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Advancing Salinity-Tolerant Rice in Bangladesh: The Case of BRRI dhan67

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A B S T R A C T

Salinity is one of the major constraints limiting rice cultivation in the coastal regions of Bangladesh, where the rising salinity of soil and water continues to threaten crop productivity and food security. To address this challenge, Bangladesh Rice Research Institute (BRRI) developed BRRI dhan67, a salt-tolerant and high-yielding rice variety derived from a cross between IR61247-3B-8-2-1 and BRRI dhan36. This study summarizes the performance, adaptation, and dissemination of BRRI dhan67 based on multi-location adaptive research trials, participatory varietal selection, and post-release adaptation and out-scaling activities conducted from 2012 to 2022 across both saline and non-saline ecosystems of Bangladesh. BRRI dhan67 consistently performed well under varying levels of salinity stress, ranging from 4 to 12 deciSiemens per meter (dS/m), producing grain yield of 3.0 to 6.09 tons per hectare (t ha^{-1}) with an average of 4.47 t ha^{-1}. In non-saline environments, grain yield ranged from 5.42 to 7.53 t ha^{-1} with a mean of 6.62 t ha^{-1}. It showed robust seedling-stage salinity tolerance, maintaining 81% survival at 12 dS/m. Growth duration ranged from 138 to 144 days in the south coastal saline region, with an average of 141 days depending on different sites and seasons, while it ranged from 145 to 152 days with an average of 148 days in non-saline favorable environments. Grain quality assessments revealed superior milling recovery and head rice recovery, alongside medium-slender grain type and desirable cooking qualities. The variety also exhibited moderate resistance to major pests and diseases, adding to its agronomic stability. Participatory trials confirmed high farmer preference and strong adaptability in real-field conditions, particularly in salt-affected coastal zones. Overall, the results highlight BRRI dhan67 as a resilient and farmer-friendly solution with strong potential to enhance rice production and sustainability in both the saline-prone and favourable rice-growing environments of Bangladesh.

1. Introduction

The importance of rice transcends mere sustenance; it is a major determinant of food security and economic stability in many countries across the world. It is the most important staple crop, feeding almost half of the world's population (Hoang et al., 2016). In 2023, 168.35 million hectares of land were used for rice cultivation all over the world, and approximately 800 million tons of annual production was achieved (FAO, 2023). Approximately 90% of global rice is produced and consumed in Asia, marking sustainable rice production in Asia as a key decisive factor for global food security (Bandumula, 2018). Rice serves as a major source of rural employment and household earnings across the humid and semi-humid regions of

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Asia, supplying 50% to 80% of daily calories for more than three billion individuals (Hossain and Fischer, 1995). Eleven countries of Asia contribute about 87% to the total global rice production. About 503.17 MT of rice is produced worldwide, where China accounts for 29.5% of the total production, followed by India (23.8%), Bangladesh (7%), Indonesia (6.9%), and Vietnam (5.4%) (USDA, 2023). The world population is projected to reach about 9.6 billion by 2050, and about a 70% increase in production will be required to feed this population, indicating global cereal production must expand by an average of 44 million metric tons annually (Debsharma et al., 2024). Meeting this demand is severely constrained by climate change, biotic and abiotic stresses, reduced availability of cultivable land, and limited resources. Salinity and drought have been identified as the most critical abiotic stresses affecting global crop production (Munns, 2011). Around 20% of the total irrigated land of the world is suffering from a salinity problem (Munns, 2005). Nearly one-third of the world's arable land is saline-prone, and over half of all arable land may be under-salinized by 2050, making salinity a serious threat to the production of sustainable agriculture (Rahman et al., 2016, Shahid et al., 2017). The huge amount of potentially arable land in South and Southeast Asia remains unused because of salinity problems in the soil (Reddy et al., 2017). Bangladesh ranks as the third highest rice producing country in the world. Being a predominantly rice-growing nation, Bangladesh faces an increasing threat to its agricultural productivity due to salinity intrusion, particularly in coastal regions. Rising sea levels, tidal flooding, and reduced freshwater flows have intensified soil salinity, especially during the dry season (Boro season), affecting millions of hectares of arable land. In Bangladesh, salinity-affected areas extend over 2.85 million hectares in the southern coastal zone (Clarke et al., 2015), which contributes about 16% of the nation's total rice output (Debsharma et al., 2024). Among cereal crops, rice is the most susceptible to salinity stress, with concentrations as low as 30 mmol L^{-1} NaCl [equivalent to an electrical conductivity (EC) of 3 dS/m] significantly reducing its growth and yield (Lutts et al., 1995). At levels exceeding 3 dS/m, most modern high-yielding rice cultivars experience yield declines of around 12% per additional dS/m, with reductions of up to 50% observed at 6 dS/m (Linh et al., 2012). Salinity limits the photosynthetic ability and growth of rice plants, causing biomass loss, partial sterility, and ultimately resulting in reduced rice yield (Radanielson et al., 2018). Salt stress influences every stage of plant growth; however, in rice, the seedling and reproductive stages are the most vulnerable (Singh and Flowers, 2010). At the seedling stage, salinity reduces root and shoot length, while at the reproductive stage, it decreases tiller number, panicle length, spikelet fertility, and the number of spikes (Krishnamurthy et al., 2016). Plant responses to salt stress represent a complex process involving diverse physiological and biochemical alterations, such as changes in relative water status, electrolyte conductivity, accumulation of reactive oxygen species (ROS), nitrogen species, and other free radicals. These disturbances disrupt cellular homeostasis by interacting with biomolecules, impairing cell viability (Liu et al., 2017). Collectively, these effects hinder plant development and ultimately reduce yield.

Enhancing sustainable intensification of agricultural production in these salt-affected areas requires new rice varieties that possess tolerance to soil salinity. Traditional high-yielding rice varieties often underperform or fail to perform satisfactorily under saline conditions, creating an urgent need for varieties that can tolerate abiotic stress while maintaining yield and quality. Thus, development and dissemination of salt-tolerant rice varieties is considered as an economically viable strategy for securing food supplies (Qin et al., 2020).

To address this challenge, the Bangladesh Rice Research Institute (BRRI) developed the salt-tolerant breeding line BR7100-R-6-6, which was later released as BRRI dhan67 in 2014. The development process integrated advanced breeding techniques and involved a multi-phase evaluation strategy. The line underwent rigorous testing through station-based yield trials, multi-location Adaptive Research Trials (ALART), as well as Participatory Varietal Selection (PVS) involving direct farmer engagement across saline-prone regions. These evaluations not only confirmed its agronomic robustness but also assessed its acceptability among farmers and end-users in real-farming conditions.

Following its release, BRRI dhan67 was further evaluated through a large-scale adaptation and out-scaling initiative from 2017 to 2022, designed to validate its field performance and promote wider adoption. Using participatory and statistically robust trial designs, the initiative documented the variety's yield performance, growth duration, salt stress tolerance, grain quality traits, and farmer's preference-essential metrics for determining its practical value.

The present study consolidates findings from both pre- and post-release evaluations of BRRI dhan67 conducted, offering a comprehensive overview of its agronomic performance, resilience, grain quality and suitability for scaling across stress-prone rice-growing ecosystems of Bangladesh.

2. Materials and methods

The vegetative stage salt-tolerant and moderately cold-tolerant, high-yielding rice variety BRRI dhan67 originated from a single cross between the parental lines IR61247-3B-8-2-1 and BRRI dhan36. The parental combination was intended to combine salinity tolerance with shorter growth duration, cold tolerance, and improved grain quality. Both the pedigree selection method and the Rapid Generation Advance

(RGA) technique were adopted in the breeding process to accelerate homozygosity and genetic fixation. After fixation of the genotype, the resulting advanced line was designated as BR7100-R-6-6. The selected line BR7100-R-6-6, showed promising traits and was subjected to a rigorous multi-phase evaluation pipeline conducted at BRRI, Gazipur, and in the saline-prone southern coastal region of Bangladesh.

Following the primary yield trials (OYT, PYT, SYT, etc.), the advanced line was included in the Regional Yield Trial (RYT) for testing along with other promising advanced lines and check varieties. Subsequently, it entered the Advanced Lines Adaptive Research Trial (ALART) conducted in six key salinity-affected sites: Debhata, Kaliganj, Shyamnagor (Satkhira); Kalapara (Patuakhali); Amtoli (Barguna); Paikgacha (Khulna); and in one non-stress environment, Gazipur. EC of the trial fields was monitored, and the trial was managed by the Adaptive Research Division of BRRI. Data like survivability (%) and salt tolerance score of the proposed line against susceptible check (BRRI dhan28) and tolerant check (BRRI dhan47), yield, different agronomic traits, insect, disease occurrence scoring, water salinity (dS/m) level, and overall adaptability of the line were evaluated.

In conventional plant breeding programs, new crop varieties are usually developed in optimal and controlled settings, which hardly reflect the marginal farm conditions and fail to perform well in stress-prone areas. To ensure adaptability under real-farming stress conditions, such as sodic soils, the advanced breeding line BR7100-R-6-6 was evaluated through Participatory Varietal Selection (PVS), a participatory approach that addresses this gap by actively involving the farmers in the evaluation and selection process during 2012-2013 using a mother-and-baby trial, enhancing relevance and adoption. It ensures that the developed varieties are well-adapted to the stress environment and meet the demands of the farming community. A validation trial was also carried out at that time. A group of farmers was invited to assess the varietal performance in the trial. Before evaluation, the objectives and layout of the trial were clearly explained. Farmers were given two positive (√) and two negative (×) ballots to vote for their most and least preferred varieties, respectively. They independently walked through the trial plots, observed plant characteristics, and submitted ballots for (a) the variety they would most like to grow and (b) the one they would least prefer, and provided qualitative feedback on varietal traits. After voting, ballots were counted jointly by researchers and farmers. A preference score (PS) was determined for each variety by calculating the number of positive votes minus the number of negative votes, divided by the total number of votes cast by the farmers. The preference score (PS) for each variety was calculated as follows:

$$PS = \frac{\text{Number of positive votes- negative votes}}{\text{Total number of positive and negative votes}}$$

The group then revisited the most liked and least liked varieties to discuss their strengths and weaknesses. This qualitative feedback provided valuable insights into farmers' priorities, including yield potential, plant vigor, disease resistance, and grain quality. This participatory evaluation facilitated farmer-centric decision-making and supported the advancement of BR7100-R-6-6 based on both agronomic performance and end-user acceptance.

Based on the superior performance of BR7100-R-6-6 in PVS and ALART, it was advanced to the Proposed Variety Trial (PVT) in the subsequent Boro 2013-2014 season. PVT trial was conducted in 10 locations of the southern saline belt, where it was evaluated against the tolerant check BRRI dhan47. Performance of the proposed line was recorded at different salinity gradients ranging from 0 dS/m to almost 15 dS/m, along with plant height (cm) and growth duration (days). Additionally, the grain quality traits such as amylose content (%), protein content (%), 1000-grain weight (g), milling recovery (%), head rice recovery (%), and the length-breadth ratio of decorticated grains were analyzed to assess their market and consumer acceptability. Reaction of the proposed line towards major diseases and insect pests was also evaluated under natural field conditions, and scoring was done based on the International Rice Research Institute (IRRI) Standard Evaluation System (SES) protocol.

Following its official released in 2014, an extensive adoption and out-scaling initiative was undertaken from 2017 to 2022 to validate the adaptability of BRRI dhan67 in different environments at farmers' fields and for its rapid dissemination. During this period, a total of 150 adaptive trials and a seed production and dissemination program were conducted across 44 upazilas in 16 districts, covering an area of approximately 50.2 hectares of land, including both saline and non-saline areas like the coastal regions of Khulna, Satkhira, Barguna, and Patuakhali, as well as inland zones like Jashore and Faridpur. Each trial comprised one to three bighas of land (0.13–0.4 ha) and was supported with inputs such as seeds, fertilizers, pesticides, signboards, and labor. Fertilizers were applied at recommended doses of N, P, K, S, and Zn at 125, 22, 75, 20, and 2.7 kg ha^{-1}, respectively, using urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, and zinc sulfate (BRRI, 2025). TSP, gypsum, zinc sulfate, and two-thirds of MoP were applied as basal during land preparation. Urea was top-dressed in three equal splits at 15, 30, and 45 days after transplanting (DAT), while MoP was top-dressed along with the third top dressing of urea. Yield and agronomic data were collected from each site. Field water salinity levels (dS/m) were monitored at critical growth stages using standard EC meters. Data collected from the trials were analyzed using the software Statistix 10.

3. Results and discussion

The PVS trial was conducted across five saline-prone coastal sites in the Patuakhali and Barguna districts. Among the tested genotypes and varieties, BR7100-R-6-6 outperformed the others by achieving the highest yield in three locations. Across the coastal sites of Bazarkhali, Sharikhali, and Pasharibunia, it demonstrated strong performance, yielding between 4.9 and 7.2 t ha^{-1} with an average of 6.3 t ha^{-1} under salinity stress conditions. In addition to yield, the genotype showed favourable growth duration and plant stature, reaching maturity in 144 days with an average plant height of 108.8 cm (Table 1). In PVS preference analysis, based on farmers' vote, BR7100-R-6-6 ranked among the top two preferred genotypes in two locations (Table 2). The preference ranking was different from location to location and yield was not the only criterion for varietal selection. It indicated that, along with its high yield potential, the proposed line also carried characteristics that matched farmers' choice and preferences, ensuring its better adaptability in that region. Thus, PVS seemed to be a favored method for confirming varieties appropriate for stress-prone regions because farmers are actively involved in selecting the variety they want (Sharma et al., 2013, Singh et al., 2014). The subsequent validation trial conducted at Sharikhali, Pasharibunia, and Paschim Rajopara reconfirmed the finding that BR7100-R-6-6 is highly compatible for the saline-prone region of Bangladesh, as it produced the highest mean yield of 6.1 t ha^{-1}. Moreover, the other agronomic traits were also obtained within preferred ranges (Table 3).

The adaptability of the proposed line was assessed under diverse salinity levels through the ALART trial conducted across seven locations, emphasizing the saline-prone regions of the country. The proposed line produced an average grain yield of 5.8 t ha^{-1}, with site-specific yields ranging from 3.6 t ha^{-1} at Debhata (EC: 2.85–5.48 dS/m) to 6.9 t ha^{-1} at Amtoli (EC: 0.56–0.79 dS/m). The check variety BRRI dhan47 recorded a slightly higher overall mean yield of 6.0 t ha^{-1} compared to BR7100-R-6-6. The performance of BR7100-R-6-6 was comparable with the check BRRI dhan47 at most of the locations, particularly at Paikgacha, achieving 4.8 t ha^{-1} yield, where it faced the highest salinity stress in the trial (EC: 3.71–9.56 dS/m) (Table 4 and Table 5). It also showed a two-day shorter growth duration than the check variety. Along with satisfactory yield and agronomic performance, BR7100-R-6-6 exhibited the highest survivability (81%) and comparable salt tolerance score (5.0) at the seedling stage to the check variety BRRI dhan47 (5.2) when exposed to an EC level of 12 dS/m (Table 6). This trait is particularly critical for ensuring crop establishment in coastal regions where saline water intrusion frequently affects germination and seedling establishment. The results indicated that BR7100-R-6-6 combines stability across stress gradients, early-stage salinity resilience, and competitive yield performance, making it suitable for the coastal and salinity-affected rice-growing regions of Bangladesh.

Based on the performance of the genotype in PVS trial and ALART, it was recommended to Proposed Variety Trial (PVT) during Boro 2013-2014. The proposed line was evaluated in ten different saline-affected regions under PVT to validate its performance (Table 7) with changes in salinity levels tracked over time (Fig. 1). Across all test locations, BR7100-R-6-6 achieved an average yield of 5.98 t ha^{-1}, clearly outperforming the salt-tolerant check BRRI dhan47, which averaged 5.48 t ha^{-1}. In fact, BR7100-R-6-6 out-yielded BRRI dhan47 in nine locations out of 10 locations, showing especially high productivity at Tala (7.27 t ha^{-1}), BRRI Satkhira Farm (7.48 t ha^{-1}), and Sonagazi (7.0 t ha^{-1}). The results showed that the proposed line has the potential to produce almost 7.5 t ha^{-1} grain yield when faced with a lower level of salinity. Batiaghata experienced the highest salinity stress, with EC levels rising from 9 to 14.5 dS/m during February to April, yet BR7100-R-6-6 still managed to outperform the check variety BRRI dhan47 by delivering a 16% higher yield at that site. These results pointed to its strong adaptability and reliable performance under varying saline conditions.

Different physico-chemical and grain quality attributes of the proposed line and the check variety BRRI dhan47 are presented in Table 8 to assess market and consumer acceptability. Although BR7100-R-6-6 showed a lower 1000-grain weight (20.9 g) than BRRI dhan47 (25.9 g), PVT results showed that this character did not compromise the yield advantage of the line. BR7100-R-6-6 showed better milling recovery (69.4%) and significantly higher head rice recovery (71.1%) compared to BRRI dhan47 (44.2%), indicating production of more finished rice, lower breakage, and higher whole grain retention after milling. Medium slender grain type of BR7100-R-6-6 makes it more desirable to the consumers than the medium bold grain type of BRRI dhan47. The protein content (8.8%) and amylose content (24.6%) of the genotype were found to be within an acceptable standard. All these traits highlight the proposed line's potential not just as a high-yielding, salt-tolerant variety, but also as one with improved grain quality that satisfies both market demands and consumer preferences, making it a strong, all-around candidate for widespread cultivation.

The proposed line BR7100-R-6-6 was tested for major diseases and insect pests in natural field conditions, and its performance was compared with the check variety BRRI dhan47 (Table 9). In the field, BR7100-R-6-6 showed excellent resistance to bacterial blight, scoring just 1, indicating high resistance; meanwhile, BRRI dhan47 was more vulnerable with a score of 7. The proposed line also showed moderate resistance (score 3) to other key threats like blast, dead heart, and white head, in contrast to BRRI dhan47, which scored 7 and 5 for the same parameters, indicating moderate susceptibility. Overall, BR7100-R-6-6 offered a stronger and more balanced defense against multiple pests and diseases, which adds to its appeal for farmers looking for a reliable, lower-maintenance variety in challenging environments. On the other hand, the Distinctness, Uniformity and Stability (DUS) test is essential for the release and registration of new varieties of notified crops. Distinguishing characters of the proposed line, BR7100-R-6-6 compared to BRRI dhan28 are flag leaf: attitude of blade, culm: length, panicle: number of effective tillers in a hill, grain: length (without dehulling), decorticated grain: length (After dehulling, before milling), decorticated grain: shape (Length-breadth ratio) and endosperm: content of amylose (Table 10). No notable change or segregation was observed in the test plots of two consecutive seasons of testing at the Seed Certification Agency (SCA) farm in Gazipur, suggesting that the proposed line is stable. In light of its consistent performance and adaptability across saline environments, the National Seed Board of Bangladesh approved the recommendation of the technical committee to officially release the proposed line, BR7100-R-6-6, as a salt-tolerant Boro variety, BRRI dhan67, for cultivation in saline-affected regions in 2014.

The adaptability of BRRI dhan67 was extensively evaluated through a multi-location adaptive trial, which comprised almost 150 trials across 16 districts of the country covering almost 50 ha of land in both saline and non-saline regions for six consecutive years (2017-2022). It provided a clear insight into how environment, genotype, and cropping year, and their interactions significantly influenced the performance of BRRI dhan67 (Karmakar et al., 2019). In saline areas, the variety produced an average yield of 4.47 t ha^{-1} while the site-specific yield ranged from 3.0 t ha^{-1} to 6.09 t ha^{-1} (Table 11), and salinity stress level varied from 4 dS/m to 12 dS/m. In severely saline-affected areas, such as Rampal, Koyra, and Shyamnagar, where the EC exceeded 8 dS/m, BRRI dhan67 recorded its lowest yield: 3.0 t ha^{-1}, 3.38 t ha^{-1}, and 3.5 t ha^{-1}, respectively (Fig. 2). In contrast, under non-saline conditions, the variety demonstrated its full potential, yielding an average of 6.62 t ha^{-1}, highest at 7.53 t ha^{-1} in Keshabpur and 7.50 t ha^{-1} in Batiaghata. Mean grain yield (6.62 t ha^{-1}) of BRRI dhan67 under a non-saline environment was significantly higher than in a saline environment (4.47 t ha^{-1}) (Tables 12 and 13). Generally, grain yield was always higher in non-saline environments compared to saline environments (Nayak et al., 2022). These data highlighted the clear performance of the climate-resilient variety BRRI dhan67 in both the stress-prone and favorable environments.

The environment had a notable impact on growth duration. In saline areas, BRRI dhan67 matured in about 141 days on average, while in non-saline environments, it took an average of 148 days to maturity. Growth duration ranged from 138 to 152 days across the environments. The lowest duration (138 days) was counted at the saline environment at Chakaria, Cox's Bazar, followed by Kaliganj, Satkhira (139 days), likely due to faster crop development in stress-affected environments. When grown in non-saline, favorable conditions, but comparatively prolonged winter existing environments (Parbatipur and Birganj, Dinajpur), the growth duration of the variety was extended up to 152 days (Fig. 3). Interestingly, while conducting extensive multi-location adaptive trials, BRRI dhan67 was found to be moderately tolerant against vegetative stage cold, particularly during the seedling stage.

These trials also contributed significantly to seed dissemination and farmer awareness. Across all locations, around 285 tons of grain were harvested, of which 54 tons (16%) were saved as seed. Interestingly, seed retention was proportionally higher in saline areas (19%) than in non-saline areas (14%), indicating stronger engagement in stress-prone zones. A total of 7,597 farmers were reached through these trials, with 1,426 (18%) showing immediate interest in adopting BRRI dhan67. The percentage of motivated farmers was also higher in saline areas (20%) compared to non-saline areas (17%), despite the latter hosting more trials (Table 13). Consequently, the adaptive trials played an important role in generating quantitative information and enhancing the adoption of BRRI dhan67 in both the saline and non-saline environments (Karmakar et al., 2021).

Overall, these findings confirmed the robustness and adaptability of BRRI dhan67 across a range of environments. Its stable performance in saline soils, coupled with its favorable growth duration and high acceptance among farmers, underscores its suitability for both marginal coastal and favourable rice-growing ecosystems in Bangladesh.

Table 1

Performance of genotypes in PVS at different locations of Patuakhali and Barguna in Boro season 2012-2013.

Serial number	Genotype	Duration (days)	Plant height (cm)	Yield (t/ha)					
				Baz	Sha	Par	Rajo	P. Rajo	Mean
1	BR7100-R-6-6	144	108.8	7.2	7.2	6.0	4.9	6.3	6.3
2	IR89578-84	143	104.2	6.7	6.8	-	4.7	-	6.1
3	IR59418-7B-21-3	143	91.0	6.5	6.9	5.5	3.9	6.4	5.8
4	IR78794-B-SAT29-1	146	98.0	6.9	6.5	5.5	4.4	5.9	5.8
5	BRRI dhan28	141	100.0	6.9	6.7	5.4	4.6	5.5	5.8
6	BRRI dhan47	147	99.7	6.7	6.6	5.8	4.4	5.2	5.8
7	BRRI dhan55	143	96.9	7.2	6.5	5.7	5.1	5.5	6.0

Baz = Bazarkhali; Sha = Sharikhali; Par = Pasharibunia; Rajo = Rajopara; P. Rajo = Pashchim Rajopara.

Table 2

Farmers' preference analysis of mother trial for rice genotypes grown at different locations at Patuakhali and Barguna in Boro season 2012-2013.

Location/PVS	Farmers preference ranking and score			
	1st +ve	2nd +ve	1st -ve	2nd -ve
Rajopara, Kolapara, Patuakhali (PVS-2)	BRRI dhan47 (0.208)	BR7100-R-6-6 (0.116)	IR59418-7B-21-3 (-0.233)	IR78794-B-Sat29-1 & BRRI dhan55 (-0.108)
Pashchim Rajopara, Kolapara, Patuakhali (PVS-2)	BRRI dhan47 (0.058)	BRRI dhan28 (0.033)	IR59418-7B-21-3 (-0.166)	IR78794-B-Sat29-1 (-0.008)
Sharikhali, Sadar, Patuakhali (PVS-2)	BRRI dhan28 (0.133)	IR89578-84 (0.025)	IR78794-B-Sat29-1 (-0.125)	BR7100-R-6-6 (-0.025)
Pashribunia, Sadar, Patuakhali (PVS-2)	BRRI dhan28 (0.191)	BR7100-R-6-6 (0.150)	IR78794-B-Sat29-1 (-0.175)	BRRI dhan47 (-0.158)
Bazarkhali, Amtoli, Barguna (PVS-2)	IR89578-84 (0.150)	BRRI dhan47 (0.083)	IR59418-7B-21-3 (-0.183)	IR78794-B-Sat29-1 (-0.043)

Farmers' preference score put in parenthesis.

Table 3

Agronomic performances of the salt-tolerant genotypes in validation trial at different locations in Boro season 2012-2013.

Serial number	Genotype	Duration (days)	PH (cm)	Yield (t/ha)			
				Sharikhali	Pasharibunia	P. Rajopara	Mean
1	BR7100-R-6-6	146	109.7	7.0	5.8	5.4	6.1
2	IR59418-7B-21-3	144	87.5	6.7	5.8	5.8	6.1
3	IR78794-B-SAT-29-1	146	97.5	6.3	5.5	5.7	5.9

PH = Plant height; P. Rajopara = Pashchim Rajopara.

Table 4

Performance of the proposed line at different zonal trials (Adaptive trial) in Boro season 2012-2013.

Genotype	GD*	Yield (t/ha)							
		L1	L2	L3	L4	L5	L6	L7	Mean
BR7100-R-6-6	150	3.6	6.4	6.3	6.5	6.9	4.8	6.3	5.8
BRRI dhna47 (Ck)	152	5.8	6.5	5.6	6.3	4.9	6.2	6.9	6.0

L1 = Debhata, Satkhira; L2 = Kaliganj, Satkhira; L3 = Shyamnagar, Satkhira; L4 = Kalapara, Patuakhali; L5 = Amtoli, Barguna; L6 = Paikgacha, Khulna; L7 = Gazipur

*GD = Growth duration; Mean of seven locations

Table 5
Water salinity/electrical conductivity (EC) range at on-farm adaptive trial (ALART) for experimental period in Boro season 2012-2013.

Location	Water salinity/EC (dS/m) range
Debhata, Satkhira	2.85-5.48
Kaligonj, Satkhira	3.65-5.52
Shyamnagor, Satkhira	2.15-4.13
Kalapara, Patuakhali	1.05-1.50
Amtoli, Barguna	0.56-0.79
Paikgacha, Khulna	3.71-9.56
Asasuni, Satkhira	2.63-6.20

Table 6
Salinity tolerance score and survivability of the proposed variety following IRRI SES at EC of 12 dS/m at the seedling stage in Boro season 2012-2013.

Proposed line with standard check	Salinity tolerance score	Survivability (%)
BR7100-R-6-6 (Proposed)	5.0	81
BRRI dhan28 (Ck)	7.0	42
BRRI dhan47 (Ck)	5.2	75

Table 7
Yield and agronomic performance of the proposed lines in the Proposed Variety Trial (PVT) in Boro season 2013-14.

Proposed line with standard check	Plant height (cm)	Growth* duration (days)	Yield (t/ha)										
			L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Mean
BR7100-R-6-6 (Proposed)	100	143	5.29	5.57	3.81	6.94	5.38	7.27	7.48	7.00	5.60	5.42	5.98
BRRI dhan47 (Ck)	105	144	4.32	4.81	3.28	6.40	5.83	7.16	7.44	6.20	4.69	4.71	5.48

L1 = Dakope; L2 = Paikgacha; L3 = Batiaghata, Khulna; L4 = Asasuni; L5 = Debhata; L6 = Tala; L7 = BRRI farm, Satkhira; L8 = Sonagazi, Feni; L9 = Patharghata, Barguna; L10 = Nazirpur, Pirojpur
*Mean of 10 locations

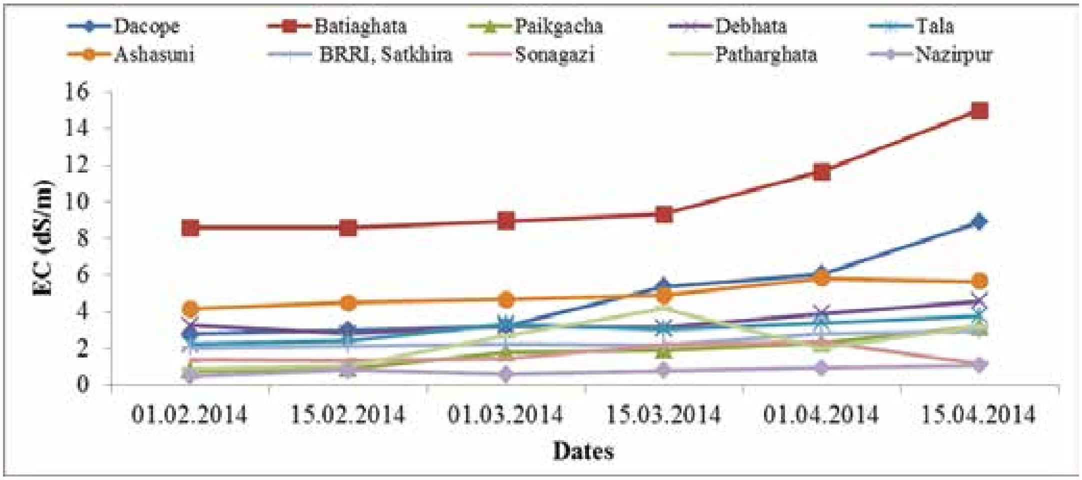

Fig. 1. Water salinity levels (dS/m) of different experimental plots during the proposed variety trials in Boro season 2013-2014.

Table 8
Physico-chemical and grain characteristics of proposed lines and standard check.

Proposed line with standard check	1000 grain weight (g)	Milling recovery (%)	Head rice yield (%)	Decorticated grain				ER	IR	Cooking time (min)	Protein (%)	Amylose (%)
				Length (mm)	Breadth (mm)	L/B	Size and shape					
BR7100-R-6-6 (Proposed)	20.9	69.4	71.1	5.9	2.1	2.8	MS	1.3	2.7	16.30	8.8	24.6
BRRI dhan47 (Ck)	25.9	67.6	44.2	5.4	2.7	2.0	MB	1.4	3.6	17.00	8.2	27.5

ER = Elongation ratio, IR = Imbibition ratio, MS = Medium slender, MB = Medium bold.

Table 9
Reaction of the proposed line against major diseases and insects under natural field conditions during Boro 2013-14.

Proposed line with standard check	Disease reaction		Insect reaction	
	BB	Blast	DH	WH
BR7100-R-6-6 (Proposed)	1	3	3	3
BRRI dhan47 (Ck)	7	7	5	5

BB = Bacterial blight; DH = Dead heart; WH = White head.

Table 10
Distinctness between BR7100-R-6-6 (Proposed line) and BRRI dhan28.

SL	Characteristics	BR7100-R-6-6 (Proposed line)		BRRI dhan28 (Check variety)		Remarks
		Code	State	Code	State	
1	Flag leaf: attitude of the blade	3	Semi erect	5	Horizontal	Distinct
2	Culm: Length	7	Long	5	Medium	Distinct
3	Panicle: number of effective tillers in a hill	7	Many	5	Medium	Distinct
4	Grain: length (without dehulling)	7	Long	9	Very Long	Distinct
5	Decorticated grain: length (After dehulling, before milling)	3	Medium	5	Long	Distinct
6	Decorticated grain: shape (Length-breadth ratio)	7	Medium slender	9	Slender	Distinct
7	Endosperm: content of amylose	3	Intermediate	5	High	Distinct

Table 11
Descriptive Statistics of BRRI dhan67 for saline environment during 2018 to 2022 Boro seasons at different districts of Bangladesh.

Variable	Growth duration (days)	Grain yield (t ha^{-1})	Total production (ton)	Seed retained		Knowledge sharing farmer (number)	Motivated farmer	
				ton	(%)		number	(%)
Mean	141	4.47	2.78	0.61	19	91	18	20
Minimum	138	3.00	1.36	0.00	0	64	5	6
Median	141	4.43	2.38	0.42	18	89	18	19
Maximum	144	6.09	4.89	2.15	50	161	38	37
Sum	5069	161.94	99.91	21.95	685	3278	656	710
N	36	36	36	36	36	36	36	36
SD	1.45	0.73	1.12	0.59	14.19	19.94	8.87	8.29
Variance	2.10	0.53	1.24	0.4	201.3	397.5	78.8	68.9
SE Mean	0.24	0.12	0.19	0.10	2.36	3.32	1.48	1.38
CV (%)	1.0	16.3	40.2	97.1	74.6	21.9	48.7	42.1

N = Number of trials; SD = Standard deviation; SE = Standard error; CV = Co-efficient of variation.

Table 12

Descriptive Statistics of BRRI dhan67 for non-Saline environment during 2018 to 2022 Boro seasons at different districts of Bangladesh.

Variable	Growth duration (days)	Grain yield (t ha^{-1})	Total production (ton)	Seed retained		Knowledge sharing farmer (number)	Motivated farmer	
				ton	(%)		number	(%)
Mean	148	6.62	4.51	0.78	14	105	19	17
Minimum	145	5.42	2.18	0.00	0	64	5	5
Median	148	6.67	3.02	0.31	9	102	15	16
Maximum	152	7.53	11.33	5.60	54	154	53	35
Sum	6067	271.22	184.73	31.86	561	4319	770	694
N	41	41	41	41	41	41	41	41
SD	1.9	0.5	2.5	1.1	12.7	27.9	11.2	6.4
Variance	3.42	0.24	6.28	1.30	160.82	779.03	125.58	40.77
SE Mean	0.29	0.08	0.39	0.18	1.98	4.36	1.75	1.00
CV (%)	1.25	7.40	55.62	146.9	92.68	26.50	59.67	37.72

N = Number of trials; SD = Standard deviation; SE = Standard error; CV = Co-efficient of variation.

Table 13

Results of BRRI dhan67 in saline and non-saline environments during 2018 to 2022 Boro seasons at different districts of Bangladesh.

Environment	Area		Mean growth duration (day)	Mean grain yield (tha^{-1})	Total production (ton)	Seed retained		Knowledge sharing farmer (number)	Motivated farmer	
	bigha	ha				ton	%		number	(%)
Saline	168.0	22.5	141	4.47	100	22	19	3278	656	20
Non-saline	207.0	27.7	148	6.62	185	32	14	4319	770	17
Grand mean	-	-	145	5.61	-	-	16	-	-	18
Grand total	375.0	50.2	-	-	285	54	-	7597	1426	-
LSD (0.05)	-	-	1.9	0.76	2.0	1.0	-	-	-	-
CV (%)	-	-	1.1	11.4	-	-	-	-	-	-

Ha = hectare; LSD = Least significant difference; CV = Co-efficient of variation.

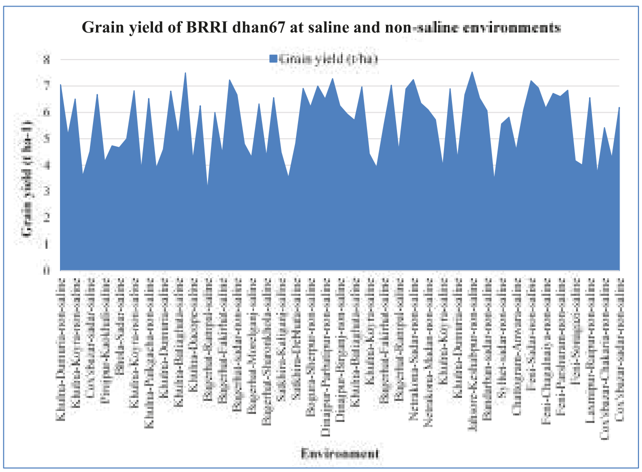

Fig. 2. Grain yield of BRRI dhan67 in saline and non-saline environments during 2018 to 2022 Boro seasons at different districts of Bangladesh.

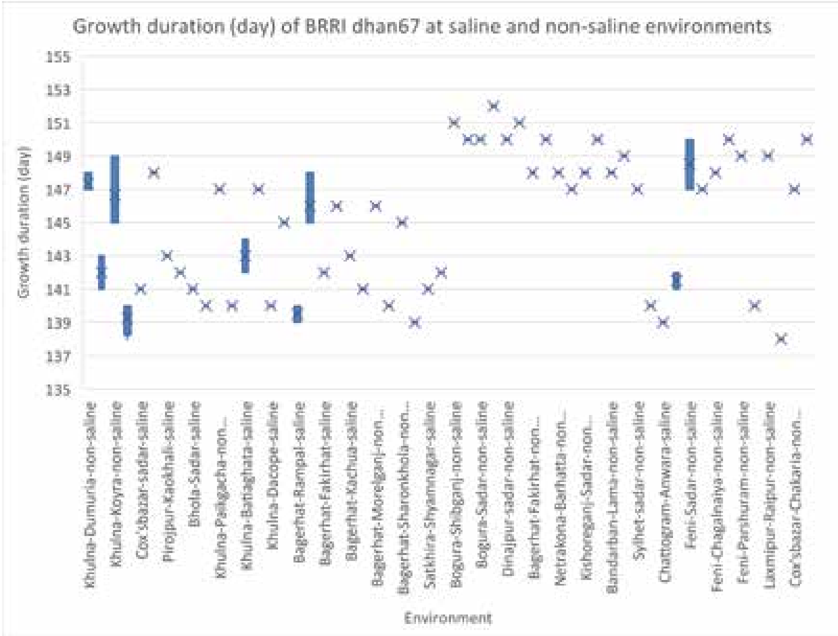

Fig. 3. Growth duration of BRRI dhan67 in saline and non-saline environments during 2018 to 2022 Boro seasons at different districts of Bangladesh.

4. Conclusion

The comprehensive multi-environment evaluation of BRRI dhan67 confirmed its strong potential as a stable and robust salt-tolerant Boro rice variety for the coastal agro-ecosystems of Bangladesh. Across both pre- and post-release phases, the variety consistently demonstrated stable grain yield, shorter growth duration, and strong adaptability to varying salinity levels, ranging from moderate to high (up to 15 dS/m). BRRI dhan67 not only outperformed the widely accepted check variety BRRI dhan47 in most trial sites, but also offered improved grain quality traits, such as better milling recovery, higher head rice recovery, and preferred slender grain type. Furthermore, its resistance to key diseases and insect pests, coupled with strong farmer preference in participatory trials, indicated its practicality and acceptance at the grassroots level. The post-release adaptation and out-scaling trials highlighted its scalability and practical utility, particularly in saline-prone regions where seed retention and farmer motivation were notably high. Overall, BRRI dhan67 represents a significant advancement in climate-resilient rice breeding, offering a viable solution to sustain rice production and enhance food security in vulnerable coastal regions of Bangladesh.

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References

Bandumula, N. (2018). Rice production in Asia: Key to global food security. Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences, 88(4), 1323–1328.

Bangladesh Rice Research Institute. (2025). Modern rice cultivation (Adhunik dhaner chash), 25th ed., pp. 5–125.

Clarke, D., Williams, S., Jahiruddin, M., Parks, K., & Salehin, M. (2015). Projections of on-farm salinity in coastal Bangladesh. Environmental Science: Processes & Impacts, 17(6), 1127–1136.

Debsharma, S. K., Rahman, M. A., Khatun, M., Disha, R. F., Jahan, N., Quddus, M. R., Khatun, H., Dipti, S. S., Ibrahim, M., Iftekharuddaula, K. M., & Kabir, M. S. (2024). Developing climate-resilient rice varieties (BRRI dhan97 and BRRI dhan99) suitable for salt-stress environments in Bangladesh. PLoS ONE, 19(1), e0294573. https://doi.org/10.1371/journal.pone.0294573

Food and Agriculture Organization of the United Nations. (2023). Production/yield quantities of rice, paddy in world. FAOSTAT. https://www.fao.org/faostat/en/#QC (accessed on 23 September 2025).

Hoang, T. M. L., Tran, T. N., Nguyen, T. K. T., Williams, B., Wurm, P., Bellairs, S., & Mundree, S. (2016). Improvement of salinity stress tolerance in rice: Challenges and opportunities. Agronomy, 6(4), 54.

Hossain, M., & Fischer, K. S. (1995). Rice research for food security and sustainable agricultural development in Asia: Achievements and future challenges. GeoJournal, 35(3), 286–298.

Karmakar, B., Mamun, M. A. A., Rahman, M. S., Islam, M. A., Islam, M. R., Mukul, M. H. R., Shamsunnaher, Zahan, A., Barua, R., Biswas, M. R., Parveen, S., Akter, S., Shaikh, N. Y., & Ahmed, B. (2019). Adaptation of promising rice genotypes for broadcast Aus season. Bangladesh Rice Journal, 23(2), 35–48. https://doi.org/10.3329/brj.v23i2.48246

Karmakar, B., Rahman, M. M., Sarkar, M. A. R., Mamun, M. A. A., Rahman, M. C., Nessa, B., Salam, M. U., & Kabir, M. S. (2021). Adoption lag minimization for increasing rice yield. Bangladesh Rice Journal, 25(1), 75–88. https://doi.org/10.3329/brj.v25i1.55180

Krishnamurthy, S. L., Gautam, R. K., Sharma, P. C., & Sharma, D. K. (2016). Effect of different salt stresses on agro-morphological traits and utilization of salt stress indices for reproductive stage salt tolerance in rice. Field Crops Research, 190, 26–33.

Linh, L. H., Linh, T. H., Xuan, T. D., Ham, L. H., Ismail, A. M., & Khanh, T. D. (2012). Molecular breeding to improve salt tolerance of rice (*Oryza sativa* L.) in the Red River Delta of Vietnam. International Journal of Plant Genomics, 2012(1), 949038.

Liu, S., Hao, H., Lu, X., Zhao, X., Wang, Y., Zhang, Y., & Wang, R. (2017). Transcriptome profiling of genes involved in induced systemic salt tolerance conferred by Bacillus amyloliquefaciens FZB42 in Arabidopsis thaliana. Scientific Reports, 7(1), 10795.

Lutts, S., Kinet, J. M., & Bouharmont, J. (1995). Changes in plant response to NaCl during development of rice (*Oryza sativa* L.) varieties differing in salinity resistance. Journal of Experimental Botany, 46(12), 1843–1852.

Munns, R. (2005). Genes and salt tolerance: Bringing them together. New Phytologist, 167(3), 645–663.

Munns, R. (2011). Plant adaptations to salt and water stress: Differences and commonalities. Advances in Botanical Research, 57, 1–32.

Nayak, S., Habib, M. A., Das, K., Islam, S., Hossain, S. M., Karmakar, B., Fritsche, R. N., Bhosale, S., Bhardwaj, H., Singh, S., et al. (2022). Adoption trend of climate-resilient rice varieties in Bangladesh. Sustainability, 14, 5156. https://doi.org/10.3390/su1409515

Qin, H., Li, Y., & Huang, R. (2020). Advances and challenges in the breeding of salt-tolerant rice. International Journal of Molecular Sciences, 21(21), 8385.

Radanielson, A. M., Angeles, O., Li, T., Ismail, A. M., & Gaydon, D. S. (2018). Describing the physiological responses of different rice genotypes to salt stress using sigmoid and piecewise linear functions. Field Crops Research, 220, 46–56.

Rahman, M. A., Thomson, M. J., Shah-E-Alam, M., de Ocampo, M., Egdane, J., & Ismail, A. M. (2016). Exploring novel genetic sources of salinity tolerance in rice through molecular and physiological characterization. Annals of Botany, 117(6), 1083–1097. https://doi.org/10.1093/aob/mcw030 PMID: 27063367

Reddy, I. N. B. L., Kim, S. M., Kim, B. K., Yoon, I. S., & Kwon, T. R. (2017). Identification of rice accessions associated with K^+/Na^+ ratio and salt tolerance based on physiological and molecular responses. Rice Science, 24, 360–364. https://doi.org/10.1016/j.rsci.2017.10.002

Shahid, S. A., Zaman, M., & Heng, L. (2018). Soil salinity: Historical perspectives and a world overview of the problem. In Guidelines for salinity assessment, mitigation and adaptation using nuclear and related techniques (pp. 43–53). Springer International Publishing, Switzerland.

Sharma, N., Sarker, M. R. A., Rahman, M. A., & Islam, M. R. (2013). Participatory varietal selection of modern T. Aman rice varieties in salt-affected coastal area of Bangladesh. Eco-friendly Agriculture Journal, 6(8), 141–145.

Singh, R. K., & Flowers, T. J. (2010). The physiology and molecular biology of the effects of salinity on rice. In Handbook of plant and crop stress (pp. 899–939). Marcel Dekker, Inc. New York.

Singh, Y. P., Nayak, A. K., Sharma, D. K., Gautam, R. K., Singh, R. K., Singh, R., & Ismail, A. M. (2014). Farmers' participatory varietal selection: A sustainable crop improvement approach for the 21st century. Agroecology and Sustainable Food Systems, 38(4), 427–444.

United States Department of Agriculture. (2023). Rice production by country—World agricultural production 2023/2024. World Agricultural Production. http://www.worldagriculturalproduction.com/crops/rice.aspx (accessed on 23 September 2025).