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Development, Release, and Popularization of the Novel Inbred Rice Variety "Mini Shail" for the Aman Season in Bangladesh

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***Abstract*— Rice is the major staple crop of Bangladesh, and alone it occupies about 78% of the arable land of the country. However, the production level is not enough to meet the demands of food security for the growing population. The present study is on the development, evaluation, release, and promotion of the new inbred rice variety "Mini Shail" (IR14A-09) for the Aman season, targeting the basic demand for food security. We conducted multi-location testing across Bangladesh, where eight advanced rice lines emanating from IRRI were put to the test. "Mini Shail" outperformed others in yield amongst its competitors' check types of BRRI dhan39 and BRRI dhan49 varieties. Through proposed variety trial (PVT) at various locations, its improved yield was confirmed, while distinctness, uniformity, and stability (DUS) testing underlined its distinctiveness on morphological characteristics. Besides, "Mini Shail" had better consumer acceptance due to slender grain and superior cooking properties with an amylose content appropriate for non-sticky rice. The National Seed Board of Bangladesh named the "Mini Shail" as Rabi dhan1 after obtaining sufficient experiences from field experiments. This variety increases yield, enhances disease tolerance, reduces production cost, and hence assures food security and profit to farmers in Bangladesh. The effective development and marketing of "Mini Shail" demonstrate that cooperation in plant breeding goes a long way in solving agricultural problems.**

Keywords*— *Field demonstration, PVT, Rice Breeding, Variety Release

I. INTRODUCTION

Rice, a cereal crop belonging to the Gramineae family, is the main staple food in Bangladesh, ranking first among cereal crops and serving as an essential source of carbohydrates. Eleven countries in Asia contribute about 87% to global rice production [1]. Rice is also accounting for approximately 78 percent of the total net cropped area for cultivation in Bangladesh. The country attains self-sufficiency in rice production to satisfy the demand of its 169.04 million population, utilizing 11.55 million hectares of cultivated land [2-3].

Ever since the country became independent, the volume of rice here seems to have catapulted almost three times to about 36.6 MT in 2019-20 from an estimated 11 MT in 1971-72 [4]. There are primarily three growing seasons for rice crops, which are Aus, Aman and Boro. Aman rice has the largest coverage as it is cultivated in an area of 5.68 million hectares and produces about 13.99 million tons [5]. The country has a total geographic area of 14.86 million hectares [6] while an area suitable for cultivation is approximately 8.57 million hectares [7].

The current levels of rice production are not enough to ensure food security to the growing population. Therefore, it is necessary to develop newer rice varieties that will be suitable for both Bangladeshi farmers and consumers if agricultural output are to be maintained and food security issues addressed. Some of the key requirements include shorter periods of growth to avoid the risk posed by pests, diseases, and particularly bad weather in addition to allowing the possibility of multiple cropping, less water usage as well as better yields and returns. Genes such as Xa5 and pita2 which confer resistance to diseases also lower production costs, reduce the negative effects of farming on the environment, and stabilize the production as well as the income of the farmers by reducing the use of chemical pesticides. These traits are critical indeed in the management of both blast and bacterial leaf blight (BLB). Sustainable agriculture, which is expected to produce more grain to meet the rising food needs due to urbanization and population growth, seeks to incorporate high productivity, while more critically, allowing retention of important characteristics such as grain quality and resistance to diseases [8].

Besides, consumer demand for slender grains with better cooking qualities requires varieties with distinct attributes to retain market share and satisfy customers for brand loyalty. Hence, such goals shall be attained through active involvements of researchers from various disciplines by integrating traditional breeding techniques with molecular breeding and modern agronomic approaches; they shall also have to interact with organizations across the globe [9]. In order to enhance the efficacy of this newly developed variety in boosting farm productivity and achieving food security, extension services are very critical in transferring cultivation techniques. Therefore, it is very important to assess the plant characteristics in relation to yield and yield components in the

advanced rice lines. This has been demonstrated in the ongoing study which compared the current varieties and advanced lines of rice as well as their recently released counterparts.

II. Materials And Methods

A. Source Material And Experimental Site

Eight advanced lines from the International Rice Research Institute (IRRI), comprising the check varieties from Bangladesh Rice Research Institute (BRRI), were employed in advanced yield trials (Table 1). We carried out the advanced yield trial (AYT) experiments at five separate sites- Cumilla, Dhaka, Mymensingh, Patuakhali, and Rajshahi throughout the Transplanted Aman (T. Aman) season 2014. We again evaluated the selected promising lines from AYT in multi-location trials at six different locations- BSMRAU Gazipur, Dhirassrom Gazipur, Joypurhat, Khajura Jessore, Paba Rajshahi and Tanore Rajshahi in the T. Aman season of 2015 (Table 1).

In the varietal release process, the Seed Certification Agency (SCA) conducted PVT (Proposed variety trial) at ten locations- BRRI Rajshahi, Bhirassrom Gazipur, Kaligonj Jhinaidah, Mawna Gazipur, Poba Rajshahi, Sherpur Bogura, Shorsha Jessore, Nurpur Jessore, Ujirpur Barishal, and Khetlal Joypurhat in T. Aman season 2018.

TABLE I. LIST OF RICE BREEDING MATERIALS USED FOR YIELD TRIALS

S/N	Designation	Category	S/N	Designation	Category
Advanced Yield Trial in T. Aman, 2014					
1	IRRI 14A-1	Salinity	6	IRRI 14A-6	Irrigated
2	IRRI 14A-2	Salinity	7	IRRI 14A-9	Irrigated
3	IRRI 14A-3	Salinity	8	IRRI 14A-10	Irrigated
4	IRRI 14A-4	Irrigated	9	BR 11(ck)	Irrigated
5	IRRI 14A-5	Irrigated	10	BRRI dhan49 (ck)	Irrigated
Multi-location Trial in T. Aman, 2015					
1.	IR 14A-09	Irrigated	4.	BR11 (ck)	Irrigated
2.	B7-S1.8-11-26-M_4-537	Irrigated	5.	BINA Dhan7 (ck)	Irrigated
3.	G 11	Irrigated			

B. Maintaining The Integrity Of The Specifications

We used a randomized complete block design (RCBD) with three replications for all trial experiments. The AYT and MLT plots were 5.4 meters long with five rows (equivalent to 5.4 square meters), while the PVT plot measured 10 meters by 2 meters (20 square meters). We planted seedlings aged 25 days at a density of 2-3 plants per hill, spaced 20 centimeters apart. Nitrogen (N) was applied in split doses at 15, 30, and 50 days after transplanting (DAT), with fertilizer doses consisting of 120:19:60:20:3.6 kg/ha of NPKSZn (260-97-120-110-11 kg/ha of Urea-TSP-Gypsum-ZnSO4, respectively), along with ZnSO4 [10]. During the last phase of land preparation, we applied phosphorus (P), potassium (K), sulfur (S), and zinc (Zn) in accordance with the fertilizer recommendations of the Bangladesh Agricultural Research Council. We used weed management techniques and irrigation as required.

C. Data Collection

We collected data for eight traits, including plant height (PH), effective tiller (ET), Panicle Length (PL), Fertile seed (FS), Sterile seed (SS), days to maturity (DTM), Thousand-grain weight (TGW), and Plot yield (YLD). We utilized those traits to describe and assess the genetic diversity of advanced rice germplasm and released cultivars.

Forty morphological traits on five randomly chosen plants of best performing advanced line with the standard check variety were observed and characterized according to the guideline of Seed Certification Agency (SCA) for Distinctness, Uniformity, and Stability (DUS) test in rice [11].

D. Statistical Analysis

We calculated analysis of variance among the traits by using the statistical software R program. We interpreted the results of the ANOVA analysis in the context of a significance level of 0.05. If the p-value associated with the ANOVA test is less than 0.05, we rejected the null hypothesis, indicating that there is evidence to support the presence of significant differences among the groups. We adjudged the mean differences with Duncan's Multiple Range Test (DMRT) using the R program.

E. Variety Release and Popularization

The release procedure of the selected line follows the regulations set by the National Seed Board, Bangladesh. The proposed line was released when the variety showed an average yield advantage over check variety and positive recommendations from the NSB Variety Evaluation Team.

A total of 1165 field demonstrations were conducted at 11 districts (Dinajpur, Rangpur, Naogoan, Bogura, Mymensingh, Jessore, Khulna, Satkhira, Barishal, Borguna and Patuakhali) in the T. Aman season 2021 for popularization of the released variety among farmers.

III. Results And Discussion

A. Advanced Yield Trial in T. Aman, 2014

We evaluated a set of eight inbred rice lines, along with two check varieties, for their performance in advanced yield trials during the T. Aman season of 2014 (Table 1). The lines were categorized based on their suitability for salinity and irrigated conditions.

The performance parameters included plant height, effective tiller number, panicle length, number of fertile and sterile seeds, 1000 grain weight, days to maturity, and yield (Table 2). Plant height varied significantly among the lines, with IRRI 14A-4 exhibiting the tallest height (92.86 cm), while BRRI dhan49 was the shortest (81.16 cm). Effective tiller numbers ranged from 9.07 (IRRI 14A-4) to 11.0 (BRRI dhan49). Panicle length was highest in IRRI 14A-2 (23.59 cm) and lowest in BRRI dhan49 (20.73 cm). The number of fertile seeds per panicle was highest in IRRI 14A-9 (127.15) and lowest in BRRI dhan49 (103.59). Sterile seed numbers were lowest in IRRI 14A-1 (32.12) and highest in BR11 (100.45).1000 grain weight was highest in IRRI 14A-10 (30.05 g) and lowest in BRRI dhan49 (19.31 g). Days to maturity ranged from 121.60 days (IRRI 14A-1) to 133.13 days (IRRI 14A-10). Yield performance was highest in IRRI 14A-9 (5.27 t/ha), followed by IRRI 14A-4 (4.41 t/ha) and IRRI 14A-5

(4.36 t/ha) (Figure 1). We recorded the lowest yield in IRRI 14A-2 (3.68 t/ha). BR11 and BRRI dhan49 had yields of 4.06 t/ha and 3.85 t/ha, respectively (Figure 1).

TABLE II. PERFORMANCES OF THE RICE ADVANCED BREEDING LINES AT ADVANCED YIELD TRIAL DURING T AMAN SEASON 2014

S/N	Designation	Plant Height	Effective Tiller	Panicle Length	Fertile Seed	Sterile Seed	1000 Grain Weight	Days to Maturity	Yield
1	IRRI 14A-1	83.61 f	9.80 d	22.43 b	116.40 e	32.12 i	26.44 c	121.60 i	4.18 ab
2	IRRI 14A-2	88.95 c	9.53 g	23.59 a	110.49 i	34.44 g	22.28 e	125.47 g	3.68 b
3	IRRI 14A-3	83.86 f	9.67 f	21.32 c	115.88 g	52.28 b	22.88 e	124.47 h	3.95 b
4	IRRI 14A-4	92.86 a	9.07 j	22.51 b	110.49 h	37.83 e	28.43 b	131.33 b	4.41 ab
5	IRRI 14A-5	91.57 b	9.13 i	23.55 a	119.23 c	33.76 h	28.55 b	131.47 b	4.36 ab
6	IRRI 14A-6	86.22 e	9.73 e	22.15 b	127.05 b	41.56 d	25.47 d	131.13 c	4.06 b
7	IRRI 14A-9	87.65 d	10.4 b	22.19 b	127.15 a	34.35 g	25.96 cd	126.60 f	5.27 a
8	IRRI 14A-10	91.38 b	9.28 h	22.67 b	117.73 d	36.69 f	30.05 a	133.13 a	4.15 ab
9	BR11	86.41 e	10.27 c	22.23 b	115.93 f	100.45 a	22.76 e	130.53 d	4.06 b
10	BRRI dhan49	81.16 g	11.0 a	20.73 c	103.59	46.87 c	19.31 f	129.60 e	3.85 b
Variance		112.5	6.7	2.8	983.7	2214.4	12.1	112.5	1.8
STD		10.6	2.6	1.7	31.4	47.1	3.5	10.6	1.3
CV		12.1	26.5	7.5	26.9	104.5	13.8	8.3	31.8

In comparison to the check varieties BR11 and BRRI dhan49, IRRI 14A-09 (Mini Shail) exhibited distinct performance advantages in Advanced Yield Trial (AYT) during the T. Aman season 2014. Mini Shail exhibited a satisfactory yield performance of 5.27 t/ha, the highest among the lines tested, which shows the potentiality of the variety as a high-yielding one [12]. Other agronomic superiorities of Mini Shail include the performance traits of plant height, effective tiller number, panicle length, and thousand grain weight.

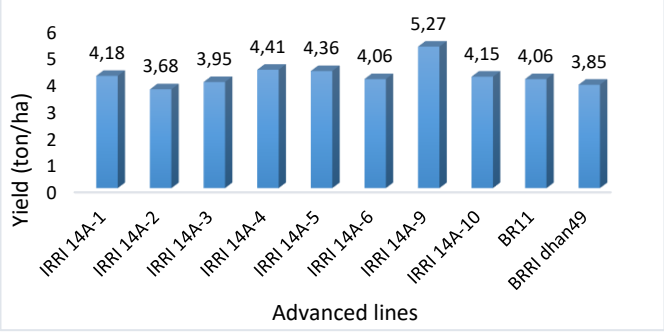

Fig. 1. The performance of the advanced breeding lines of rice during the advance yield trial in 2014

The line showed the best characteristics with respect to a number of filled grains per panicle (127.15) and indictable 1000-grain weights (30.05 g), which are the prime requirements for attaining high yield [13-14]. The shortened days to maturity (121.60 days) relative to the controls offers a distinct benefit, possibly allowing for the introduction of another crop cycle or better still, responding to the climatic conditions of the T. Aman season.

B. Multi-location Trial in T. Aman, 2015

Three advanced lines, IR14A-09, B7-S1.8-11-26-M4-537, and G11, along with check varieties BR11 and BINA Dhan7, were evaluated across six locations (Table 3). Plant height was highest in BR11 (123.14 cm) and lowest in BINA Dhan7 (102.26 cm). Effective tiller numbers were highest in B7-S1.8-11-26-M4-537 (9.7) and lowest in BR11 (7.2). Days to maturity varied, G11 matured in 134.7 days and BINA Dhan7 matured in 113.2 days. Yields varied across locations, with IR14A-09 showing the highest mean yield (5.61 t/ha). The other lines showed lower mean yields, with B7-S1.8-11-26-M4-537 having the lowest (3.93 t/ha).

TABLE III. PERFORMANCES OF THE RICE ADVANCED BREEDING LINES AT MULTI-LOCATION TRIAL DURING T AMAN SEASON 2015

Entries	Plant Height	Effective Tiller	Days to Maturity	Yield						
				BSMRAU, Gazipur	Dhirassrom, Gazipur	Joypurhat Sadar	Khajura, Jessore	Paba, Rajshahi	Tanore, Rajshahi	Mean
IR14A-09	113.23 c	8.9 b	126.4 d	5.35	5.87	5.24	5.63	5.34	6.20	5.61 a
B7-SI.8-11-26-M3-537	102.78 d	9.7 a	134.2 b	3.74	3.89	3.89	3.95	4.36	3.76	3.93 c
G11	122.33 b	7.5 c	134.7 a	5.20	5.07	5.31	5.06	4.88	4.73	5.04 b
BR11(Check)	123.14 a	7.2 d	127.5 c	5.60	3.17	5.37	4.13	5.59	4.83	4.78 b
BINA dhan7(Check)	102.26 d	9.1 b	113.2 e	3.88	3.71	3.45	3.30	3.69	3.03	3.51 c
Variance	88.55	1.96	68.55	-	-	-	-	-	-	0.85
STD	9.41	1.40	8.28	-	-	-	-	-	-	0.92
CV	8.34	16.49	6.51	-	-	-	-	-	-	20.09

The effectiveness of Mini Shail was, moreover, confirmed in the Multi-Location Trials (MLTs) held in 2015 at six different locations. Consistency and versatility which are imperative for wider adoption were demonstrated by Mini Shail when it achieved the highest average yield of 5.61 t/ha in different environments [14-15]. The performance of the line in different agroecological zones underlines its suitability as a robust variety to increase rice cultivation in Bangladesh.

C. Distinctness, Uniformity, and Stability (DUS) Testing

The Seed Certification Agency (SCA) conducted DUS tests in 2016 and 2017 to compare the IR14A-09 (branded as Mini Shail) with BRRI dhan39. We summarized the critical characteristics in Table 4. Mini Shail exhibited distinct differences from BRRI dhan39 in leaf color (dark green vs. green), culm length (long vs. medium), grain length (long vs. medium), and grain shape (slender vs. medium slender).

TABLE IV. DISTINCTNESS, UNIFORMITY, AND STABILITY (DUS) TEST DATA SHEET OF IR14A-09

S/N	Characteristics	BRRI dhan39 (check)		IR14A-09 (Proposed as Rabi dhan1)		Remark
		Code	State	Code	State	
1	Leaf sheath: anthocyanin color	1	Absent	1	Absent	
2	Leaf color	2	Green	3	Dark Green	Distinct
3	Penultimate leaf: pubescence of blade	7	Strong	7	Strong	
4	Penultimate leaf: anthocyanin color of auricles & collar	1	Absent	1	Absent	
5	Penultimate leaf: coloration of ligules	9	Present	9	Present	
6	Penultimate leaf: the shape of the ligules	3	Two-cleft	3	Two-cleft	
7	Flag leaf: attitude of blade	1	Erect	1	Erect	
8	Time of heading (50% of plants with heads)	5 (100 days)	Medium	5 (105 days)	Medium	
9	Male sterility (only for hybrid rice)	-	-	-	-	
10	Lemma & plea: anthocyanin color	1	Absent	1	Absent	
11	Lemma & plea: anthocyanin color below apex	1	Absent	1	Absent	
12	Lemma: anthocyanin color of apex	1	Absent	1	Absent	
13	Spikelet: the color of stigma	1	White	1	White	
14	Culm diameter	5	Large	5	Large	
15	Culm: Length	5 (80.0 cm)	Medium	7 (83.0 cm)	Long	Distinct
16	Stem: anthocyanin color of nodes	1	Absent	1	Absent	
17	Stem: Intensity of anthocyanin color of nodes	-	-	-	-	
18	Stem: anthocyanin color of internodes	1	Absent	1	Absent	
19	Panicle: length	7(26.0cm)	Long	7(29.0 cm)	Long	
20	Panicle: the curvature of main axis	7	Strong	7	Strong	
21	Panicle: number of effective tillers in plant	5 (8)	Medium	5 (9)	Medium	
22	Spikelet: Pubescence of lemma & plea	7	Strong	7	Strong	
23	Spikelet: the color of the tip of lemma	1	White	1	White	
24	Panicle: awn in spikelet	1	Absent	1	Absent	
25	Panicle: length longest awn	-	-	-	-	
26	Panicle: distribution & color of awns	-	-	-	-	
27	Panicle: attitude of branches	3	Semi-Erect	3	Semi-Erect	
28	Panicle: exertion	9	Well exerted	9	Well exerted	
29	Time of maturity	5 (125 days)	Medium	5 (130 days)	Medium	
30	Grain wt of 1000 fully developed grains (at 12%)	5 (23.34g	Medium	5 (23.87g	Medium	
31	Grain: length (without dehulling)	5 (7.62mm)	Medium	7 (8.25 mm)	Long	Distinct
32	Spikelet: Sterile lemma length					
33	Decorticated grain: length (After dehulling, before milling)	3 (6.0 mm)	medium	5 (6.7 mm)	Long	Distinct
34	Leaf senescence	5	Intermediate	5	Intermediate	
35	Decorticated grain: shape (Length-breadth ratio)	7 (3.00)	Medium Slender	9 (3.35)	Slender	Distinct
36	Decorticated, unpolished grain: Color	1	White	1	White	
37	Polished grain: the size of white core or chalkiness	1	Absent	1	Absent	
38	Endosperm: content of Amylose	5 (27.0)	High	5 (26.0)	High	
39	Decorticated grain aroma	1	Not scented	1	Not scented	
40	Other distinct special characters (if any)					

The DUS testing was able to discriminate Mini Shail from BRRI dhan39 according to a number of morphological features, including the color of the leaves, the length of the culms, and the properties of the grain. These characteristics are necessary for the identification of varieties and the preservation of those varieties under laws that protect plant varieties [16-17]. According to Julio [18], the long and slender grains of Mini Shail are a desirable characteristic in both domestic and foreign markets. This is because they coincide with the tastes of consumers and the expectations of the market.

D. Proposed Variety Trial (PVT)

IR14A-09 (branded as Mini Shail) was tested in ten locations during 2018 to study its yield performance against BRRI dhan39 (Table 5). The yield advantage of Mini Shail over BRRI dhan39 ranged from 21.4% to 70.7% in different locations. It was highest in Rajshahi, 6.47 t/ha, and lowest in Shorsa, Jashore, 4.62 t/ha.

TABLE V. YIELD PERFORMANCES OF THE RICE ADVANCED BREEDING LINE DURING THE PROPOSED VARIETY TRIAL (PVT), 2018

Designation	BRRI, Rajshahi	BSMRAU, Gazipur	Kaligonj, Jhinaidah	Khetlal, Joypurhat	Mawna, Gazipur	Nurpur, Jashore	Poba, Rajshahi	Sherpur, Bogra	Shorsa, Jashore	Ujirpur, Barishal
IR14A-09	6.30	4.92	6.47	5.47	6.10	5.89	6.19	5.23	4.62	5.14
BRRI dhan39 (Check)	5.13	3.98	5.17	3.90	3.83	4.30	4.90	3.07	3.47	4.23
Yield advantage (%)	22.7	23.6	25.2	40.2	59.2	37.1	26.3	70.7	33.3	21.4

The proposed variety (IR14A-09) demonstrated a yield advantage ranging from 22.7% to 70.7% compared to the check variety (BRRI dhan39) across different locations. The proposed variety demonstrated significant yield advantages, especially in areas such as Shorsa (Jashore), Khetlal (Joypurhat), and Sherpur (Bogra), where the yield advantage surpassed 30% (Table 5). The proposed variety has demonstrated a 35% average yield advantage compared to the check variety BRRI dhan39, and it has received recommendations from the Variety Evaluation Team of NSB across various locations in Bangladesh.

The results of the proposed variety trials feature the dominant effects of genotype, location, and interactions on yield performance. The tested variety (IR14A-09, branded as Mini Shail) consistently performed better than the control

variety in multiple locations, thus indicating its prospects for wide scale use (Figure 2). The yield advantages described in the breeding strategy emphasize on the importance of creating high yielding adaptive varieties not only to the targeted zone but also to the various farming systems of the zone.

TABLE VI. GRAIN PROPERTIES OF MINI SHAIL (IR14A-09)

Designation	1000 grain wt. (g)	Milling Yield (%)	Head Rice Yield (%)	Decorticated grain				Protein (%)	Amylose (%)
				Length (mm)	Breadth (mm)	L/B	Size & shape		
Mini Shail (IR14A-09)	23.87	71.0	64.0	6.7	2.0	3.35	Long Slender	7.8	26.0
BRRI dhan39 (Check)	23.34	71.5	64.5	6.0	2.0	3.00	Medium Slender	7.6	26.5

The PVT demonstrated a marked superiority in yield of Mini Shail in comparison with BRRI dhan39, with improvements between 21.4% and 70.7% in yield being recorded at ten locations. The exceptionally better yield advantage, especially at Rajshahi and Shorsa, Jashore, indicated that Mini Shail has a high adaptation capability and may bring about a revolution in the local rice production [19]. The ability to perform over different environments over the years illustrates the genetic stability and adaptability of Mini Shail which make it a suitable candidate for mass cultivation production.

E. Grain Properties

Mini Shail would have been wider acceptability due to long grain (6.7mm) and length-breadth ratio 3.35 which is higher than the check variety (Table 6, Figure 3). Indeed, consumers prefer long, slender grain. Mini Shail showed a milling outturn percentage of 71% and a head rice recovery percentage of around 64%, which are in acceptable ranges. Protein content of the Mini Shail is 7.8%, which is similar to the check variety BRRI dhan39 (7.6%). The amylose percentage is 26%, which will ensure that the rice does not stick when cooked. The cooking time of Mini Shail is similar to “miniket” branded rice. The plane rice has soft and non-sticky appearance.

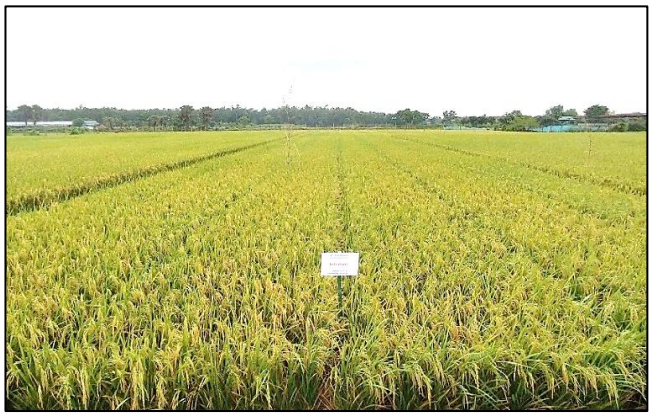

Fig. 2. Visual representation of the Mini Shail (IR14A-09) field

Mini Shail is a variety of rice whose grain properties are specifically developed to meet the diverse expectations of consumers in terms of quality. Its features include a longer grain size (6.7mm) and a reasonable length-breadth ratio (3.35). The variety has a milling outturn of 71% and a head rice recovery of 64%, both of which are within commercially viable limits [20]. This guarantees that millers can make a profit from their activities [21]. In addition, Mini Shail contains protein level of 7.8% and has amylose content of 26% in the product, enhancing the nutritional value of the product and appealing cooking qualities like non-sticky texture that are vital for customer satisfaction [22-23].

BRRI dhan39 Mini Shail BR11

Fig. 3. Grain comparison of Mini Shail (IR14A-09) with mega varieties

F. Variety Release and Popularization

On the recommendation of the National Technical Committee of NSB, the 99th National Seed Board meeting released the candidate line IR14A-09 as Rabi dhan1 in 2019. The seed law restricts the submission of private sector products as new varieties for release in 2019. Therefore, the applicant signed a national-level PPP agreement with Rajshahi University and submitted the application to NSB for the release of "Rabi dhan1", adhering to the laws governing the naming of new rice varieties.

We conducted field demonstrations across 11 districts in 2021 to popularize Mini Shail. 1165 plots were evaluated, with yields ranging from 3.21 t/ha to 7.04 t/ha (Table 7). We recorded the highest yield in Satkhira (7.04 t/ha) and the lowest in Mymensingh (3.21 t/ha). Overall, Mini Shail showed a mean highest yield of 6.35 t/ha and a mean lowest yield of 4.49 t/ha across all locations.

TABLE VII. FIELD DEMONSTRATION AT 11 DISTRICTS OF BANGLADESH IN 2021 FOR THE POPULARIZATION OF MINI SHAIL

S/N	District	No of plot	Highest Yield/ha	Lowest Yield/ha
1	Dinajpur	199	6.47	3.95
2	Rangpur	100	6.17	3.94
3	Naogaon	100	6.42	5.11
4	Bogura	100	5.93	4.45
5	Mymensingh	168	6.30	3.21
6	Jashore	98	6.42	4.94
7	Khulna	100	6.44	4.45
8	Satkhira	50	7.04	4.42
9	Barishal	100	6.2	4.32
10	Borguna	50	6.52	6.19
11	Patuakhali	100	5.93	3.95
	Total/Average	1165	6.35	4.49

The National Seed Board (NSB) indicates the notable accomplishment in the release of Mini Shail as Rabi dhan1. The association between the ACI limited and Rajshahi University, fostered by a public-private partnership (PPP) agreement, demonstrates the importance of such collaborations in improving agricultural research and dissemination of improved varieties [24]. Related to compliance with local regulations, but more importantly, to the active promotion of Mini Shail's image is its expected economic scope and market placement.

Field demonstrations across 11 districts offer practical experience regarding the effectiveness of Mini Shail in actual agricultural practice. The highest yield reported from Satkhira is 7.04 t/ha, while the highest average yield at all sites is 6.35 t/ha which proves the high yield potential of Mini Shail (Table 7) [25]. The demonstrations stressed the wide range of adaptability of the variety and its ability to increase rice productivity in many different agroecological zones [26-27].

G. Grain Properties

The popular name "Shail Dhan" has a long history of rice cultivation during "Aman" season in Bangladesh. It was famous for the best quality plane rice dish. Recently, the "Miniket" brand has gained popularity among millers and consumers due to its slender grains and good cooking rice properties. Importantly, ACI is branding "Mini Shail" as the variety Rabi dhan1 possesses dual properties of slender grain, and NSB released it for cultivation in the "Aman" season nationwide.

The origin of branding Mini Shail lies in the age-old tradition of "Shail Dhan" and the popularity of the brand 'Miniket.' ACI limited smartly placed Mini Shail by synergizing the best attributes of slender grains with the cooking qualities of Rabi dhan1, which appeals to both the old and modern-day audience. This dual branding not only enhances the marketability but also appeases the customers enhancing the chances of potential market gains [28] increasing returns in the market.

Some of the notable benefits of Mini Shail are its shorter period of growth (130 days), increased yield (1.5 MT/ha in comparison with BRRI dhan39 and 0.8 MT/ha in comparison with BRRI dhan49), as well as good resistance to diseases (BLB and Blast); hence it is better than the currently existing varieties. The relatively lower cost of production due to the disease resistance trait and higher returns from long slender grains in the market, who further enhance its economic viability for the farmers [29].

H. Grain Properties

Mini Shail has a yield potentiality of 6-7 MT/ha (average 5.8 MT/ha); however, it has a 0.8 MT/ha yield advantage over mega variety BRRI dhan49 and 1.5 MT/ha over BRRI dhan39. Duration of Mini Shail is also 05 days shorter than BRRI dhan49 with non-lodging and non-shuttering habits. Also, the variety has been showing resistance against BLB and blast diseases, which will reduce the cost of production. Grain properties are found suitable over check varieties, and that contributes to selling at a higher price over BRRI dhan49 and BRRI dhan39.

Mini Shail showed substantial benefits in terms of production and quality when compared to mega varieties such as BRRI dhan49 and BRRI dhan39. The fact that it is resistant to lodging and shattering, in addition to having an average yield advantage of 0.8 MT/ha over BRRI dhan49 and 1.3 MT/ha over BRRI dhan39, demonstrates that it has the potential to surpass these commonly grown varieties [30]. Because of its non-sticky and high-quality grain, Mini Shail also provides a competitive advantage in the market, which has the potential to bring in better prices and improve the profitability of individual farmers.

IV. CONCLUSIONS

Comprehensive evaluation and approval of Mini Shail (IRRI 14A-09) across AYT, MLT, and DUS testing, PVT trials and field demonstrations at different locations brought its potential as a high-yielding adaptive commercial variety for Bangladesh during the Aman season. Combined with Mini Shail high-yield advantages, good grain quality, and wide adaptability suggest that it is well suited for large-scale cultivation in the rice field of Bangladesh as a strategic approach to improving both rice productivity and farmer income. The successful marketing and acceptance of Mini Shail can be used as a template for the future development and market release of new varieties, which will contribute to economic development and food security in Bangladesh.

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