BRRI Dhan107: High Protein Premium Quality Rice Variety for Irrigated Ecosystem in Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author MAK planned the experiment and lead the research, designed the carried out the research and reviewed the manuscript. Authors TKH and RRM performed the statistical analysis. Author TKH, RRM, AKMS and URS carried out the research on the field. Authors AKMS, URS and RRM collected the data. Author AKMS wrote the manuscript. Authors AKMS, TKH, RRM and MAK managed the literature searches. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

A newly released high protein enriched, premium quality type high yielding, extra-long slender grain containing rice variety BRRI dhan107 which suitable for irrigated ecosystem of Bangladesh, is an improvement over existing high protein enriched and premium quality type rice varieties for Bangladesh. The variety has satisfactorily passed the Proposed Variety Trial (PVT) conducted in the farmers' field in Boro 2022-23 season. As a result National Seed Board (NSB) approved this variety

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for commercial cultivation in the Boro season (dry season) in 2024. It has modern plant type with 103 cm plant height and matures by 148 days. The proposed variety showed 1.20 t/ha higher yield than check variety BRRI dhan50. Identifying characters of this variety are green leaf, intermediate plant height, semi-erect flag leaf, extra-long slender grain, intermediate leaf senescence. On an average it can produce 8.19 t/ha grain yield, although with appropriate management under favorable environment it can give up to 9.57 t/ha yield. Thousand grain weight of the variety is 26.1 gm and head rice yield is 60.1%. High protein (10.02%) enriched BRRI dhan107 has high amylose (29.1%) with extra-long slender (7.6 mm) type grain. The high protein enriched, premium quality type rice variety BRRI dhan107 is a superb variety for cultivating in the Boro season (dry) and farmers as well as the country can be nutritionally and economically benefited by the cultivation of BRRI dhan107.

1. INTRODUCTION

"In Bangladesh, the agricultural sector plays a crucial role in achieving development objectives such as poverty reduction and enhanced food security. The key to achieving these goals lies in the uptake of contemporary agricultural techniques, notably the adoption of modern rice varieties (MVs). Rice serves as the staple food source for over three billion individuals across Asia, where the production and consumption of rice account for over 90% of the global total" [1]. "Rice stands as the primary staple crop in Bangladesh, serving as a crucial element for ensuring food security. Cultivation of rice spans across the country, occurring year-round across varying landscapes, from elevated areas to low-lying regions, within three distinct seasons. The introduction of modern rice varieties took place in the mid-1960s, prompting the establishment of the Bangladesh Rice Research Institute (BRRI) in 1970. BRRI was founded with the aim of developing improved rice varieties tailored to the specific growing conditions prevalent in Bangladesh" [2].

"The quality of rice grains is a multifaceted characteristic encompassing aroma, flavor, milling properties, visual appearance, and the overall experience of cooking and consuming the rice" [3,4]. "The eating and cooking quality (ECQ) of rice plays a crucial role in determining its economic worth in the market and fostering consumer satisfaction. As such, it has been a primary focus in rice breeding initiatives due to its significance" [5]. "A comprehensive comprehension, achieved through the amalgamation of grain quality and sensory research findings, has been utilized to develop superior-quality rice varieties leveraging post-genomic resources. The adoption of new rice genotypes by both producers and consumers relies not solely on their capacity for increased yield, but there's also a recent focus on elite genotypes capable of meeting consumer demands for superior grain quality, emphasizing premium-value varieties" [6]. Assessment of rice quality can also be based on specific characteristics or attributes, which are categorized as either intrinsic or extrinsic factors [7]. Variability in rice quality, widely acknowledged, has been affirmed through endeavors to analyze rice quality across various countries and regions. This involves collaboration with local experts and the examination of the physico-chemical properties of the grain [8].

Quality serves as a significant driver in enhancing the value chain of food in developing nations. Nonetheless, defining "rice quality" is complex and lacks a universally applicable definition, particularly in the rice sector. Furthermore, there is a lack of consensus on the appropriate methods for measuring it. Unlike agronomic traits, which can be quantified by their impact on yields or stress tolerance, assessing quality attributes is more intricate as it is subjective and varies depending on the context [9]. "It is difficult to evaluate rice grain quality preferences from a global perspective because rice quality differs between countries and target zones" [4]. "For instance, consumers in Southern China, India, Bangladesh, Sri Lanka, and Pakistan show a preference for long, slender grains with varying textures ranging from fluffy to firmer. To cater to these preferences, breeders focus on developing varieties with intermediate to high amylose content. On the other hand, consumers in northern China, Japan, and South Korea prefer medium grains with a softer texture, leading to the development of varieties with lower amylose content. The productivity and quality of rice depend on the genetic characteristics of cultivars, as well as environmental factors and management practices. Selecting the appropriate variety is crucial for increasing rice production.

Rice yield fluctuates due to various growing conditions such as different geographical locations, seasonal variations, and varying planting dates" [10]. "It is, therefore, to evaluate the performance of rice varieties through appropriate cultural practices to get maximum yield and quality in multi-locations trial is very important. Development of rice cultivars with a high yielding ability is one of the most fundamental approaches for dealing with the expected increase in the world demand" [11]. While there is ample research data available on individual rice varieties, there is a scarcity of documented comparative studies focusing on the morpho-physiological characteristics of rice cultivars specifically during the Boro season in Bangladesh.

This research work gives an account of growth and yield performance of a new high protein enriched premium quality rice variety to meet up the demand of the nations and describes the relationship between grain yield and trial locations as well as morpho-physiological characters of the variety. This study describes the breeding procedures, parental lineage, agro-morphological characters and grain quality of BRRI dhan107.

2. MATERIALS AND METHODS

Bangladeshi local variety Lata Balam was collected by Bangladesh Rice Research Institute (BRRI) in 2015 from farmers' field and pure line selection was done from it to develop BRRI dhan107. The selected pure line was tested for three (3) years in the research field of BRRI, Gazipur and then it was evaluated in the experimental field of BRRI regional stations in 2019 as well as in different farmers' fields of Bangladesh in 2020. Regional Yield Trial (RYT) was conducted to evaluate specific and general adaptability with check variety BRRI dhan50 in on-station condition of ten regional station of BRRI in Randomized Complete Block (RCB) design with three replications during Boro 2019-20 season (dry season). After proper yield evaluation Advanced Line Adaptive Research Trial (ALART) was done to evaluate specific and general adaptability with check variety BRRI dhan50 in the farmers' field condition during Boro 2020-21 season, conducted by Adaptive Research Division (ARD) of BRRI. Genotypes of the trial were 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 seedling to 80% grain maturity. Grain yield data was taken from 10 sq-m sample plot in each replication. In Boro 22-23, the pure line from Lata balam (proposed as BRRI dhan107) was evaluated by the National Seed Board (NSB) of Bangladesh in ten locations of farmers' field in Proposed Variety Trial (PVT). Due to its successful performance in the PVT, National Seed Board (NSB) released the pure line of Lata balam as BRRI dhan107 as a high protein (10.02%) enriched premium quality balam type high yielding Boro rice variety for cultivating throughout the country in 2024. The data analyses of the experiments were done with software namely PBTools and Microsoft excel 2013 [12].

3. RESULTS AND DISCUSSION

3.1 Regional Yield Trial (RYT)

The agro-morphological characteristics of BRRI dhan107 is shown in Table 1. It has intermediate plant height which indicates lodging tolerance. BRRI dhan107 has semi-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. The pure line of Lata Balam gives a growth duration of 158 days with a 93 cm plant height.

The pure line of Lata balam showed the maximum average yield (6.59 t/ha) followed by BRRI dhan50 (Table 1). High yield is the prime objective in developing modern rice varieties with an addition of high protein content (10.02%). BRRI dhan107 showed higher yield than the check variety in Boro 2019-20 season in RYT. This higher yield of BRRI dhan107 was due to its genetic potentiality of producing higher and longer grains per panicle.

3.2 Advanced Line Adaptive Research Trial (ALART)

The pure line of Lata Balam (BRRI dhan107) and check variety BRRI dhan50 were evaluated in ten locations at the farmers' field of Bangladesh. Results are showed in the Table 2. Highest grain yield potentiality was found for the pure line of Lata Balam in Poba, Rajshahi (8.15 t/ha) (Table 2). On an average the pure line of Lata Balam (BRRI dhan107) yielded higher than BRRI dhan50. Also almost disease free in some

locations. The strong plant stature (103 cm) of the variety made it lodging tolerant. Growth duration was found two days earlier than the check variety BRRI dhan50. Farmers preferred the pure line of Lata Balam for their better yield, extra-long slender grain as well as premium quality and high protein content.

3.3 Proposed Variety Trial (PVT)

Performance of the proposed variety at on farm trial, Boro 2022-23 season are shown in Table 3. Evaluation of the proposed variety at on farm trial was performed by the National Seed Board (NSB) of Bangladesh in Boro 2022-23 season. The highest yield of the tested genotype was found with 9.571 t/ha at Feni. The average grain yield indicated that the variety could be produce more with proper crop management. The grain yield range of check variety BRRI dhan50 was found from 5.539-8.397 t/ha where the yield range of the proposed variety was found 6.336-9.571 t/ha. The proposed variety gives yield 9.571 t/ha in Feni, 9.461 t/ha in BRRI RS Rangpur, 9.380 t/ha in Joshore, 9.360 t/ha in BINA Mymensingh, 7.914 t/ha in BRRI RS Bhanga, Faridpur, 7.713 t/ha in Dinajpur, 7.537 t/ha in Cumilla, 7.495 t/ha in Bogura, 7.110 t/ha in BRRI Gazipur and 6.336 t/ha in Barishal. On an average BRRI dhan50 produced 6.997 t/ha yield whereas the proposed variety produced 8.188 t/ha yield, that is 1.20 t/ha higher for compared the check variety (17.67% higher yield) (Table 3). Growth duration of the proposed variety was ranged from 135 days to 148 days in depending on the agro climatic situation in the Boro season. Mean growth duration of the proposed variety was found 143 days which is similar to the check variety BRRI dhan50 (Table 3).

3.4 Disease and Insect Reaction

BRRI dhan107 (pure line of Lata Balam) showed tolerance to major diseases and insects under the natural field condition in the field of plant breeding division. The variety showed a bacterial score 1, sheath blight score 1 meaning it is tolerant to bacterial blight and sheath blight disease (Table 4a). For the insects the BRRI dhan107 (pure line of Lata Balam) showed less symptoms than the check variety BRRI dhan50 (Table 4a and Table 4b).

3.5 Physicochemical Properties

BRRI dhan107 has an extra-long slender grain where length is 7.6 mm and breadth is 1.8 mm. The milling outturn of the variety is 70.8% with the head rice recovery 60.1% (Table 5a). BRRI dhan107 is straight and it could be milled in any kind of milling machine. This result revealed that BRRI dhan107 will get high market price because of high protein (10.02%), extra-long slender type grain (Fig. 1). The protein and amylose percentage of BRRI dhan107 is 9.8% and 29.1% randomly (Table 5b).

Distinguishing characters of the candidate pure line of Lata Balam (BRRI dhan107) compared to the similar variety e.g. BRRI dhan50 are Penultimate leaf: pubescence of blade; Time of heading (50% of plants with heads); Culm diameter; Culm: Length; Panicle: number of effective tillers in plant; Spikelet: Pubescence of lemma & palea; Panicle: exertion; Time of maturity; Grain: wt of 1000 fully developed grains (at 12%); Endosperm: content of amylose; Decorticated grain: aroma (Table 6).

Distinctness: The above serial number 3, 8, 14, 15, 21, 22, 28, 29, 30, 38 and 39 indicated that the candidate variety Lata Balam is distinctly different from the check variety BRRI dhan50.

Uniformity: At 50% heading date time only 0.5% off-type was observed for both the lines. It indicated that the candidate variety Lata Balam 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 varieties.
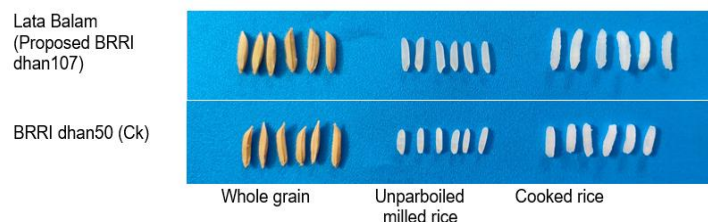
Fig. 1. Pictorial view of whole grain, unparboiled milled rice and cooked rice of Lata Balam (Proposed BRRI dhan107)

Table 1. Morphological and agronomic characters of the proposed variety, regional yield trial (RYT), Boro 2019-20

SN	Designation	Plant height (cm)*	Growth duration (days)*	Grain yield (t/ha)										
				Gazi	Rang	Raj	S.khira	Kus	Cumi	Bari	S.gazi	Habi	Bhanga	Mean
1	Lata Balam	93	158	6.85	6.59	5.04	6.39	7.95	6.25	6.91	5.68	6.27	8.0	6.59
2	BRRI dhan50 (Ck)	84	160	6.02	6.15	5.61	6.00	7.68	5.57	5.78	5.73	6.23	8.42	6.32
	LSD (0.05)	4.03	2.54	0.78	0.52	0.61	0.44	0.84	0.47	0.4	0.38	0.6	1.37	0.64
	Heritability	0.9	0.96	0.69	0.91	0.74	0.82	0.7	0.86	0.81	0.9	0.79	0.7	0.79

* mean value of ten locations.

Table 2. Performance of the proposed variety at different Zonal Trial, Advanced Line Adaptive Research Trial (ALART), Boro 2020-21

SN	Designation	Plant height (cm) *	Growth duration (days) *	Grain yield (t/ha)										
				Chirir bandar Dinajpur	Mitha pukur, Rang pur	Dhunot, Bogura	Poba, Raj shahi	Goda gari, Raj shahi	Sadar, Kush tia	Sadar, Sat khira	Ful gazi, Feni	Kapa sia, Gazi pur	BRRI Gaz	Mean
1	Lata Balam	103	154	6.31	6.97	7.66	8.15	6.51	5.52	5.72	5.85	6.06	6.51	6.53
2	BRRI dhan50 (Ck)	87	152	5.44	6.03	8.37	6.91	5.74	6.96	6.41	6.16	5.91	5.69	6.36
	LSD (0.05)	1.24	0.21	0.77										0.30
	CV	2.28	0.23	7.39										2.90

* mean value of ten locations

Table 3. Performance of proposed variety in Proposed Variety Trial (PVT) at ten locations, Boro 2022-23

Locations	Lata Balam (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	141	7.110	146	5.916	20.18
Cumilla	135	7.537	137	6.070	24.17
Feni	144	9.571	149	7.369	29.88
Bogura	148	7.495	148	6.322	18.55
Dinajpur	145	7.713	145	6.897	11.83
BRRI R/S Bhanga, Faridpur	147	7.914	146	7.193	10.02
Barishal	135	6.336	129	5.539	14.39
Joshore	148	9.380	146	8.397	11.71
BINA, Mymensingh	141	9.360	145	8.093	15.66
BRRI R/S Rangpur	148	9.461	152	8.178	15.69
Range	135-148	6.336-9.571	129-152	5.539-8.397	10.02 to 29.88
Mean	143	8.188	144	6.997	17.67

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

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

Designation	BB	ShB	Blast	DH	WH
Lata Balam	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 4b. Reaction of the proposed variety against major diseases and insects under artificial inoculated condition at BRRI

Designation	BB	ShB	Blast	BPH	WBPH	GLH
Lata Balam	5	9	7	7	7	9
BRRI dhan50 (Ck)	9	9	9	9	9	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).

Table 5a. Physical properties of the proposed variety, Boro 2019-20

Designation	Milling outturn (%)	Head rice yield (%)	Milled Rice length (L) (mm)	Milled Rice breadth (B) (mm)	L-B ratio	Size & Shape	Thousand weight (g)	grain Appearance
Lata Balam	70.8	60.1	7.6	1.8	4.2	Extra LS	26.1	Very Good
BRRI dhan50 (Ck)	70.5	59.9	6.6	1.6	4.0	LS	19.0	Good

Table 5b. Chemical and cooking properties of the proposed variety Boro 2019-20

Designation	Amylose (%)	Protein (%)	Cooking time (min)	Elongation ratio (ER)	Imbibition Ratio (IR)	Chalkiness	Antioxidant properties, Boro 2020-21	
							TPC (ug/g GAE)	FRAP (uM AAE)
Lata Balam	29.1	10.02	15.0	1.4	4.2	Tr	6.70	266
BRRI dhan50 (Ck)	26.8	8.2	17.3	1.2	3.9	Tr/ Opaque (few)	6.46	257

Tr: Translucent, TPC: Total Phenolic Content, FRAP: Ferric Reducing Antioxidant Power Assay
 # TPC is important plant constituents with redox properties responsible for antioxidant activity. It can be calculated as natural compound (gallic acid) equivalent (GAE)
*FRAP measures the antioxidant potential in samples through the reduction of ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}) by antioxidants present in the samples.

Table 6. Distinctness between BR8862-29-1-5-1-3 (Proposed line) with similar variety BRRI dhan50

SN	Characteristics	Lata Balam (Proposed Variety)		BRRI dhan50 (Check Variety)		Remarks
		Code	State	Code	State	
1	Leaf sheath: anthocyanin color	1	Absent	1	Absent	
2	Leaf color	2	Green	2	Green	
3	**Penultimate leaf : pubescence of blade**	**5**	**Medium**	**1**	**Absent**	**Distinct**
4	Penultimate leaf : anthocyanin color of auricles & collar	1	Absent	1	Absent	
5	Penultimate leaf: ligule	9	Present	9	Present	
6	Penultimate leaf: shape of the ligule	3	Two cleft	3	Two cleft	
7	Flag leaf: attitude of blade	3	Semi erect	3	Semi erect	
8	**Time of heading (50% of plants with heads)**	**7 (120d)**	**Late**	**9 (125d)**	**Very Late**	**Distinct**
9	Male strility	1	Absent	1	Absent	
10	Lemma & palea: anthocyanin coloration	1	Absent	1	Absent	
11	Lemma & palea: anthocyanin coloration below apex	1	Absent	1	Absent	
12	Lemma: anthocyanin coloration of apex	1	Absent	1	Absent	
13	Spikelet: color of stigma	1	White	1	White	
14	**Culm diameter**	**3 (5.3mm)**	**Medium**	**1**	**Small**	**Distinct**
15	**Culm: Length**	**5 (70cm)**	**Medium**	**3**	**Short**	**Distinct**
16	Stem: anthocyanin coloration of nodes	1	Absent	1	Absent	
17	Stem: Intensity of antho coloration of nodes	-	-	-	-	
18	Stem: anthocyanin coloration of internodes	1	Absent	1	Absent	
19	Panicle: length	7	Long	7	Long	
20	Panicle: curvature of main axis	5	Medium	5	Medium	
21	**Panicle: number of effective tillers in plant**	**7**	**Many**	**5**	**Medium**	**Distinct**
22	**Spikelet: Pubescence of lemma & palea**	**7**	**Strong**	**5**	**Medium**	**Distinct**
23	Spikelet: color of tip of lemma	2	Yellowish	2	Yellowish	
24	Panicle: awn in spikelet	1	Absent	1	Absent	
25	Panicle: length longest awn	-	-	-	-	
26a	Panicle: distribution of awns	-	-	-	-	
26b	Panicle: color of awns	-	-			
27	Panicle: attitude of branches	3	Semi erect	3	Semi-erect	
28	**Panicle: exertion**	**9**	**Well exerted**	**5-7**	**Just exerted to moderately exerted**	**Distinct**
29	**Time of maturity**	**7 (150d)**	**Late**	**9 (155d)**	**Very Late**	**Distinct**
30	**Grain: wt of 1000 fully developed grains (at 12%)**	**7 (25.1 g)**	**High**	**3**	**Low**	**Distinct**
31	Grain: length (without dehulling)	9 (11.27mm)	Very long	9	Very Long	
32	Spikelet : Sterile lemma length	7 (3.23mm)	Very long	-	-	
33	Decorticated grain: length (After dehulling, before milling)	7 (8)	Very long	7	Very long	
34	Leaf senescence	5	Intermediate	5	Intermediate	
35	Decorticated grain: shape (Length-breadth ratio	9 (5.5)	Slender	9	Slender	

SN	Characteristics	Lata Balam (Proposed Variety)		BRRI dhan50 (Check Variety)		Remarks
		Code	State	Code	State	
36	Decorticated, unpolished grain: color	1	white	1	White	
37	Polished grain: size of white core or chalkiness	1	Very small	1	Very small	
38	**Endosperm : content of amylose**	**5 (29.1%)**	**High**	**3**	**Intermediate**	**Distinct**
39	**Decorticated grain: aroma**	**1**	**Absent**	**5**	**Lightly present**	**Distinct**
40	**Other distinct special character (if any)**					

4. CONCLUSIONS

In conclusion, BRRI dhan107 was released as a high yielding premium quality along with high protein enriched rice variety to meet the nutritional (protein) demand of the country. Adaptability tests of this variety under multi-location trials in the farmers' field showed satisfactory performance with respect to grain yield, slenderness and some yield contributing parameters. It is anticipated that this rice variety will contribute to the nutritional value of Bangladesh. Farmers can cultivate this variety in irrigated ecosystem and thus it will also increase total productivity as well as it is capable to meet up nutritional demand and earn foreign currency through export.

ACKNOWLEDGEMENTS

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/116612