

Development of high-yielding fine grained rice variety BRRI dhan108 for irrigate boro areas of Bangladesh

Abstract

Increasing yield potential of rice is vital to feed the growing population and rain quality improvement is also important. Therefore, Bangladesh Rice Research Institute (BRRI) has developed a high-yielding rice variety BRRI dhan108 with fine grain for Boro season. BRRI dhan108 has been developed by hybridization between IR 80561 and China inbred 321- followed by pedigree selection. Under RYT, this line was evaluated in 2021, as well as it was evaluated under ALART in 2022. Then, it was evaluated in the Proposed Variety Trial (PVT) with standard checks BRRI dhan100 in 10 locations. From 2021 to 2023, mean yield of proposed variety was 7.6 t ha⁻¹ in RYT, 6.8 t ha⁻¹ in ALART and 8.5 t ha⁻¹ in PVT in respect to 7.6 t ha⁻¹ yield of check variety Bangabandhu dhan100. This variety gave around 1.0 t/ha yield advantage than check variety BRRI dhan100. The lodging score (3) of BRRI dhan108 indicating its better performance than other check varieties. A high spikelet density and promising morphological traits (good plant type, good tillering ability (17), erect flag leaves, long and wide flag leaves of BRRI dhan108 indicated its superiority over check varieties. BRRI dhan108 has lesser thousand grain weight of only 16.3 gm compared with 1000 grain weight of Zira (17.3 gram)- whereas the grain breadth of BRRI dhan108 is only 1.7 mm compared with grain breadth of BRRI dhan100. The lower breadth indicates less degree of polishing will be required for BRRI dhan108 during milling. This grain quality feature will be preferable to millers for marketing clean rice without over-polishing. Therefore, farmers can be economically more benefited for fine grain and higher yield of BRRI dhan108. Thus, the higher yield potentiality and fine grain type of BRRI dhan108 suggested its suitability to replace low-yielding Jira rice in northern districts of Bangladesh.

Keywords: Yield contributing traits, morphological traits, high spikelet density, over-polishing, outer endospermic layer.

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A S M Masuduzzaman,¹ Nusrat Jahan,²
Afroza Awal Shoily,³ Khandakar Md.
Iftakharuddaula,¹ Sheikh Maniruzzaman,⁴ A K
M Shalahuddin,⁴ T. Yeasmin⁵

¹Chief Scientific Officer, Plant Breeding Division, Bangladesh Rice Research Institute (BRRI), Bangladesh

²Scientific Officer, Plant Breeding Division, Bangladesh Rice Research Institute (BRRI), Bangladesh

³Scientific Officer (TRB-BRRI), Plant Breeding Division, Bangladesh Rice Research Institute (BRRI), Bangladesh

⁴Senior Scientific Officer, Plant Breeding Division, Bangladesh Rice Research Institute (BRRI), Bangladesh

⁵Research Assistant, Environmental Science and Disaster Management Department, Noakhali Science and Technology University, Bangladesh

Correspondence: A S M Masuduzzaman, Chief Scientific Officer, Plant Breeding Division, Bangladesh Rice research Institute (BRRI), Gazipur-1701, Bangladesh, Email masudbrri@gmail.com

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Abbreviations: BRRI, bangladesh rice research institute; BBS, bangladesh burro of statistic; RYT, regional yield trial; ALART, advanced line adaptive research trial; PVT, proposed variety trial; NSB, national seed board.

Introduction

¹Bangladesh ranks as the third-largest producer of rice globally, reaching about 39.1 million tons in 2023. The country had become basically self-sufficient in food grain production in recent years. From 1970 to 2023, area planted to rice increased slightly; but rice production increased about 4.0 times more from the base period- as a result of adoption of modern varieties and technologies developed by BRRI, increased irrigated areas and increased use of production inputs. Modern varieties spread to 97% of irrigated boro areas and widely cultivation of varieties BRRI dhan28 and BRRI dhan29 was the major breakthrough of yield increase in favorable boro areas of Bangladesh.² Now, yield of modern varieties are now stagnant or declining.³ So, yield potential of a variety needs to be increased. Future revolution in rice production should arise from the productivity increase in favorable irrigated boro areas. Breeders are working to develop very high yielding rice varieties for favorable (Boro) areas. BRRI-IRRI-CSISA and NATP-PIU-BARC project started 'high yielding rice breeding program' and developed a number of improved rice genotypes (300-350 filled grains/panicle) those provided yield more than BRRI dhan28 and 63. Efforts were taken to release the most promising one as a variety.

Rice is the major crop, but income from rice is comparatively lower. Grain quality improvement is important because it enhances consumer's welfare and expands market potential.⁴ In recent years, scientists and breeders have focused on improving the quality of rice for different purposes and markets. There is a demand of fine grain Jira type rice in domestic market of Bangladesh. These varieties command high prices and can increase the purchasing capacity of the farmers. Jira type paddy is widely grown in Northern districts for its fine grain and better price.⁵ Many northern region paddy traders are now selling polished rice varieties in the name of Jira. The Department of Agricultural Marketing (DAM) revealed that above 5.17 million tons of rice are wasted in the country every year for over-polishing. In this context, there is a need to develop fine grain rice that might be beneficial to reduce over-polishing of rice. Most of the released boro varieties are not Jira grain type. Fine-grain modern varieties should be developed for irrigated boro areas. Bangladesh Rice Research Institute (BRRI) has placed emphasis to development of fine grain rice varieties with higher yield. BRRI recently released fine grain BRRI dhan108 aims to increase income of our farmers, consumer's welfare and cope with the over-polishing of rice grain.

CSISA and NATP-PIU-BARC project- utilized ideotype breeding approaches and developed high yielding fine grain genotypes. Then, efforts were taken for conducting different multi-location yield trials during boro season for select best high yielding genotype with fine grain. Regional Yield Trial (RYT), Advanced Line Adaptive Research Trial (ALART) and Proposed Variety Trial (PVT) were conducted.

National Seed Board (NSB) approved BRR1 dhan108 in 2024 for commercial cultivation in the Boro season throughout the country. Transfer and uptake of technologies were greatly enhanced by farmer's participation in variety selection process. High-yielding rice variety BRR1 dhan108 gave better yield over existing check varieties. Therefore, this research paper has described those adaptive trials in different agro-ecological conditions in Bangladesh. Finally, BRR1 dhan108 was evaluated in respect to improved yield contributing in different locations with some morphological and yield contributing traits analysis.

Materials and Methods

BRR1 dhan108 is an outcome of a single cross between two breeding lines IR 80561 (fine grain) x Chinese inbred 321 (higher yield) with a hope to develop a HYV Jira type fine grained rice variety. The pedigree of BRR1 dhan108 is BRH11-9-11-4-5B having a yield potential of 10 tons/hectare and medium slender fine grain. The crossing was done in 2012 and fixed line was developed through

hybridization followed by modified bulk and pedigree selection under NATP-PIU-BARC project.

Multi-location yield trials and disease-insect scoring

Advanced breeding line BRH11-9-11-4-5B was evaluated along with standard check BRR1 dhan63 and Bangabandhu dhan100 in Regional yield Trail (RYT), ALART (Advanced Line Adaptive Research Trail) and Proposed Variety Trail (PVT). The promising line BRH11-9-11-4-5B was subjected to a multi-location trial over 3 years to evaluate specific and general adaptability with standard check variety in Randomized Complete Block (RCB) design with three replications at farmers' field conditions during Boro season.

Seedlings were raised in seed-beds and 25-35 days old seedlings were transplanted in paddled field at a spacing of 25 cm x 15 cm (2-3 seedling per hill). Recommended doses of fertilizer were applied (Table 1) in proper doses and proper time. Better agronomic practices and intensive care were taken for yield trails in farmer's field. Hand weeding and irrigation were done in proper time.

Table 1 Fertilizer application time, splits and amount under improved management practices

Fertilizer	Total fertilizer kg/bigha	Basal application kg/bigha	Top dressing time and amount kg/bigha		
			1 st , 5-7 DAT	2 nd , 30-35 DAT	3 rd , 50-55 DAT, before PI
Cow dung	600	600	-	-	-
Urea	42	14	-	14	14
MoP	20	15	-	-	5
TSP	17	17	-	-	-
Gypsum	15	15	-	-	-
Zn	1.5	1.5	-	-	-

1 bigha, 1338 square meter, DAT, days after transplanting; PI, panicle initiation

Grain yield data was taken from 10 sq-m sample plot in each replication. Other yield-contributing traits were taken, after harvesting crop at 90% maturity (no grain drops out, as it has highly shattering tolerance). Growth duration was counted from seeding to 90% grain maturity.

Materials were scored for disease-insect resistance in natural conditions.

Yield contributing and morphological traits of BRR1 dhan108

BRR1 dhan108 with check varieties were grown during Boro season, 2021. The experiment was laid out in RCB design with 3 replications at BRR1, Gazipur. Seedlings were raised in seedbeds and 25-35 days old seedlings were transplanted in paddled field at a spacing of 25 cm x 15 cm (2-3 seedling per hill) following RCB design in 3 replications in boro season. Recommended doses of fertilizer were applied (Table 1) in proper doses and proper time. Full dose of TSP, Gypsum and ZnSO₄ was applied as basal; Urea top dressing time during boor season: 1st at 5-7 days after seeding (DAS), 2nd at 30-35 DAS and 3rd before booting stage. Hand weeding and irrigation were done in proper time. BRR1 dhan108 was evaluated with checks for yield contributing (Panicle length, cm; tiller per hill; filled grain per panicle) and morphological traits (Flag leaf length, cm; Flag leaf breadth, cm; lodging score 1 to 9; diameter of lower inter-node; length of lower inter-node; and flag leaf angle).

Physico-chemical properties

Grain physico-chemical properties and cooking qualities were measured. Grain was harvested at maturity and samples were then dried. Clean grain samples were used for analysis using standardized methods by GQN Division. Physical properties estimates are: milling yield (%), head rice yield (%), grain length (mm) and breadth (mm) and thousand grain weight (grams). Chemical properties estimates are: protein (%) and amylose content (%). Cooking qualities estimates are: imbibitions ratio and elongation.

Data analysis

All traits related to yield were examined from mean of each of three replicated samples. The data analyses of the experiments were done with software namely PBTtools (Version 1.3) and Microsoft excel 2019.

Results and Discussion

Regional yield trial (RYT)

The Regional Yield Trial (RYT) was conducted in twelve BRR1 regional stations. BRR1 dhan108 has growth duration of 147 days with 94 cm plant height. BRR1 dhan108 showed the maximum average yield (7.6 t/ha), followed by BRR1 dhan63 (Table 2). High yielding is the prime objective in developing modern rice varieties with an addition of Jira type grain. BRR1 dhan108 showed a higher

yield than the check varieties in Boro 2020-21 season in RYT. This higher yield of BRRI dhan108 was due to its genetic potentiality of producing higher grains per panicle than check varieties.

Table 2 Performance of the proposed lines at regional yield trial (RYT), Boro, 2020-21

Designation	GD	PH	Location-wise Yield (tha ⁻¹)												yield (tha ⁻¹)
			Bar	Bha	Cum	Gaz	Hab	Kus	Raj	Ran	Sat	Srj	Son	Gop	
BRRI dhan108	147	94	6.6	9.3	6.9	9.0	7.0	7.5	6.3	6.6	7.6	8.6	6.8	9.0	7.6
BRRI dhan63	146	87	6.4	8.4	6.6	7.8	6.8	7.9	6.4	6.8	6.3	9.0	6.7	9.2	7.3

*GD, Growth duration (days); PH, Plant height (cm); BAR, Barishal; BHA, Bhanga, Faridpur; Cum, Cumilla; Gaz, Gazipur; Hab, Habiganj; Kus, Kustia; Raj, Rajshahi; Ran, Rangpur; Sat, Satkhira; Srj, Sirajganj; Son, Sonagazi, Feni; Gop, Gopalganj

Advanced line adaptive research trial (ALART)

The advanced line BRH11-9-11-4-5B (BRRI dhan108) with check varieties BRRI dhan63 and local check Zira were evaluated in twelve locations at the farmers' field of Bangladesh in Boro, 2021-22 led by Adaptive Research Division, BRRI. The advanced line BRH11-9-11-4-5B (BRRI dhan108) gave a higher yield in each of the locations

compared to cheek variety BRRI dhan63 and local check Zira. It gave highest 7.7 tha⁻¹ yield in Sirajganj and Rangpur, whereas lowest yield in Habiganj (5.6 tha⁻¹) (Table 3). On average, the variety yielded significantly higher than BRRI dhan63 and Zira. Growth duration was found 2-3 days later than cheek variety BRRI dhan63 and Zira. Farmers preferred BRH11-9-11-4-5B (BRRI dhan108) for its high yielding capability acceptable growth duration.

Table 3 Grain yield, Growth duration and plant height under ALART (SHR) in Boro, 2021-22

Designation	GD	PH	Location-wise Yield (tha ⁻¹)													Yield tha ⁻¹
			Go	Raj	Srj	Gaz	Ha	Sat	Ku	Ran	Cu	Ba	Bh	So		
BRH11-9-11-4-5B	149	101	7.3	7.6	7.7	7.1	5.6	5.6	6.6	7.7	6.2	6.9	7.5	6.2	6.8	
BRRI dhan63 (CK)	148	91	6.1	6.8	7.2	6.8	5.0	5.5	6.5	7.3	5.6	6.2	7.3	6.1	6.4	
Jira (CK)	146	105	5.3	4.8	6.5	5.2	4.5	5.5	5.7	5.9	5.0	5.6	5.2	5.8	5.4	
LSD 0.05	1.01	6.11	0.96													0.28
CV%	0.41	3.67	9.35													

*GD, Growth duration (days); PH, Plant height (cm); Locations- Go, Gopalganj; Raj, Rajshahi; Srj, Sirajganj; Gaz, Gazipur; Hab, Habiganj; Sat, Satkhira; Kus, Kustia; Ran, Rangpur; Cu, Cumilla; Ba, Barishal; Bh, Bhanga, Faridpur; So, Sonagazi, Feni

Proposed Variety trial (PVT)

In Boro 2022-23 seasons, performance of the advanced line BRH11-9-11-4-5B (BRRI dhan108) under on-farm trial with check variety Bangabandhu dhan100 are shown in Table 4. The trial was conducted in ten locations at the farmers' field supervised by the National Seed Board (NSB) of Bangladesh. The highest yield of the proposed line was found with 10.2 in Jashore sadar followed by 9.9 t/ha in BRRI, Rangpur. The average grain yield 8.51 t/ha indicated that the variety could produce more yield with proper crop management. The grain yield range of Bangabandhu dhan100 (Check) was found from 7.9-8.8 t/ha. On average, Bangabandhu dhan100 produced 7.60

t/ha yield whereas BRH11-9-11-4-5B (BRRI dhan108) produced 8.70 t/ha yield, that is 1.10 t/ha higher for the variety (around 14.5% higher yield). For instance, in each of the location, there was yield advantage ranged from 25.87% (Jashore Sadar) to 8.60% (Bogura Sadar). Growth duration was ranged from 139 days (Barishal) to 155 days (Faridpur) depending on the agro-climatic situation in the Boro season. Mean growth duration of the proposed variety was found 146 days which delayed for four days than the check variety Bangabandhu dhan100 (Table 4). After PVT evaluation, the NSB team found BRH11-9-11-4-5B as a superior genotype in respect to higher grain yield compared to check variety and released as BRRI dhan108.

Table 4 Performance of the proposed line at proposed variety trial (PVT), Boro, 2022-23

Locations	Proposed Variety		Check		Yield increase (%) over check
	BRRI dhan108		Bangabandhu dhan100		
	Duration (Days)	Yield (tha ⁻¹)	Duration (Days)	Yield (tha ⁻¹)	
BRRI, Gazipur	150	7.9	144	6.7	17.91%
BRRI, Faridpur	155	9.4	144	8.2	14.63%
Sadar Jashore	149	10.2	145	8.1	25.92%
Sadar Feni	143	8.8	142	7.6	15.79%
Laksham, Cumilla	139	8.1	134	6.5	24.61%
Bogura Sadar	148	8.1	143	7.4	9.45%
Babuganj, Barishal	139	7.8	129	6.8	14.70%
BRRI, Rangpur	152	9.9	145	8.8	12.50%
Sadar, Dinajpur	145	8.6	145	7.1	22.12%
Average	146	8.7	142	7.6	17.51%

Yield contributing and morphological traits analysis

The yield contributing and morphological characteristics of BRR1 dhan108 compared with check varieties are shown in Table 5. The lodging score (3) of BRR1 dhan108 indicates its better lodging tolerance performance than other check varieties. BRR1 dhan108 has good plant type, good tillering ability (17), and more filled grains per panicle (250) than check varieties. An average of 250 filled grains per panicle of BRR1 dhan108 is much more than check variety BRR1 dhan100.⁶ A high spikelet density in BRR1 dhan108 contributed to

the better yield.^{6,7} Genotypes with a higher number of effective tillers per plant and lodging tolerance could produce higher grain yields.⁸ The research findings shows that higher spikelet number per panicle is correlated with yield. Promising morphological traits (erect flag leaves, long and wide flag leaves,) of BRH11-9-11-4-5B indicated its superiority over check varieties. These findings suggest that those traits could be useful in breeding program for yield improvement of rice.⁹⁻¹¹ Direct selection of yield-related traits has been used as an effective strategy for yield improvement.

Table 5 Yield contributing and morphological character of BRR1 dhan108 with check Bangabandhu dhan100, BRR1 dhan63 and Zirashail, Boro 2022-2023

Genotypes	Pan Length, cm	Tillers per hill	Filled spikelet per Panicle	FLL, cm	FLB,cm	Log score	Dia LI	Length LI	FL Angle
BRR1 dhan108	26.5	17	250	37	1.6	3	10	3	<30 degree
Bangabandhu dhan100	23.5	14	165	33	1.3	5	8	4	> 30 degree
BRR1 dhan63	22.8	14	167	28	1.4	5	8	6	> 30 degree
Jira	21.6	12	140	32	1.3	7	7	7	> 30 degree

* Pan Length cm, panicle length (cm); FLL cm, flag leaf length (cm); FLB cm, flag leaf breath (cm); Log, lodging score(1 to 9); Dia LI, diameter of lower internode; Length LI, length of lower internode, FL Angle, flag leaf angle

Disease and insect reaction

BRR1 dhan108 showed tolerance to major diseases and insects under the natural field condition and artificial inoculated condition. The variety showed score 3 for each of the diseases bacterial blight,

sheath blight and blast, meaning it is highly tolerant to the mentioned disease (Table 6). The variety also showed moderate tolerance to brown plant hopper and susceptible reaction to green leaf hopper and WBPH. BRR1 dhan63 also showed more susceptible symptoms.

Table 6 Disease and insect reaction of BRR1 dhan108 in comparison with standard checks Bangabandhu dhan100 and BRR1 dhan63 and Local check Zirashail

SI No.	Genotypes	Field condition					Artificial inoculated condition						
		BB	ShB	Blast	BPH	GLH	WBPH	BB	ShB	Blast	BPH	GLH	WBPH
1	BRR1 dhan108	3	3	3	5	5	7	3	5	3	5	5	7
2	Bangabandhu dhan100	5	5	5	9	7	7	5	5	5	7	7	7
3	BRR1 dhan63	5	7	5	9	7	7	5	5	5	9	7	7
4	Jira	5	7	7	7	7	9	5	7	7	7	7	7

*BB, bacterial blight; ShB, sheath blight; BPH, brown plant hopper; GLH, green leaf hopper; WBPH, white backed plant hopper. Disease and pest severity scale (1 – 9). Score 1 for best and 9 for poor.

Physico-chemical properties of BRR1 dhan108

BRR1 dhan108 has medium slender grain having a length-breadth ratio of 3.2. The milling outturn of the variety was 72.0% with the

head rice recovery 65.0% and apparent amylose content 24.5%- its cooked rice is non-sticky. The unique and very special feature of the variety is its thousand grain weight that is only 16.3 gram (Table 7).

Table 7 Physico-chemical grain quality of BRR1 dhan108 in comparison with standard checks Bangabandhu dhan100 and BRR1 dhan63 and local check Jira

SI No.	Genotypes	MY	HRY	LEN	BR	L/B Ratio	Shape	ER	IR	PRO	TGW	AAC
1	BRR1 dhan108	72	65	5.5	1.7	3.2	MS	1.2	4.3	8.8	16.3	24.5
2	Bangabandhu dhan100	70	64	5.4	1.9	2.8	MB	1.3	4.5	7.8	18.7	26.4
3	BRR1 dhan63	71	54	6.8	1.6	4.3	LS	1.4	4.7	7	21.7	26.3
4	Jira	69	47	6.1	1.7	3.5	LS	1.4	4.3	7.3	17.3	26.8

*MY, milling Yield (%); HRY, head rice yield (%); LEN, length (mm); BR, breadth (mm);IR, imbibition Ratio; ER, elongation ratio; IM, intermediate medium; SM, short medium; PRO, protein (%);TGW, thousand grain weight(gram);AAC, aparent amylose content (%)

The field of BRR1 dhan108 showed uniform flowering and the grain type is medium slender as like as Jira dhan (Figure 1 to Figure 6). BRR1 dhan108 can be a well-suited combination for finer grain shape, and higher yield compared with other check varieties. BRR1 dhan108 has a lesser thousand grain weight of only 16.3 gm compared with 1000 grain weight of Zira (17.3 gram); the grain breath of BRR1 dhan108 is 1.7 mm compared with 1.9 mm grain breath of BRR1 dhan100- the lower breath indicates less degree of polishing will be required for BRR1 dhan108 during grain milling. This grain quality feature will be preferable to millers for marketing clean rice without over-polishing

as like as traditional Jira cultivar. This new rice variety could replace low-yielding Jira rice in northern districts. Thus, consumers would be able to take health benefits by consuming the vitamin and mineral rich outer endospermic layer of dhan108. Outer layers are rich in dietary fiber, crude oil, and crude ash, but the endosperm is rich in starch only. Polished rice refers to rice which has been milled to remove the husk, bran, germ, and varying amounts of grain nutrients contain, leaving a starch-rich grain.¹² Lower polishing might save food value and other minerals like Iron, Calcium, Vitamin B-1, Vitamin B-2, etc in BRR1 dhan108.



Figure 1 Active tillering stage BRRi dhan I 08 having attractive plant type, strong stems, high tillering with deep-green leaves



Figure 2 Hard dough stage BRRi dhan I 08 having dense panicle and more grains per panicle



Figure 3 Maturity stage Field evaluation of BRRi dhan I 08 at farmer's field.



Figure 4 BRRi Dhan I 08 with more grains per panicle and fine grain (like Jira).



Figure 5 BRRi Dhan I 08 BRRi dhan 28.



Figure 6 BRRi dhan I 08 and Minikit brand.

Conclusions

Newly released BRRi dhan I 08, can give 1.0-1.5 t/ha more yield than Bangabandhu dhan I 00 and can be a promising variety in terms of grain production, slenderness, and some yield contributing factors. Adaptability tests of these varieties under multi-location trials in the farmers' field showed satisfactory performance with respect to grain yield and some yield-contributing parameters. Finally, after evaluation, the NSB team found BRH11-9-11-4-5B as a superior genotype in respect to medium slender type grain with higher grain yield compared to check variety BRRi dhan 63 and Bangabandhu dhan I 00 and has been released as BRRi dhan I 08 in 2024. It is anticipated that BRRi dhan I 08 will contribute to increased yield and income of farmers for its better yield performance and fine grain type.

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