BRRI dhan104: BRRI's Basmati Type Aromatic Rice Variety for Irrigated Ecosystem in Bangladesh

ABSTRACT

An enhancement over already available premium quality enriched aromatic rice varieties for Bangladesh is the recently announced BRRI dhan104 type of rice, which has long slender grain and is high yielding and ideal for Bangladesh's irrigated ecology. The variety has satisfactorily passed the Proposed Variety Trial (PVT) conducted in the farmers' field in Boro 2021-22 season. As a result National Seed Board (NSB) approved this variety for commercial cultivation in the Boro season (dry season) in 2022. It has modern plant type with 92 cm plant height and matures by 147 days. The proposed variety showed 0.68 t/ha higher yield than check variety BRRI dhan50. Identifying characters of this variety are green leaf, intermediate plant height, erect flag leaf, long slender grain, and intermediate leaf senescence. In average, it can produce 7.30 t/ha grain yield but it has potentiality to give 8.71 t/ha grain yield under favorable climatic condition and appropriate agronomic management. Thousand grain weight of the variety is 21.5 gm and head rice yield is 57.2%. It is strong aromatic basmati type rice variety (according to GCMS system the value of volatile aromatic compound is 2.12 ppm), 29.2% amylose content with 8.9% protein content. Farmers can benefit financially from growing the premium quality enriched aromatic rice variety BRRI dhan104 and the total rice production will be increased along with possible to earn foreign currency by export this variety. Among the released variety by BRRI, the BRRI dhan104 is the only variety of aromatic basmati type.

Keywords: BRRI dhan104, Aromatic, Premium quality, Dry season, Long slender grain, Amylose

1. INTRODUCTION

Genotypes of aromatic rice (*Oryza sativa* L.) are recognized by their distinctive aroma when processed and cooked. This kind of rice is excellent; it is prepared for special occasions and is thought to be of the highest quality [1]. Compared to other non-aromatic rice varieties, aromatic rice cultivars are more expensive on the market. Due to the high demand for this type of rice for both domestic consumption and export, Bangladesh has seen a rise in the popularity of its cultivation in recent years [1]. Despite the fact that for better output, the agro-climate must be mostly favorable. Less than 2% of Bangladesh's total rice-growing land is used to grow aromatic rice [2]. "It was planned for more than 4,000 landrace varieties of rice to be favored in various regions of Bangladesh. Only a few of these have distinctive quality characteristics, such as fineness, aroma, taste, and protein content" [3]. "In general most of the premium quality rice cultivars are low yielding, there are few locally adapted premium quality rice varieties namely Chiniatop, Kalizira and Kataribhog are available". [4] A few high-quality modern rice varieties, including BR5, BRRI dhan34, BRRI dhan37, BRRI dhan38, BRRI dhan50, and BRRI dhan70, have been released by the Bangladesh Rice

Research Institute (BRRI). After meeting the needs of the local market, these cultivars are also exportable. It was expected that 12.5% of the total transplant Aman rice production area will be occupied by aromatic rice cultivars [5]. Due to its high costs and potential for export, the production of aromatic rice is becoming more widespread in Bangladesh [6]. “Regardless of their cost, it is currently preferred by more clients. Commercially speaking, the introduction of contemporary high yielding rice varieties resulted in a 23% increase in farmers' overall income” [7]. “Data on morpho-physiological traits are crucial in rice breeding. For specific breeding ideas to enhance those cultivars, it is essential to understand the physiological performance and genetic expression of the selective modern and aromatic rice cultivars. In varietal expansion projects, identifying promising morpho-physiological traits associated with quality and yield is essential. Regarded as being influenced by the degree of treatment or milling, grain size and shape, appearance, smell, and other culinary characteristics” [1,8]. A significant majority of consumers favor fine rice varieties that are aromatic and have excellent cooking qualities. Customers need aromatic rice greatly because of its distinctive flavor and taste. This kind of rice has excellent market value and potential for export [9]. Despite the fact that a fragrant rice variety may grow and produce food in many different places, its quality characteristics are tied to the area where it is being developed locally [10]. “For everyday use as steamed rice as well as for polao, biriani, jarda, and firni type arrangements that are offered at important celebrations, Bangladesh has a few good aromatic rice varieties with superb eating quality. Chinigura, one of the aromatic rice cultivars, dominated the field, securing more than 70% of the homesteads in the northern areas of Naogaon and Dinajpur. Aromatic rice varieties occupied 30% of the rice fields in these regions” [11]. When compared to other rice cultivars, aromatic rice yielded lower yields (1.5 to 2.0 t ha-1), but at a higher cost and with less work put into development [12]. In Bangladesh, around 3000 - 5000 local cultivars are grown [1,13]. The most important component for increasing rice production is the choice of appropriate rice crop varieties. Rice yield varies due to the growth conditions, such as distinct growing regions, seasonal changes, unique planting dates, and so forth [14]. “Development of rice cultivars with a high yielding ability is one of the most fundamental approaches for dealing with the predictable upsurge in the world demand” [15]. Due to consumer preference, aromatic or fragrant rice is a particular variety that is marketed at a premium price. An commercially significant grain characteristic of rice is fragrance [16]. “Small changes in the aroma might affect a product's acceptance or rejection by consumers, making aromatic rice a valuable asset. Indica (Hsien) and japonica (Keng), the two main varietal groups of Oryza sativa, have been recognized in China since antiquity. The three isozyme groupings Group I (indica), Group V (indica), and Group VI (tropical japonica) make up the traditional fragrant rice types” [17]. The manifestation of scent varies depending on the surroundings when favorable conditions are not present throughout the aromatic rice's growth stage. Additional research must be done to connect the genetic, molecular, and chemical elements of aromatic rice to the role of the enzymes responsible for the scent and environmental mitigation [18]. There is a wealth of studies on various rice varieties, but little is known about a comparison of the morpho-physiological traits of rice cultivars in Bangladesh during the Boro (dry) season. This research work describes the growth and yield performance of a novel, high-yielding aromatic basmati type of rice variety and indicates the connection between grain yield and trial sites as well as

the variety's morphological and physiological characteristics. The breeding practices, parental lineage, agro-morphological traits, and grain quality of BRRI dhan104 are all described in this study.

2. MATERIALS AND METHODS

BRRI dhan104 was developed from crosses between IR74052-217-3-3/BR7150-11-7-4-2-16 at Bangladesh Rice Research Institute (BRRI) with a hope to develop premium quality enriched aromatic rice variety through pedigree method. The cross was done in 2007 and the pedigree of BRRI dhan104 was BR8862-29-1-5-1-3. At BRRI five year evaluation with standard check variety BR8862-29-1-5-1-3 promising line was subjected to Regional Yield Trial (RYT) to evaluate specific and general adaptability in on-station condition of eight regional stations of BRRI in Randomized Complete Block (RCB) design with three replications in Boro 2018-19 season. After proper yield evaluation BR8862-29-1-5-1-3 was subjected to Advanced Line Adaptive Research Trial (ALART) to evaluate specific and general adaptability with standard check BRRI dhan50 in the farmers' field condition in Boro 2019-20 season, conducted by Adaptive Research Division (ARD) of BRRI. Genotype of the trial was tested for different physico-chemical properties, cooking qualities, best planting time, disease-insect resistance in natural condition, plant height, tillering ability were recorded from the ten random plants excluding border rows and plants surrounded by any missing hills. Growth duration was counted from seeding to 80% grain maturity. Grain yield data was taken from 10 sq-m sample plot in each replication. "In Boro 2021-22, BR8862-29-1-5-1-3 (proposed as BRRI dhan104) was evaluated by the National Seed Board of Bangladesh (NSB) in the ten locations of farmers' field of Bangladesh in Proposed Variety Trial (PVT). Finally after proper evaluation, the NSB team found BR8862-29-1-5-1-3 as a superior genotype in respect to high aroma content, long slender type grain with higher grain yield compared to check variety BRRI dhan50 and has been released as BRRI dhan104 in 2022. The data analyses of the experiments were done with software namely PBTools" [19].

3. RESULTS AND DISCUSSION

3.1 Regional Yield Trial (RYT)

The agro-morphological characteristics of BRRI dhan104 is shown in Table 1. It has intermediate plant height which indicates lodging tolerance. BRRI dhan104 has erect green flag leaf which facilitates maximum solar light uptake. The Regional Yield Trial (RYT) of this line was conducted in ten BRRI regional stations of Bangladesh. BR8862-29-1-5-1-3 gave a growth duration of 159 days with 92 cm plant height. BR8862-29-1-5-1-3 showed the maximum average yield (6.37 t/ha), followed by BRRI dhan50 (Table 1). High yield is the prime objective in developing modern rice varieties with an addition of premium quality enriched aromatic rice variety. It is strong aromatic rice variety (according to GCMS system the value of volatile aromatic compound is 2.12 ppm). BRRI dhan104 showed higher yield than the check variety in Boro 2018-19 season in RYT. This higher yield of BRRI dhan104

was due to its genetic potentiality of producing higher and longer grains per panicle than check variety.

Table 1. Morphological and agronomic characters of the proposed variety at Regional Yield Trial, Boro 2018-19

	Designation	Plant height (cm)*	Growth duration (days)*	Grain yield (t/ha) Average
1	BR8862-29-1-5-1-3	92	159	6.37
5	BRRI dhan50 (Ck)	81	158	5.91
	LSD (0.05)	**3.41**	**2.46**	
	Heritability	**0.92**	**0.90**	

* mean value of ten locations

3.2 Advanced Line Adaptive Research Trial (ALART)

BR8862-29-1-5-1-3 (BRRI dhan104) one advanced line and check variety BRRI 50 were evaluated in ten locations at the farmers' field of Bangladesh. Results are showed in the Table 2. BR8862-29-1-5-1-3 gave higher yield in five locations compared to check variety BRRI dhan50, it gave 7.14 t/ha in Jhalokathi, 7.47 t/ha in Faridpur, 6.12 t/ha in Rajshahi, 6.77 t/ha in Jashore and 5.87 t/ha in Sherpur. Highest grain yield potentiality was found for BR8862-29-1-5-1-3 in Faridpur (7.47 t/ha) (Table 2). The result shows the yield potentiality of BR8862-29-1-5-1-3 (BRRI dhan104) over the check variety. On an average, BR8862-29-1-5-1-3 (BRRI dhan104) yielded parallel to BRRI dhan50. BR8862-29-1-5-1-3 was almost disease free in some locations. The strong plant stature (95 cm height) of the advanced line made it lodging tolerant. Growth duration was found same as check variety BRRI dhan50. Farmers preferred BR8862-29-1-5-1-3 for its high yielding capability, acceptable growth duration and strong aroma content.

Table 2. Performance of the proposed variety at different Zonal Trial, Advanced Line Adaptive Research Trial (ALART), Boro 2019-20

Designation	Plant height (cm)*	Growth duration (days)*	Grain yield (t/ha) L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Mean
BR8862-29-1-5-1-3	95	158	7.14	7.47	5.89	6.12	6.45	5.54	6.77	4.57	5.87	5.24	6.11
BRRI dhan50 (Ck)	86	158	5.95	6.79	6.08	5.76	6.51	5.89	6.73	5.28	5.68	5.72	6.04
LSD (0.05)	**1.0**	**0.4**					**0.54**						**0.17**

* mean value of ten locations L1= Jhalokathi, Barishal, L2= Faridpur, L3= Feni, L4= Rajshahi, L5= Rangpur, L6= Habiganj, L7= Jashore, L8= Kushtia, L9= Sherpur, L10=Gazipur)

3.3 Proposed Variety Trial (PVT)

Performance of the BR8862-29-1-5-1-3 (BRRI dhan104) at on farm trial, Boro 2021-22 season are shown in Table 3. Evaluation of the BR8862-29-1-5-1-3 (BRRI dhan104) at on farm trial was performed by the National Seed Board (NSB) of Bangladesh in Boro 2021-22 season. The highest yield of the proposed line was found with 8.71 t/ha at BRRI, Gazipur.

The average grain yield 7.29 t/ha indicated that the variety could be produce more with proper crop management. The grain yield range of BRRI dhan50 (Check) was found from 4.33-7.76 t/ha. BR8862-29-1-5-1-3 (BRRI dhan104) gave highest yield in eight locations, it gave yield 8.71 t/ha in BRRI, Gazipur; 8.15 t/ha in BINA, Mymensingh; 7.36 t/ha in Feni; 7.16 t/ha in Cumilla; 5.60 t/ha in Bogura; 6.88 t/ha in Barishal; 6.63 t/ha in BRRI Rangpur and 7.18 t/ha in Dinajpur. On an average BRRI dhan50 produced 6.61 t/ha yield whereas BR8862-29-1-5-1-3 (BRRI dhan104) produced 7.29 t/ha yield, that is 0.68 t/ha higher from the check variety. The proposed variety (BR8862-29-1-5-1-3) gave 11.33% higher yield with 17.94% higher yield in top six locations than BRRI dhan50 (Table 3). Growth duration of BR8862-29-1-5-1-3 (BRRI dhan104) was ranged from 139 days to 156 days in depending on the agro climatic situation in the Boro season. Mean growth duration of the proposed variety was found 147 days which is similar to the check variety BRRI dhan50 (Table 3).

Table 3. Performance of proposed variety in Proposed Variety Trial (PVT) at ten locations, Boro, 2021-22

Locations	BR8862-29-1-5-1-3 (Proposed Variety)		BRRI dhan50 (Ck)		Yield advantage (%) than BRRI dhan50*
	Growth duration (days)	Grain yield (t/ha)	Growth duration (days)	Grain yield (t/ha)	
BRRI, Gazipur	147	8.71	148	7.33	**18.96**
BINA, Mymenshingh	149	8.15	154	7.12	**14.47**
BRRI R/S, Faridpur	151	7.40	151	7.76	-4.64
Jashore	140	7.70	139	7.73	**-0.39**
Feni	140	7.37	138	6.67	**10.49**
Cumilla	139	7.16	143	6.36	12.58
Bogura	156	5.60	155	4.33	29.33
Barishal	145	6.88	145	5.81	18.41
BRRI Rangpur	150	6.63	153	5.82	**13.91**
Dinajpur	148	7.18	147	7.17	**0.14**
Range	**139-156**	**5.60-8.71**	**138-155**	**4.33-7.76**	**-4.64 to 29.33**
Mean	**147**	**7.29**	**147**	**6.61**	**11.33 (17.94% higher in top six locations)**

*Yield advantage (%) of proposed variety over the check variety

3.4 Disease and Insect Reaction:

BR8862-29-1-5-1-3 (BRRI dhan104) showed tolerance to major diseases and insects under the natural field condition in the field of plant breeding division. The variety showed a ShB score 1 and blast score 0, meaning it is tolerant to ShB and blast disease (Table 4).Under artificial inoculated condition BR8862-29-1-5-1-3 (BRRI dhan104) showed less score than BRRI dhan50, meaning it is more tolerant to blast disease compared to BRRI dhan50, BR8862-29-1-5-1-3 (BRRI dhan104) also showed better performance against BPH and WBPH compared to BRRI dhan50 (Table 5).

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Table 4. Reaction of the proposed variety against major diseases and insects under natural field condition at BRRI farm

Designation	BB	ShB	Blast	DH	WH
BR8862-29-1-5-1-3	1	1	0	1	1
BRRI dhan50 (Ck)	1	3	0	1	1

BB = Bacterial Blight, ShB = Sheath Blight, DH = Dead Heart, WH = White Head
Disease and Insect severity scale (0 – 9)

Table 5. Reaction of the proposed variety against major diseases and insects under artificial inoculated condition at BRRI

Designation	BB	ShB	Blast	BPH	WBPH	GLH
BR8862-29-1-5-1-3	9	9	5	7	5	7
BRRI dhan50 (Ck)	9	9	9	9	7	7

BB = Bacterial Blight; ShB = Sheath Blight, BPH = Brown Plant Hopper; WPH= White Backed Plant Hopper; GLH = Green Leaf Hopper, Disease and Insect severity scale (0 – 9)

3.6 Physicochemical properties:

BR8862-29-1-5-1-3 (BRRI dhan104) is a long slender grain having length is 7.5 mm and breadth is 1.7 mm. The milling outturn of the variety is 69% with the head rice recovery 57.2%. BRRI dhan104 is straight and it could be milled in any kind of milling machine. This result revealed that BRRI dhan104 will get high market price because of strong aromatic basmati type rice variety (according to GCMS system the value of volatile aromatic compound is 2.12 ppm). The protein and amylose percentage of BRRI dhan104 is 8.9% and 29.2% respectively (Table 6).

Table 6a. Physical properties of the proposed line, Boro 2018-19

Designation	Milling outturn (%)	Head rice yield (%)	Milled Rice length (L) (mm)	Milled Rice breadth (B) (mm)	L-B ratio	Size & Shape	Thousand grain weight (g)	Appearance
BR8862-29-1-5-1-3	69.0	57.2	7.5	1.7	4.5	LS	21.5	Good
BRRI dhan50 (Ck)	70.5	59.7	6.6	1.6	4.2	LS	18.0	Good

Table 6b. Chemical and cooking properties of the proposed line, Boro 2018-19

Designation	Amylose (%)	Protein (%)	Cooking time (min)	Elongation ratio (ER)	Imbibition Ratio (IR)	Aroma
BR8862-29-1-5-1-3	29.2	8.9	16.0	1.3	3.4	Strong
BRRI dhan50 (Ck)	26.8	8.4	17.3	1.2	3.3	Light

Distinguishing characters of the candidate variety BR8862-29-1-5-1-3 (BRRI dhan104) compared to the similar variety e.g. BRRI dhan50 are penultimate leaf : Leaf color; Penultimate leaf : pubescence of blade; Flag leaf: attitude of blade; Panicle: length; Panicle: exertion; Grain: wt of 1000 fully developed grains (at 12%); Spikelet : Sterile lemma length;

Leaf senescence; Decorticated, unpolished grain: color and Decorticated grain: aroma containing distinct special character (if any) (Table 7).

Table 7. Distinctness between BR8862-29-1-5-1-3 (Proposed line) with similar variety BRRI dhan50

SN	Characteristics	BR8862-29-1-5-1-3 (Proposed Variety)		BRRI dhan50 (Check Variety)		Remarks
		Code	State	Code	State	
01	Leaf color	1	Pale Green	2	Green	Distinct
02	Penultimate leaf : pubescence of blade	5	Medium	1	Absent or very weak	Distinct
03	Flag leaf: attitude of blade	1	Erect	3	Semi erect	Distinct
04	Panicle: length	5	Medium	7	Long	Distinct
05	Panicle: exertion	9	Well exerted	5	Just	Distinct
06	Grain: wt of 1000 fully developed grains (at 12%)	5	Medium (20.83 g)	3	Low	Distinct
07	Spikelet : Sterile lemma length	7	Very Long (3.04 mm)	3	Medium	Distinct
08	Leaf senescence	5	Intermediate	1	Slow	Distinct
09	Decorticated, unpolished grain: color	1	White	2	Late brown	Distinct
10	Decorticated grain: aroma	9	Strongly present	5	Lightly present	Distinct

Uniformity: At 50% heading date time only 0.5% off-type was observed. It indicated that the candidate variety BR8862-29-1-5-1-3 is uniform according to UPOV standard.
Stability: In the test plots of two consecutive seasons trials, no remarkable variation and segregation were noted which imply the stability of the candidate variety.

After proper evaluation by the National Seed Board of Bangladesh (NSB) in the ten locations of farmers' field of Bangladesh, BR8862-29-1-5-1-3 has been released as BRRI dhan104 in the year 2022. The pictorial view of BRRI dhan104 in the field condition with its grain, rice are shown in figure 1 and 2.

Fig. 1. P**ictorial view of BR8862-29-1-5-1-3 (BRRI dhan104) in the field condition**

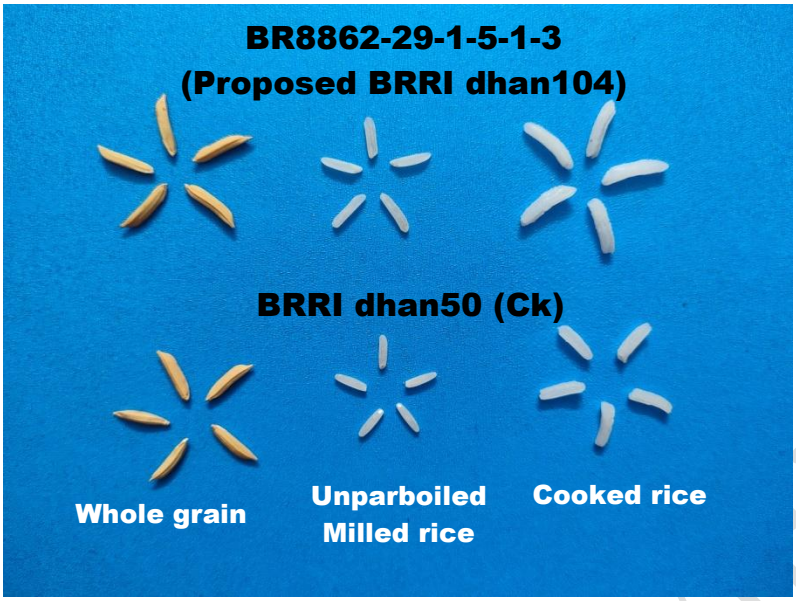

Fig. 2. P**ictorial view of grain of BR8862-29-1-5-1-3 (BRRI dhan104) and BRRI dhan50**

4. CONCLUSION

To sum up, BRRI dhan104 was made available as a high yielding, strong aromatic basmati type rice variety to satisfy the nation's desire. This variety's adaptability testing in the farmers' field under multiple locations trials demonstrated satisfactory performance in terms of grain production, slenderness, and some yield-contributing factors. BRRI dhan104 will be popular at farmers' level quickly and because of its high yielding premium quality enriched aromatic rice characteristics the total rice production will be increased along with possible to earn foreign currency by export this variety.

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