



BRRRI Dhan102: An Irrigated Ecosystem-Friendly Zinc-Enriched Rice Variety for Bangladesh

Md. Abdul Kader ^a, AKM Shalahuddin ^a,
Tapas Kumer Hore ^a, Ratna Rani Majumder ^a,
SM Tariqul Islam ^a, Md. Ehsanul Haq ^{a*}, Urmi Rani Shaha ^a,
Kaniz Fatema ^a, Partha Sarathi Biswas ^a
and Khandakar Md. Iftekharuddaula ^a

^a Plant Breeding Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An enhancement over already available zinc-enriched rice varieties for Bangladesh is the recently announced by BRRRI dhan102 class 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 2020-21 season. As a result, National Seed Board (NSB) approved this variety for commercial cultivation in the *Boro* season (dry season) in 2022. It was modern plant type with 103 cm plant height and matures by 150 days. The proposed variety showed 0.27 t/ha higher yield than check variety BRRRI dhan29. Identifying characters of this variety are green leaf, intermediate plant height, erect flag leaf, long slender grain, and intermediate

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

leaf senescence grain. In average, it can produce 8.10 t/ha grain yield, but it has potentiality to give 9.55 t/ha grain yield. Thousand grain weight of the variety is 22.7 gm and head rice yield is 62%. The rice has zinc content 25.5 mg/kg, 28% amylose content with 7.5% protein content. Farmers can be benefited financially from growing the zinc-enriched variety BRR1 dhan102 and the nation as a whole will be benefited nutritionally from its production throughout the Boro season (dry season).

Keywords: BRR1 dhan102; dry season; long slender grain; amylose; zinc enriched.

1. INTRODUCTION

“To achieve the development objectives of reducing poverty and boosting food security in Bangladesh depends heavily on the agricultural sector. Adoption of contemporary agricultural technologies, such as current rice varieties, is essential for reducing poverty and enhancing food security through promoting agricultural growth. Asia, where more than 90% of the world's rice is produced and consumed, is home to more than three billion people, who eat rice as a staple diet” [1]. “The primary staple food produced in Bangladesh is rice, which is also a key crop for ensuring food security. On high land to low land in three seasons, rice is farmed here all year long. In the middle of the 1960s, modern rice types were introduced in Bangladesh. To create contemporary rice varieties more suitable to local growing conditions, Bangladesh Rice Research Institute (BRR1) was founded in 1970” [2].

“But today, it's known that zinc deficiency is widespread, especially in underdeveloped nations” [3,4]. “According to estimates, zinc insufficiency affects two billion people worldwide. The fifth most common reason for the loss of healthy life years in developing nations is zinc deficiency. In industrialized nations, zinc deficiency primarily affects the older population” [5]. It is estimated that the elderly make up around 30% of the population who is zinc deficient. Since it is well recognized that zinc homeostasis plays a crucial role in immune responses like the inflammatory response and the oxidative stress response, many chronic diseases seen in the elderly are likely caused by zinc shortage. Therefore, a zinc shortage may contribute to diseases including Rheumatoid Arthritis, diabetes, atherosclerosis, reduced cognitive function, and age-related macular degeneration (AMD), by aggravating chronic inflammation and inducing oxidative stress [6]. Importantly, animal studies show that thymic atrophy, lymphopenia, and faulty lymphocyte responses are signs of immune

system damage brought on by zinc deficiency [7]. These findings highlight how crucial zinc nutrition is, especially in developing nations where subpar sanitation, public health, and immunization practices increase the risk of infection [8].

Rice quality and yield are influenced by management approaches, the surrounding environment, and the hereditary potential of cultivars. To increase rice output, choosing the proper type of variety is one of the most important factors. Changes in growth conditions, such as diverse growing regions, seasonal variations, unique planting dates, and so on, affect rice yield [9]. Therefore, it is crucial to assess how well different rice varieties perform using the right cultural techniques in order to get the highest yield and quality possible throughout trials across multiple areas. One of the most essential strategies for addressing the anticipated rise in global demand for rice is the creation of cultivars with high yielding potential [10]. Numerous studies have been conducted on specific rice varieties, but few have compared the morpho-physiological traits of rice cultivars grown in Bangladesh throughout the Boro season. In order to meet national need, this research work provides an account of the growth and yield performance of a new high yielding zinc rice variety. It also discusses the relationship between grain yield and trial locations as well as the variety's morpho-physiological characteristics. The breeding practices, parental lineage, agro-morphological traits, and grain quality of BRR1 dhan102 are all described in this research article.

2. MATERIALS AND METHODS

BRR1 dhan102 was developed from multiple crosses between IR 91153-AC 117/IR05F102//IR 68144-2B-2-2-3-1-166//IR 66/4/NSIC RC 158/NEGRO//BRR1 dhan29 at International Rice Research Institute (IRRI) with a hope to develop zinc enriched rice variety and the pedigree of BRR1 dhan102 is IR99285-1-1-1-P2. In 2014

Bangladesh Rice Research Institute (BRRI) collected this advanced line from International Rice Research Institute (IRRI) through Introduction method. At BRRI four year evaluation with standard check variety IR99285-1-1-1-P2 promising line was subjected to Regional Yield Trial (RYT) to evaluate specific and general adaptability with standard check variety 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 IR99285-1-1-1-P2 was subjected to Advanced Line Adaptive Research Trial (ALART) to evaluate specific and general adaptability with standard check BRRI dhan29 and BRRI dhan84 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 2020-21, IR99285-1-1-1-P2 (proposed as BRRI dhan102) 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 IR99285-1-1-1-P2 as a superior genotype in respect to high zinc content (25.5 mg/kg), long slender type grain with higher grain yield compared to check variety BRRI dhan29 and has been released as BRRI dhan102 in 2022. The data analyses of the experiments were done with software namely PTools and Microsoft excel 2013 [11,12].

3. RESULTS AND DISCUSSION

3.1 Regional Yield Trial (RYT)

The agro-morphological characteristics of BRRI dhan102 is shown in Table 1. It has intermediate plant height which indicates lodging tolerance. BRRI dhan102 has erect, long, green flag leaf which facilitates maximum solar light uptake. The Regional Yield Trial (RYT) of this line was conducted in eight BRRI regional stations of Bangladesh. IR99285-1-1-1-P2 have a growth duration of 159 days with 101 cm plant height. IR99285-1-1-1-P2 showed the maximum average yield (7.17 t/ha), followed by BRRI

dhan29 and BRRI dhan84 (Table 1). High yielding is the prime objective in developing modern rice varieties with an addition of high zinc content (25.5 mg/kg). BRRI dhan102 showed higher yield than the check varieties in Boro 2018-19 season in RYT. This higher yield of BRRI dhan102 was due to its genetic potentiality of producing higher and longer grains per panicle than check varieties.

3.2 Advanced Line Adaptive Research Trial (ALART)

IR99285-1-1-1-P2 (BRRI dhan102) one advanced line and check varieties BRRI dhan29, BRRI dhan84 were evaluated in ten locations at the farmers' field of Bangladesh. Results are showed in the Table 2. IR99285-1-1-1-P2 gave higher yield in four locations compared to check variety BRRI dhan29, it gave 9.12 t/ha in Faridpur, 7.80 t/ha in Feni, 6.72 t/ha in Rajshahi and 7.00 t/ha in Sherpur. Highest grain yield potentiality was found for IR99285-1-1-1-P2 in Faridpur (9.12 t/ha) (Table 2). Also, it gave higher yield in all locations compared to the check variety BRRI dhan84. The result shows the yield potentiality of IR99285-1-1-1-P2 (BRRI dhan102) over the check varieties. On an average, IR99285-1-1-1-P2 (BRRI dhan102) yielded parallel to BRRI dhan29 but significantly higher than BRRI dhan84. IR99285-1-1-1-P2 was almost disease free in some locations. The strong plant stature (103 cm height) of the advanced line made it lodging tolerant. Growth duration was found two days earlier than the check variety BRRI dhan29 and 13 days earlier than the check variety BRRI dhan84. Farmers preferred IR99285-1-1-1-P2 for its high yielding capability, acceptable growth duration and high zinc content as well as long slender grain quality.

3.3 Proposed Variety Trial (PVT)

Performance of the IR99285-1-1-1-P2 (BRRI dhan102) at on farm trial, Boro 2020-21 season are shown in Table 3. Evaluation of the IR99285-1-1-1-P2 (BRRI dhan102) at on farm trial was performed by the National Seed Board (NSB) of Bangladesh in Boro season 2020-21. The highest yield of the proposed line was found with 9.55 t/ha at BINA, Mymensingh. The average grain yield 8.11 t/ha indicated that the variety could be produce more with proper crop management. The grain yield range of BRRI dhan29 (Check) was found from 6.45-9.88 t/ha. IR99285-1-1-1-P2 (BRRI dhan102) gave yield

8.68 t/ha in BRRI, Gazipur; 8.90 t/ha in BRRI R/S, Faridpur; 7.81 t/ha in Jashore; 7.39 t/ha in Feni; 7.84 t/ha in Cumilla; 7.07 t/ha in Bogura; 6.38 t/ha in Barishal; 8.43 t/ha in BRRI R/S, Rangpur and 9.07 t/ha in Dinajpur. On an average BRRI dhan29 produced 7.84 t/ha yield whereas IR99285-1-1-1-P2 (BRRI dhan102) produced 8.11 t/ha yield, that is 0.27 t/ha higher

for the variety (around 4% higher yield) (Table 3). Growth duration of IR99285-1-1-1-P2 (BRRI dhan102) was ranged from 141 days to 167 days in depending on the agro climatic situation in the Boro season. Mean growth duration of the proposed variety was found 150 days which is two days earlier than the check variety BRRI dhan29 (Table 3).

Table 1. Morphological and agronomic characters of the proposed variety at regional yield trial, Boro 2018-19

SN	Designation	Plant height* (cm)	Growth duration* (days)	Grain yield* (t/ha)
1	IR99285-1-1-1-P2 (Proposed Variety)	101	159	7.17
2	BRRI dhan29 (Ck)	96	156	7.05
3	BRRI dhan84 (Ck)	101	142	6.04
	LSD at 5%	2.35	5.42	0.61
	Heritability	0.81	0.75	0.77

* Mean value of eight locations

Table 2. Performance of the IR99285-1-1-1-P2 (BRRI dhan102) at different zonal trial in farmers' field, Boro 2019-20

Designation	Plant height (cm)	Growth duration (days)	Grain yield (t/ha)										Mean
			L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	
IR99285-1-1-1-P2 (proposed variety)	103	160	7.42	9.12	7.80	6.72	7.12	6.62	7.46	7.32	7.00	6.39	7.37
BRRI dhan29 (Ck)	103	162	7.52	9.03	7.26	6.47	7.28	7.62	7.66	8.23	6.63	6.76	7.43
BRRI dhan84 (Ck)	103	147	5.93	5.07	6.12	4.57	6.51	3.01	6.57	6.61	6.27	5.83	5.94
LSD at 5%	1.0	0.21	0.52										0.17

*Mean of ten locations (L1= Jhalokathi, L2= Faridpur, L3= Feni, L4= Rajshahi, L5= Rangpur, L6= Habiganj, L7= Satkhira, L8= Kushtia, L9= Sherpur, L10= Gazipur)

Table 3. Performance of proposed variety in Proposed Variety Trial (PVT) at ten locations, Boro, 2020-21

Locations	IR99285-1-1-1-P2 (proposed variety)		BRRI dhan29 (Ck)		% Yield advantage than BRRI dhan29
	Growth duration (days)	Grain yield (t/ha)	Growth duration (days)	Grain yield (t/ha)	
BRRI, Gazipur	153	8.68	156	7.53	15.27
BINA, Mymensingh	150	9.55	152	8.59	11.18
BRRI R/S, Faridpur	151	8.90	151	9.88	-9.92
Jashore	146	7.81	150	7.36	6.11
Feni	141	7.39	142	6.83	8.20
Cumilla	142	7.84	144	8.04	-2.49
Bogura	149	7.07	150	6.99	1.14
Barishal	145	6.38	147	6.45	-1.09
BRRI R/S, Rangpur	167	8.43	167	8.11	3.95
Dinajpur	159	9.07	159	8.57	5.83
Range	141-167	6.38-9.55	142-167	6.45-9.88	-9.92 to 15.27
Mean	150	8.11	152	7.84	3.82 (8.42% higher in top six locations)

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

3.4 Disease and Insect Reaction

IR99285-1-1-1-P2 (BRRi dhan102) 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 0 and blast score 0, meaning it is tolerant to bacterial blight and blast disease (Table 4). Under artificial inoculated condition IR99285-1-1-1-P2 (BRRi dhan102) showed less score than BRRi dhan29, meaning it is more tolerant to blast disease compared to BRRi dhan29 (Table 5).

3.5 Physicochemical Properties

BRRi dhan102 is a long slender grain having length is 6.2 mm and breadth is 2.0 mm. The milling outturn of the variety is 70% with the head rice recovery 62%. BRRi dhan102 is straight and it could be milled in any kind of milling machine. This result revealed that BRRi dhan102 will get high market price because of zinc (25.5 mg/kg), long slender type grain. The protein and amylose percentage of BRRi dhan102 is 7.5 and 28% respectively (Table 6).

Distinguishing characters of the candidate variety IR99285-1-1-1-P (BRRi dhan102) compared to

the similar variety e.g. BRRi dhan81 are penultimate leaf : pubescence of blade, Panicle: length, Panicle: exertion, Grain: length (without dehulling), Decorticated, unpolished grain: color and high zinc containing distinct special character (if any) (Table 7).

3.5.1 Uniformity

At 50% heading date time only 0.5% off-type was observed. It indicated that the candidate variety IR99285-1-1-1-P2 is uniform according to UPOV standard.

3.5.2 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, BR8631-12-3-5-P2 has been released as BRRi dhan102 in the year 2022. The pictorial view of BRRi dhan102 in the field condition with its grain, rice are shown in Figs. 1 and 2.

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

Designation	Disease and insect severity score					
	BB	ShB	Blast	BPH	WBPH	GLH
IR99285-1-1-1-P2 (proposed variety)	0	3	0	0	0	0
BRRi dhan29 (Ck)	1	3	0	0	0	0

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)



Fig. 1. Pictorial view of IR99285-1-1-1-P2 (BRRi dhan102) in the field condition

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

Designation	Disease and insect severity score					
	BB	ShB	Blast	BPH	WBPH	GLH
IR99285-1-1-1-P2 (proposed variety)	7	9	7	9	5	7
BIRRI dhan29 (Ck)	7	9	9	9	7	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 6. Physico-chemical 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	Zinc (mg/kg)	Amylose (%)	Protein (%)	ER	IR
IR99285-1-1-1-P2 (proposed variety)	70	62	6.2	2.0	3.1	LS	25.5	28.0	7.5	1.3	4.1
BIRRI dhan29 (Ck)	70	61	6.0	2.0	3.0	MB	18.2	26.9	7.0	1.4	4.5

ER: Elongation Ratio, IR: Imbibition Ratio

Table 7. Distinctness between IR99285-1-1-1-P2 (proposed variety) with similar variety BIRRI dhan81

SN	Characteristics	BIRRI dhan81 (check variety)		IR99285-1-1-1-P2 (proposed variety)		Remarks
		Code	State	Code	State	
01	Penultimate leaf : Pubescence of blade	3	Weak	5-7	Medium-Strong	Distinct
02	Panicle: Length	5	Medium	7	Long	Distinct
03	Panicle: Exertion	7	Moderate	5	Just	Distinct
04	Grain: Length (without dehulling)	7	Long	9	Very Long	Distinct
05	Decorticated, unpolished grain: Color	2	Light brown	1	White	Distinct
06	If any	Zn enriched (17.52 mg/kg)		Zn enriched (25.5 mg/kg)		Distinct



Fig. 2. Pictorial view of rough rice and polished rice of IR99285-1-1-1-P2 (BIRRI dhan102)

4. CONCLUSIONS

To sum up, BRR1 dhan102 was made available as a high yielding, zinc-enriched rice variety to satisfy the nation's desire for nutrition. 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. This zinc rice type is projected to improve Bangladesh's nutritional status. This cultivar can be grown by farmers in an irrigated condition, which will boost overall yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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