



BRR1 Dhan100: A Zinc Enriched Rice Variety Suitable 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. Author MAK designed and carried out the research. Author MEH performed the statistical analysis. Authors TKH, AKMS and MEH carried out the research on the field. Authors AKMS, MEH, KF and RRM collected the data. Authors MEH and RRM wrote the manuscript. Authors MEH, KF and PSB managed the literature searches. Authors KMI and PSB reviewed the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Recently released zinc enriched, high yielding, medium slender grain containing rice variety BRR1 dhan100, appropriate for irrigated ecosystem of Bangladesh is an improvement over existing zinc enriched rice varieties for Bangladesh. The variety has satisfactorily passed the Proposed Variety Trial (PVT) conducted in the farmers' field in Boro 2019-20 season. As a result National Seed Board (NSB) approved this variety for commercial cultivation in the Boro season (dry season) in 2021. It has modern plant type with 101 cm plant height and matures by 148 days. The proposed variety showed 1.20 t/ha higher yield than check variety BRR1 dhan84. Identifying characters of this variety are green leaf, intermediate plant height, erect flag leaf, medium slender grain, intermediate leaf senescence grain. It can produce 7.7 - 8.8 t/ha grain yield. Thousand grain weight of the variety is 16.7 gm and head rice yield is 64%. The rice has zinc content 25.7 mg/kg, 26.8% amylose

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content with 7.8% protein content. The zinc enriched BRR1 dhan100 is a superb variety for cultivating in the Boro season (dry) and farmers can be economically benefited and the country will be nutritionally benefited by the cultivation of BRR1 dhan100.

Keywords: BRR1 dhan100; dry season; slender grain; rice & zinc enriched.

1. INTRODUCTION

In Bangladesh, for achieving the development goals of alleviating poverty and increasing food security agriculture is playing a vital role. Reducing poverty and improving food security through stimulating agricultural growth primarily depends on the adoption of modern high yielding rice varieties (MVs) enhanced by modern agricultural technologies. Rice is the staple food for more than three billion people in Asia, where more than 90% of the world's rice is produced and consumed [1]. Rice is the main staple food grown in Bangladesh and is playing a crucial role for food security. Modern varieties of rice were introduced to Bangladesh in the mid-sixties and now rice is grown throughout the year on high land to low land in three rice growing seasons. In Bangladesh, Bangladesh Rice Research Institute (BRR1) was set up in 1970 to develop modern rice varieties better suited to local growing condition [2].

Nowadays, developing countries are struggling with nutritional deficiencies where zinc deficiency is known to be very common [3,4]. Effects of zinc deficiency can be estimated on about two billion people worldwide. In developing countries, zinc deficiency is the 5th leading cause for the loss of healthy life years. Elderly population mainly in the industrial countries is affected by zinc deficiency [5]. Nearly 30% of the elderly population is considered to be zinc deficient. Since zinc homeostasis is known to be important in immunological reactions such as the inflammatory response, and the oxidative stress response, multiple chronic diseases observed in the elderly are probably related to zinc deficiency. Hence, diseases such as Rheumatoid Arthritis, diabetes, atherosclerosis, impaired cognitive function, as well as age-related macular degeneration (AMD) may be due to zinc deficiency, worsening chronic inflammation and triggering oxidative stress [6]. Importantly, zinc deficiency results in a compromised immune system, as evidenced by thymic atrophy, lymphopenia, and defective lymphocyte responses in animal studies [7]. These data underscore the importance of zinc nutrition, particularly in underdeveloped countries where

the risk of infection is heightened because of poor sanitation, public health, and vaccination strategies [8].

Yield and quality of rice relies upon the hereditary capability of cultivars, it encompassing environment and the management practices. Selection of right type of variety is most vital components for expanding rice production. Yield of rice changes because of growing condition, for example, different locations, seasonal fluctuations, distinctive dates of planting and so forth [9]. 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 [10]. There is a lot of research information on specific rice variety, but a little is documented on comparative study of morpho-physiological characters of rice cultivars during Boro season in Bangladesh [11]. Main objective of this program was to development of high yielding rice varieties with improved nutritional quality in term of high zinc ($Zn \geq 24$ mg/kg) in slender type polished grain. This research work gives an account of growth and yield performance of a new high yielding zinc 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 BRR1 dhan100.

2. MATERIALS AND METHODS

2.1 Early Varietal Development Stage

BRR1 dhan100 was developed from crosses between BR7166-5B-5/BG305 in the year 2006 with a hope to develop zinc enriched rice variety in Bangladesh Rice Research Institute (BRR1) Gazipur, Bangladesh. The F_1 plants were grown in the net house of BRR1 along with respective parents and the confirmed F_1 populations were crossed with BRR1 dhan29 in 2007. The cross

was confirmed and registered as BR8631. The pedigree of BRR1 dhan100 is BR8631-12-3-5-P2. The next year disease and insect free, lodging resistant belonging to long slender grain along with strong plants were selected in F₂ population. Pedigree selection method was followed for handling of the segregating generations within and among the rows in F₃-F₅ generations. Some homozygous progeny lines with desirable characteristics were isolated in F₆ generations. During the period of generation advance, progeny rows were selected which were resistant against diseases and insects under field condition. In Boro 2013-14 season, several tolerant homozygous lines were tested in Observational Trial (OT) against BRR1 dhan28 to observe homogeneity in heading, tolerance to lodging, resistance to diseases and insects as well as overall phenotypic acceptance at field condition [11].

2.2 Advanced Breeding Stage

In Boro 2014-15 season, the sister lines of the advanced breeding materials were tested for Preliminary Yield Trial (PYT) for primary yield evaluation. Then after proper selection in 2015, promising sister lines were tested in Secondary Yield Trial (SYT) for confirmation of the yield of the materials in the Gazipur farm in Boro 2015-16 season. Out of all lines 1 promising line was subjected to Regional Yield Trial (RYT) to evaluate specific and general adaptability with standard check BRR1 dhan28 and BRR1 dhan74 in on-station condition of five regional station of BRR1 in randomized complete block (RCB) design with three replications in Boro 2016-17 season. After proper yield evaluation one advanced material (BR8631-12-3-5-P2) was subjected to Advanced Line Adaptive Research Trial (ALART) to evaluate specific and general adaptability with standard check BRR1 dhan28 and BRR1 dhan74 in the eight farmers' field condition in Boro 2018-19 season, conducted by Adaptive Research Division (ARD) of BRR1. RYT and ALART was conducted to evaluate specific and general adaptability of the advance breeding lines as compared with standard checks in on-station and on-farm conditions. 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.

2.3 Final Approval by NSB

In Boro 2019-20, BR8631-12-3-5-P2 (proposed as BRR1 dhan100) 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 BR8631-12-3-5-P2 as a superior genotype in respect to high zinc content (25.7 mg/kg), grain yield, lodging tolerance, 1.20 t/ha higher yield than check variety BRR1 dhan84, medium slender type grain and has been released as BRR1 dhan100 in the year 2021. The data analyses of the experiments were done with software namely PBTools and Microsoft excel 2013 [12,13].

3. RESULTS AND DISCUSSION

3.1 Regional Yield Trial (RYT)

The agro-morphological characteristics of BRR1 dhan100 is shown in Table 1. It has intermediate plant height which indicates lodging tolerance. BRR1 dhan100 has erect, long, green flag leaf which facilitates maximum solar light uptake. The Regional yield trial (RYT) of this line was conducted in five BRR1 Regional stations of Bangladesh. BR8631-12-3-5-P2 gives a growth duration of 152 days with a 102.4 cm plant height.

BR8631-12-3-5-P2 showed the maximum average yield (5.8 t/ha), followed by BRR1 dhan28 and BRR1 dhan74 (Table 1). High yield is the prime objective in developing modern rice varieties with an addition of high zinc content (25.7 mg/kg) (Table 6b). BRR1 dhan100 showed higher yield than the check varieties in Boro 2016-17 seasons in RYT. This higher yield of BRR1 dhan100 was due to its genetic potentiality of producing higher and longer grains per panicle than BRR1 dhan74.

3.2 Advanced Line Adaptive Research Trial (ALART)

BR8631-12-3-5-P2 (BRR1 dhan100) one advanced line and check variety BRR1 dhan28, BRR1 dhan74 were evaluated in eight locations at the farmers' field of Bangladesh. Results are showed in the Table 2. The significant variation was found for grain yield of the genotypes across

the locations. Highest grain yield potentiality was found for BR8631-12-3-5-P2 (8.24 t/ha) in Rajshahi (Table 2). And BR8631-12-3-5-P2 gives yield 7.33 t/ha in Chottogram, 7.45 t/ha in Feni, 5.73 t/ha in Habiganj, 6.60 t/ha in Khulna, 5.77 t/ha in Barishal, 6.16 t/ha in Dinajpur and 7.51 t/ha in BRRRI Gazipur. The result shows the higher yield potentiality of BR8631-12-3-5-P2 (BRRRI dhan100) over the check varieties. On an average BR8631-12-3-5-P2 (BRRRI dhan100) yielded higher than BRRRI dhan28 and BRRRI dhan74. BR8631-12-3-5-P2 were almost disease free in some locations. The strong plant stature (101 cm) of the variety made it lodging tolerant. Growth duration was found two days earlier than the check variety BRRRI dhan74. Farmers preferred BR8631-12-3-5-P2 for their better yield, shorter growth duration and high zinc content as well as medium slender grain quality.

3.3 Proposed Variety Trial (PVT)

Performance of the BR8631-12-3-5-P2 (BRRRI dhan100) at on farm trial, Boro 2019-20 season are shown in Table 3. Evaluation of the BR8631-12-3-5-P2 (BRRRI dhan100) at on farm trial was performed by the National Seed Board (NSB) of Bangladesh in Boro 2019-20 season. The highest yield of the genotype was found with 8.77 t/ha at BRRRI, Rangpur. The average grain yield indicated that the variety could be produce more with proper crop management. The grain yield range of BRRRI dhan74 (Check) was found from 6.44 - 8.75 t/ha and BRRRI dhan84 (Check) was found from 5.27 - 7.46 t/ha. BR8631-12-3-5-P2 (BRRRI dhan100) gives yield 7.61 t/ha in Feni, 8.15 t/ha in Shahjahanpur, 6.88 t/ha in Narendrapur, 7.85 t/ha in BRRRI Gazipur, 7.15 t/ha in BINA, 8.63 t/ha in Faridpur, 7.45 t/ha in Laksham, 8.77 t/ha in Rangpur, 7.15 t/ha in Babuganj and 7.25 t/ha in Dinajpur. On an average BRRRI dhan84 produced 6.49 t/ha yield whereas BR8631-12-3-5-P2 (BRRRI dhan100) produced 7.69 t/ha yield, that is 1.20 t/ha higher

for the variety (19.56% higher yield) (Table 3). Growth duration of BR8631-12-3-5-P2 (BRRRI dhan100) was ranged from 138 days to 158 days in depending on the agro climatic situation in the Boro season. Mean growth duration of the variety was found 148 days which is four days earlier than the check variety BRRRI dhan84 (Table 3). Zinc content of BRRRI dhan84 is 25.7 mg/kg (Table 5).

3.4 Disease and Insect Reaction

BRRRI dhan100 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, meaning it is tolerant to bacterial blight. The variety is found moderate resistant to sheath blight disease and resistant to Blast (Table 4). For the insects the variety is also tolerant to brown plant hopper for the dead heart and white head symptoms. BRRRI dhan74 also more or less showed similar symptoms.

3.5 Physicochemical Properties

BRRRI dhan100 is a medium slender grain having length is 5.33 mm and breadth is 1.94 mm. The milling outturn of the variety is 70.03% with the head rice recovery 64% (Table 6a). BRRRI dhan100 is straight and it could be milled in any kind of milling machine. This result revealed that BRRRI dhan100 will get high market price because of zinc (25.7 mg/kg), medium slender type grain. The protein and amylose percentage of BRRRI dhan100 is 7.8 and 26.8% respectively (Table 6b).

After proper evaluation by the National Seed Board of Bangladesh (NSB) in the ten locations of farmers' field of Bangladesh, BR8631-12-3-5-P2 has been released as BRRRI dhan100 in the year 2021. The pictorial view of BRRRI dhan100 in the field condition with its grain, rice are shown in Figs. 1 and 2.

Table 1. Morphological and agronomic characteristics of BR8631-12-3-5-P2 (BRRRI dhan100), on-station Regional Yield Trial, Boro 2016-17

SN	Designation	Plant height* (cm)	Growth duration* (days)	*Yield (t/ha)
1	BR8631-12-3-5-P2	102.4	152	5.8
2	BRRRI dhan28(CK)	91.2	142	5.5
3	BRRRI dhan74(CK)	82	148	4.7
	LSD <0.05	1.21	0.49	0.18

* Mean value of five locations

Table 2. Performance of the BR8631-12-3-5-P2 (BRRI dhan100) at different zonal trial in farmers' field, Boro 2018-19

SN	Designation	Plant height* (cm)	Growth duration* (days)	Yield in different locations								Mean Yield (t/ha)
				L1	L2	L3	L4	L5	L6	L7	L8	
1	BR8631-12-3-5-P2	101	146	7.33	7.45	5.73	6.60	5.77	8.24	6.16	7.51	6.85
2	BRRRI dhan28 (CK)	100	146	6.38	6.48	4.09	6.50	5.57	7.31	5.39	7.56	6.16
3	BRRRI dhan74 (CK)	94	148	5.68	6.11	5.84	6.70	6.17	7.35	6.19	7.55	6.44
	LSD <0.05	1.0	0.72	0.30								0.22

*Mean of eight locations (L1=Chottogram, L2=Feni, L3=Habiganj, L4=Khulna, L5=Barishal, L6= Rajshahi, L7= Dinajpur, L8= BRRRI Gazipur)

Table 3. Performance of the BR8631-12-3-5-P2 (BRRI dhan100) at Proposed Variety Trial in farmers' field, Boro 2019-20

Locations	BR8631-12-3-5-P2		BRRRI dhan74		BRRRI dhan84		*Higher yield % than BRRRI dhan74	*Higher yield % than BRRRI dhan84
	Growth duration (days)	Yield (t/ha)	Growth duration (days)	Yield (t/ha)	Growth duration (days)	Yield (t/ha)		
Feni, Chottogram	150	7.61	145	7.48	139	6.56	1.74	16.01
Shahjanpur, Bogura	150	8.15	150	8.14	145	7.33	0.12	11.19
Narendrapur, Jashore	141	6.88	145	6.35	141	5.97	8.35	15.24
BRRRI, Gazipur	150	7.85	149	7.17	146	5.27	9.48	48.96
BINA, Mymensingh	149	7.15	154	6.44	151	6.24	11.02	14.58
BRRRI, Faridpur	150	8.63	150	7.40	145	6.57	16.62	31.35
Laksham, Cumilla	148	7.45	145	7.46	138	6.84	0.13 % less	8.92
BRRRI, Rangpur	158	8.77	159	8.75	151	6.20	0.23	41.5
Babuganj, Barishal	138	7.15	140	6.46	144	6.46	10.68	10.68
Sadar, Dinajpur	146	7.25	146	8.43	139	7.46	14 % less	2.8 % less
Mean	148	7.69	148	7.41	144	6.49	4.41	19.56
LSD <0.05	0.65	0.20	0.65	0.20	0.65	0.20		

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

Table 4. Reaction of the BR8631-12-3-5-P2 (BRRi dhan100) against major diseases and insects under natural field condition, Boro 2016-17

Designation	BB	ShB	Blast	DH	WH
BR8631-12-3-5-P2	1	3	0	1	1
BRRi dhan74 (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 BR8631-12-3-5-P2 (BRRi dhan100) against major diseases and insects under artificial condition, Boro 2016-17

Designation	BB	ShB	Blast	BPH	WBPH	GLH
BR8631-12-3-5-P2	5	5	7	9	9	7
BRRi dhan74 (Ck.)	5	5	7	9	9	7

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

Table 6a. Physical properties of BR8631-12-3-5-P2 (BRRi dhan100)

Proposed variety/line	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
BR8631-12-3-5-P2	70.03	64	5.33	1.94	2.75	MS	16.7	Good

Table 6b. Chemical and cooking properties of BR8631-12-3-5-P2 (BRRi dhan100)

Proposed variety/line	Zinc (mg/kg)	Amylose (%)	Protein (%)	Cooking time (min)	Elongation Ratio (ER)	Imbibitions Ratio (IB)
BR8631-12-3-5-P2	25.7	26.8	7.8	14.0	1.35	4.5



Fig. 1. Pictorial view of BR8631-12-3-5-P2 (BRRl dhan100) in the field condition




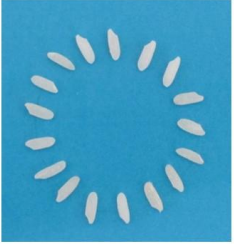


	BR8631-12-3-5-P2	BRRl dhan74	BRRl dhan84
Rough rice			
Polish rice			

Fig. 2. Pictorial view of Rough Rice, Brown Rice and Plished Rice of BR8631-12-3-5-P2 (BRRl dhan100)

4. CONCLUSION

In conclusion, BRR1 dhan100 was released as a high yielding, zinc enriched rice variety to meet the nutritional (zinc) 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 zinc 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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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