was applied during final land preparation and Urea was applied as top-dressing in three equal splits (BRRI, 2017). Thirty-five days old healthy rice seedlings were transplanted in the experimental plot in 14 August 2018. The standard rice cultivation and management practices were followed (BRRI, 2017). The crop was harvested at the maturity stage (Purple rice on 10 December 2018; other cultivars on 25 December 2018), 80% of grains attained characteristics golden colour and data on grain yield and yield contributing traits were recorded.

Table 1. Weather data of experimental site during the period of the experiment in 2018 §

Month	Air temperature (°C) †			Rainfall (mm) ‡	RH (%) †	Sunshine (h) ‡
	Maximum	Minimum	Average			
July	31.6	26.5	29.1	522.7	87	101.8
August	33.2	26.8	30	97.6	81	179.6
September	32	26.1	29.1	408.6	87	125.6
October	32.4	24.2	28.3	31.7	84	200.9
November	29.5	18.1	23.4	1	81	204.8
December	27.5	14.4	21.1	0	81.4	180.3

† Monthly average; ‡ Monthly total; RH = Relative humidity; § Source: Weather Yard, Department of Irrigation and Water Management, Bangladesh Agricultural University.

2.4 Data collection

Data on yield contributing characters and yield were recorded from five randomly selected hills from each plot. The yield parameters recorded are plant height (cm), number of total, effective and non-effective tillers hill^{-1}, panicle length (cm), number of total, filled and unfilled grains panicle^{-1}, length and number of primary branches panicle^{-1}, number of filled and unfilled grains in a primary branch, length and number of secondary branches in a primary branch, number of filled and unfilled grains in secondary branch and 1000-grain weight (g). The grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) were also recorded. Harvest index (%) was calculated using the following formula:

$$HI = \frac{Y_E}{Y_B} \times 100 \qquad (1)$$

where, HI = harvest index (%), Y_E and Y_B designate economic and biological yields (t ha^{-1}), respectively.

2.5 Statistical analysis

Data were analyzed statistically following the analysis of variance (ANOVA) technique, using Statistix 10 software package and means were separated by Duncan's new multiple range test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

3 Results and Discussion

3.1 Plant height and tiller production

Plant height was significantly influenced by both cultivar and spacing (Table 2). The longest plant (138.9 cm) was obtained from the combination of BRRI dhan34 and 25 cm × 15 cm spacing, and the shortest (95.7 cm) was obtained in Purple rice at 15 cm × 15 cm spacing. The length of Purple rice cultivar varied from 95.7 cm to 101.8 cm (Table 2), which was similar to the previously published report (Hoque, 2018). The differences in plant height might be due to heredity or genetic character of a cultivar. The results were in agreement with BRRI (2017) report, which stated that plant height differed among the cultivars. Hariyono and Zaini (2018) reported that wider spacing produced the tallest plant. The higher number of seedlings per unit area at larger planting density decreases the availability of soil nutrient per hill, which affects plant height and also growth (Li et al., 2013). The total number of tillers hill^{-1} was influenced by the interaction between cultivar and spacing (Table 2). Both the highest number of total and effective tillers hill^{-1} (14.28 and 12.99, respectively) was produced by BRRI dhan46 at 25 cm × 15 cm spacing. On the contrary, the lowest number of total and effective tillers hill^{-1} (11.25 and 10.10, respectively) was produced in the combination of BRRI dhan34 and 15 cm × 15 cm spacing, which was statistically identical with BRRI dhan34 at 20 cm × 15 cm spacing and Purple rice at 15 cm × 15 cm spacing. Moro et al. (2016) reported that wider spaced plants received more nutrient, moisture and light which led the plants to produce more tillers plant^{-1}. At wider spacing, plants also exploit more light for photosynthesis and produce more carbohydrate thus subsequently the number of effective tillers hill^{-1} has increased (Rajput et al., 2016). Moreover, cultivars have a significant influence on the number of total and effective tillers hill^{-1} (Howlader et al., 2017). The highest number of non-effective tillers hill^{-1} (1.65) was observed in BR22 at 15 cm × 15 cm spacing and the lowest number (0.82) was in Purple rice at 20 cm × 15 cm spacing (Table 3). Li et al. (2013) reported a negative correlation between planting density and number of productive tiller hill^{-1}. Tillers at different planting densities become infertile (non-effective) possibly due to smaller individual tiller size (Hayashi et al., 2006).

3.2 Panicle related descriptors

Panicle size and other components were significantly affected by both rice cultivars and spacing (Table 3). For example, the longest panicle (25.73 cm) was observed in BRRI dhan46 at the spacing 25 cm × 15 cm

Table 2. Effect of cultivar and spacing on plant height and tillering habit of rice plant

Interaction †	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}
Purple rice × S1	95.7 k	11.72 de	10.67 e
Purple rice × S2	98.4 j	11.92 d	11.10 d
Purple rice × S3	101.8 i	12.88 c	11.51 cd
BR22 × S1	117.8 h	13.50 b	11.84 c
BR22 × S2	120.8 g	13.54 b	12.33 b
BR22 × S3	123.4 f	13.70 b	12.64 ab
BRRI dhan34 × S1	132.6 c	11.25 e	10.10 f
BRRI dhan34 × S2	134.9 b	11.31 e	10.27 f
BRRI dhan34 × S3	138.9 a	12.63 c	11.27 d
BRRI dhan46 × S1	121.9 g	12.71 c	11.37 d
BRRI dhan46 × S2	126.2 e	13.74 b	12.73 ab
BRRI dhan46 × S3	130.7 d	14.28 a	12.99 a
LSD(0.05)	1.29	0.519	0.394
CV (%)	0.63	2.4	2.01

† S1 = 15 cm × 15 cm, S2 = 20 cm × 15 cm, S3 =25 cm × 15 cm; In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)

and the shortest one (15.78 cm) was found in BRRI dhan34 at the spacing 20 cm × 15 cm. Although the highest number of primary branch panicle^{-1} (13.28) was observed in Purple rice at 15 cm × 15 cm spacing, the shortest primary branch (8.33 cm) and lowest number of secondary branch in primary branch (15.05) was observed in Purple rice. On the contrary, the lowest number of primary branch panicle^{-1} (10.30) was in BRRI dhan34 and 20 cm × 15 cm spacing. Both the longest primary branch (14.27 cm) and highest number of secondary branch in primary branch (25.26) were observed in the combination of BR22 and 25 cm × 15 cm spacing (Table 3). The length of secondary branches varied from 2.45 cm to 2.03 cm and was observed in BRRI dhan46 at 25 cm × 15 cm spacing and BRRI dhan34 at 20 cm × 15 cm spacing, respectively. Ranawake et al. (2019) also showed that panicle length varied among the cultivars under investigation. Genetic variation may attribute this kind of variation in panicle components. Variations in panicle length, number and length of primary and secondary branches on the rachis of different cultivars were also observed by Sarwar and Ali (1998) and Mo et al. (2012).

The number of grains panicle^{-1} in Purple rice varied from 116.4–140.5 and this was also significantly influenced by the interaction effect of cultivar and spacing (Table 3). At spacing 25 cm × 15 cm, both the highest number of grains and unfilled grains panicle^{-1} (192.8 and 57.95) were observed in BR22 and Purple rice, respectively. At larger spacing, plants produced higher number of larger leaves, which produced more photosynthates/assimilates (Kuddus, 2019). The partitioning of assimilates towards panicle may increase the number of grains panicle^{-1}. The highest number of unfilled grains panicle^{-1} in Purple rice may indicate the scope of improvement in photosynthetic efficiency and assimilate partitioning for this cultivar to increase the grain yield. However, at the spacing 20 cm × 15 cm, and the lowest number of grains and unfilled grains panicle^{-1} (116.4 and 14.52) were observed in Purple rice and BRRI dhan34, respectively. Both the highest number of filled grains in primary branch and secondary branches (18.83 and 3.51) was observed in BRRI dhan46 with 25 cm × 15 cm and 15 cm × 15 cm spacing, respectively. The lowest number of filled grains in the primary branch (11.86) was observed in Purple rice at 20 cm × 15 cm spacing and the lowest number of filled grains in the secondary branch (2.03) in BRRI dhan34 at 20 cm × 15 cm spacing (Table 3). Ranawake et al. (2019) reported that the number of grains panicle^{-1} was varied among the cultivars due to their genetic variation. Hariyono and Zaini (2018) also showed that the number of grains panicle^{-1} varies with different spacing. Spikelet number per panicle became smaller at higher planting densities in non-flooded fields, which may partly be due to nitrogen deficiency of rice plants with higher planting densities, as indicated by lower SPAD values (Hayashi et al., 2006). The highest number of unfilled grains in primary and secondary branches (7.21 and 1.15) was observed in BR22 with 20 cm × 15 cm and 25 cm × 15 cm spacing, respectively. The lowest number of unfilled grains in primary and secondary branches (5.50 and 0.90) was observed in BRRI dhan34 at the spacing 25 cm × 15 cm and 15 cm × 15 cm, respectively. Howlader et al. (2017) also reported differences in the number of unfilled grains panicle^{-1} due to genetic makeup of the cultivar. Planting density showed negative correlations with panicle length, total and filled grain number panicle^{-1} (Li et al., 2013).

Table 3. Effect of cultivar and spacing on panicle structure descriptors of rice plant

Interaction †	PL(cm)	PBpan^{-1}	PBLen (cm)	FG PB^{-1}	UG PB^{-1}	SBpan^{-1}
Purple rice × S1	22.02 e	13.28 a	8.627 fg	11.86 h	5.31 g	15.05 h
Purple rice × S2	24.13 bc	12.22 b-d	8.913 f	12.90 g	5.39 g	15.56 fg
Purple rice × S3	23.63 cd	11.79 c-e	8.330 g	13.29 f	5.35 g	15.32 gh
BR22 × S1	23.19 c-e	11.28 d-f	13.99 a	16.26 e	6.41 cd	25.04 ab
BR22 × S2	22.38 de	10.84 ef	14.11 a	17.71 d	7.21 a	24.78 b
BR22 × S3	23.49 cd	12.25 b-d	14.27 a	17.95 cd	6.54 cd	25.26 a
BRRI dhan34 × S1	15.78 f	10.57 f	10.46 e	12.87 g	6.24 de	15.38 gh
BRRI dhan34 × S2	16.63 f	10.30 f	10.92 d	12.92 g	5.69 fg	16.46 e
BRRI dhan34 × S3	15.95 f	10.95 ef	11.06 d	13.25 f	5.50 g	15.85 f
BRRI dhan46 × S1	25.04 ab	12.23 b-d	12.63 c	18.21 bc	6.72 bc	21.16 c
BRRI dhan46 × S2	25.55 a	12.60 a-c	13.36 b	18.31 b	6.97 ab	21.47c
BRRI dhan46 × S3	25.73 a	12.98 ab	12.83 c	18.83 a	5.94 ef	20.71 d
LSD(0.05)	1.18	0.912	0.303	0.326	0.355	0.408
CV (%)	3.17	4.57	1.53	1.25	3.43	1.25

Interaction †	SBLen (cm)	FG SB^{-1}	UG SB^{-1}	TGpan^{-1}	FGpan $^{-1}$	UGpan^{-1}
Purple rice × S1	2.16 d	2.26 d	0.97 c-f	132.0 e	74.13 g	36.79 b
Purple rice × S2	2.21 cd	2.38 d	0.66 g	116.4 f	78.03 fg	38.36 b
Purple rice × S3	2.26 c	2.75 c	0.96 d-f	140.5 d	82.59 f	57.95 a
BR22 × S1	2.04 f	3.19 b	0.93 ef	181.2 bc	148.3 d	13.68 e
BR22 × S2	2.10 e	3.25 b	1.01 b-e	178.9 c	162.9 c	16.00 de
BR22 × S3	2.07 ef	3.32 b	1.15 a	192.8 a	173.2 b	19.64 c
BRRI dhan34 × S1	2.05 ef	2.84 c	0.90 f	127.9 e	110.2 e	17.71 cd
BRRI dhan34 × S2	2.03 f	2.86 c	1.05 bc	128.5 e	113.0 e	14.52 e
BRRI dhan34 × S3	2.07 ef	2.92 c	1.06 b	129.0 e	115.3 e	17.34 cd
BRRI dhan46 × S1	2.33 b	3.51a	0.99 b-e	188.2 ab	165.4 c	17.91 cd
BRRI dhan46 × S2	2.33 b	3.60 a	1.04 b-d	183.4 bc	167.3 bc	16.07 de
BRRI dhan46 × S3	2.45 a	3.63 a	0.96 d-f	195.5 a	181.1a	15.33 de
LSD(0.05)	0.054	0.169	0.076	7.88	7.41	2.35
CV (%)	1.17	3.29	4.01	2.95	3.34	5.9

† S1 = 15 cm × 15 cm, S2 = 20 cm × 15 cm, S3 =25 cm × 15 cm; PL = panicle length, PBpan^{-1} = Number of primary branch panicle^{-1}, PBLen = Length of primary branch, FG PB^{-1} = Filled grains primary branch^{-1}, UG PB^{-1} = Unfilled grains primary branch–$^{-1}$, SBpan^{-1} = Number of secondary branches panicle^{-1}, SBLen = Length of secondary branch, FG SB^{-1} = Filled grains secondary branch^{-1}, UG SB^{-1} = Unfilled grains secondary branch–$^{-1}$, TGpan^{-1} = Total number of grains panicle^{-1}, FGpan^{-1} = Number of filled grains panicle^{-1}, UGpan^{-1} = Number of unfilled grains panicle^{-1}; In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)

Table 4. Effect of cultivar and spacing on 1000-grain weight and yield descriptors of rice plant

Interaction †	WTG (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	BY (t ha^{-1})	HI (%)
Purple rice × S1	21.92 c	3.02 h	3.45 ef	6.47 g	46.67 b
Purple rice × S2	21.40 d	3.26 g	3.13 f	6.39 g	51.03 a
Purple rice × S3	21.88 c	3.55 f	3.60 e	7.15 f	49.65 a
BR22 × S1	20.96 e	5.80 d	7.66 bc	13.46 d	43.08 c
BR22 × S2	21.07 de	5.90 cd	7.93 b	13.83 c	42.66 cd
BR22 × S3	21.00 de	6.02 bc	8.78 a	14.80 b	40.67 d
BRRI dhan34 × S1	16.24 fg	3.93 e	7.25 d	11.18 e	35.16 e
BRRI dhan34 × S2	15.98 g	3.92 e	7.30 cd	11.24 e	34.97 e
BRRI dhan34 × S3	16.45 f	3.99 e	7.50 cd	11.49 e	34.77 e
BRRI dhan46 × S1	31.34 b	6.16 b	8.57 a	14.73 b	41.82 cd
BRRI dhan46 × S2	31.58 b	6.35 a	8.64 a	14.99 ab	42.36 cd
BRRI dhan46 × S3	32.08 a	6.33 a	8.96 a	15.29 a	41.40 cd
LSD(0.05)	0.386	0.161	0.363	0.355	1.86
CV (%)	1.01	2	3.13	1.78	2.61

† S1 = 15 cm × 15 cm, S2 = 20 cm × 15 cm, S3 =25 cm × 15 cm; WTG = 1000-grain weight (g), BY = Biological yield, HI = Harvest index; In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)

3.3 1000-grain weight and yield

The interaction effect between cultivar and spacing had no significant influence on 1000-grain weight (Table 4). However, the heaviest 1000-grain (32.08 g) was produced in the combination of BRRI dhan46 at the spacing 15 cm × 15 cm and the lowest one (15.98 g) was obtained in the combination of BRRI dhan34 at the spacing 20 cm × 15 cm. The highest grain weight commonly observed in wider spacing because in wider spacing plant get more light, water and nutrient and more photosynthesis ensuring assimilate partitioning towards the grain, and ultimately weight of the grain increased. Li et al. (2013) and Hariyono and Zaini (2018) reported that spacing had a significant influence on 1000-grain weight. Zheng et al. (2006) also reported that the seed setting rate and 1000-grain weight of Liangyopeijiu varied with different planting density.

The (grain) yield components of rice are is the function of number of effective tiller hill^{-1}, number of filled grain panicle^{-1}, and 1000-grain weight (Yoshida, 1981). The interaction between cultivar and spacing had a significant effect on the grain yield (Table 4). The highest grain yield (6.35 t ha^{-1}) was found in the combination of BRRI dhan46 and 25 cm × 15 cm spacing. The lowest grain yield (3.02 t ha^{-1}) was found in Purple rice at 15 cm × 15 cm spacing. The highest straw yield (8.96 t ha^{-1}) was found in the combination of BRRI dhan46 and 25 cm × 15 cm spacing while the lowest straw yield (3.13 t ha^{-1}) was found in Purple rice at 20 cm × 15 cm spacing. The yield potential of Purple rice was similar to BRRI dhan34 (Table 4). The maximum grain yield of Purple rice (3.55 t ha^{-1}), similar to Binadhan-13 (3.5 t ha^{-1}; (BINA, 2020)), was very close to that of BRRI dhan34 (3.99 t ha^{-1}) (Table 4). However, the land can be available earlier for the next crop, as the lifespan of Purple rice (115 days; (Kuddus, 2019)) was relatively shorter compared to that of BRRI dhan34 (135–145 days). Therefore, we can cultivate short duration Purple rice cultivar to make the land available for early winter crops. If this purple rice cultivar possesses any additional value e.g., texture, taste, aroma, nutritional quality, etc., this could become a popular cultivar to farmers. Hence, further studies on nutritional quality aspects are recommended.

3.4 Biomass yield and Harvest Index

The biomass weight is a measure of a crop's photosynthetic performance and the harvest index is a measure of the economically useful fraction of the biological yield (Yoshida, 1981). The highest biomass yield (15.29 t ha^{-1}) was found in the combination of BRRI dhan46 and 25 cm × 15 cm spacing and the lowest one (6.47 t ha^{-1}) was found in Purple rice at 15 cm × 15 cm spacing. Numerically, the highest (51.03%) harvest index (HI) was found in Purple rice at 20 cm × 15 cm spacing and the lowest one (34.77%) was found in BRRI dhan34 at 25 cm × 15 cm. The HI of Purple rice cultivar at all the spacing used was very similar to modern, high yielding, rice cultivars (Yoshida, 1981), though the grain yield was relatively lower than those of modern rice cultivars due to lower biomass yield (Table 4).

4 Conclusions

The short duration Purple rice (lifespan 115 days) possesses the yield potential close to the aromatic rice

BRRI dhan34. All the studied morphological traits, yield contributing characters and yields differed significantly among the cultivars. 25 cm × 15 cm planting density was found to be better for both growth and grain yield of Purple rice and the check cultivars studied. Further (comparative) studies between Purple rice and cultivar(s) with similar features e.g., short duration, short stature, popular cultivars, etc. and growing season in different agro-ecological zone(s) are suggested for better understanding of the yield potential of this cultivar. Moreover, Purple rice could be used as potential breeding material for its exceptional morphological characteristics. Grains with exceptional traits e.g., texture, taste, aroma, nutritional quality, etc., could popularize the cultivar to farmers and consumers, therefore, the nutritional quality aspects of this cultivar also might be a topic of future research.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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