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Zinc Enriched High Yielding Rice Variety BRRI dhan84 for Dry Season Rice Growing Areas of Bangladesh

Md. Abdul Kader[1], Partha Sarathi Biswas[1], Tamal Lata Aditya[2], Mohammad Anisuzzaman[1], Tapas Kumer Hore[1] and Md. Ehsanul Haq[1*]

[1]Plant Breeding Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh.
[2]Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh.

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. Authors TKH and MEH performed the statistical analysis. Authors MA and TKH carried out the research on the field. Authors PSB and MA collected the data. Authors TLA and MEH wrote the manuscript. Authors TLA and PSB 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.

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ABSTRACT

A newly released zinc enriched, high yielding, slender and red pericarp grain containing rice variety BRRI dhan84, suitable for dry ecosystem (*Boro* season) of Bangladesh is an improvement over existing zinc enriched rice varieties for Bangladesh. The main objective of this research was to develop the of high yielding rice varieties with improved nutritional quality in term of high zinc (Zn≥24 mg/kg) in polished grain. The study was taken in 2004 by crossing between BRRIdhan29/IR68144//BRRI dhan28///BR11 and it takes near about 13 years to develop the targeted variety. After selection of one homozygous advanced line (BR7831-59-1-1-4-5-1-9-P1) the Regional Yield Trial (RYT) was conducted in *Boro* 2014-15 saeson and the Advanced Line Adaptive Research Trial (ALART) was evaluated at different farmers' field in *Boro* 2015-16 season and different yield trials were conducted using Randomized Complete Block Desing (RCBD). The variety has satisfactorily passed the Proposed Variety Trial (PVT) conducted in the farmers' field in *Boro*

**Corresponding author: E-mail: shawonjess01@gmail.com;*

2016-17 season. As a result National Seed Board (NSB) approved this variety for commercial cultivation in the dry season (*Boro* season) in 2017. It has modern plant type with 96 cm plant height and matures by 140 days. The salient feature of this variety is the red colored grain, earlier than check variety, the proposed variety showed higher yield than check variety BRRI dhan28. Identifying characters of this variety are dark green leaf, semi erect flag leaf, long slender and red colored grain. It can produce 6.0-6.5 t/ha grain yield. Thousand grain weight of the variety is 22.8 g and it has colored grain tip. The rice has zinc content 27.6 mg/kg, 25.9% amylose content with 9.7% protein content. BRRI dhan84 was released as a high yielding, zinc enriched rice variety to meet the nutritional (zinc) demand of the country. The zinc enriched BRRI dhan84 is a superb variety for cultivating in the dry (*Boro*) season and farmers can be economically benefited and the country will be nutritionally benefited by the cultivation of BRRI dhan84.

Keywords: BRRI dhan84; dry season; red grain; rice and zinc enriched.

1. INTRODUCTION

Agriculture plays the vital role for achieving the development goals to alleviating of poverty and increasing the food security in Bangladesh. Reducing poverty and improving food security through stimulating agricultural growth primarily depends on the adoption of modern agricultural technologies, including modern rice varieties (MVs). 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 the vital crop for food security. Here, rice is grown throughout the year on high land to low land in three seasons. In the mid-sixties, recent varieties of rice were familiarized in Bangladesh. In Bangladesh, Bangladesh Rice Research Institute (BRRI) was set up in 1970 to develop modern rice varieties better suited to local growing condition [2].

Nowadays, however, zinc deficiency is known to be very common, especially in developing countries [3]. Near about two billion people are projected to be pretentious by zinc deficiency. Zinc insufficiency is the 5th leading cause for the loss of healthy life years, in developing countries. For industrial countries, mainly the elderly population is affected by zinc deficiency [4]. Nearly 30% of the elderly population is considered to be zinc deficient. Meanwhile zinc homeostasis is known to be significant in immunological reactions such as the inflammatory reaction, and the oxidative stress reaction, 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 insufficiency, deteriorating chronic inflammation and prompting oxidative stress [5]. Importantly, zinc deficiency results in a compromised immune system, as evidenced by thymicatrophy, lymphopenia, and defective lymphocyte responses in animal studies [6]. These statistics underscore the prominence of zinc nutrition, particularly in underdeveloped countries where the risk of infection is heightened because of poor hygiene, public health, and vaccination strategies [7].

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 [8]. 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 [9]. 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. 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 BRRI dhan84.

2. MATERIALS AND METHODS

BRRI dhan84 was developed from crosses between BRRIdhan29/IR68144//BRRI dhan28///BR11 in the year 2004 with a hope to develop zinc enriched rice variety in Bangladesh Rice Research Institute (BRRI) Gazipur, Bangladesh. The pedigree of BRRI dhan84 is BR7831-59-1-1-4-5-1-9-P1. The F_1 plants were grown in 2005 in the net house of BRRI along with respective parents. The cross was confirmed and registered as BR7831. The next year disease and insect free, lodging resistant belonging to long slender grain along with strong plants were selected in F_2 population. Pedigree selection method was followed for handling of the segregating generations within and among the rows in F_3-F_5 generations. Some homozygous progeny lines with desirable characteristics were isolated in F_6 generations. During the period of generation advance, progeny rows were selected which were resistant against diseases and insects under field condition. In *Boro* 2011-12 season, several tolerant homozygous lines were tested in Observational Trial (OT) against BRRI dhan28 to observe homogeneity in heading, tolerance to lodging, resistance to diseases and insects as well as overall phenotypic acceptance at field condition. In *Boro* 2012-13 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 2013, promising sister lines were tested in Secondary Yield Trial (SYT) for confirmation of the yield of the materials in the Gazipur farm in *Boro* 2013-14 season. Out of all lines 1 promising line was subjected to Regional Yield Trial (RYT) to evaluate specific and general adaptability with standard check BRRI dhan28 in on-station condition of nine regional station of BRRI in randomized complete block (RCB) design with three replications in *Boro* 2014-15 season. After proper yield evaluation one advanced material (BR7831-59-1-1-4-5-1-9-P1) was subjected to Advanced Line Adaptive Research Trial (ALART) to evaluate specific and general adaptability with standard check BRRI dhan28 in the farmers' field condition in *Boro* 2015-16 season, conducted by Adaptive Research Division (ARD) of BRRI. Genotypes of the trial were verified for different physico-chemical properties, cooking qualities, best planting time, disease-insect resistance in natural condition, plant height, tillering ability were documented 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* 2016-17, BR7831-59-1-1-4-5-1-9-P1 (proposed as BRRI dhan84) was evaluated by the National Seed Board of Bangladesh (NSB) in the eight locations of farmers' field of Bangladesh in Proposed Variety Trial (PVT). Finally after proper evaluation, the NSB team found BR7831-59-1-1-4-5-1-9-P1 as a superior genotype in respect to high zinc content (27.6 mg/kg), grain yield, lodging tolerance, earlier than BRRI dhan28, long slender type grain and has been released as BRRI dhan84 in the year 2017. The data analyses of the experiments were done with software namely PBTools and Microsoft excel 2013 [10,11].

3. RESULTS AND DISCUSSION

3.1 Regional Yield Trial (RYT)

The agro-morphological characteristics of BRRI dhan84 is shown in Table 1. It has moderate plant height with BRRI dhan28 which indicates lodging tolerance. BRRI dhan84 has erect, long, dark green flag leaf which facilitates maximum solar light uptake. The Regional yield trial (RYT) of this line was conducted in nine BRRI Regional stations of Bangladesh. BR7831-59-1-1-4-5-1-9-P1 showed the maximum average yield (6.60 t/ha), followed by BRRI dhan28 (Table 1). High yield is the prime objective in developing modern rice varieties with an addition of high zinc content (27.6 mg/kg). BRRI dhan84 showed higher yield than the check variety in *Boro* 2014-15 seasons in RYT. This higher yield of BRRI dhan84 was due to its genetic potentiality of producing higher and longer grains per panicle than BRRI dhan28. Growth duration of BRRI dhan84 was found two days earlier than BRRI dhan28.

3.2 Advanced Line Adaptive Research Trial (ALART)

BR7831-59-1-1-4-5-1-9-P1 (BRRI dhan84), one advanced line and check variety BRRI dhan28 were evaluated in ten 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. Highest grain yield potentiality over check variety was found for BR7831-59-1-1-4-5-1-9-P1 in Habiganj (0.93 t/ha higher yield than the check variety) (Fig. 1). The result visualizes the higher yield potentiality of BRRI dhan84 over the check variety. On an average BRRI dhan84 yielded higher than BRRI dhan28. Both the genotypes were almost disease free in some locations. The strong plant

stature (97 cm) of the variety made it lodging tolerant. Growth duration was found two days earlier than the check variety BRRI dhan28. Farmers preferred BR7831-59-1-1-4-5-1-9-P1 for their better yield, shorter growth duration and high zinc content as well as long slender grain quality.

3.3 Proposed Variety Trial (PVT)

Performance of the BR7831-59-1-1-4-5-1-9-P1 (BRRI dhan84) at on farm trial, *Boro* 2016-17 season are shown in Table 3. Evaluation of the BR7831-59-1-1-4-5-1-9-P1 (BRRI dhan84) at on farm trial was performed by the National Seed Board (NSB) of Bangladesh in *Boro* 2016-17 season. The highest yield of the genotype was found with 7.86 t/ha at Monirampur, Jashore. The average grain yield indicated that the variety could be produce more with proper crop management. The grain yield range of BRRI dhan28 (Check) was found from 4.94 - 7.46 t/ha. On an average BRRI dhan84 produced 6.57 t/ha yield whereas BRRI dhan28 produced 6.33 t/ha yield, that is 0.24 t/ha higher for the variety (Table 3). Growth duration of BRRI dhan84 was ranged from 134 days to 146 days in depending on the agro climatic situation in the *Boro* season. Mean growth duration of the variety was found 140 days which is two days earlier than the check variety BRRI dhan28 (Table 3). Zinc content of BRRI dhan84 is 27.6 mg/kg which much higher than BRRI dhan28 (15.3 mg/kg) (Table 5).

3.4 Disease and Insect Reaction

BRRI dhan84 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 resistant to sheath blight disease and Blast (Table 4). For the insects the variety is also tolerant to brown plant hopper for the dead heart and white head symptoms. BRRI dhan28 also more or less showed similar symptoms.

Table 1. Morphological and agronomic characteristics of BRRI dhan84, on-station regional yield trial, *Boro* 2014-15

Designation	Plant height (cm)*	Growth duration (days)*	Grain yield (t/ha)*
BR7831-59-1-1-4-5-1-9-P1 (Proposed Variety BRRI dhan84)	96	141	6.6
BRRI dhan28 (Ck.)	95	143	6.3
LSD (0.05)	2.0	3.20	0.25
Heritability %	0.85	0.82	0.86

** Mean value of nine locations*

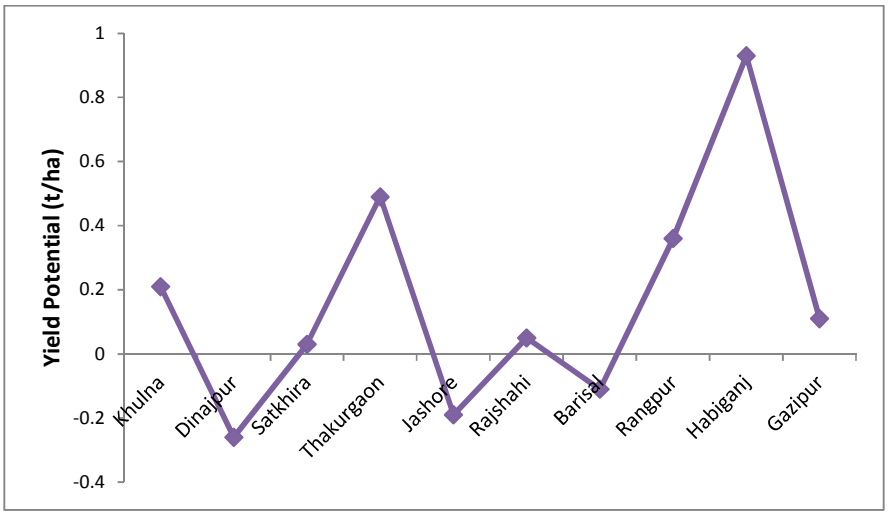

Fig. 1. Yield potential of BR7831-59-1-1-4-5-1-9-P1 (Proposed Variety BRRI dhan84) over check variety BRRI dhan28

3.5 Physico-chemical Properties

BRRI dhan84 is a long slender grain having length is 6.4 mm and breadth is 2.0 mm whereas the length of BRRI dhan28 is 6.3 mm and breadth is 1.9 mm. The milling outturn of the variety is 70% with the head rice recovery 53% which is nearly to the check variety (Table 6). BRRI dhan84 is straight and it could be milled in any kind of milling machine. This result revealed that BRRI dhan84 will get high market price because of zinc (27.6 mg/kg), long slender type grain like popular rice variety of BRRI dhan28. The protein and amylose percentage of BRRI dhan84 is 9.7 and 25.9% respectively (Table 6).

After proper evaluation by the National Seed Board of Bangladesh (NSB) in the eight locations of farmers' field of Bangladesh, BR7831-59-1-1-4-5-1-9-P1 has been released as BRRI dhan84 in the year 2017. The pictorial view of BRRI dhan84 in the field condition with its grain, \rice are shown in Figs. 2 and 3.

Table 2. Performance of the BR7831-59-1-1-4-5-1-9-P1 (BRRI dhan84) at different zonal trial in farmers' field, *Boro* 2015-16

Designation	Plant height (cm)*	Growth duration (days)*	Grain yield (t/ha)										
			Khulna	Dinajpur	Satkhira	Thakurgaon	Jashore	Rajshahi	Barisal	Rangpur	Habiganj	Gazipur	Average
BR7831-59-1-1-4-5-1-9-P1(Proposed Variety BRRI dhan84)	97	142	6.01	5.74	5.51	6.45	5.64	5.33	6.11	5.68	5.72	6.12	5.83
BRRI dhan28 (Ck.)	94	140	5.80	6.00	5.48	5.96	5.83	5.28	6.22	5.32	4.79	6.01	5.66
LSD (0.05)	1.88	2.31											0.15

** Mean value of ten locations*

Table 3. Performance of the BR7831-59-1-1-4-5-1-9-P1 (BRRI dhan84) at Proposed Variety Trial in farmers' field, *Boro* 2016-17

Locations	BR7831-59-1-1-4-5-1-9-P1		BRRI dhan28 (Check)	
	Growth duration (days)	Grain yield (t/ha)	Growth duration (days)	Grain yield (t/ha)
BRRI Farm, Gazipur	143	6.62	141	5.77
Silimpur, Bogra sadar	140	6.51	140	6.60
Kustia sadar	146	6.38	144	6.25
Habra, Dinajpur	148	5.73	149	5.46
Paba, Rajshahi	142	6.94	144	6.86
Monirampur, Jashore	136	7.86	136	7.46
Bhanga, Faridpur	134	6.93	137	7.10
Habiganj sadar	144	5.66	141	4.94
Mean	140	6.57	142	6.33
LSD (0.05)	1.65	0.18	1.65	0.18
Heritability %	0.86	0.79	0.86	0.79

Table 4. Reaction of the BRRI dhan84 against major diseases and insects under natural field condition, Boro 2016-17

Designation	BB	ShB	Blast	DH	WH
BR7831-59-1-1-4-5-1-9-P1 (Proposed Variety BRRI dhan84)	1	1	3	1	1
BRRI dhan28 (Ck.)	1	1	7	1	1

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

Fig. 2. Pictorial view of BRRI dhan84 in the field condition

Table 5. Reaction of the BRRI dhan84 against major diseases and insects under artificial condition, *Boro* 2016-17

Designation	BB	ShB	Blast	BPH	WBPH	GLH
BR7831-59-1-1-4-5-1-9-P1	5	7	3	5	3	7
BRRI dhan28 (Ck.)	5	7	7	9	5	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 6. Physico-chemical properties of BRRI dhan84

Designation	Milling Yield (%)	Head rice yield (%)	Decorticated grain				1000 grain wt (g)	Protein (%)	Amylose (%)	Zinc (mg/kg)
			Length (mm)	Breadth (mm)	L-B Ratio	Size and shape				
BR7831-59-1-1-4-5-1-9-P1 (BRRI dhan84)	70	53	6.4	2.0	3.3	LS	22.8	9.7	25.9	27.6
BRRI dhan28(Ck.)	71	60	6.3	1.9	3.3	LS	21.1	8.9	27.5	15.3

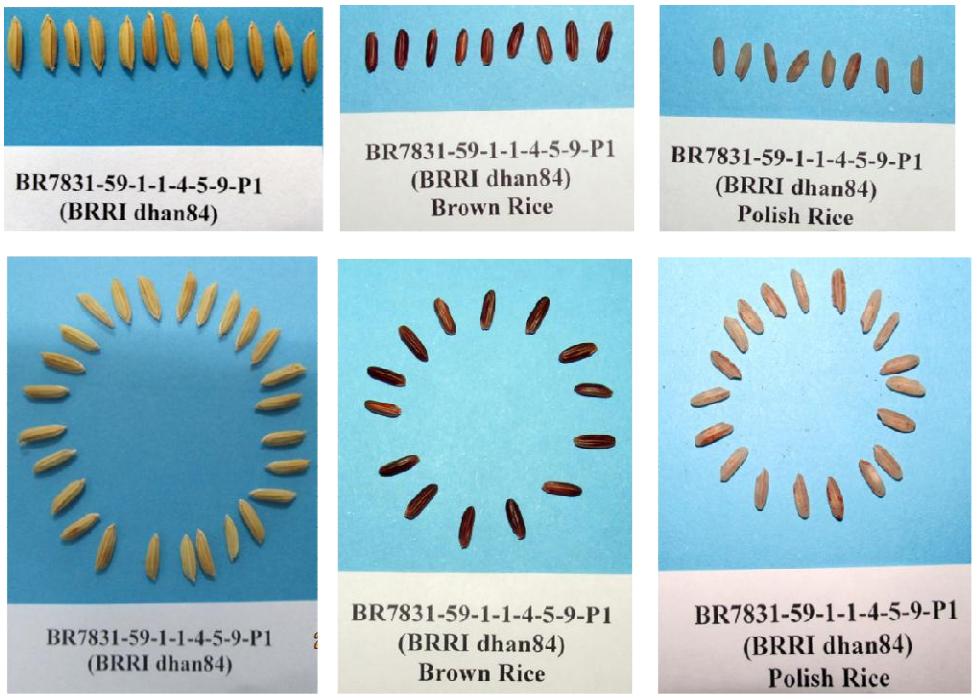

Fig. 3. Pictorial view of Rough Rice, Brown Rice and Plished Rice of BRRI dhan84

4. CONCLUSIONS

In conclusion, BRRI dhan84 was released as a great yielding, zinc improved 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 *Boro* (dry) season 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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