



BRRI ANNUAL REPORT 2022-2023



BANGLADESH RICE RESEARCH INSTITUTE

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Contents

vii	Preface
viii	Personnel
xv	Weather information
xviii	Abbreviations and acronyms

1 Plant Breeding Division

2	Summary
2	Variety development

25 Biotechnology Division

26	Summary
27	Development of Double Haploid Rice Through anther Culture
34	Development Of Rice Variety Through Somaclonal Variation
35	Development Of Rice Variety Through Wide Hybridization
35	Development Of Rice Variety Through Mutation Breeding
36	Development Of Rice Variety Through Marker Assisted Selection
37	Rice Transformation
37	Genome Editing Through Crispr
37	C4 Rice Development

39 Genetic Resources and Seed Division

40	Summary
40	Rice Germplasm Conservation And Management
45	Seed Production And Variety Maintenance
51	Exploratory And Genetic Studies

59 Grain Quality and Nutrition Division

60	Summary
61	Grain Quality Character
63	Nutritional Quality Assessment Of Rice
63	Grain Quality Parameters For Consumer Preference
66	Commercial Rice Based Products

87 Hybrid Rice Division

88	Summary
89	Development Of Parental Materials
90	Evaluation Of Parental Lines And Hybrids
100	Seed Production Of Parental Lines And Hybrids
107	Agronomy Division
108	Summary
108	Planting Practices
118	Soil Health Improvement
120	Yield Maximization Good Agricultural Practice (Gap)
121	Weed Management
124	Soil Microbiology And Management
126	Molecular Trait Management

127 Soil Science Division

128	Summary
134	Identification And Management Of Nutritional Disorder
137	Integrated Nutrient Management
140	Soil And Environmental Problems
149	Soil Microbiological Studies

153 Irrigation and Water Managment Division

154	Summary
155	Water Use Efficiency Improvement In Irrigated Agriculture
158	Land Productivity Improvement In The Costal Environment
158	Sustainable Management Of Water Resources

159	Utilization Of Renewable Energy
160	Technology Validation In The Farmers' Field
169	Plant Physiology Division
170	Summary
171	Salinity Tolerance
172	Submergence Tolerance
173	Drought Tolerance
175	Heat Tolerance
178	Cold Tolerance
181	Growth Studies And Yield Potential
189	Genome Editing
191	C4 Rice Development
193	Entomology Division
194	Summary
195	Survey And Monitoring Of Rice Arthropods
201	And Natural Enemy
201	Biological Control Of Rice Insect Pests
202	Evaluation Of Chemicals And Botanicals Against Rice Insect Pest
203	Insecticide Toxicology
205	Host Plant Resistance
206	Integrated Pest Management
208	Vertebrate Pest Management
209	Plant Pathology Division
210	Summary
212	Transferable Technology
212	Survey And Monitoring Of Rice Disease
223	Epidemiology, Yield Loss And Grain Quality Studies
224	Disease Management
226	Technology Transfer
227	Rice Farming Systems Division
228	Summary
230	Cropping Pattern Development For Favourable Ecosystem
234	Development Of Cropping Pattern For Stress Prone Environment
235	Development Of Cropping Pattern For Hilly Areas
237	Validation And Delivery Of Cropping System Technology
238	Integrated Farming Systems Research And Development
241	Agricultural Economics Division
242	Summary
243	Estimation Of Costs And Return Of Mv Rice Cultivation At The Farm Level
246	Adoption Determinants And Profitability Of Stress-Tolerant (Drought) Rice In Selected Areas Of Bangladesh
250	Effect Of Subsidy On Mechanization In Rice Cultivation: An Evidence From Combined Harvester In Haor Areas
253	Assessment Of Food Security Of Garo Tribe In Selected Areas Of Mymensingh Division
256	Impact Of Poverty Reduction On Nutrition Security In Bangladesh
258	Livelihood Vulnerability To Flood Hazard In Bangladesh
261	Agricultural Statistics Division
262	Summary
263	Stability Analysis Of Brri Varieties
266	Comparative Study For Rice Yield Estimation By Adjusting Moisture Content
268	Genotype × Environment Interaction Of Brri Varieties
277	Maintenance Of Rice And Related Database
278	Minimizing Agro Micro Climatological Risk Factors For Maximizing Sustainable Rice Production In Bangladesh
279	Suitability Mapping Of Brri Released Varieties
280	Climate Mapping Of Temperature And Rainfall Of Bangladesh
281	Season Wise Rice Area Mapping Of Bangladesh
281	Projected Climatic Factors (2050) Maps Of Bangladesh

283	Suitability Mapping Of Various Cropping Pattern
285	Capacity Building Through Training
286	Develop A Web Application To Calculate The Stability Index For Brri Stability Model
286	Establishing A Platform For Bbri Developed Management Information System (Mis)
287	Digitalized Budget Management System Of Brri
287	Digitalized Quota Management System Of Brri
288	Digitalized Salary Management System Of Brri
288	Digitalized Labour Management System Of Brri
288	Digitalized Casual Leave Application System
288	Information And Communication Technology (Ict) Activities
293	Farm Management Division
294	Summary
296	Research Activies
321	Farm Machinery and Postharvest Technology (FMPHT) Division + Workshop Machinery and Maintenance (WMM) Division
322	Summary
326	Agricultural Machinery Development And Testing
350	Milling And Processing Technology
356	Renewable Energy
362	Precision Agriculture
364	Industrial And Farm Level Extension
367	Adaptive Research Division
368	Summary
368	Technology Validation
385	Technology Dissemination
389	Promotional Activities
391	Training Division
392	Summary
392	Capacity building and technology transfer
396	Effectiveness of imparted rice production training
397	BRRI RS, Barishal
398	Summary
399	Variety Development
400	Yield Trial 2022-23
408	Pest Management
411	Disease Management
414	Crop Soil Water Management
417	Socio Economic And Policy Programme Area
420	Technology Transfer
427	BRRI RS, Bhanga
428	Summary
429	Variety Development
433	Farming Systems Research
435	Crop-Soil-Water Management
438	Socio-Economics And Policy
438	Technology Dissemination
457	BRRI RS, Cumilla
458	Summary
459	Results: Varietal Development Programme Area
462	Pest Management Programme Area
464	Crop-Soil-Water Management
466	Technology Transfer Programme Area
466	Brri Cumilla Karmasuchi

469	BRRI RS, Habiganj
470	Summary
470	Varietal Development
473	Crop-Soil-Water Management
474	Pest Management
475	Technology Transfer
479	BRRI RS, Rajshahi
480	Summary
481	Varietal Development
486	Pest Management
488	Rice Farming Systems
490	Technology Transfer
493	BRRI RS, Rangpur
494	Summary
494	Varietal Development Programme (Vdp)
496	Development Of Hybrid Rice Parental Lines And Hybrids
504	Crop-Soil-Water Management
508	Socio-Economic
508	Technology Transfer Demonstration
513	BRRI RS, Satkhira
514	Summary
517	Varietal Development, Trb
517	Aggri Network Trials In Bangladesh For Salt-Stress Prone Environment
521	Crop-Soil-Water Management
522	Socio-Economic And Policy
522	Technology Transfer
543	BRRI RS, Sonagazi
544	Summary
548	Variety Development
555	Pest Management
556	Crop-Soil Water Management
559	Socio-Economic And Policy
559	Technology Transfer
562	Enrichment Of Seed Stock
565	BRRI RS, Kushtia
566	Summary
567	Varietal Development
581	Rice Farming Systems
584	Crop-Soil-Water Management
587	Socio-Economics And Policy
592	Technology Transfer
593	Enrichment Of Seed Stock
595	BRRI RS, Sirajganj
596	Summary
596	VARIETAL DEVELOPMENT PROGRAMME
608	Pest Management Programme
609	Technology Transfer
611	BRRI RS, Gopalganj
612	Summary
618	Rice Germplasm Collection And Characterization
619	Technology Transfer

Preface

The present volume of BRRI Annual Report is a summary of research works carried out by 19 research divisions and 11 regional stations of the institute during July 2022 to June 2023. This document consists of the significant portions of the research covering eight programme areas.

The programme areas such as variety development, crop-soil-water management, rice farming systems, pest management, socio-economics and policy, farm mechanization, technology transfer and regional stations representing the broader conceptual frameworks of BRRI activities. With a target to sustain Bangladesh's achievements as a rice surplus country BRRI scientists have been engaged in developing different location specific, climate smart, stress tolerant rice varieties and some nutritionally enriched premium quality ones.

Another group of BRRI scientists dedicated their time and energy to develop and disseminate resource-saving profitable environment friendly technologies along with some management tools such as alternate wetting and drying (AWD) technique, low-cost water distribution system, rice transplanter, integrated crop management (ICM) practices, rice-based farming systems and popularization of BRRI machinery.

Furthermore, BRRI developed high yielding rice varieties along with management technologies were demonstrated in different agro-ecological zones of the country.

Above all, the present report includes various research results out of activities that attempted to minimize yield gap between research level and farmer's fields. It also includes research initiatives dedicated to finding out coping strategies to face the effects of changing climate like increased flash floods, salinity, excessive heat and drought as well as severe cold.

I acknowledge all the efforts that helped bring out the publication and special thanks for those who contributed with different capacities.

I hope the report will be useful for the scientists, extension agents, policy makers and other partners home and abroad to be updated on continuous research activities at BRRI.



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Director General
BRRI

Personnel

Director General's Office

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Director General

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Chief Scientific Officer and former Head
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Scientific Officer
Md Ashiqur Rahman, BSc Ag(Hons)
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5 Abroad for higher studies

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Hybrid Rice Division

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 Masuda Akter, *PhD*
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 S M Mofijul Islam, *PhD*
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 Md Nazrul Islam, *PhD*
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 Md Imran Ullah Sarkar, *MS1*
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 Afsana Jahan, *MS*
Scientific Officer
 Tanjina Islam, *MS*
Scientific Officer
 1 On deputation for higher studies

Irrigation And Water Management

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Entomology Division

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Scientific Officer

** Left BRRI on 20.08.2023 for Post Doctoral studies*

***Joined from regional station on 06.02.23*

**** Left BRRI on 01.03.2023 for Higher studies*

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Principal Scientific Officer

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Bodrun Nessa, PhD

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Hosne Ara Dilzahan, MS

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*ABM Mostafizur, MS****

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Afroz Zahan, PhD
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Md Romel Biswash, MS**
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Mir Mehedi Hasan, BScAg***
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Md Niaz Morshed, MS
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Khandakar Khalid Ahmed, MS
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* PRL
** Deputation for PhD
*** Deputation for MS
**** Joined from BRRI RS, Cumilla

Training Division

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Muhammad Sajidur Rahman, PhD
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Scientific Officer

Md Motalib Hossain, MS

Scientific Officer (TRB Project) Transferred to BRRI HQ;*

*** Joined BRRI RS, Barishal from BRRI RS, Bhanga*

BRRI RS, Bhanga

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Tasnia Ferdous

Scientific Officer

Bijoya Saha

Scientific Officer

Most Tanziatul Husna

Most Nusrat Zahan

Scientific Officer (TRB)

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Most Mahamuda Khatun, MS

Scientific Officer

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+ Transferred to BRRI Habiganj

** Transferred to BRRI HQ

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2Joined at BRRI RS Rajshahi on 25 November 2022

3Transferred BRRI Gazipur on 12 January 2023

4Joined BRRI RS Rajshahi on 14 August 2022

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Mst Selima Zahan, MS

*Senior Scientific Officer**

Anowara Akhter, PhD

Senior Scientific Officer

Lipi Ara Khatun, MS

*Scientific Officer***

Tapon Kumar Roy, MS

*Scientific Officer***

Md Rashid Shahriar Ripon, MS

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Md Khalid Hasan Tarek, MS

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Wazifa Afrin, MS

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Chief Scientific Officer and Head

Md. Amanut Ullah Razu, PhD

Scientific Officer

Tamal Patra Shuvo, MS

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 Md Raihan Uddin
*MS, Scientific Officer***
 Md Asib Biswas
MS, Scientific Officer
 Md Ariful Islam Khalid, MS
Scientific Officer
 Md Al-Imran Hasan
*MS, Scientific Officer***
 Tanzila Ferdous, MS
*Scientific Officer**
 Sania Tamanna, B. Sc. (Ag.)
Scientific Officer
 Md Zahirul Haque
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*** Joined to other Organization*

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Principal Scientific Officer and Head
 Md Asif Rahman, MS3*
Scientific Officer
 Md Eftekhari Uddin, MS
Scientific Officer
 Md Masud Rana
Scientific Officer
 Kh. Dil Afroze, MS
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 Nahida Akter, MS
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 Md Ariful Islam2*
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 Mostafa Kamal6*
Store Officer
 Khurshid Jahan Sihab7
Store Officer
 Md Sajol Mia1*
Assistant farm manager
 Md Saidul Islam
Power tiller driver
 Md. Mohabbot Ali

UDA cum Accountant
 Shahabaj Khan4*
LDA cum Computer Operator
 Md Hossen Khan
 MLSS
*(1*Transferred to Sirajgonj on 25-07-2022, 2*joining on 31-07-2022 and Transferred to Rajshahi on 27-02-2023 ,3joining on 11-09-2022, 4*Transferred to Gopalgonj on 09-01-2023, 5joining on 09-02-2023, 6*Transferred to Head Office on 05-03-2023, 7joining on 12-03-2023)*

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Principal Scientific Officer and Head
 ABM Anwar Uddin, PhD
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*Scientific Officer***
 Nymphaea Parveen, MS
*Scientific Officer***
 Tanzila Ferdous, MS
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 Md Sajal Miah, Dip. in Ag,
 AFM ***

BRRI RS, Gopalganj
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Weather report: Manual weather stations

During the reporting year (July'2022 to June'2023) from BRRI Gazipur and other different seven regional station (Barishal, Rangpur, Bhanga, Habiganj, Sonagazi, Comilla and Rajshahi) several weather parameter information were collected and stored in plant physiology division. A brief summary of the data were presented below:

Temperature

Among the eight weather station both highest mean maximum and lowest mean minimum temperature was observed at Rajshahi at June'2023 and January'2023 (38.82°C and 10.28°C respectively). Considering other station, April'2023 has the highest mean maximum temperature at Comilla (35.5 °C) Barishal (34.99°C), Sonagazi (34.65°C) and Habiganj (34.4°C). At Gazipur hottest month was feel at May (34.91°C). The July and August was the hottest month of Rangpur (30.95°C) and Bhanga (35.16°C).

As usually January was the coolest month observed all of the station. The lowest mean minimum temperature observed at Gazipur (13.0°C), at Comilla (14.41°C), Barishal (13.01°C), Sonagazi (13.81°C), Rangpur (10.3°C), Bhanga (12.39) and Habiganj (14.59°C).

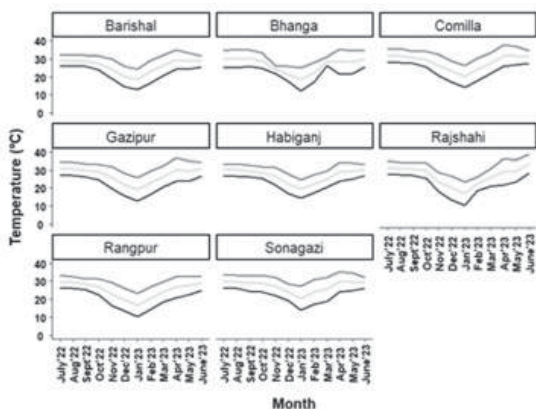


Fig.: Monthly mean maximum (top line), average (middle line) and minimum (lower line) temperature of BRRI Gazipur and Seven regional station during July'2022 to June'2023

Rainfall

During the reporting year highest rainfall was received by Barishal (1630mm) followed by Son-

agazi (1626 mm), Comilla (1616 mm), Habiganj (1570mm), Rangpur (1391mm), Gazipur (1372mm), Rajshahi (807 mm) and lowest rainfall received by Bhanga (425 mm). At June'2023 highest rainfall received by Comilla (452mm), Gazipur (303.6mm) and Rangpur (410.8 mm) at August'2023 by Habiganj (281.1 mm) and Rajshahi (276.6 mm). At Sonagazi highest rainfall was received at September'2022 (470 mm). Highest rainfall received at the month of October'2022 at Barishal (495 mm)

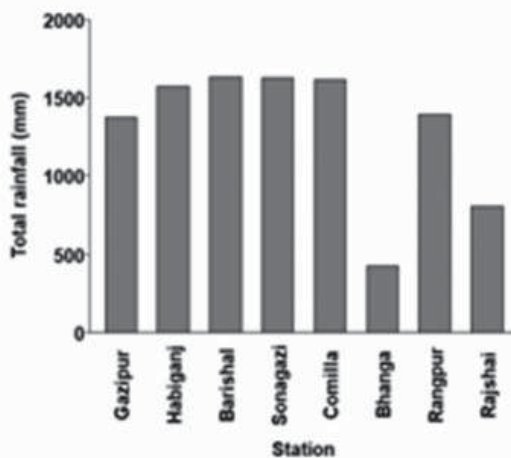


Fig.: Total Rain fall received at different stations during reporting year (July-2022 to June 2023)

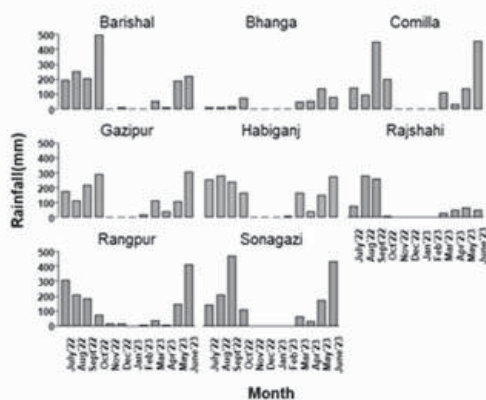


Fig.: Monthly total rainfall and of BRRI Gazipur and Seven regional station during July'2022 to June'2023

Relative Humidity (RH)

Relative humidity was higher at morning for all the station of which highest was observed at June'2023 at Bhanga and Sonagazi and at May'2023 at Gazipur, at September'2022 at Barishal, and Comilla. On the other hand it was lowest at Sonagazi and Bhanga on February'2023, at Barishal, Rajshahi and Gazipur and Rangpur on April'2023, at Comilla on January'2023.

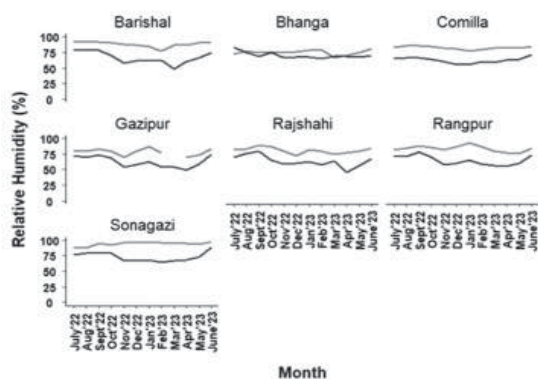


Fig.: Monthly mean Relative Humidity (%) of BRRi Gazipur and Six regional station during July'2022 to June'2023. (Top line RH at 9 am and lower line RH at 2pm)

Sunshine hours and solar radiation

Gazipur, Comilla and Barishal faced higher sunshine hours at March'2023 as well as higher solar radiation intensity. At month of November'2021 Sonagazi and Rangpur received higher sunshine hour, at July Bhanga received higher solar radiation intensity as well as sunshine hours.

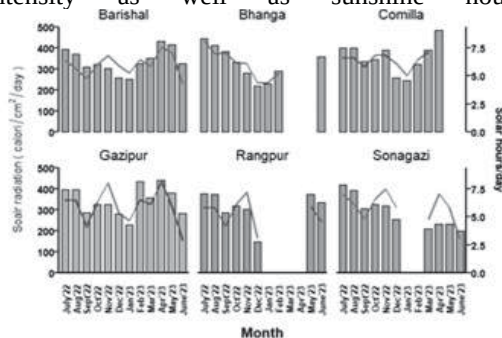


Fig.: Monthly mean sunshine hrs (line graph) and solar radiation of BRRi Gazipur and five regional station during July'2022 to June'2023

Abbreviation and acronyms

AEZ	= agroecological zone
ALART	= advanced line adaptive research trial
ARIMA	= auto regressive integrated moving average
As	= arsenic
AT	= active tillering
AWD	= alternate wetting and drying
AYT	= advanced yield trial
B. Aman	= broadcast Aman
BADC	= Bangladesh Agricultural Development Corporation
B. Aus	= broadcast Aus (upland rice)
Bak	= bakanae
BARI	= Bangladesh Agriculture Research Institute
BB	= bacterial blight
B	= Blast
BC	= back cross
BCR	= benefit-cost-ratio
BI	= blast
BLB	= bacterial leaf blight
BINA	= Bangladesh Institute of Nuclear Agriculture
BMDA	= Barind Multi Purpose Development Authority
BPH	= brown plant hopper
BR	= Bangladesh rice
BS	= breeder seed
BRRI	= Bangladesh Rice Research Institute
BWDB	= Bangladesh Water Development Board
BShB	= bacterial sheath blight
CAB	= Commonwealth Agriculture Bureau
ck	= check
cm	= centimetre
CDB	= Carabid beetle
CMS	= cytoplasmic male sterile
CSW	= continuous standing water
CV	= common variance, co-efficient of variation
DAE	= Department of Agricultural Extension (Bangladesh)
DAP	= drought animal power
DAS	= days after seeding
DAT	= days after transplanting
DH	= dead heart
DHB	= dark-headed borer
DMRT	= Duncan's multiple range test
DNA	= deoxyribonucleic acid
DNI	= Direct normal irradiance
DHI	= Diffuse horizontal irradiance
DTF	= days to flowering
DWSR	= Direct wet seeded rice
DWR	= deepwater rice
ET	= evapotranspiration

FS	= foundation seed
FMPHT	= Farm Machinery and Postharvest Technology
GABA	= gamma amino buteric acid
GH	= grasshopper
GHG	= green house gas
GM	= gall midge
GMB	= green mirid bug
GLH	= green leafhopper
GoB	= Government of Bangladesh
GRS	= Genetic Resources and Seed
GSR	= green super rice
GQN	= Grain Quality and Nutrition
GWP	= global warming potential
HA	= Habiganj Aman
HAT	= hours after treatment
HB	= Habiganj Boro
HNRP	= Hill Nerica Rice Productivity
ht	= height
IIRON	= International Irrigated Rice Observational Nursery
INGER	= International Network for Genetic Evaluation of Rice
INM	= integrated nutrient management
IPM	= integrated pest management
IPNS	= integrated plant nutrition system
IRRI	= International Rice Research Institute (Philippines)
IRSSTN	= International Rice Soil Stress Tolerance Nursery
IURON	= International Upland Rice Observational Nursery
LCC	= leaf colour chart
LBB	= lady bird beetle
LHC	= long-horned cricket
Lit/ha	= litre per hectare
LR	= leaf roller
LSc	= leaf scald
LSD	= least significant difference
LV	= local variety
LIV	= local improved variety
MAS	= marker assisted selection
MER	= micronutrient enriched rice
ML	= monogenic line
MLT	= multi-location trial
MMT	= million metric tons
MR	= moderately resistant
MT	= maximum tillering
MV	= modern variety
meq	= milli equivalent
NGO	= non-government organization
NIL	= near isogenic line
NIR	= net irrigation requirement
NSB	= National Seed Board (Bangladesh)
OC	= oil cake
OHLH	= orange headed leafhopper

OT	=	observational trial
OYT	=	observational yield trial
PAcp	=	phenotypic acceptance
PI	=	panicle initiation
PQR	=	premium quality rice
PVART	=	proposed variety adaptive research trial
PVS	=	participatory varietal selection
PVT	=	proposed variety trial
PYT	=	preliminary yield trial
QTL	=	quantitative trait loci
RCB design	=	randomized complete block design
RF	=	rainfall
RH	=	rice hispa
RLF	=	rice leaf folder
RLR	=	rice leaf roller
RPT	=	rice production training
RS	=	Regional station
RTV	=	rice tungro virus
RWM	=	rice whorl maggot
RWS	=	relative water supply
RYT	=	regional yield trial
SAAO	=	Sub Assistant Agricultural Officer
SB	=	stem borer
SCA	=	Seed Certification Agency (Bangladesh)
SD	=	standard deviation
SES	=	standard evaluation system
ShB	=	sheath blight
ShR	=	sheath rot
SPDP	=	seed production and dissemination trial
SPIRA	=	Strengthening Physical Infrastructure and Research Activities
SR	=	solar radiation, stem rot
STB	=	soil test based
STPD	=	staphylinid
SYT	=	secondary yield trial
T. Aman	=	transplanted Aman
T. Aus	=	transplanted Aus
TGW	=	1000-grain weight
TLS	=	truthfully labelled seed
TOC	=	Training and operation cell
TRB	=	Transforming Rice Breeding
TSP	=	triple super phosphate
USG	=	urea super granule
WMM	=	Workshop Machinery and Maintenance
WBPH	=	white-backed plant hopper
WS	=	wet season
WSR	=	wet-seeded rice
WTR	=	weed tolerant rice
wt	=	weight
YSB	=	yellow stem borer

Plant Breeding Division

- 2 Summary**
- 2 Variety development**

SUMMARY

For the development of rice varieties under different ecosystems, 695 crosses were made and 530 crosses were confirmed during 2022-23. A total of 5,31,077 individual plants were advanced from F₂₋₆ generation following single seed decent (SSD) method under rapid generation advance (RGA) condition. From line-stage testing (LST), 6,430 genotypes were selected based on yield and other agronomic performances. A total of 1,639 genotypes from observational yield trial (OYT) and 1,014 advanced breeding lines were selected from different yield trials (PYT, SYT, AYT, RYT, ALART and PVT). A total of 49 germplasm from different biotic and abiotic screening nurseries were selected during T. Aman and Boro season to use as parents in the breeding programme.

National Seed Board (NSB) of Bangladesh has released two promising genotypes viz BR8862-29-1-5-1-3 and BRC266-5-1-1-1 as BRRI dhan104 and BRRI dhan105, respectively for cultivation throughout the country in Boro season and BR8781-16-1-3-P2 has been released as BRRI dhan106 for non-saline tidal submergence areas for Aus season. BRRI dhan104 is a premium quality aromatic Basmati type high yielding Boro rice variety. The size and shape is extra-long slender (7.5 mm) with white colour grain of newly developed Basmati type variety. It is a strong aromatic rice variety (according to GCMS system the value of volatile aromatic compound is 2.12 ppm). Its grain contains 29.2% amylose and 8.9% protein. Weight of 1000 mature grain of the variety is around 21.5 grams. The average yield of BRRI dhan104 is 7.30 t/ha with 147 days growth duration, its potential yield can be up to 8.71 t/ha under favourable environment and appropriate agronomic management. BRRI dhan105 is high yielding low GI Boro rice for cultivation throughout the country. The average yield of BRRI dhan105 is 7.6 t/ha with 148 days growth duration, its potential yield can be up to 8.5 t/ha under favourable environment and appropriate agronomic management. As the GI value of this rice variety is 55 so it can be called a low GI or diabetic rice. The amount of amylose and protein of the variety is 27.0% and 7.3%, respectively. BRRI

dhan106 is a high yielding rice variety suitable for non-saline tidal submergence areas for Aus season. The average yield of BRRI dhan106 is 4.8 t/ha with 117 days growth duration. Lodging tolerance is the special feature of this variety. Amylose content is 27.2% and protein content of this variety is 8.5%.

VARIETY DEVELOPMENT

Development of upland rice (B. Aus). Efforts were made to develop upland rice varieties with multiple traits viz quick seedling emergence, vigorous growth, short growth duration (90-100 days); tolerance to lodging and drought and pre-harvest sprouting tolerance; medium bold to medium slender grains and good eating quality. In 2022-23, eleven crosses were made using 17 parents. Out of seven crosses, six crosses were confirmed as true F₁s through hybridity test. Out of 2,262 lines, 64 genotypes derived from 14 crosses were selected from LST based on identical flowering, grain type traits and phenotypic acceptability under field condition. Twenty-seven entries were selected considering growth duration, yield, uniformity of morpho-agronomic traits and superiority over the standard checks from 207 advanced breeding lines in OYT. Eight genotypes such as BR12236-5R-6, BR12244-5R-24, BR12248-5R-18, BR12248-5R-22, BR12248-5R-37, BR12248-5R-65, BR12248-5R-122 and BR12263-5R-75 were selected from 15 tested entries on the basis of yield and short growth duration in PYT-1. In PYT-2, four genotypes were selected namely, BR12239-5R-136, BR12244-5R-190, BR12246-5R-97 and BR12248-5R-31 from fourteen and in PYT-3, seven genotypes were evaluated but none of the entry was selected. Four genotypes viz BR11262-B-109-3-47, BR10756-2B-8-72, BR10409-15-2-8 and BR10417-15-2-11 were selected from seven tested entries in SYT.

Improvement of jhum rice under upland rice programme was implemented to develop high yielding rice variety with low (10-19%) to high (>25%) grain amylose content and drought tolerance along with good eating quality for jhum cultivation acceptable to tribal population of Chattogram hill districts. Seventeen crosses were made involving parental genotypes from local Jhum cultivars, exotic varieties, single BRRI variety, promising advanced breeding lines having low to high level

amylose content. Seven crosses were confirmed as true F_1 . Six F_2 populations were grown for generation advance through field RGA (Rapid generation advance). A total of 9,180 progenies obtained from 17 crosses of F_4 generation were advanced through field RGA. Twenty-three entries from 48 tested genotypes in OYT were selected. Four PYTs were conducted in 2022. Among them, four and six genotypes were selected from 14 and 18 genotypes of PYT-1 and PYT-3, respectively. In each of the PYT-2 and PYT-4 trials, two different sets having eight genotypes were evaluated but none of the entries was promoted for succeeding trial. Seven out of 16 entries were selected in SYT. An

advanced yield trial was conducted in six locations of three hilly districts (Khagrachori, Rangamati and Bandarban) of Bangladesh. Eight genotypes including BRRI dhan83 as standard check and one local check i.e., most popular cultivar specific to each location were evaluated. The other six common genotypes for each of the six trials were Chinese rice, Japanese black rice, Mongthongno, IR1-DQ157-R6-D1, GSR IR1DQ121-Y6-D2 and BR (Bio)10376-AC4-1-3. Among all the entries, despite heterogeneity in climatic condition and topographic architecture, BRRI dhan83 was the top yielder entry in every trial (**Table 1**).

Table 1. Performance of the genotypes in AYT, development of Jhum Rice, 2022-23.

Genotype	PH (cm)	GD (day)	L1	L2	L3	L4	L5	L6	Yield (t/ha)
Chinese rice	104	118	1.3	1.4	2.8	2.1	0.9	2.2	1.8
Japanese black rice	110	135	0.9	0.8	0.5	1.2	0.5	1.9	1.0
Mongthongno	121	105	1.5	1.5	2.6	1.5	1.4	2.9	1.9
IR1-DQ157-R6-D1	107	126	1.4	1.4	2.1	1.7	1.1	2.3	1.7
GSR IR1DQ121-Y6-D2	97	118	1.1	1.7	2.4	1.7	1.9	2.2	1.8
BR(Bio)10376-AC4-1-3	94	117	1.1	1.2	2.8	1.7	1.5	2.2	1.8
BRRI dhan83	112	110	2.0	1.9	2.9	2.0	2.1	3.9	2.5
LSD < 0.05	10.8	6.9	0.3	0.3	0.5	0.6	0.3	0.5	0.4
H2b	0.84	0.94	0.93	0.92	0.93	0.69	0.95	0.93	0.91

PH=Plant Height (cm); GD= Growth duration (day); L1=Rowangchori, Bandarban; L2=Sadar, Bandarban; L3=Matiranga, Khagrachori; L4=Sadar, Khagrachori; L5=Kaptai, Rangamati; L6=Sadar, Rangamati.

Investigators: M A Hossain and N Jahan

Development of transplanted Aus rice (T. Aus). The project was aimed to develop short duration (105-110 days), high yield potential genotypes having tolerance to lodging and heat (high temperature) at the reproductive phase, pre-harvest sprouting and good grain quality. In total, 30 crosses were made using 40 parents and 4,127 F_1 seeds were obtained; 23 crosses were confirmed as true F_1 ; 24,300 progenies of 53 crosses in T.

Aus season were advanced through modified field rapid generation advance (FRGA) technique. Out of 7,700 lines of 22 crosses, 792 uniform lines were identified from LST based on uniformity in heading, plant height, and acceptable grain type in the field condition. Finally, 697 fixed lines were selected from 792 lines on the basis of trait genotyping with 12-SNP indica panel. Forty genotypes were selected from 318 entries from observational yield trial (OYT), 24 advanced lines out of 195 from AYT#1

and AYT#2 were selected for T. Aus growing areas of Bangladesh on the basis of homogeneity with respect to plant height, phenotypic acceptability at vegetative and maturity stages and physicochemical properties. Three genotypes were selected from RYT#1 and two genotypes were selected from RYT#2 for non-saline tidal ecosystem, along with the check BRRI dhan27, BRRI dhan48 and BRRI dhan98. The proposed line BR8781-16-1-3-P2 was

evaluated along with the check variety BRRI dhan27 under PVT in six locations of non-saline tidal T. Aus growing areas of Bangladesh and proposed line was recommended to release as variety BRRI dhan106 (**Table 2**). Lodging tolerance is the special feature of this variety. Amylose content is 27.2% and protein content of this variety is 8.5% (**Figs. 1 and 2**)

Table 2. Performance of BRRI dhan106 in proposed variety trial, T. Aus 2022-23.

Designation	Plant height* (cm)	Growth duration* (day)	Mean Yield (t/ha)	Amy (%)	Protein (%)	Milling outturn (%)	Head rice yield (%)	ER (%)	Size & shape
BR8781-16-1-3-P2 (BRRI dhan106)	125	117	4.8	27.2	8.5	72.4	59.1	1.5	MB
BRRI dhan27 (Ck.)	141	114	4.1	27.5	7.6	68.8	65.4	1.4	MB

*Mean of five locations



Fig. 1. Pictorial view of BRRI dhan106.

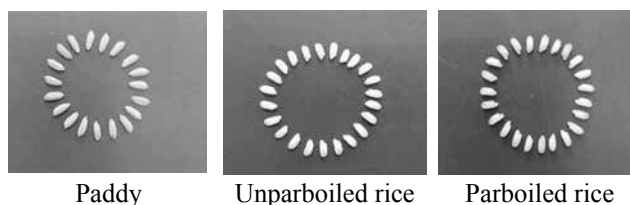


Fig. 2. Grain picture of BRRI dhan106.

Evaluation of heat resilient varieties with reduced impact of combined high day and high night temperatures on rice productivity with added premium grain quality for improving livelihoods in South and Southeast Asia under AYT. The experiment was conducted at five locations namely Gazipur, Rajshahi, Kushtia, Lalpur and Dinajpur during late Boro 2022-23. Sixteen entries including two checks BRRI dhan98 (local check) and N22 (tolerant check) were evaluated under participatory variety selection (PVS) at four locations namely Rajshahi, Kushtia, Lalpur and Dinajpur. PVS preference analysis for entries was done by the team

consisting of farmers, researchers, DAE personals, scientific assistant (SA), sub assistant agricultural officer (SAAO), dealers, millers, seed producer, local leaders, local NGOs. A number of male and female participants were chosen to participate in the PVS programme. Each farmer was provided six paper ballots (three with a tick mark for chosen entries and three with a cross mark for worst entries) and they were given necessary instructions on how to cast ballots for best and worst lines. After casting the votes, these were counted by the scientists and displayed in front of the farmers using the flip chart board.

Considering all the locations IRRI 154 (PVS-2), IR18C1005 (PVS-3), IR18C1010 (PVS-8), IR18C1002 (PVS-12), IR18C1004 (PVS-14) and BRRI dhan98 (PVS-15) were selected by the participants under PVS programme. Among the selected genotypes, IRRI154 (PVS-2) and IR18C1004 (PVS-14) were got the maximum time positive first and second ranked in the trial sites.

Investigators: M Khatun, S K Debsharma, J Ferdousy and Nese Sreenivasulu

Improvement of rice for shallow flooded and deep-water environment. The major objectives of the project were to develop high yielding (4.0-5.0 t/ha) rice varieties for deep (>1.0 m), shallow flooded area (up to 1.0 m depth), shallow deep area (30 cm water) and medium deep area (50-60 cm water) along with submergence, facultative elongation and hypoxia tolerance. In total, 23 crosses were made by using 20 parents and produced 2,500 F₁ seeds. In total seven F₁ crosses were confirmed through QC SNP panel analysis. A total of 11,754 progenies of 73 crosses (3,064 progenies of 15 F₂ crosses, 3,295 progenies of 19 F₃ crosses, 3,541 progenies of 20 F₄ crosses, 1,881 progenies of 19 F₅ crosses) were advanced through RGA. In yield trials, 34 genotypes were selected out of 83 genotypes. In OYT the genotype BR11186-5R-119 produced the highest yield (3.5 t/ha) which is significantly

higher than the check variety BRRI dhan91 (1.8 t/ha) whereas in AYT the genotype BR11186-5R-549 (3.5 t/h) produced the highest yield which was significantly higher than the check variety BRRI dhan91 (1.7 t/ha). The heritability obtained for growth duration was ranging from 82% to 88% and grain yield was ranging from 61 % to 74% indicating acceptable level of precision in these experiments. Through maintenance breeding 15 shallow flood tolerant genotypes and land races were grown and maintained for future use.

Two lines BR10230-7-19-2B (3.1 t/ha) and BR9392-6-2-1B (3.0 t/ha) were selected out of six genotypes in the ALART under deep water (100-150 cm) condition. The ALART materials were suggested for evaluating as re-trial due to damage of crops in four locations (**Table 3**). On the other hand, BR10260-5-15-21-6B was evaluated in PVT trial and this line produced 1.45 t/ha more yield than the check variety BRRI dhan91 (**Table 4**). However, the PVT material was suggested to evaluate as re-trial due to damage of crops in three locations. In T. Aman (stagnant water) 2022-23, RYT#Tall materials were evaluated with four breeding lines and the check BRRI dhan91. The highest yield was observed in the advanced line BR10247-14-18-7-3B (4.94 t/ha) followed by the line BR10238-5-1-9-3B (4.82 t/ha) and BR9892-8-2-2B (4.70 t/ha).

Table 3. Grain yield performance of genotypes in advanced line adaptive research trial (ALART), development of deepwater Aman rice varieties, T. Aman 2022-23.

Designation	GD (day)	PH (cm)	Locations				Mean Yield (t/ha)
			Farid pur	Sadar, Gopalganj	Shahjad, Sirajganj	Sadar, Gazipur	
BR10230-7-19-2B	169	177	4.09	3.5	2.06	2.58	3.05
BR9892-6-2-2B	167	179	3.64	2.8	1.14	2.35	2.48
BR9376-6-2-2B	167	160	3.59	3.1	1.12	2.3	2.52
BR9392-6-2-1B	168	167	4.31	3.1	1.67	2.99	3.01
BR-KM (Mun)PL-5-7-3-B	167	209	2.82	2.6	1.59	2.13	2.28
BR-DL(Hbj)-PL-12-4-7-B	176	211	2.22	2.4	1.54	1.89	2.01

Fulkori (ck)	177	179	1.82	2.7	1.86	1.77	2.03
LSD (0.05)	14	0.45			0.46		

Table 4. Performance of the proposed line (BR10260-5-15-21-6B) at proposed variety trial (PVT) under shallow flooded condition, B. Aman 2022-23.

Location	Proposed variety		Check	
	BR10260-5-15-21-6B		BRRI dhan91 (ck)	
	Duration (day)	Yield (t/ha)	Duration (day)	Yield (t/ha)
Talma, Faridpur	197	3.35	160	3.14
BRRI, Gopalganj	187	6.58	166	2.95
Rangunia, Chattogram	186	5.06	156	3.51
BRRI, Cumilla	203	3.08	208	2.22
Baraigram, Natore	166	1.15	158	1.10
Sahajadpur, Sirajganj	185	5.96	162	3.17
BRRI, Gazipur	187	1.88	176	0.83
Average	187	3.86	169	2.41

Investigators: Sharmistha Ghosal, A S M Masuduzzaman, S Maniruzzaman, Z A Riyadh, Afroza Awal Shoiily and K M Iftekharuddaula

Development of rainfed lowland rice (RLR).

The project aims to develop genotypes superior to standard varieties and adaptable to rainfed lowland environment in T. Aman season. In T. Aman, 5,329 F_1 seeds were obtained from 27 single crosses and 35 crosses were confirmed as true hybrid using 10-SNP *indica* QC panel. A total of 8,362 individual progenies of 32 crosses from F_3 - F_5 generations were harvested through RGA method in T. Aman season. In Boro 2022-23, 20,025 progenies were harvested out of 59 crosses from F_2 and F_4 generations through RGA method. A total 384 genotypes were selected from 6,783 progenies of line stage testing (LST) trial. **Figure 3** presents the selection intensity of the genotypes of LST. A total of 507 genotypes were evaluated from two observation yield trials (OYT) in Gazipur, Cumilla and Rangpur. Among the tested genotypes 104 genotypes were selected for advanced yield trial (AYT). Sixteen out of 53 tested

genotypes from AYT were selected for conducting in regional yield trial (RYT).

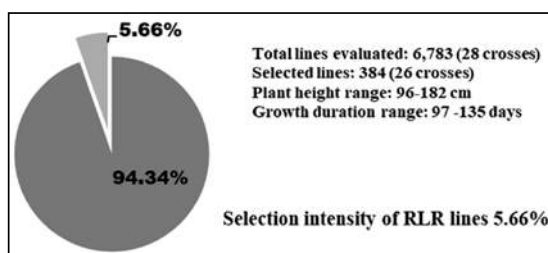


Fig. 3. Selection intensity in the genotypes of LST, RLR, T. Aman 2022-23.

Investigators: M A Kader, R R Majumder, T K Hore, U R Shaha and K Fatema

Development of rice varieties for favourable Boro environment.

The aim of this project was to develop improved genotypes with high yield potential (≥ 8.0 t/ha), earliness (135-145 days) and

accepted grain quality for favourable irrigated ecosystem in Bangladesh. Thirty-four crosses were made using 29 varieties/lines as parents targeting to develop high-yielding breeding lines enriched with favourable alleles of key target traits, viz disease resistance (blast and BLB), insect resistance (BPH) and acceptable grain quality (amylose, chalkiness, palatability, zinc content, etc). In total 36 crosses out of 39 were confirmed as true F_1 through a hybridity test using QC SNP genotyping. From segregating RGA nurseries, in total 29,723 individual plants were advanced from 118 cross combinations of F_2 - F_5 generations. Out of 2,548 lines tested in LST,

219 lines were selected based on the presence of the favourable alleles of key target genes for BLB resistance (*xa5*, and *Xa21*), blast resistance (*Pi-ta*, *Pi-9* and *Pb1*), grain quality (*Wx-a* and *Wx-10*) and uniformity in plant height, days to flowering, grain size and shape. The genotyping profile of the selected LST line (**Fig. 4**) shows that out of 259 selected uniform lines 84.56% (219) had high amylose specific allele of *Wx-a*, 52.1% had *Wx-10*, 25.0% had SCT1 (seedling stage cold tolerance), 22% had qPSST7 (reproductive stage cold tolerance). A set of 34 lines were identified as genetically superior lines containing different combinations of genes (**Table 7**).

Table 7. List of genetically superior lines identified from 2,548 LST tested during Boro 2022-23.

Gene combination	Trait	No. of lines
<i>Pi9</i>	Blast	09
<i>Pi9+SCT1</i>	Blast+ Seedling stage cold tolerance	07
<i>Pi9+Xa21+SCT1</i>	Blast+BLB+Seedling stage cold tolerance	01
<i>SCT1+Xa21</i>	BLB+Seedling stage cold tolerance	13
<i>SCT1+qPSST3</i>	Seedling and reproductive stage cold tolerance	01
<i>xa5+Xa21+qPSST3</i>	BLB+Reproductive stage cold tolerance	03
Total	34	34

Forty-seven genotypes out of 694 tested in four locations following the sparse testing model of genomic selection in OYT were selected based on genomic BLUP for yield. Out of 49 breeding lines tested in two groups of AYT at three locations, three genotypes having 149-153 days growth duration and 16.4 - 28.8% yield advantage over BRRI dhan28 (153 days growth) and 9.9-21.7% yield advantage over Bangabandhu dhan100 (151 days growth duration) and five breeding lines yielding 16.2 - 29.7% advantage with 153-154 days growth duration over BRRI dhan81 with 149 days growth duration were selected for further advancement. From RYT, two short-duration lines (7.0 t/ha in 144 days, 6.5 in 145 days), four medium-duration (151-153 days) lines yielding 6.8 -7.2 t/ha, and one long duration (161 days) breeding line having a yield of 7.99 t/ha were selected for further advancement.

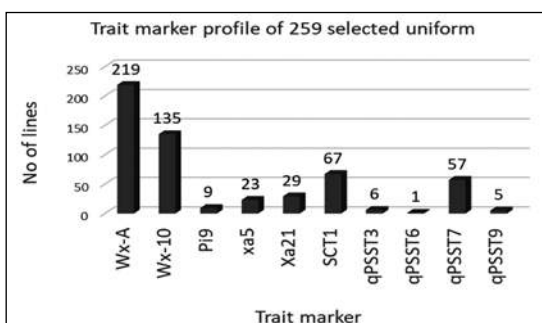


Fig 4. Trait marker profile of 259 uniform breeding lines selected from LST trial during Boro 2022-23.

Investigators: Md Anisuzzaman, Istiak Hossain Joy and P S Biswas

Development of cold tolerant rice. The major objective of the project was to develop high yielding and short duration (6.0-7.0 t/ha yield and

135-145 days growth duration for *haor* areas) and high yielding medium duration (6.5-7.5 t/ha yield with 145-150 days growth duration for Northern regions) rice varieties tolerant to cold stress at seedling and reproductive stage. Thirty-five crosses were made using 32 parents for the development of high-yielding breeding population enriched with favourable alleles of key target traits, *viz* cold tolerance at seedling and reproductive stage, and disease resistance. Thirty-five crosses out of 39 were confirmed as true F₁ through a hybridity test using QC SNP genotyping. In total 5,712 individual plants were advanced from 27 crosses of F₂-F₄ and BC₁F₂ generations of segregating RGA populations. Fifty genotypes out of 414 breeding lines and 27 genotypes out of 235 breeding lines tested under natural cold stress (at the booting stage) and non-stress conditions at two locations in OYT-1 and OYT-QTL, respectively were selected based on significantly higher yields than the check varieties of similar growth duration under non-stress condition and minimum yield reduction under cold stress condition for further yield trial. In AYT with 134 breeding lines tested in two seeding staggers

(1st one on 22-23 October 2022 to expose PI stage of the crop at a low average temperature below 20°C and 2nd one on 15-20 November 2022) at three *haor* locations of Kishoreganj, Habiganj and Sunamganj, 11 breeding lines including eight short duration (151-154 days) with yield 5.9-6.8 t/ha and three long duration (159-161 days) lines with 6.8-6.9 t/ha from cold stressed batch and 11 breeding lines including two short duration (144-145 days) with yield 6.2-6.9 t/ha and nine medium duration (146 -153 days) with 7.0 -7.8 t/ha were selected for further evaluation. In RYT, six lead breeding lines were tested at 10 *haor* locations of Nikli (Kishoreganj), Tahirpur (Sunamganj), Nabiganj, Baniachong, and Ajmeriganj of Habiganj. Among the lines, BR11894-R-R-R-R-169 yielded 5.97 t/ha (**Table 8**) at low temperature <20°C in the reproductive stage (when planted earlier than regular time) but produced 6.91 t/ha with 148-150 days growth duration at non-stress regular time, while the check varieties BRRI dhan28 and BRRI dhan67 yielded respectively 4.31 t/ha and 5.00 t/ha with 153 days and 157 days growth duration in the cold stressed early planted batch.

Table 8. Yield of the breeding lines tested in three *haor* locations in regional yield trial (RYT) during Boro 2022-23.

Designation	Yield (t/ha)								
	Nikli1	Nikli2	Nikli3	Tah2	Tah3	Hab1	Hab2	Hab3	Avg
BR11646-5R-388	4.39	4.16	3.99	5.32	4.21	4.21	2.18	4.54	4.12
BR11894-R-R-R-R-105	6.60	4.65	5.30	3.10	2.83	5.14	4.69	2.81	4.68
BR11894-R-R-R-R-169	6.59	5.17	4.84	5.39	7.64	6.82	5.76	7.84	5.97
BR11894-R-R-R-R-228	7.02	4.76	4.59	3.54	3.34	4.35	3.92	3.85	4.42
BR11894-R-R-R-R-329	6.78	4.09	3.71	3.79	4.08	4.30	4.18	2.26	4.15
IR18A1859	5.68	0.98	0.93	1.90	2.53	2.43	3.37	1.73	2.44
BRRI dhan28	4.06	3.92	3.11	4.52	4.45	5.47	3.63	5.31	4.31
BRRI dhan67	5.56	4.62	5.50	4.59	3.58	5.50	5.73	4.91	5.00
BRRI dhan89	6.48	5.46	6.33	5.35	5.48	4.54	5.24	2.44	5.17
LSD (0.05)	0.68	0.46	0.66	0.79	0.39	0.81	0.25	0.37	0.44
H2b (%)	96.95	88.63	95.73	90.29	85.33	88.35	73.84	92.38	90.19

Investigators: Md Anisuzzaman, Istiak Hossain Joy and P S Biswas

Development of salt tolerant rice (STR). The objective of this project is to develop high yielding

salt tolerant rice cultivars based on product profile. Salinity is one of the major constraints for the rainfed lowland and Boro rice ecosystem in the southern coastal zone of Bangladesh. In T. Aman season, 29

crosses were made using 40 well characterized elite parents with higher genetic merit/breeding values and various alleles of interest. A total of 39 F_1 s were confirmed as true hybrids through hybridity test via F_1 verification by quality check (QC) genotyping with purity SNP panel during T. Aman season. In T. Aman season, 41,192 segregating progenies derived from 110 crosses were advanced in F_2 - F_5

generations using FRGA technique. Yield trials were carried out in Gazipur, Debhata, Kaliganj and BRRI Farm, Satkhira in T. Aman season. In LST, out of **5,085** breeding lines of 30 crosses, 452 lines were selected on the basis of strong culm with good plant ideotype, acceptable grain type and uniformity at heading in field condition (**Fig. 5**)

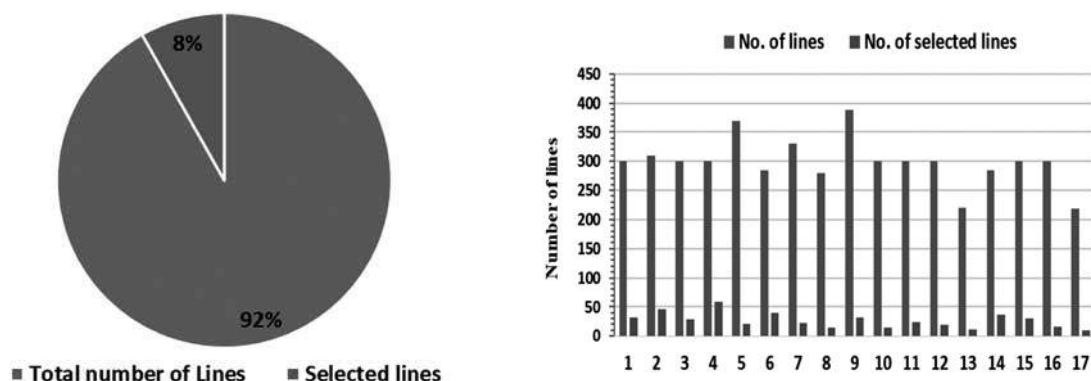


Fig.5. Number of lines of LST population, T. Aman 2022-23.

Out of 772 genotypes, 237 genotypes were selected from OYT. Four PYTs (PYT-1 to PYT-4) were conducted using 179 breeding lines following alpha

lattice design. One hundred seven genotypes were selected from these trials depending on grain yield, salinity tolerance and phenotypic acceptability.

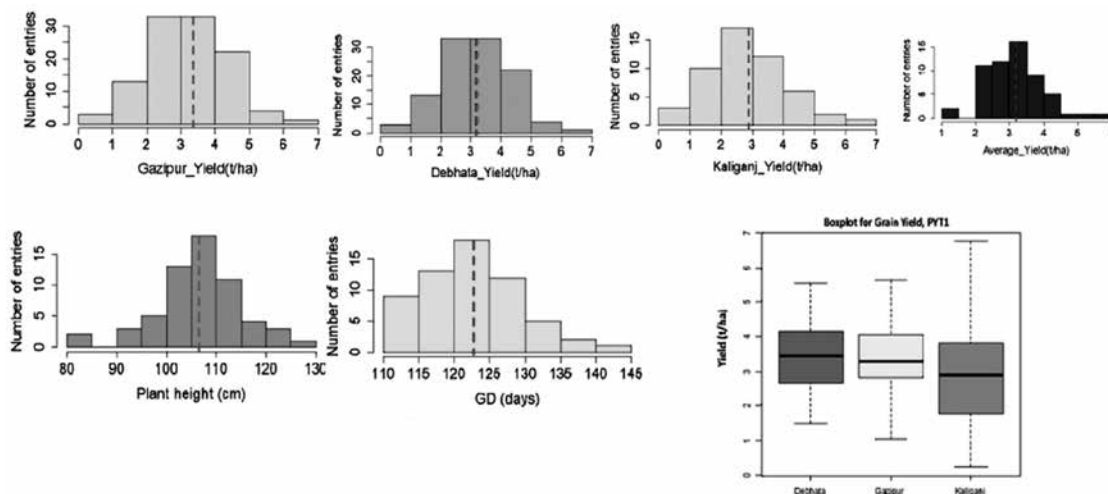


Fig 6. Graphical illustrations show the frequency distribution (number of entries) for yield, growth duration and plant height traits of PYT-1 trial at three locations, T. Aman 2022-23.

Forty-five genotypes, out of 105 were selected from AYT-1 and AYT-2 (**Fig. 6**). In ALART, three genotypes were evaluated and one genotype (BR11716-4R-102) was recommended for PVT.

The mean grain yield of selected line (BR11716-4R-102) ranged from 3.30 t/ha to 6.52 t/ha in ten locations, which were significantly higher than the check varieties. (**Table 9**).

Table 9. Performance of genotypes in ALART, STR, salinity breeding, T. Aman 2022-23.

Genotype	Growth duration (days)	Grain yield (t/ha)								
		Westbyde BRRI Gaz	Kaliganj (Satk)	Debhata (Satk)	Sadar (Gopalganj)	Sadar (Bagerhat)	Feni (Sonagazi)	Companiganj (Noakhali)	Kolapara (Patua)	Mean
BR11712-4R-218	121	4.05	4.34	4.47	4.57	4.57	6.03	4.91	2.89	4.48
BR11716-4R-102	121	4.29	4.42	4.27	4.90	4.90	6.52	5.30	3.30	4.74
BR11723-4R-172	122	3.64	4.34	4.37	4.47	4.47	5.86	5.11	2.43	4.34
BRRI dhan73 (Ck)	122	1.51	4.08	3.93	4.00	4.00	4.82	4.44	2.81	3.70
BRRI dhan87 (S. Ck)	127	4.17	4.08	4.00	4.43	4.43	5.44	5.00	2.58	4.27
% Yield increase over BRRI dhan87		2.89	8.33	6.65	10.61	10.61	20.0	6.0	27.91	11.0
LSD <0.05						0.323				
CV (%)						7.74				



Fig.7. Field view of OYT lines, Experimental plot, Satkhira, T. Aman, 2022-23.

In Boro Season, 35 crosses were made using 64 breeding values. A total of 32 F_1 s were confirmed as true hybrids through F_1 verification by quality

check (QC) genotyping with purity SNP panel. In total 49,590 segregating progenies from 114 crosses (F_2 - F_5 generation) were harvested from FRGA nursery and grown in the subsequent generation. In LST trial, 956 lines out of 6,277 lines were selected on the basis of desirable plant type, grain quality and uniformity at flowering under field condition

(Figs. 7, 8, 9 and 10). A total of 146 genotypes were selected out of 312 from OYT based on growth duration, grain yield, and homogeneity in different morpho-agronomic traits. Out of 159 genotypes, 45 genotypes were selected from four PYTs. Thirty-one genotypes were selected from three AYT.

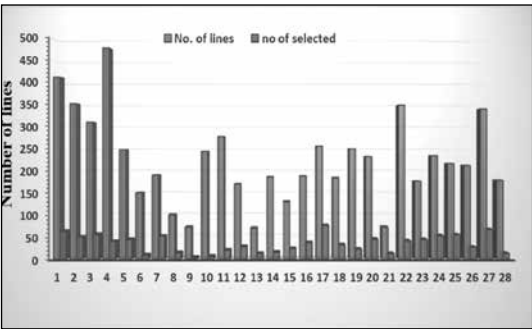


Fig. 8. Frequency distribution of LST lines in Boro 2022-23.

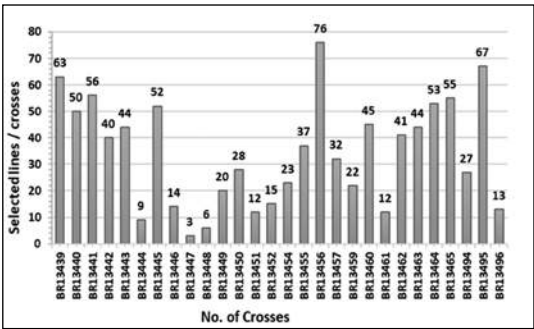


Fig. 9. Number of selected lines from LST population, Boro 2022-23.

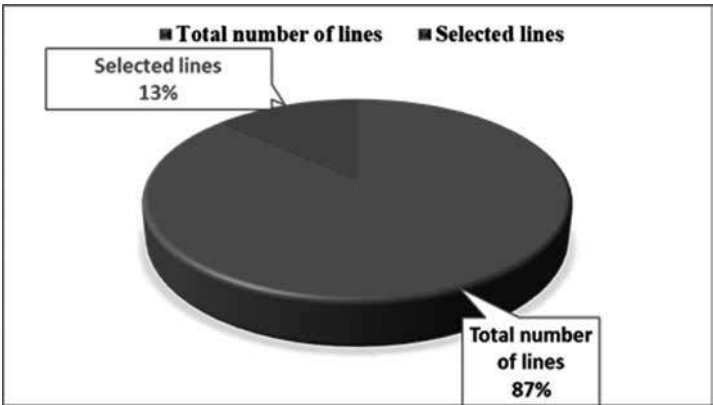


Fig. 10. The selection pressure imposed during identification of desirable LST lines in Boro 2022-23.

Thirty-one genotypes were evaluated under four RYT and two genotypes BR11712-4R-93 and BR11717-4R-12 were selected from RYT-1 to conduct ALART (Table 10). These two genotypes

produced higher yield than the check variety BRRI dhan89 and BRRI dhan99 at six locations and showed higher tolerance to salt stress during Boro season 2022-23.

Table 10. Performance of genotypes in RYT, STR, salinity breeding, T. Aman 2022-23.

Genotype	Grain yield (t h a ⁻¹)											
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	Ave
BR11712-4R-44	5.9	4.1	4.5	8.2	6.7	5.1	4.8	6.7	8.7	6.8	7.03	6.2
BR11712-4R-93	5.2	4.2	3.0	8.3	8.1	7.8	5.5	5.4	8.6	7.1	7.85	6.5
BR11717-4R-12	7.6	4.7	4.7	7.2	7.7	7.7	6.7	6.4	8.9	6.4	5.95	6.7
BR11727-4R-6	7.5	6.6	4.8	6.6	7.8	7.1	6.1	5.3	8.6	7.0	5.86	6.6
BR11712-4R-346	6.7	5.0	3.9	7.0	8.1	6.8	5.6	5.8	8.8	5.6	5.13	6.2
BR11712-4R-70	5.9	4.6	3.3	5.9	7.5	7.1	5.1	6.5	8.3	7.1	5.51	6.1
BR11713-4R-398	6.6	4.4	4.4	6.1	7.7	6.6	5.1	4.9	8.6	5.8	6.4	6.1
BRR1 dhan67 (T.ck)	6.6	5.2	4.5	6.6	7.0	6.8	5.8	6.1	7.4	6.4	7.71	6.4
BRR1 dhan89 (S.ck)	6.6	3.1	2.5	7.4	8.0	7.7	7.2	6.8	8.2	6.7	7.36	6.5
BRR1 dhan99 (T.ck)	7.5	5.6	4.3	7.3	7.8	7.4	6.5	6.2	8.3	6.9	6.6	6.8
LSD < 0.05	1.27	0.67	0.69	0.81	0.25	0.64	0.28	0.75	1.03	0.53	2.57	
H ² b	0.7	0.9	0.9	0.9	0.96	0.91	0.41	0.8	0.39	0.88	0.38	

Locations: L1=Satkhira Farm, L2=Debhata, L3=Kaliganj, L4=Sonagazi, L5=Rajshahi, L6=Rangpur, L7=Habiganj, L8=Kushtia, L9=Bhanga, L10=Cumilla and L11=Gazipur

Investigators: M. Akhlasur Rahman, Hasina Khatun, R F Disha, Nusrat Jahan, K M Iftekharuddaula, T. H. Ansari, Muhiuddin Faruquee, Md. Mizan Ul Islam, Sheikh Farah Diba, M. Rafiqul Islam and Waseem Hussain

AGGRi Network Trials in Bangladesh for Salt-Stress Prone Environment. Two hundred breeding lines from IRRI along with six international check varieties and four national check varieties were evaluated at two locations viz Shyamnagar and Kaliganj upazilas of Satkhira during Boro 2022 to select superior genotypes aiming to include directly in the variety release system or use as parents in the breeding programme.

In Shyamnagar, grain yield was ranged from 0.34 t/ha (IR21LT1560) to 2.02 t/ha (A69-1, IR21LT1564) with growth duration 120 days (IR21LT1081) to 147 days (IR21LT1239), respectively. Among 200 entries, only 13 genotypes were selected based on salinity tolerance at hotspot condition (**Fig.11**), grain type and grain yield. The genotype IR21LT1564 produced better yield (2.02 t/ha) than BRR1 dhan99 (1.49 t/ha) and Binadhan-10 (1.69 t/ha) and similar yield with A69-1. One genotype may be considered

as potential to evaluate in the advanced yield trial in the next season as stage-2 and also could be recycled as a parent in the breeding programme. On the contrary, none of the genotypes including checks were survived in Kaliganj, Satkhira.

It is important to note that when the trial plot was salinized using irrigation water with high salinity (EC ~7.0 dS/m), the irrigation water enters into the trial plot from one side and then this salt water ran off towards the other end of trial plot and salt accumulated in the distal (other part) part of the trial field. The salinity gradient in two opposite directions of the trial site was not equal. Thus, the genotypes of the distal part of the trial did not survive due to excessive accumulation of salt, consequently the salt stress was higher as well. Although we were unable to collect data from both the replications in these unavoidable circumstances, however, we had selected 13 genotypes based on phenotypic acceptability, yield under salt stress in hotspot salinity condition.

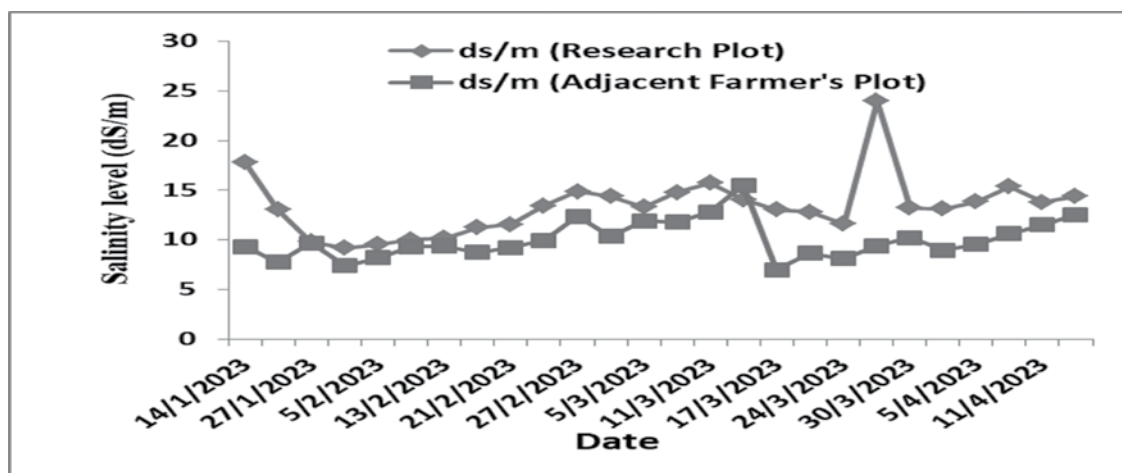


Fig. 11. Salinity level (electrical conductivity: EC expressed in dS/m) at trial plots Shyamnagar during Boro season 2022-23.

Investigators: MAkhlaur Rahman, Hasina Khatun, R F Disha, Nusrat Jahan, K M Iftekharuddaula, T. H Ansari, Muhiuddin Faruquee, Md Mizan Ul Islam, Sheikh Farah Diba, M Rafiqul Islam and Waseem Hussain

Evaluation of AFACI materials in Stage-1 trial.

The experiment was conducted in two locations viz Kaliganj and Debhata in the coastal area. Out of 104 tested entries only seven entries were survived in Kaliganj whereas, no entries were survived due to severe salinity in Debhata. Table 11 shows the

survived genotypes and their performance. Those genotypes showed poor performance in Kaliganj but survived under high level of salinity (5.35-26.30 ds/m), they were selected for conducting stage 2 trial. Almost all the entries were damaged and yield of seven entries were very low, for instance, the highest yield was 0.22 t/ha for IR18T1137. Both the checks- BRRI dhan89 and BRRI dhan67 were completely damaged. The salinity graph of Kaliganj revealed that the genotypes faced the gradual increase of salinity stress from transplanting to maturity with its severity during the sensitive

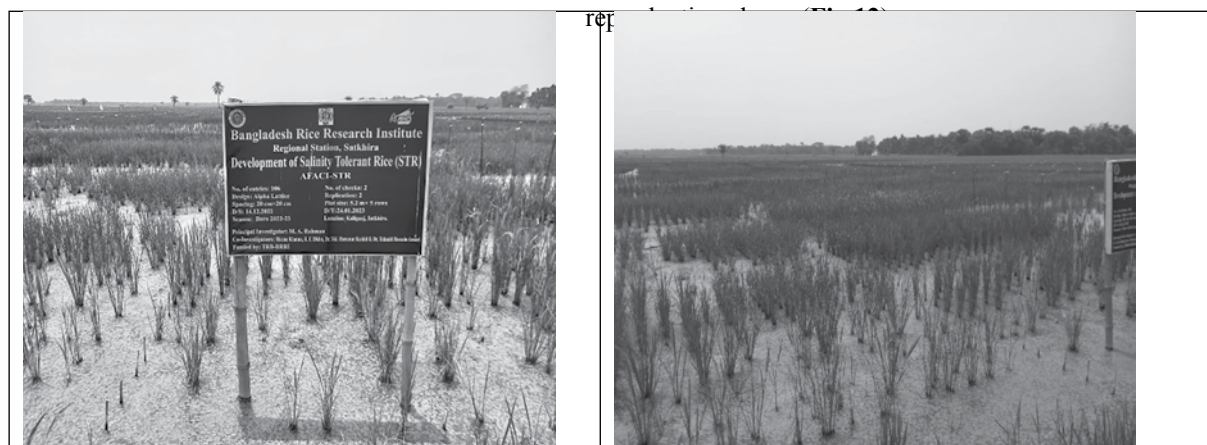


Fig. 12. Field view of AFACI-1 trial during irrigated season (Boro) 2022-23.

The selected genotypes identified as potential sources of salinity tolerance and may be included in

Table 11. The performance of selected genotypes from AFACI Stage-1, salinity tolerant rice (STR)

Entry no.	Designation	GD	PH	ET	Grain yield (t ha ⁻¹)
25	IR15T1319	126	89	61	0.15
42	IR18T1137	126	87	65	0.22
60	IR16F1148	126	91	71	0.20
98	IR129420-B-30-B-2-1	127	78	77	0.05
102	IRRI 104	127	83	79	0.18
104	IRRI 154	127	82	79	0.13
106	IRRI 230	130	83	81	0.18

GD= Growth duration in days, PH= plant height in cm, ET= Effective tiller number

Investigators: M Akhlasur Rahman, Hasina Khatun, R F Disha, Nusrat Jahan, K M Iftekharuddaula, T H Ansari, M H Rashid

Development of premium quality rice (PQR).

T. Aman. Efforts were made to develop aromatic and non-aromatic fine quality rice with national and international standards (Kalizira/Chinigura/Kataribhog/Radhunipagol/Jasmine type) and photosensitive rice for domestic use and export. In T. Aman 2022-23, a total of 62 crosses (42 single crosses and 12 backcrosses for PQR and nine single crosses for photosensitive rice) were made. Total 63 crosses (40 for PQR and 23 for photosensitive rice) were confirmed as true hybrids using quality control SNP panel analysis. A total of 14,962 progenies from 76 crosses (7,083 progenies of 14 F₂ crosses, 6131 progenies of 36 F₃ crosses, 876 progenies of 12 F₄ crosses and 872 progenies of 14 F₅ crosses) were advanced through RGA under PQR. A total of 2,460 progenies from 23 crosses (1,001 progenies of eight F₂ crosses, 594 progenies from five F₃ crosses, 638 progenies from five F₄ crosses and 227 progenies from five F₅ crosses) were advanced through RGA under photosensitive programme. Under, PQR 87 fixed lines were selected from 1,625 fixed lines of eight crosses and from photosensitive rice breeding programme, 20 fixed lines out of 197 fixed lines were selected from LST. From observational yield trial (OYT) 11 genotypes were selected out of 35 genotypes from PQR. From preliminary yield

the variety release system and also can be utilized as donors in forward breeding of STR breeding programmd.

breeding in Kaliganj, Satkhira during Boro 2022-23.

trial (PYT), A total of 11 genotypes were selected out of 24 genotypes under PQR programme and 11 genotypes were selected out of 25 genotypes under photosensitive rice breeding programme. A total of 11 genotypes were selected out of 24 genotypes under PQR programme and nine genotypes were selected out of 22 genotypes under Photosensitive rice breeding programme from advanced yield trial (AYT). Two promising genotypes were evaluated under PQR-ALART but none of the genotypes were selected. In OYT, the genotype BR9053-16-3-4-1 produced the highest yield (5.4 t/ha) which is non-aromatic having BRRI dhan90 type grain quality genotype that could be used as recipient parent. In PYT, the katary type aromatic genotype BR9178-7-2-4-4-P1 produced the highest yield of 5.5 t/ha with a growth duration of 120 days. In AYT, the genotype BR10824-5-6-4-1 having BRRI dhan34 type aromatic grain having stronger plant type produced 4.2 t/ha yield with similar growth duration of BRRI dhan34. Under photosensitive rice programme, under PYT, the genotype BR10212-4-3-1 produced significantly higher yield (6.6 t/ha) than the check varieties BR22 (4.6 t/ha) and BR23 (5.2 t/ha) followed by the genotype BR10212-17-3-2 (6.5 t/ha) having strong photosensitivity. The heritability obtained for growth duration was ranging from 86% to 92% and

grain yield was ranging from 54 % to 82% indicating acceptable level of precision in these experiments. Through maintenance breeding, 235 genotypes including 146 aromatic rice landraces were grown as panicle to row method to be maintained as nucleus stock for future use.

Investigators: Sharmistha Ghosal, S Maniruzzaman, M M Yasmin and K M Iftekharuddaula.

Boro. The project aims to develop aromatic and non-aromatic fine quality rice with international (Basmati/Banglamati/SoruBalam type) standards in Boro season for domestic use and export quality. Totally 3,559 F₁ seeds were obtained from 42 crosses. Twenty-nine F₁ crosses were confirmed out of 29 crosses as true hybrid. In total 19,165 progenies of 48 crosses from F₂, F₃ and F₅ generations were advanced through RGA method. A total 383 genotypes were selected from 3,060 progenies of LST trial. A total of 607 genotypes were evaluated in three OYT in Gazipur, Rajshahi and Rangpur. Among the tested genotypes, 66 genotypes were selected and forwarded in advanced yield trial (AYT). In AYT, 15 genotypes were selected out of 61 tested genotypes. In RYT, five genotypes were selected to forward in ALART out of 12 genotypes. An experiment of G×E interaction of Basmati rice

on physico-chemical and cooking properties were set up with 26 different Basmati genotypes at 14 locations in Bangladesh to evaluate the performance, the experiment will be repeated in T. Aman and Boro 2023-24 for selecting the best genotypes and environment. The genotype Lata Balam was evaluated in PVT trial and recommended as variety by committee in all 10 locations with $\geq 10\%$ yield advantage (**Table 12**). The proposed line BR8862-29-1-5-1-3 was evaluated along with the check variety BRRI dhan50 under PVT in 10 locations of Boro cultivation throughout the country of Bangladesh and proposed line was recommended to release as variety BRRI dhan104. as a premium quality aromatic Basmati type high yielding Boro rice variety for cultivation throughout the country in its 108th meeting held on 26 December 2022. It is a strong aromatic rice variety (according to GCMS system the value of volatile aromatic compound is 2.12 ppm). Its grain contains 29.2% amylose and 8.9% protein. The size and shape of the grain is extra-long slender (7.5 mm), white colored Basmati type and non-sticky. Although the average yield BRRI dhan104 is 7.30 ton/hectare, its yield potentiality is up to 8.71 ton per hectare under favourable environment and appropriate agronomic management (**Table 13, Figs. 13 and 14**)

Table 12. Performance of proposed variety (Lata Balam) in proposed variety trial (PVT) at ten locations, Boro 2022-23.

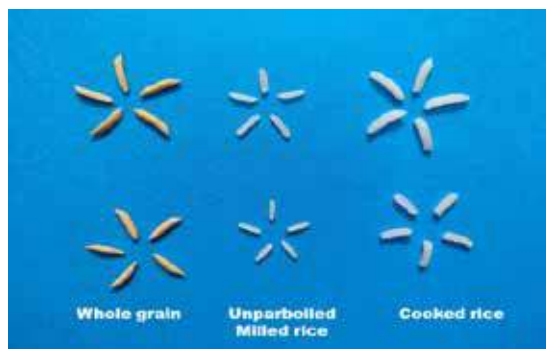
Location	Lata Balam (Proposed variety)		BRRI dhan50 (Ck)		% Yield advantage than BRRI dhan50*
	Growth duration (day)	Grain yield (t/ha)	Growth duration (day)	Grain yield (t/ha)	
BRRI HQ, Gazipur	141	7.110	146	5.916	20.18
Cumilla	135	7.537	137	6.070	24.17
Feni	144	9.571	149	7.369	29.88
Bogura	148	7.495	148	6.322	18.55
Dinajpur	145	7.713	145	6.897	11.83
BRRI RS, Bhanga	147	7.914	146	7.193	10.02
Barishal	135	6.336	129	5.539	14.39
Joshore	148	9.380	146	8.397	11.71
BINA, Mymensingh	141	9.360	145	8.093	15.66
BRRI RS, Rangpur	148	9.461	152	8.178	15.69
Range	135-148	6.34-9.57	129-152	5.54-8.40	10.0 to 29.9
Mean	143	8.188	144	6.997	17.67

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

Table 13. Performance of BRRI dhan104 in proposed variety trial, Boro 2021-22.

Designation	Plant height (cm)	Growth duration (day) *	Grain yield (t/ha) *	Grain characteristics						
				Head rice yield (%)	L-B ratio	Size and shape	Elongation ratio	Protein (%)	Amy (%)	Aroma
BRRI dhan104 (BR8862-29-1-5-1-3)	92	147	7.3	57.2	4.5	LS	1.3	8.9	29.2	Strong
BRRI dhan50 (ck)	81	147	6.6	59.7	4.2	LS	1.2	8.4	26.8	Light

*Mean of ten locations (BRRI-Gazipur; BRRI-Rangpur, BRRI-Faridpur, BINA-Mymensingh; Jashore, Feni, Cumilla, Bogura, Dinajpur, Barishal)

**Fig. 13. Pictorial view of BRRI dhan104.****Fig. 14. Grain picture of BRRI dhan104.**

NSB released BRC266-5-1-1-1 as BRRI dhan105 as a high yielding low GI Boro rice for cultivation throughout the country in its 109th meeting held on 2 March 2023. The average plant height of BRRI dhan105 is 101 cm and its growth duration is 148 days. The average yield of BRRI dhan105 is 7.6 t/ha. However, with proper care, under favourable environment it can yield 8.5 t/ha. The result of PVT showed that BRRI dhan105 yielded 8.39% higher than the check variety BRRI dhan58 in top five

locations. The grain quality of the rice is excellent. As the GI value of this rice is 55, so it can be called a low GI or diabetic rice. The amount of amylose and protein of the variety is 27.0% and 7.3%, respectively. The weight of 1000 grain of BRRI dhan105 is 19.4 grams. The grain colour of BRRI dhan105 is as like as straw and the milled rice of the variety is medium slender and white. BRRI dhan105 will play an effective role in controlling diabetes as a low GI rice (**Table 14, Figs.15 and 16**)

Table 14. Performance of BRRI dhan105 in proposed variety trial, Boro 2021-22.

Designation	Plant height (cm)	Growth duration (day) *	Grain yield (t/ha) *	Grain characteristics						
				Head rice yield (%)	L-B ratio	Size and shape	Elongation ratio	Protein (%)	Amy (%)	Glycemic Index (GI) Value
BRRI dhan105 (BRC266-5-1-1-1)	101	148	7.61	66.5	3.2	MS	1.4	7.3	27.0	55.0
BRRI dhan58 (Ck)	100	147	7.65	65.7	3.0	MS	1.4	8.9	26.0	64.1

*Mean of ten locations (BRRI-Gazipur; BRRI-Rangpur, BRRI-Faridpur, BINA-Mymensingh; Jashore, Feni, Cumilla, Bogura, Dinajpur, Barishal)



Fig. 15. Pictorial view of BRRI dhan105.

Investigators: R R Majumder, T K Hore, U R Shaha and M A Kader.

Development of Antioxidant Enriched Rice Variety. The main objective of the project was to develop anthocyanin enriched value-added rice genotypes with high yield potential for rainfed and irrigated ecosystems in Bangladesh. In T Aman 2022-23, a total of 15 crosses were made using 13 parents and 2,273 F₁ seeds were obtained, and 25 single crosses were selected and confirmed through QC SNP panel analysis. Panicles of 10,698 progenies from 21 crosses (6,962 progenies of eight F₂ crosses, 2,144 progenies of four F₃ crosses, 1,025 progenies of four F₄ crosses and 567 progenies of five F₅ crosses) were advanced through RGA. A total of 163 fixed lines from 1,682 fixed lines were selected from 11 crosses of LST. In OYT, 51 genotypes were selected out of 245 (two trials) aromatic and non-aromatic genotypes. A total of 54 genotypes were selected out of 176 (four trials) aromatic and non-aromatic genotypes. From advanced yield trial (AYT) 11 genotypes were selected out of 30 genotypes. In OYT, the genotype BR12839-4R-8 produced the highest yield (6.8 t/ha). In PYT, the short duration genotype BR12839-4R-137 produced the highest grain yield (6.1 t/ha) with 123 days growth duration whereas the medium duration genotype BR12839-4R-106 produced the highest yield (6.2 t/ha) having growth duration 129 days. The strong plant type with aromatic genotype BR12836-4R-312 produced the yield 5.5 t/ha in PYT. In AYT, the highest yielder genotype

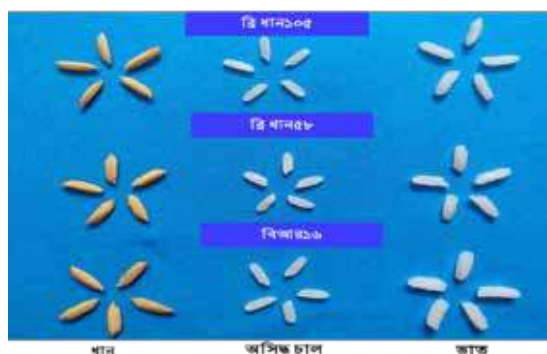


Fig. 16. Grain picture of BRRI dhan105.

was BR12839-4R-157-2 producing 6.3 t/ha yield followed by the genotype BR12839-4R-5-2 which produced 6.0 t/ha with the growth duration of 132 and 130 days, respectively. In Boro 2022-23, a total of 26 crosses were made using 25 parents and 5,997 F₁ seeds were obtained, and six single crosses were confirmed and selected through QC SNP panel analysis. Panicles of 17,400 progenies from 41 crosses (4,000 progenies of six F₂ crosses, 10,100 progenies of 23 F₃ crosses, 2,500 progenies of eight F₄ crosses and 800 progenies of four F₅ crosses) were advanced through RGA. A total of 34 fixed lines were visually selected from four crosses of LST. In OYT, 32 genotypes out of 110 genotypes were selected. In PYT, seven genotypes out of 24 genotypes were selected. From advanced yield trial (AYT), eight aromatic and 11 non-aromatic genotypes out of 42 genotypes were selected from two trials. From two RYT trials (short and medium duration), one short duration (out of three genotypes) and two medium duration genotypes (out of three genotypes) having the higher C3G content were selected. In AYT, the genotype BR12839-4R-106 produced highest yield, which is 7.5 t/ha with growth duration 152 days followed by the genotype BR12839-4R-34-1 producing yield of 6.9 t/ha having growth duration 149 days. These two genotypes possessed very high amount of antioxidant (C3G) which were 479 and 459 mg/kg, respectively. In AYT#aromatic, the aromatic genotype BR12839-4R-124-2 produced the highest yield (6.84 t/ha) followed by the genotype BR12836-4R-312 (6.8 t/ha). C3G contents of these genotypes were 242 and 305 mg/

kg respectively. In RYT#medium duration, the highest yielder genotype was BR12839-4R-157-2 producing 7.12 t/ha yield followed by the genotype BR12839-4R-5-2 which produced 6.8 t/ha yield in Gazipur. Both of the selected genotypes have higher C3G contents i.e. 268 and 209 mg/kg, respectively. The growth durations of these genotypes were 142 and 140 days, respectively.

Investigators: Sharmistha Ghosal, S Maniruzzaman, M M Yasmin and K M Iftekharuddaula.

Development of high yielding superior variety (SHR). Two RYT#s- RYT-Swarna (Swarna type) and RYT (short slender) under recommended management practices were evaluated during T. Aman 2022-23. In RYT#Swarna, five materials

were evaluated with the check variety BRRI dhan94. The line BR9396-6-2-2B (5.8 t/ha) produced significantly higher yield over the check variety BRRI dhan94 (5.1 t/ha) and BRRI dhan87 (5.3 t/ha). In RYT#short slender type, three materials were evaluated with the check variety BRRI dhan49. BRH13-2-14-2-1B (5.42 t/ha) and BRH13-7-9-3-2B (5.40 t/ha) produced significantly higher yield over the check variety BRRI dhan49 (4.97 t/ha). In ALART (zirasail type), five materials were evaluated and the advanced line BRH13-2-4-7-2B (5.0 t/ha) was recommended on the basis of yield, growth duration for PVT (**Table 5**). In ALART (ELS and LS type), five entries were evaluated with the check variety BRRI dhan62 and BRRI dhan75 but none of the entries were selected.

Table 5. Performance of genotypes in advanced line adaptive research trial (ALART), development of high yielding superior variety (SHR), T. Aman 2022-23.

Designation	GD (day)	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	Mean Yield (t/ha)
BRH15-24-7B	110	5.3	4.2	4.0	5.0	4.8	5.9	5.1	5.7	6.3	4.5	4.6	5.0
BRH13-1-9-7B	112	4.7	5.1	3.6	5.2	4.8	6.1	5.1	5.3	5.9	5.0	4.3	5.1
BRH13-2-4-7-2B	110	5.8	3.9	4.0	5.4	5.2	6.0	4.8	5.4	5.8	4.3	4.4	5.0
BRH10-1-14-6-2B	111	5.7	4.1	4.6	5.4	4.1	5.0	5.1	4.9	5.5	4.0	4.4	4.8
BR10247-4-7-4B	111	4.0	3.1	3.6	5.0	3.3	3.4	3.7	4.6	4.2	4.0	4.1	3.9
Zirashail (ck)	106	3.8	2.9	3.4	4.3	3.9	4.5	3.7	4.2	4.9	3.3	4.3	3.9
BRRI dhan57 (ck)	107	4.4	3.6	4.4	4.7	3.7	4.9	3.8	5.1	4.8	4.2	4.2	4.3

In ALART (Zira type), two advanced lines from four entries were recommended for PVT against the check variety BRRI dhan81 and Zira during Boro 2022-23. BRH11-9-11-4-5B was evaluated

under PVT trial in Boro 2021-22 in 10 locations. The genotype produced 8.52 t/ha which showed 12% yield advantage over the check variety Bangabandhu dhan100 (**Table 6**).

Table 6. Performance of proposed variety (BRH11-9-11-4-5B) in proposed variety trial (PVT) at ten locations, Boro 2022-23.

Location	Proposed variety		Check		% yield increase over check
	BRH11-9-11-4-5B		Bangabandhu dhan100		
	Duration (day)	Grain yield (t/ha)	Duration (day)	Yield (t/ha)	

BRRI,Gazipur	150	7.93	144	6.71	18.18%
BINA, Mymensingh	146	6.43	144	8.23	-21.87%
BRRI, Faridpur	155	9.38	144	8.28	13.29%
Sadar Jashore	149	10.17	145	8.08	25.87%
Sadar Feni	143	8.82	142	7.64	15.45%
Laksham, Cumilla	139	8.06	134	6.54	23.24%
Bogura Sadar	148	8.08	143	7.44	8.60%
Babuganj, Barishal	129	7.84	129	6.87	14.12%
BRRI, Rangpur	152	9.87	145	8.80	12.16%
Sadar, Dinajpur	145	8.63	145	7.03	22.76%
Average	146	8.52	142	7.56	

Investigators: A S M Masuduzzaman and Afroza Awal Shoily

Development of Zinc Enriched Rice (ZER).

The project also prioritizes development of stress tolerant zinc enriched rice varieties in a combination of submergence + zinc, drought + zinc, salinity + zinc and cold + zinc enriched rice with improved grain yield. The experiments were conducted in both T. Aman and Boro seasons. In T. Aman season, 20 single crosses were made that produced 2,955 seeds. A total of 45 crosses were selected and confirmed as true F_1 s. A total of 23,376 individual segregating progenies were harvested during the reporting period from 114 crosses from F_2 - F_6 generations from FRGA. A total of 239 LST lines were harvested based on visual observation on homogeneity in flowering, plant height and grain size and shape out of 2,856 progenies. A total of 15 genotypes were selected from 70 genotypes based on their performances and grain yield in comparison to check varieties. Eight genotypes were selected from PYT#1 and PYT#2 based on better grain yield and other agronomic performances out of 20 and 36 genotypes, respectively. In Boro season, 15 single crosses were made that produced 1,639 seeds. A total of 11 crosses were confirmed as true F_1 s. A total of 56,080 progenies were harvested from F_2 - F_6 generation from FRGA. Out of 7,065 progenies, 484 progenies were selected from LST. Seventeen advanced genotypes were selected for SYT from 61 in PYT. Five genotypes were selected out of 15 genotypes from SYT based on yield performances. The advanced line BR9674-1-4-1-3-P1 was considered for re-RYT.

Investigators: M A Kader, R R Majumder, T K Hore, S M T Islam, U R Shaha and K Fatema.

Development of disease resistant rice.

Efforts were made for developing varieties resistant to bacterial blight (BB), rice tungro virus (RTV) and blast diseases. The experiments were conducted in both T. Aman and Boro seasons. Twelve crosses for BB and 15 for blast in T. Aman and nine crosses for BB and 12 for blast were made in Boro season. Ten crosses for BB and 12 for blast in T. Aman and seven crosses for BB and nine for blast in Boro season were confirmed as true F_1 . A total of 18,000 progenies for BB and 17,500 progenies for blast were advanced from F_{2-6} generation through green-house RGA and FRGA. Three hundred thirty-three uniform lines were isolated from 4,100 LST lines in T. Aman and out of 4,071 lines, 382 were identified from LST in Boro season based on uniformity in heading, plant height, and grain type. Nine genotypes for BB were selected from observational yield trial (OYT) in T. Aman season whereas 60 entries out of 460 for BB during Boro season showed better yield potential and agronomic performance over the check varieties and tolerance to BB. From AYT, four advanced lines were promoted based on growth duration, grain yield and BB score compared to the check varieties in T. Aman season and 18 genotypes out of 67 for BB were selected in Boro season. In the regional yield trial (RYT), two genotypes for T. Aman season and five for Boro performed better compared to yield, growth duration, BB resistance, and better grain quality characters but yield was not >10% higher than the check varieties. Therefore, the high-yielding background

BB-resistant promising lines will be used as a genetic resource to develop high-yielding disease-resistant varieties. Blast resistant genotypes, which were developed by the scientist of Plant Pathology Division, were evaluated in ALART. Considering blast resistance, two genotypes were recommended as short duration genotypes comparing the check variety BRRI dhan28 and two were recommended as long duration genotypes comparing the check variety BRRI dhan89 for evaluating in PVT during Boro 2023-24.

Investigators: M Khatun, S K Debsharma, J Ferdousy, M A I Khan, T H Ansari and M A Latif

Development of Insect Resistant Rice. The main thrust of the project was to develop varieties resistant to gall midge (GM), brown plant hopper (BPH) and white backed plant hopper (WBPH). The experiments were conducted in both T. Aman and Boro seasons. In the T. Aman season, 19 crosses for forward breeding, three BC₁F₁ and four BC₂F₁ crosses for line augmentation and three crosses for QTL deployment were made, and 15 crosses were confirmed as true hybrids using quality check (QC) genotyping with purity SNP panel. In total 57,132 segregating progenies from 82 crosses of F₂-F₅ generations were advanced through Field Rapid Generation Advanced (FRGA) technique. Out of 2,803 F_{5,6} LST lines derived from 16 different crosses, 229 genotypes were selected based on strong plant architecture, grain type and uniformity in heading under field condition as well as the presence of the favourable alleles of key target genes for BPH (*bph9*, *bph17_1*, *bph17_2*, *bph17_3* and *bph32*), Gm (*Gm4_3* and *Gm4_4*) and grain

quality (*Wx-A* and *Wx-10*). The yield trials (OYT, PYT and AYT) were conducted at three locations of BRRI Gazipur, Cumilla and Rangpur. Forty-eight genotypes were selected from 228 breeding lines in OYT. Two selected OYT genotypes had both *bph17* and *bph32*, one genotype had both *bph17* with *Gm4*, and one had *bph17*, *bph32* with *Gm4* SNP favourable alleles. Twenty-four genotypes were selected from 100 genotypes in PYT. Ten genotypes were selected from 28 lines in AYT. Table 15 shows the performance and favourable alleles of selected OYT and AYT genotypes. In Boro season, 20 crosses for forward breeding, three crosses for pre-breeding, three F₁ and three BC₂F₁ crosses for line augmentation were made, and 16 crosses were confirmed as true hybrids through F₁ verification using quality check (QC) genotyping with purity SNP panel. A total of 56,511 individual plants were advanced from 76 crosses in F₂-F₅ generations by FRGA technique. In LST, 754 lines having strong plant architecture, grain quality, uniformity in heading under field condition and the presence of the favourable alleles of key target genes for BPH (*bph9*, *bph17_1*, *bph17_2*, *bph17_3* and *bph32*), Gm (*Gm4_3* and *Gm4_4*) and grain quality (*Wx-A* and *Wx-10*) were selected from 5,889 F_{5,6} breeding lines that are the descendants of 23 crosses. Eighty genotypes out of 360 were selected from OYT that were tested in three locations. Twenty-five lines were selected from 82 lines in PYT. Out of 30 genotypes, 12 were selected from AYT for further evaluation. Total 65 parental lines were maintained in insect resistant maintenance breeding programme.

Table 15. Grain yield, agronomic performance and favourable alleles for trait of interest of selected genotypes from OYT and AYT lines, IRR, T. Aman 2022-23.

Designation	GD (day)	PH (cm)	Yield (t/ha)				Field BPH Score (SES)	BPH Score (SES)	Trait of interest (ToI)
			Gaz	Cum	Ran	Pooled			
OYT									
BR 13088-4 R-357	119	97	4.9	5.6	NA	4.5	9	5	<i>Bph32, Wx-A_group</i>
BR 13088-4 R-423	118	112	7.1	6.6	3.4	5.7	5	5	<i>Bph32, Wx-A_group</i>
BR 13088-4 R-424	123	113	5.7	5.8	2.7	4.7	5	5	<i>Bph32, Wx-A_group</i>
BR 13089-4 R-155	116	139	4.4	4.6	2.5	3.8	7	5	<i>Wx-A_group</i>

BR 13094-4 R-235	107	110	5.7	5.0	1.8	4.2	7	5	<i>Bph32, Wx-A_group</i>
BR 13094-4 R-250	118	113	4.0	5.3	4.7	4.7	5	5	<i>Wx-A_group</i>
BR 13094-4 R-251	112	121	7.2	5.1	3.6	5.3	5	5	<i>Bph32, Wx-A_group</i>
BR 13100-4 R-149	114	123	5.0	3.2	NA	3.4	9	9	<i>Bph17_all, Bph32</i>
BR 13100-4 R-181	115	114	3.4	5.2	NA	3.5	9	7	<i>Bph17_all, Gm4, Wx-A_group</i>
BR 13100-4 R-255	111	105	5.4	4.2	3.1	4.2	7	7	<i>Bph17_all, Bph32, Gm4</i>
AYT									
BR 11296-4 R -74	128	119	6.4	5.6	3.3	5.1	3	7	<i>Bph32, Wx-A_group</i>
BR 11296-4 R -74	128	119	6.4	5.6	3.3	5.1	3	5	<i>Bph32, Wx-A_group</i>
BR 11044-4 R -47	117	115	5.6	4.7	4.9	5.0	5	5	<i>Bph17_all, Gm4, Wx-A_group</i>
BR 11295-4 R -387	130	126	6.1	5.3	2.9	4.8	5	7	<i>Bph32, Gm4</i>
BR 11035-4 R -101	114	123	7.2	5.4	3.4	5.3	5	5	<i>Bph17_all, Bph32, Gm4, Wx-A_group</i>
BR 11052-4 R -234	119	114	6.6	5.4	3.4	5.1	7	9	<i>Bph17_all, Bph32, Wx-A_group</i>
BR 11295-4 R -486	122	114	6.2	5.3	2.9	4.8	5	7	<i>Bph32</i>
IRBPHN-SVIN013-18	117	123	4.2	6.6	4.3	5.0	5	5	<i>Bph17_all, Bph32</i>
BR 11040-4 R -137	123	123	6.3	5.9	3.7	5.3	3	7	<i>Bph32, Wx-A_group</i>
BR 11033-4 R -33	126	126	5.6	6.4	2.8	4.9	6	5	<i>Gm4, Wx-A_group</i>

Investigators: Md Ruhul Amin Sarker, Hasina Khatun, Ribed Farzana Disha and M Akhlasur Rahman

Development of submergence and water stagnation tolerant rice varieties. The project aims for the development of high yielding rice varieties tolerant to submergence (flash flooding) and medium stagnant water (MSW) stresses. Totally 43 single crosses were made and 4,500 F₁ seeds were produced. Thirty-four single crosses were confirmed and selected through QC SNP panel analysis. A total of 25,395 progenies from 80 crosses (4,930 from 12 F₂ crosses, 12,220 from 22 F₃, 4,680 from 27 F₄ progenies, 810 from nine F₅ progenies, and 2,755 from ten F₆ progenies) were harvested at the time of maturity, processed with proper labels and preserved. The ranges of mortality percentage of different RGA generations were around 7%. From LST population, 3,006 lines from 12 crosses were genotyped with trait markers using custom SNP panel among which 162 lines were selected based on uniformity and traits markers like *Sub1*, *Wx-A_group*, *Wx-A_NB*, *xa13*, *Xa21* etc. In yield trial, 368 genotypes were tested out of which 150 genotypes were selected based on phenotypic acceptance,

growth duration, survivability and higher yield performance. From OYT, 76 genotypes out of 271 genotypes, from AYT_Early, 44 genotypes out of 118 genotypes, from AYT_Late, 17 genotypes out of 58 genotypes, from PVS one genotype out of ten genotypes were selected. Two lines were evaluated in ALART from which one line was recommended to evaluate in PVT, one line was evaluated in PVT and the line performed better over the check. In OYT, the genotype BR12154-5R-65-2 with 88% survivability produced the highest yield of 6.7 t/ha under stress condition and on average yielded 6.5 t/ha followed by the genotype BR12487-5R-75 produced 6.7 t/ha under controlled stress and on average 6.2 t/ha with 92% survivability. In INGER, the early genotype SV1582 produced highest yield (5.6 t/ha) under rainfed condition where two checks BRRI dhan87 and BRRI dhan52 yielded only 4.8 t/ha and 4.6 t/ha, respectively. In AYT_Early genotype BR12162-5R-350-3 and IR15F1886 produced the highest yield of 7.0 t/ha followed by BR11692-5R-345 (6.7 t/ha) and SV1179 (6.6 t/ha) under controlled stress condition. In AYT_Late, the genotype IR13F582 produced the highest yield of 7.2 t/ha with 89% survivability in control stress condition followed by the genotype IR93339129-B-7-7-B-B-B-16 (7.1

t/ha) with 84% survivability. In ALART (ALART_Tidal submergence), the genotype BR9158-19-9-6-50-2-HR1 produced significantly higher yield (4.89 t/ha) over both check BRRI dhan52 (4.49 t/ha) and BRRI dhan44 (4.31 t/ha) with similar growth duration. This line was recommended to evaluate in PVT in T. Aman 2023-24. In PVT, the genotype IR16F1148 yielded 5.28 t/ha which was 18% higher than the check variety BINA dhan11 (4.48 t/ha) but national technical committee (NTC) recommended for re-PVT in next T-Aman season as there was less flood in the farmer's field condition (Table 16). The

heritability obtained for grain yield under stress of all trials conducted was ranging from 44 % to 95%, whereas that for non-stress trials was ranging from 38 % to 83%, indicating acceptable level of precision in these experiments. Through maintenance breeding, 280 genotypes including submergence tolerant land races were grown as panicle to row method to be maintained as nucleus stock for future use.

Investigators: Sharmistha Ghosal, S Maniruzzaman, Z A Riyadh, A Rahman, R Hassan and K M Iftekharuddaula.

Table 16. Grain yield performance of genotypes in advanced line adaptive research trial (ALART), development of submergence tolerant rice, T. Aman 2021-22.

Designation	Under rainfed condition			Yield under submergence stress condition								
	Plant height (cm)	Growth duration (day)	Yield (t/ha) at Gazipur	Gazipur water tank	Rangpur water tank	Rangpur Sadar	Lalmonirhat Sadar	Aditmari Lalmonirhat	Gaibandha	Kurigram	Chittagong	Mean
IR16F1148	120	124	5.31	5.66	5.44	5.64	4.95	5.05	4.04	3.84	5.57	5.02
BRRI dhan71 (Sus. ck)	118	117	4.37	0.00	5.2	5.18	4.15	4.72	3.65	1.43	3.43	3.47
Binadhan11 (Tol.ck)	111	120	3.99	4.76	4.7	5.15	4.45	4.26	3.91	3.02	3.0	4.16
LSD _{0.05}	5.28	1.17	0.60					0.68				0.24
CV (%)	2.76	0.56	8.5					9.52				

Development of drought tolerant rice (DTR).

The project aims to develop high yielding drought tolerant rice varieties under rainfed lowland rice ecosystem in T. Aman season. In, T. Aman 2022-23, 4,147 F₁ seeds were obtained from 25 crosses using 14 parents and 14 crosses were confirmed as true hybrids using 10 SNP *indica* QC panel. A total of 4,523 progenies were harvested from F₃ generation through RGA method. From LST, 293 lines were selected from 2,058 progenies of 20 crosses. A total of 619 genotypes were evaluated in two OYTs in Gazipur, Rajshahi and Rangpur. Among the tested genotypes, 41 were selected and forwarded in AYT. In AYT, seven genotypes were selected from 30 based on yield performances. Two genotypes were selected from RYT for advancing in ALART.

Investigators: M A Kader, R R Majumder, T K Hore, U R Shaha and K Fatema

Development of water saving and aerobic rice varieties.

The objective of the project was to develop short duration water-use-efficient rice genotypes with 10% more yield than the check varieties under transplanted alternate wetting and drying (AWD) and aerobic conditions. A total of 35 crosses were made using 35 parents and 2,350 F₁ seeds were obtained, and 14 single crosses were selected and confirmed through QC SNP panel analysis. A total of 8,037 individual panicles were selected from 30 crosses (4,430 of 13 crosses from F₂, 3,315 of 13 crosses from F₃ and 292 of four crosses from F₅) were harvested through RGA. From yield trial, 37 genotypes were selected out of 143 genotypes. In OYT, 12 genotypes were selected from 63 genotypes. From PYT, 25 genotypes were selected from 80 genotypes. In OYT, among all selected genotypes the line IR 126999-B-32-2-1-

3 produced the highest yield (7.0 t/ha). In PYT#1 the genotype IR16T1009, significantly produced the highest yield (6.7 t/ha) over the check variety BRRI dhan88 (5.6 t/ha). In PYT#2, the genotype BR11690-5R-98-P1 significantly produced the highest yield (7.8 t/ha) over the check variety BRRI dhan88 (6.9 t/ha) and BRRI dhan100 (6.4 t/ha). In RYT, none of the tested genotypes were selected, both the tested entry BR11206-5B-351 and BR11204-5B-224 produced similar yield (6.6 t/ha) with the check variety BRRI dhan58 (6.8 t/ha). The heritability obtained for growth duration and grain yield of all the trials conducted was ranging from 85 % to 95%, and 44 % to 85%, respectively indicating acceptable level of precision in these experiments.

Investigator: Sharmistha Ghosal, S Maniruzzaman, Z A Riyadh and K M Iftekharuddaula.

Deployment and validation of high beta-carotene rice, high iron and zinc rice varieties (Healthier Rice). The main objective of the project was to develop high yielding transgenic rice varieties with enhanced provitamin-A, iron and zinc content in polished rice grain. In T. Aman 2022-23, 1,420 BC₂F₁ seeds were obtained from three backcrosses. However, in three backcrosses (BR11723-4R-27, BRRI dhan81 and BRRI dhan87), none of the

hemizygous plant (H type) was found. Five hundred and forty-seven homozygous plants (B type) were selected from 1,047 plant of BC₃F₃ generation. Twelve promising lines were selected based on their grain yield, carotenoid content and other yield contributing for further evaluation. In Boro, 980 F₁ seeds were obtained from three crosses. Total 260 BC₃F₁ seeds were obtained from three backcrosses.

Investigators: M A Kader, R R Majumder, T K Hore, U R Shaha and K Fatema.

International Network for Genetic Evaluation of Rice (INGER). This project focused on sharing and use of germplasm and breeding lines through international platform for the acceleration of genetic improvement of rice varieties. Totally 49 genotypes were selected out of 195 genotypes of nine INGER nursery sets of which four genotypes were selected out of 32 genotypes of one INGER nursery sets of Aus, 31 genotypes out of 109 genotypes from six INGER nursery sets of T. Aman 2022-23 and 14 genotypes out of 54 genotypes from two INGER nursery sets of Boro 2022-23 seasons were selected to be used in different breeding programmes for direct use in the breeding pipeline.

National Coordinator: K M Iftekharuddaula
Key Cooperator: Sharmistha Ghosal

Biotechnology Division

26	Summary
27	Development of Double Haploid Rice Through anther Culture
34	Development Of Rice Variety Through Somaclonal Variation
35	Development Of Rice Variety Through Wide Hybridization
35	Development Of Rice Variety Through Mutation Breeding
36	Development Of Rice Variety Through Marker Assisted Selection
37	Rice Transformation
37	Genome Editing Through Crispr
37	C4 Rice Development

SUMMARY

Thirty experiments were conducted in 2022-23. For developing low glycemic index (GI) rice variety five doubled haploid lines derived from a cross between BRRI dhan29 and Kanaklata were grown as SYT during T. Aman 2022 and among them three lines were selected. Doubled haploids plants from BRRI dhan90/Kataribhog cross were evaluated during T. Aman 2022 and 33 fixed lines were selected. Four double haploid plants from cross of BRRI dhan38/Bashful (Acc. No. 3954) were evaluated in Boro 2022-23. Among them, eight plants were selected for the development of premium quality rice. Eighty- One double haploid lines from cross of BRRI dhan50/Bashful (Acc. No. 3954) were evaluated in Boro 2022-23. Among them 160 plants were selected. During Boro 2022-23, six and eight lines for antioxidant enriched black rice were selected from PYT and OT respectively. Seven and six lines for antioxidant enriched black rice were also selected from PYT and OT respectively during T Aman 2022. Three hundred and twenty-six somaclonal variants (SCV₃) of Kalijira were harvested from 126 SCV₂ lines for further evaluation. Forty-seven and 89 homozygous antioxidant enriched black rice lines were selected during T. Aman 2022 and Boro 2022-23 respectively from SC₅ generation. Seed culture was done by using seeds of Kataribhog, Tulshimala, Radhunipagol and Shakkhorkhana (Local varieties) to create somaclonal variations. A total of 57 plants were regenerated after seed culture. Seeds were harvested from these plants. A total of 84 plants from different generation of embryo rescued plants derived from different wide crosses were evaluated during T. Aman 2022 and 38 (F4) plants were selected from BRRI dhan28/*O. nivara* (IRGC103821), BRRI dhan28/*O. glaberrima* (IRGC105190), BRRI dhan87/*O. glaberrima* (IRGC105190), BRRI dhan48/*O. glaberrima* (IRGC105190) for generation advancement. A total of 29 (F4) plants from different wide crosses were evaluated in Boro 2022-23. Among them 44 plants (F5) were selected from BRRI dhan28/*O. glaberrima* (IRGC105190), BRRI dhan87/*O. glaberrima* (IRGC105190) and BRRI dhan48/*O. glaberrima* (IRGC105190). Besides, nine and five

lines derived from wide cross of BRRI dhan28/*O. nivara* (IRGC103821) were evaluated as OT and PYT, respectively. Among them five and three lines were selected. Nine (BC₂F₃) and thirty (BC₂F₃) plants from backcross progeny of previously embryo rescued plants were evaluated during T. Aman 2022 and Boro 2022-23, respectively. Among them 30 (BC₂F₃) plants and 11 (BC₂F₄) plants were selected, respectively. A total of 36 Kataribhog and 29 Tulshimala (M₂) plants were evaluated during T. Aman 2022. Among them six Kataribhog (M₃) plants and 31 Tulshimala (M₃) plants were selected during T. Aman 2022 for generation advancement. One hundred and eighty-two F₆ progenies were selected based on aroma, growth duration and plant height from the cross between BRRI dhan87 and Kalijira for the development of high yielding aromatic rice. All the tested aromatic lines were confirmed by functional marker of fragrance gene *BADH2* in early generation. A three way crosses, two doubled crosses and six crosses were done for the development of submergence tolerant aromatic rice. For the development of both BB and blast resistant lines four crosses were made and F₁ seeds were harvested. BRRI dhan29 was transformed with salt tolerant genes (*GlyI* and *GlyII*) and 17 fixed lines were harvested from T₅ plants. *AeMDHAR* salt tolerant gene (from mangrove plant) containing transgenic plant was crossed with BRRI dhan28 to introgress *AeMDHAR* salt tolerant gene. Three BC₂F₃ plants of BRRI dhan28 were harvested for further evaluation. Besides, *AeMDHAR* salt tolerant gene (from mangrove plant) containing transgenic plant was crossed with BRRI dhan92 and 81 F₁ seeds were harvested. For deactivation of *BADH2* gene, guide sequence of *BADH2* was cloned in binary vector pRGEB31 and was confirmed by PCR. Hundred M₃ of BRH-11-9-11-4-5B were selected from 31 M₂ to reduce the sterility during Boro 2022-23. One hundred and sixty M₃ plants were selected from 91 M₂ Kilijira lines during T Aman 2022 for aromatic rice variety development. Fifty-three M₃ plants of BRRI dhan87 were selected for further selection to develop high yielding sheath blight resistant rice varieties. For the development of high yielding rice variety 50 fixed mutant lines of BR11 were evaluated and 12 lines were selected during

Boro 2022-23. Besides, during T. Aman 2022, fifty fixed lines were selected from 200 pedigree lines. A total of 7000 M4 lines Kaoun (*Setaria italica*) have been developed for further study. These lines are gradually raised, subjected to CO₂ stress in low concentration (20 ppm) CO₂ chamber for 72 hours and high-throughput screened for loss of C4 functions. So far, 291 M4 lines have been screened and among them three seemed to have lost C4 properties. These lines are being maintained very

carefully for further study. Protocol for regeneration of BRRI dhan92, BRRI dhan96 and BRRI dhan103 were established.

DEVELOPMENT OF DOUBLE HAPLOID RICE THROUGH ANTHR CULTURE

Low glycemic index (GI) rice variety

Five doubled haploid lines were grown as SYT in T Aman 2022. Among them three lines were selected for regional yield trial (RYT) in hilly areas. (Table 1).

Table 1. Agronomic characteristics of selected anther culture derived materials. SYT-1, T. Aman 2022.

Designation	Plant height (cm)	Growth duration (days)	Yield (t/ha)	Remarks
BR (Bio)10381-AC11-7-1	128	123	7.08	Amylose content
BR (Bio)10381-AC11-8-1	116	100	3.65	19-22%
BR (Bio)13031-AC1-2	108	108	6.04	
BR (Bio)10381-AC30-2	112	108	4.07	
BR (Bio)10381-AC11-1	116	108	6.15	
BRRI dhan71 (ck)	130	115	6.10	-
BRRI dhan87 (ck)	123	123	5.56	lodging
CV			4.58	
LSD			0.44	

Bold = Selected

Investigator: Jannatul Ferdous, Shahanaz Sultana and Md Enamul Hoque.

Premium quality rice variety through anther culture

A total of 7,609 hybrid anthers from ten crosses were plated on N6 media for anther culture during T. Aman 2022. A total of 16 calli were obtained from different crosses and no plants were regenerated yet. Twelve crosses were done during T. Aman 2022 for future anther culture programme. A total of 491 F1 seeds were harvested from them and will be used for future anther culture. Seeds of regenerated green plants (DH₁) from BRRI dhan90/Kataribhog cross were evaluated during T. Aman 2022. Among them 33 fixed lines (DH₂) were selected. Four double haploid lines from BRRI dhan38/Bashful (Acc. No. 3954) along with the check BRRI dhan87 and BRRI dhan103 were evaluated as OT during T. Aman 2022. No line was selected due to lodging problem. Four double haploid plants from BRRI dhan38/Bashful (Acc. no. 3954) were evaluated

in Boro 2022-23. Among them eight plants were selected for generation advancement. One hundred three double haploid plants from cross of BRRI dhan50/Bashful (Acc. no. 3954) were evaluated in T. Aman 2022. Among them, 81 double haploid plants were selected for generation advancement. Eighty-One double haploid plants from the cross of BRRI dhan50/Bashful (Acc. no. 3954) were evaluated in Boro 2022-23. Among them, 160 plants were selected for generation advancement.

Investigator: Nilufar Yasmin Shaikh, Ripon Kumar Roy, S M Hisam Al Rabbi

Salt tolerant rice variety through anther culture

A total of 3,382 hybrid anthers from six crosses were plated on N6 media for anther culture during Boro 2022-23. N6 media were used for callus induction and MS media containing 4mg/L BAP + 1.2mg/L NAA + 1.0 mg/L Kinetin were used for plant regeneration. In total 33 calli were obtained from different crosses and no green plants were regenerated yet.

Investigator: Nilufar Yasmin Shaikh, Ripon Kumar Roy, S M Hisam Al Rabbi

High yielding Aus rice variety

In Aus 2020, a total of 328 F₁ seeds were harvested from ten crosses for future anther culture programme.

Investigator: Shampa Das Joya, S M Hisam Al Rabbi, Ripon Kumar Roy and Md Arafat Hossain

Antioxidant enriched black rice variety

Twelve and 16 antioxidant enriched black rice lines were evaluated as PYT and OT in T Aman 2022. Seven and six lines were selected, respectively for further evaluation (Tables 2 and

3). Besides, 47 somaclonal variants (SCV_s) of antioxidant enriched black rice were evaluated as pedigree in T. Aman 2022. One hundred and five SCV plants were selected.

During Boro 2022-23, five antioxidant enriched black rice were developed using anther culture and were evaluated in RYT and three lines were selected for ALART (Table 4). Moreover, during Boro 2022-23, 13 and 21 antioxidant enriched black rice were evaluated as PYT and OT respectively. Among them six and eight lines were selected (Tables 5 and 6).

Investigator. Jannatul Ferdous, Shahanaz Sultana and Md Enamul Hoque.

Table 2. Agronomic characteristics of selected anther culture derived materials. PYT-1, T. Aman/2022.

Designation	Plant height (cm)	Growth duration (days)	Yield (t/ha)
BR (Bio)13028-AC24-5-1-4	132	106	4.35
BR (Bio)13028-AC24-5-2-1	120	111	4.38
BR (Bio)13028-AC24-5-3-5	120	105	5.37
BR (Bio)13028-AC24-5-4-3	120	106	5.63
BR (Bio)13028-AC24-5-4-4	113	107	5.02
BR (Bio)13028-AC24-5-5-1	144	108	3.11
BR (Bio)13028-AC24-5-5-2	103	107	5.31
BR (Bio)13028-AC24-7-1-3	98	108	4.49
BR (Bio)13028-AC24-7-3-4	127	113	4.78
BR (Bio)13028-AC24-7-6-2	121	117	4.80
BR (Bio)13028-AC24-8-2 -3	118	112	5.35
BR (Bio)13028-AC15-2-4-1	113	108	5.39
BRRI dhan71(ck)	122	113	4.29
BRRI dhan87(ck)	129	123	5.88
CV (%)			5.88
LSD(0.05)			0.48

Bold = Selected

Table 3. Agronomic characteristics of selected anther culture derived materials. OT-1, T. Aman/2022.

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
BR (Bio)13030-4-1-1-2	158	105	4.11
BR (Bio)13030-4-1-1-3	114	106	4.72
BR (Bio)13030-4-1-1-4	119	108	4.28

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
BR (Bio)13030-4-1-1-6	106	108	3.09
BR (Bio)13030-3-1-2-1	153	112	4.23
BR (Bio)13030-3-1-3-1	113	109	2.84
BR (Bio)13030-6-1-1-1	127	105	3.52
BR (Bio)13030-6-1-1-2	124	108	3.86
BR (Bio)13030-7-1-1-1	119	109	4.54
BR (Bio)13030-7-1-1-2	130	105	3.86
BR (Bio)13029-1-2-1-1	124	104	3.66
BR (Bio)13029-3-1-1-1	130	112	4.33
BR (Bio)13029-3-1-2-3	127	106	3.10
BR (Bio)13029-3-1-2-4	120	110	4.72
BR (Bio)13029-3-1-3-1-1	119	112	4.82
BR (Bio)13029-3-1-3-1-2	119	108	4.27
BRRI dhan71 (ck)	119	113	5.23
BRRI dhan87 (ck)	122	125	5.30

Bold = Selected

Table 4. Agronomic characteristics of selected anther culture derived materials. RYT, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)									
			Gazi	Cum	Bari	Gopal	Sonag	Sira	Raj	Kush	Satk	Avg.
BR (Bio)13028-AC24-1-2	113	145	7.01	6.28	5.2	7.23	6.26	6.95	7.54	4.33	5.14	6.22
BR (Bio)13028-AC24-2-3	98	145	6.28	5.67	3.8	6.02	5.93	6.95	5.36	3.39	5.3	5.41
BR (Bio)13028-AC24-2-4	99	141	5.28	6.42	3.8	6.28	4.72	6.09	6.62	3.96	4.84	5.33
BR (Bio)13028-AC24-3-3	104	143	6.01	6.39	4.8	6.71	6.25	5.91	6.3	3.8	5.23	5.71
BR (Bio)13028-AC11-3-1	97	143	5.43	5.26	5.1	6.31	5.77	6.01	6.47	4.77	5.81	5.66
BRRI dhan86	90	141	5.42	6.54	4.2	6.56	5.73	6.91	6.36	5.63	6.91	6.03
BRRI dhan96	89	141	7.01	6.69	4.6	6.85	6.59	7.04	6.66	6	6.94	6.49

Bold = Selected

Table 5. Agronomic characteristics of selected anther culture derived materials. PYT, Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
BR (Bio)13029- AC2-2-2	120	142	4.94
BR (Bio)13029-AC6-2-6	104	143	5.17
BR (Bio)13029-AC6-3-2	146	141	4.75

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
BR (Bio)13028-AC1-2-2	128	140	3.99
BR (Bio)13028- AC1-2-3	114	145	4.13
BR (Bio)13028- AC1-2-4	108	142	6.51
BR (Bio)13028- AC1-2-7	115	148	5.83
BR (Bio)13028- AC2-2-2-1	107	152	5.77
BR (Bio)13028- AC2-2-2-3	141	142	3.90
BR(Bio)13030- AC5-2-1	127	140	5.33
BR(Bio)13030- AC13-2-2	102	143	5.21
Lansan-2-1	140	139	3.94
Lansan-2-2	126	142	5.01
BRRI dhan86 (ck)	88	144	4.84
BRRI dhan96 (ck)	89	142	6.11

Bold = Selected

Table 6. Agronomic characteristics of selected anther culture derived materials. OT, Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
BR (Bio)13028-AC24-4-4-2	114	145	5.15
BR (Bio)13028-AC24-5-2-2	122	142	5.69
BR (Bio)13028-AC11-2-1-1	118	141	5.65
BR (Bio)13028-AC11-2-2-3	117	143	7.68
BR (Bio)13028-AC15-1-1-1	98	148	4.51
BR (Bio)13028-AC15-3-1-2	109	143	5.78
BR (Bio)13028-AC24-3 -2-2	127	141	4.87
BR (Bio)13028-AC24-3 -2-3	120	145	4.67
BR (Bio)13028-AC24-3 -2-4	104	143	5.34
BR (Bio)13028-AC24-3-5-1	109	141	6.37
BR (Bio)13028-AC24-4-2-2	108	142	6.64
BR (Bio)13028-AC24-4-2-3	109	144	3.95
BR (Bio)13028-AC24-4-3-3	116	141	7.94
BR (Bio)13028-AC24-4-3-4	100	145	4.55
BR (Bio)13028-AC24-4-4-2	108	143	5.05
BR (Bio)13028-AC24-5-2-4	103	150	6.15
BR (Bio)13030-AC 1-2-3	107	143	6.65
BR (Bio)13030-AC 2-2-1	110	145	5.31
BR (Bio)13030-AC 6-3-1	105	142	5.86
BR (Bio)13030-AC 6-4-1	110	141	7.47
BR (Bio)13028- AC1-2-3	114	143	4.27
BRRI dhan86	91	143	5.53

Bold = Selected

High Yielding photoperiod sensitive rice variety

A total 6,884 anthers from nine crosses were plated in two media. No callus was found from nine cross combinations. A total 3,445 anthers were plated in two media.

Besides, anther culture was done from F₂ generation plants. Four calli were found from BRRI dhan71/ Gainja cross combination but no green plants was regenerated.

Investigator. Md Arafat Hossain, S M Hisam Al Rabbi, Ripon Kumar Roy, Shampa Das Joya, Sentu Rahman

Development of Aus rice variety through anther culture

Forty-four advanced lines were grown in an observational yield trial in Aus 2022. Among them, 23 lines were selected (Table 7) based on plant type, yield, and growth duration for the preliminary yield trial.

Table 7. Agronomic characteristics of selected anther culture derived lines in OT-1, Aus 2022.

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
BR(Bio)15085-AC2-3	121	100	5.65
BR(Bio)15085-AC2-8	116	108	5.66
BR(Bio)15085-AC2-9	122	107	5.79
BR(Bio)15085-AC2-10	114	112	5.67
BR(Bio)15085-AC6-6	127	112	6.12
BR(Bio)15085-AC6-10	120	109	5.69
BR(Bio)15085-AC6-12	111	110	5.87
BR(Bio)15086-AC11-5	108	110	5.90
BR(Bio)15086-AC11-7	108	108	5.64
BR(Bio)15086-AC11-9	107	110	5.70
BR(Bio)15086-AC15-4	111	110	5.57
BR(Bio)15086-AC15-5	115	112	5.77
BR(Bio)15086-AC15-6	118	112	5.66
BR(Bio)15086-AC16-9	114	110	5.73
BR(Bio)15086-AC17-8	110	110	5.86
BR(Bio)15086-AC16-10	119	111	5.95
BR(Bio)15086-AC18-11	120	109	5.87
BR(Bio)15086-AC16-14	115	113	5.95
BR(Bio)15086-AC50-6	106	110	5.82
BR(Bio)15086-AC51-6	103	110	6.18
BR(Bio)15086-AC51-7	107	111	5.72
BR(Bio)15086-AC114-8	115	110	5.90
BR(Bio)15086-AC118-14	130	110	5.61
BRRI dhan48 (ck)	103	106	4.95
BRRI dhan98 (ck)	104	113	5.55

Investigator: Ripon Kumar Roy, S M Hisam Al Rabbi, Nilufar Yasmin Shaikh, Md Arafat Hossain, Shampa Das Joya

Development of photosensitive rice through anther culture

Forty-eight advanced lines having taller seedling capabilities were grown in Aman 2022. Among

them, 64 plants were selected for further evaluation. An observation yield trial (OT) was done in Aman 2022, where 25 advanced lines were grown and six lines were selected (Table 8) for further evaluation.

Table 8. Agronomic characteristics of selected anther culture derived lines in OT-2, Aman 2022.

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
BR (Bio) 8033-AC5-1-1-HR1	121	137	5.79
BR (Bio) 8033-AC5-1-1-HR2	120	136	5.51
BR (Bio) 8033-AC5-1-2-HR1	122	135	5.60
BR (Bio) 8033-AC5-1-2-HR2	121	136	5.39
BR (Bio) 8033-AC7-1-1-HR1	123	137	5.62
BR (Bio) 8033-AC7-1-1-HR2	122	135	5.43
BRRI dhan76 (ck)	140	149	4.48
Sada Mota (Local ck)	160	153	4.07

Investigator: Ripon Kumar Roy, S M Hisam Al Rabbi, Nilufar Yasmin Shaikh, Md Arafat Hossain, Shampa Das Joya

Development of Aman Rice for the favourable ecosystem through anther culture

Thirty-five advanced lines were grown in an observation yield trial (OT) in Aman 2022.

Twenty promising advanced lines were selected (Table 9) for further evaluation.

Investigator: Ripon Kumar Roy, S M Hisam Al Rabbi, Nilufar Yasmin Shaikh, Md Arafat Hossain, Shampa Das Joya

Table 9. Agronomic characteristics of selected anther culture derived lines in OT-1, Aman 2022.

Designation	Plant height (cm)	Growth vuration (day)	Yield (t/ha)
BR (Bio)15086-AC101-4-1	110	115	6.45
BR (Bio)15086-AC101-4-2	112	114	6.46
BR (Bio)15086-AC101-4-3	113	120	6.70
BR (Bio)15086-AC101-4-4	112	119	6.67
BR (Bio)15086-AC102-5-1	110	119	6.83
BR (Bio)15086-AC102-5-2	112	120	6.88
BR (Bio)15086-AC105-6-1	113	123	7.25
BR (Bio)15086-AC105-6-2	112	125	7.30
BR (Bio)15086-AC112-7-1	110	123	6.60
BR (Bio)15086-AC112-7-2	112	122	6.80
BR (Bio)15086-AC112-8-1	112	118	7.06
BR (Bio)15086-AC112-8-2	114	119	7.15
BR (Bio)15086-AC114-8-1	113	122	7.25
BR (Bio)15086-AC116-9-1	110	115	6.42

Designation	Plant height (cm)	Growth vuration (day)	Yield (t/ha)
BR (Bio)15086-AC116-9-2	112	117	6.47
BR (Bio)15086-AC116-10-1	110	114	6.44
BR (Bio)15086-AC118-14	110	121	6.98
BR (Bio)15086-AC118-15	112	122	7.15
BR (Bio)15086-AC119-16	113	120	7.30
BR (Bio)15086-AC120-18	112	122	7.18
BRRI dhan87 (ck)	120	128	6.52

Development of Boro rice for the favourable ecosystem using anther culture techniques

Nineteen and 16 advanced lines were evaluated in two preliminary yield trial as PYT-1 and PYT-2 in

Boro 2022-23. Thirteen lines were selected (Table 4) from each PYT for further evaluation (Tables 10 and 11)

Table 10. Agronomic characteristics of selected anther culture derived lines in PYT-1, Boro 2023.

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
BR (Bio)15085-AC1-1	119	155	7.82
BR (Bio)15085-AC3-3	121	157	7.91
BR (Bio)15085-AC9-1	120	157	7.16
BR (Bio)15085-AC27-2	109	155	9.26
BR (Bio)15085-AC28-2	108	156	8.92
BR (Bio)15085-AC29-1	103	155	8.97
BR (Bio)15085-AC38-1	103	152	9.33
BR (Bio)15085-AC62-1	105	154	9.06
BR (Bio)15085-AC63-1	116	157	7.85
BR (Bio)15086-AC11-1	109	152	9.12
BR (Bio)15086-AC12-1	111	157	8.43
BR (Bio)15086-AC13-2	107	154	9.35
BR (Bio)15086-AC14-1	108	157	8.09
BR (Bio)15086-AC14-6	107	153	9.40
BR (Bio)15086-AC15-1	116	157	8.80
BR (Bio)15086-AC16-3	110	155	9.16
BR (Bio)15086-AC58-1	105	158	9.30
BR (Bio)15086-AC58-2	106	150	8.57
BR (Bio)15086-AC59-6	110	159	8.67
BRRI dhan58 (ck)	103	158	7.37
BRRI dhan89 (ck)	107	164	8.25
BRRI dhan92 (ck)	108	166	8.33
BRRI dhan96 (ck)	90	149	7.17

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
CV	1.13	0.69	3.18
LSD	2.53	2.22	0.56

Note: Bold-marked genotypes are selected for further evaluation in Boro 23-24.

Table 11. Agronomic characteristics of selected anther culture derived lines in PYT-1, Boro 2023.

Designation	Plant height (cm)	Growth Duration (day)	Yield (t/ha)
BR (Bio)15085-AC1-4	110.70	159	9.21
BR(Bio)15085-AC3-14	115.80	164	8.36
BR(Bio)15085-AC9-6	118.90	160	7.26
BR(Bio)15085-AC9-7	116.30	166	8.03
BR(Bio)15085-AC19-1	105.90	154	8.57
BR(Bio)15085-AC21-3	108.50	154	8.88
BR(Bio)15085-AC24-2	119.20	154	8.32
BR(Bio)15085-AC27-3	109.90	153	8.19
BR(Bio)15085-AC29-5	105.60	158	8.89
BR(Bio)15085-AC63-8	110.40	168	9.07
BR(Bio)15085-AC63-9	108.70	166	8.91
BR(Bio)15086-AC13-6	101.77	166	9.41
BR(Bio)15086-AC16-1	106.80	167	8.52
BR(Bio)15086-AC58-3	103.45	163	8.83
BR(Bio)15086-AC58-5	111.43	149	8.42
BR(Bio)15086-AC59-8	105.55	163	8.78
BRRI dhan58 (ck)	104.78	158	7.36
BRRI dhan89 (ck)	108.02	163	8.25
BRRI dhan92 (ck)	106.60	164	8.41
BRRI dhan96 (ck)	89.03	148	7.17

Note: Bold-marked genotypes are selected for further evaluation in Boro 23-24.

Investigator: Ripon Kumar Roy, S M Hisam Al Rabbi, Nilufar Yasmin Shaikh, Md Arafat Hossain, Shampa Das Joya, Sentu Rahman, M A Monsur, M N Islam, M M Rana, T Halder, T K Roy

DEVELOPMENT OF RICE VARIETY THROUGH SOMACLONAL VARIATION

Development of premium quality rice (Kalijira type) through somaclonal variation

One hundred and twenty-six lines somaclonal variants (SCV₂) of Kalijira were grown in T. Aman 2022. Three hundred and twenty-six plants were selected for further evaluation.

Investigator: Shahanaz Sultana, Jannatul Ferdous and Md Enamul Hoque

Premium quality rice variety through somaclonal variation

Seed culture was done to create somaclonal variations in T. Aman 2022. Seeds of Kataribhog, Tulshimala, Radhunipagol and Shakkhorkhana (Local varieties) were used in this experiment. Culture Medium consisting of MS basal salts (Murashige and Skoog, 1962) with 2.0 mg/l of 2,4-D were used for callus induction and MS media containing 4mg/L BAP + 1.2mg/L NAA + 1.0

mg/L Kinetin were used for plant regeneration. A total of 57 plants from Kataribhog (13), Tulshimala (02), Radhunipagol (23) and Shakkhorkhana (19) were regenerated after seed culture. Seeds were harvested from these plants.

Investigator: Nilufar Yasmin Shaikh, Ripon Kumar Roy, S M Hisam Al Rabbi

Antioxidant enriched black rice variety

Eighty-nine somaclonal variants (SCV_s) of antioxidant enriched black rice were evaluated as pedigree in Boro 2022-23. Sixty-seven SCV plants were selected. In addition, 25 somaclonal variants (SCV_o) of antioxidant enriched black rice were regenerated from seeds of Selasih-SC14-12-2 and seeds were harvested from those somaclonal variants.

Investigator: Jannatul Ferdous, Shahanaz Sultana and Md Enamul Hoque

DEVELOPMENT OF RICE VARIETY THROUGH WIDE HYBRIDIZATION

Wide hybridization followed by embryo rescue

A total of 84 plants from different generation of embryo rescued plants were evaluated in T. Aman 2022 and Boro 2022-23. Among them 44 plants (F5) were selected from BRRI dhan28/*O. glaberrima* (IRGC105190), BRRI dhan87/*O. glaberrima* (IRGC105190), BRRI dhan48/*O. glaberrima* (IRGC105190) for generation advancement. Five lines derived from wide cross of BRRI dhan28/*O. nivara* (IRGC103821) were evaluated as PYT along with check BRRI dhan96 in Boro 2022-23. Among them three lines were selected for further evaluation. Thirty (BC₂F₃) plants from backcross progeny of previously embryo rescued plants were evaluated in Boro 2022-23. Among them 11 plants (BC₂F₄) were selected for generation advancement.

Table12. Agronomic characteristics of lines derived from wide cross of BRRI dhan28/*O. nivara* (IRGC103821) evaluated as PYT in Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
BR (Bio)13035-ERBC1-6-1 -1	100	145	7.35
BR (Bio)13035-ERBC1-6-1 -2	97	146	7.38
BR (Bio)13035-ERBC1-6-1 -5	101	145	6.97
BR (Bio)13035-ERBC1-6-1 -6	97	147	7.32
BR (Bio)13035-ERBC1-6-1 -7	98	146	6.79
BRRI dhan96 (ck)	84	149	7.30
CV	1.95	0.50	4.27
LSD	3.19	1.28	0.54

Investigator: Nilufar Yasmin Shaikh, Ripon Kumar Roy, S M Hisam Al Rabbi

Development of Aman rice through wide hybridization

Five embryo rescued BC₂F₂ population which was developed by using HYV (BR11, BRRI dhan33, BRRI dhan39 BRRI dhan52, BRRI dhan66) and *Oryza rufipogon* (Acc No103404) were grown in Aman 2022. Among them, 276 plants were selected.

Investigator: Ripon Kumar Roy, S M Hisam Al Rabbi, Nilufar Yasmin Shaikh, Md Arafat Hossain, Shampa Das Joya

DEVELOPMENT OF RICE VARIETY THROUGH MUTATION BREEDING

Development of high yielding rice variants using EMS

During T. Aman 2022, a total of 200 EMS treated mutant lines of BR11 was evaluated as pedigree. Among them 50 plants were selected for further evaluation. Besides, during Boro 2022-23, 50 fixed lines were evaluated as OT and twelve lines were selected for further evaluation

Investigator: Shahanaz Sultana, Jannatul Ferdous, Shampa Das Joya and Md Enamul Hoque

Table 13. Agronomic characteristics of selected lines in OT, Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t/ha)
T4-BR11-4-1-1	120	157	9.54
T4-BR11-5-1-2	120	159	8.65
T4-BR11-5-1-3	124	161	9.62
T4-BR11-7-1-1	124	159	9.86
T4-BR11-17-1-3	105	150	7.42
T4-BR11-26-1-2	126	157	8.01
T4-BR11-53-1-1	121	148	9.33
T4-BR11-53-1-2	120	146	9.06
T4-BR11-83-1-1	120	161	8.05
T4-BR11-100-1-2	111	156	8.59
T4-BR11-104-23-8-3	114	154	8.01
T4-BR11-104-23-8-4	110	150	7.84
BRRI dhan74	101	146	7.18
BRRI dhan89	109	159	7.98
BRRI dhan92	110	162	8.14
BRRI dhan96	88	146	6.56

Development of variants using NMU of BRH-11-9-11-4-5B having reduced sterility

Thirty-one lines (M_3) along with check were transplanted in Boro 2022-23. One hundred plants were selected for further evaluation

Investigator: Shahanaz Sultana, Jannatul Ferdous, S.M Hisham Al Rabbi, Shampa Das Joya and Md Enamul Hoque.

Development of Kilijira type rice variety through mutation by NMU

Seed from 91 M_2 Kilijira lines were transplanted in T. Aman 2022 along with the check. A total of 168 M_3 plants were selected during T. Aman 2022 for further evaluation.

Investigator: Shahanaz Sultana, Jannatul Ferdous, S M Hisham Al Rabbi, Shampa Das Joya and Md Enamul Hoque.

High yielding sheath blight resistant rice variety

Twenty-two M_2 plants were grown in the field to observe the yield and disease reaction. Fifty-three M_3 plants were selected for further evaluation.

Investigator: Md Arafat Hossain, S M Hisam Al Rabbi, Ripon Kumar Roy, Shamima Akter

Premium quality rice through mutation by EMS

EMS treated seeds of two local varieties (Kataribhog and Tulshimala) were used in this experiment. Thirty-six Kataribhog plants (M_2) and 29 Tulshimala plants (M_2) were evaluated during T. Aman 2022. Among them six Kataribhog (M_3) plants and 31 Tulshimala (M_3) plants were selected for generation advancement.

Investigator: Nilufar Yasmin Shaikh, Ripon Kumar Roy, S M Hisam Al Rabbi and Md Arafat Hossain

DEVELOPMENT OF RICE VARIETY THROUGH MARKER ASSISTED SELECTION

Marker assisted selection for fragrance gene *BADH2*

One hundred and seven pedigree lines developed from a cross between BRRI dhan87 and Kalijira were evaluated as pedigree. Among them 312 plants were selected on the basis of aroma, growth duration and plant height. All the tested aromatic

lines were confirmed by using functional marker of fragrance gene *BADH2* in early generation. The primers combination of ESP and IFAP amplified the fragrance specific allele at 257 bp. On the other hand, the primers combination of INSP and EAP amplified the expected non-fragrance-specific allele (355 bp).

Investigator: Jannatul Ferdous, Shahanaz Sultana and Md Enamul Hoque.

Marker assisted selection for aromatic and tidal submergence tolerance rice genotype

A three way cross, two doubled crosses and six crosses were done. A total of 599 F₁ seeds of different crosses were harvested for further confirmation.

Investigator: Jannatul Ferdous, Shahanaz Sultana and Md Enamul Hoque.

Development of multiple disease resistant (blast and bacterial blight) rice varieties using marker assisted selection

To develop multiple disease resistant (blast and bacterial blight) rice varieties F₁ plants of four crosses such as BR (Bio)11447-1-28-14-3/IR64Pi9 (L), BR (Bio)11447-1-28-14-3/IR64Pi9 (E), BR (Bio)11447-3-10-7-1/IR64Pi9 (L), BR (Bio)11447-3-10-7-1/IR64Pi9 (E) were grown and F₂ seeds were harvested from four crosses.

Investigator: Jannatul Ferdous, Shahanaz Sultana and Md. Enamul Hoque, Ashik Ikbal Khan

Genome wide association mapping for photosensitivity of rice

An association mapping panel of 160 accessions comprised of varieties, landraces and advanced breeding lines of T. Aman season were used for the study. Heading data were taken in the short-day conditions for two years and long-day condition in one year. They were raised in the long-day condition in the current year and data taking is being continued on that. Data taking will be continued in the short-day conditions as well. The plants will be genotyped also for final association mapping analysis.

Investigator: S M Hisam Al Rabbi, Ripon Kumar Roy, Md Arafat Hossain and Munnujan Khanam

RICE TRANSFORMATION

Development of salt tolerant transgenic rice with *GlyI* and *GlyII*

A total of 18 T₄ plants were grown in transgenic greenhouse and among them 21 T₅ plants were confirmed by *GlyI* specific primer. T₅ progenies were grown in the transgenic green house for further evaluation.

Investigator: Shampa Das Joya, S M Hisam Al Rabbi, Ripon Kumar Roy and Md Arafat Hossain

Introgression of salt tolerant gene

AeMDHAR salt tolerant gene (from mangrove plant) containing transgenic plant was crossed with BRRI dhan28 to introgress *AeMDHAR* salt tolerant gene. Three BC₂F₃ plants of BRRI dhan28 were harvested for further evaluation. Besides, *AeMDHAR* salt tolerant gene (from mangrove plant) containing transgenic plant was crossed with BRRI dhan92 to introgress *AeMDHAR* salt tolerant gene. Eighty-one F₁ seeds were harvested.

Investigator: Shahanaz Sultana, Jannatul Ferdous, Shampa Das Joya and Md Enamul Hoque.

GENOME EDITING THROUGH CRISPR

Development of high yielding aromatic rice lines through genome editing

For deactivation of *BADH2* gene, two primer were designed for construct preparation. Vector pRGEB31 was used in this experiment. Guide sequence of *BADH2* was cloned into binary vector pRGEB31 and confirmed by PCR.

Investigator: Shahanaz Sultana, Jannatul Ferdous, Shampa Das Joya, Md Enamul Hoque, Hirendro Nath Barman, Sentu Rahman

C4 RICE DEVELOPMENT

Identification of *Setaria* mutants losing C4 properties

A number of 7,000 M₄ lines of Kaoun (*Setaria italica*) have been developed for further study (Fig. 1). These lines are gradually being raised

and subjected to CO₂ stress in low concentration (20 ppm) CO₂ chamber for 72 hours and high-throughput screened for loss of C4 functions. High throughput screening of 291 mutant lines detected

three lines losing C4 properties which are being maintained for future studies.

Investigator: S M Hisam Al Rabbi, Ripon Kumar Roy, Munnujan Khanam, Sazzadur Rahman

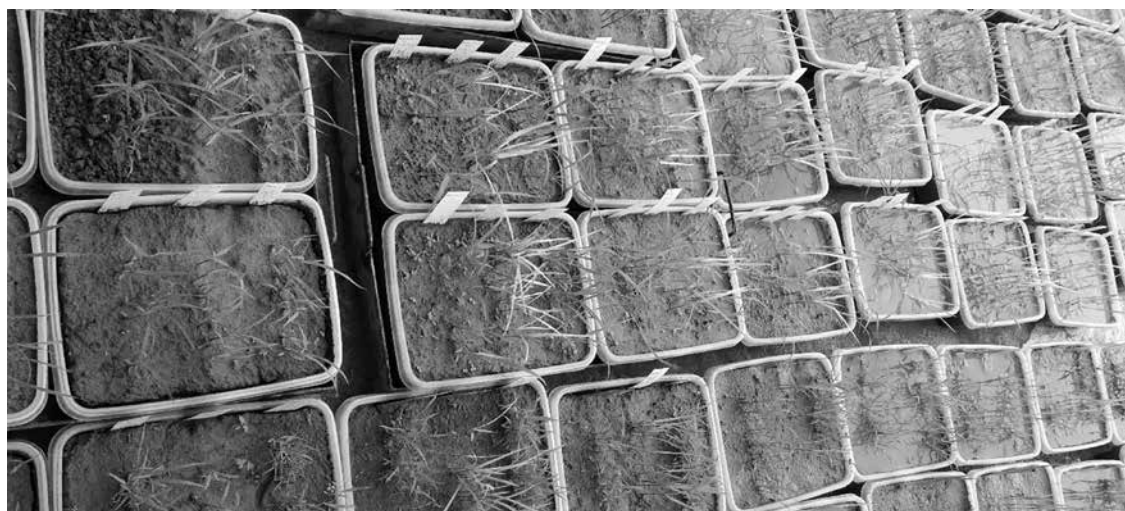


Fig. 1. M4 Kaoun plants are subjected to CO₂ stress in low concentration (20 ppm) CO₂ chamber.

Basic Research

Study on kernel elongation of rice

Sixty-four selected genotypes were grown in T. Aman 2022 and the seeds were harvested from single plant to make genetic purity. These pure seeds were grown in net house and purified seed from single hill were harvested for further analysis.

Investigator: Shahanaz Sultana, Jannatul Ferdous, Shampa Das Joya, Md Enamul Hoque, Habibul Bari Sojib

Effect of hormone on plant regeneration of rice genotypes

Three different regeneration media eg A (2 mg/ml BAP+1mg/ml kinetin+1 mg/ml NAA), B (4 mg/ml BAP+1.2 mg/ml kinetin+0.5 mg/ml NAA) and C (1mg/ml BAP+1mg/ml Kinetin+1mg/ml NAA) were used to observe the regeneration ability of BRRI dhan92, BRRI dhan96 and BRRI dhan103 rice genotypes. The highest calli was produced by BRRI dhan103 followed by BRRI dhan92 and BRRI dhan103. The highest plant regeneration was observed in BRRI dhan103 under B and C media

followed by A media. The lowest regeneration was showed by BRRI dhan96 under C media.

Investigators. Md Sentu Rahman, Sadia Jafrin, Jannatul Ferdous, Shahanaz Sultana, Md Arifat Hossain and Md Enamul Hoque

Genetic Resources and Seed Division

40	Summary
40	Rice Germplasm Conservation And Management
45	Seed Production And Variety Maintenance
51	Exploratory And Genetic Studies

SUMMARY

In total, 193 rice germplasm of which three of Aus, 24 of B. Aman, 109 of T. Aman and 57 of Boro varieties were collected from different districts of Bangladesh. One hundred and thirty-two germplasm accessions and new collections (NC) of which 26 germplasm in T. Aus 2021-22, 50 in T. Aman 2022-23 and 56 in Boro 2022-23 seasons were morphologically characterized using ‘Rice Germplasm Descriptors and Evaluation Form’ of Genetic Resources and Seed Division (GRSD).

Rejuvenation of 2,386 accessions was completed of which 629 accessions in T. Aus 2021-22, 1107 in T. Aman 2022-23 and 650 in Boro 2022-23 seasons. On the other hand, a total of 742 entries/ samples of Aus 2021-22 season were processed and stored of which 655 in short-, 38 in medium- and 49 in long-term storages during 2022-23. Similarly, 1,334 entries of T. Aman 2022-23 were processed and stored of which 900 in short-, 175 in medium- and 259 in long-term storages respectively. Apart from this, 173 new germplasm were registered as new accessions (from accession number 8,696 to 8,868) in BRRI Genebank. Besides, 2,778 samples were supplied to 48 different users in the reporting year.

One hundred nineteen BRRI developed and recommended rice varieties were maintained along with nucleus seed. Besides, nucleus seed stocks of 71 varieties were produced for the source of breeder seed (BS). In total, 273.86 tons of breeder seeds with tags of which 173.28 tons of 21 Boro varieties, 32.48 tons of nine Aus varieties and 68.1 tons of 36 T. Aman varieties were produced during 2022-23. At the same time, a total of 259.765 tons of breeder seeds with tags of which 169.454 tons of 21 Boro varieties, 31.063 tons of nine Aus varieties and 59.248 tons of 36 T. Aman varieties were distributed among 696 partners (GO, NGO and PS) of BRRI ‘Rice Seed Network’. Again, 1,451 kg of 11 varieties of seeds were distributed as TLS with cash and 9,663 kg of 22 varieties of seeds were distributed as free of cost to farmers and different users on T. Aman 2022-23 season.

RICE GERmplasm CONSERVATION AND MANAGEMENT

Germplasm collection and acquisition. Two collection field trip were made during the reporting year and in total, 193 rice germplasm of which three of Aus, 24 of B. Aman, 109 of T. Aman and 57 of Boro rice varieties were collected from different districts of Bangladesh including hilly areas (Fig. 1).



Fig. 1. Pictorial views of collecting rice germplasm from different areas of Bangladesh.

Germplasm rejuvenation for storage. Rice germplasm were rejuvenated to increase the seed for safe storage in the Genebank. The experiment was carried out under transplanted conditions using double rows of 5.4 m long per accession with 20 × 20 cm spacing between rows and plants respectively. Fertilizers were applied @ 60:20:40 kg NPK/ha in T. Aus and T. Aman and @ 80:20:40 kg NPK/ha in Boro seasons.

In total 2,386 germplasm of which 629 accessions (between Acc. 0001 to 2500) in T. Aus 2021-22, 1,107 accessions (between Acc. 6001 to 8560) in T. Aman 2022-23 and 650 accessions (between Acc. 6601 to 8800) in Boro 2022-23 were rejuvenated in field for getting fresh seed and on average 500 g of seeds per accession were produced for storage.

PI: Armin Bhuiya (T. Aus), Tonmoy Chakrabarty (T. Aman) and Md Humayun Kabir Baktiar (Boro).

Morphological characterization of germplasm.

Three experiments were conducted to characterize 132 rice germplasm (accessions as well as new collections) of which 26 in T. Aus 2021-22, 50 in T. Aman 2022-23 and 56 in Boro 2022-23 through 53 agro-morphological traits (both 20 quantitative and 33 qualitative characters) using the Rice Germplasm Descriptors and Evaluation Form (2018), GRSD, BRRI. The experiments were conducted using a single row of 5.4 m long for each entry/accession with 20 × 20 cm spacing between rows and plants respectively. Fertilizers were applied @ 60:20:40 kg NPK/ha in T. Aus and T. Aman and @ 80:20:40 kg NPK/ha in Boro seasons. Appropriate control measures were taken for insect, pests, diseases and weeds when necessary.

In Aus 2021-22, among the 26 germplasm accessions, one germplasm had short (<135 days) and the rest 25 had medium (135-150 days) growth duration (Table 1). Eleven germplasm were found with short (<110 cm), 12 medium (110-130 cm) and three with long (>130 cm) plant height. In case of panicle length (cm), one both had short (≤20) and extra long (>30), 12 germplasm had medium (21-25) and 12 had long (26-30) panicles. For 1000-grain weight (TGW), two germplasm had low (16-19 g), five had medium (20-23 g), six had high (24-27 g) and 13 had very high (>27 g) grain weights.

For yield, one germplasm had low (<5 g), six had medium (5-10 g) and 19 germplasm had higher (>10 g) yield per hill. The shortest growth duration (129 days) was observed in Mangthang. The shortest plant height (82.5 cm) was observed in Charurik and the longest (140.6 cm) in Mymensingh. Binni Dhan had the lowest (15.0 g) and Lal Binni had the highest (41 g) TGW. The highest yield per hill (26.53 g) was observed in Kokru.

PI: Armin Bhuiya

In T. Aman 2022-23, all 50 NC germplasm were characterized. Among them, 12 had short (≤135 days), 35 had medium (136-142 days) and three had long (≥149 days) growth duration (Table 2). In case of plant height (cm), 15 germplasm were found with short (≤93), 15 were medium (94-114) and 20 with long (≥135) height. For panicle length (cm), 15 germplasm had short (≤23), 34 had medium (24-28) and one had long (≥33) panicles. Similarly for TGW (g), 20 germplasm had low (≤23), 29 had moderate (24-32) and one with very high (≥41) grain weights. Twenty-four germplasm had low (≤13 g), 23 had medium (14-23 g) and three possessed high yields (≥33 g) per hill. Besides, IR10M210, IR99107-B-B-B-B-27, IR16A3524 had the longest (149 days) growth duration and IR11N202 had the lowest (128 days) growth duration. IR98430-B-B-B-B-11 was found with shortest (73.40 cm) and Chini Gura was with the highest (134.80 cm) plant height. The lowest effective tiller percent (82.50) was observed in Kjalail and the highest (98.70) in Khoiadhan. The longest panicle length (31.40 cm) was observed in Chini Gura and the shortest (19.80 cm) in Hori dhan. Shakkorkhana had the lowest (14.00 g) and Khoiadhan had the highest (40.82 g) TGW. Goti Swarna dhan had the lowest (3.15 g) and Shakkorkhana possessed the highest (32.03 g) yield per hill.

PI: Tonmoy Chakrabarty.

In Boro 2022-23, among the 56 germplasm accessions, 18 had medium (135-145 days) and 38 had long (>145) growth duration (Table 3 and Fig. 2). Similarly, 30 germplasm were found with short (<110 cm), 24 medium (110-130 cm) and two with long (130) plant height.

Table 1. Some important features of characterized germplasm in T. Aus 2021-22.

Growth duration (day)		Plant height (cm)		Panicle length (cm)		No. of tiller		No. of effective tiller		Grain LB ratio		TGW		Yield/hill (g)	
Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries
<135	1	<110	11	≤20	1	<10	26	<6	11	<1.1	0	≤15	0	<5	1
135-150	25	110-130	12	21-25	12	10-15	0	6-10	15	1.1-2.0	7	16-19	2	5-10	6
>150	0	>130	3	26-30	12	>15	0	>10	0	2.1-3.0	15	20-23	5	>10	19
				>30	1					>3.0	4	24-27	6		
												>27	13		
Shortest	Mangthang	Shortest	Charurik	Shortest (18.9)	Abdulla Dhan	Lowest	Mangthang	Lowest	Mangthang	Lowest	Binni Dhan	Lowest	Binni Dhan	Lowest	Binni Dhan
(129)		(82.6)				(4)		(4)		(1.5)		(15)		(4.26)	
Longest	Chewma	Longest	Mymensingh	Longest	Mymensingh	Highest	Ponkhiraj	Highest	Ponkhiraj	Highest	Checheo Kali Ita	Highest	Lal Binni	Highest	Kokru
(147)		(140.6)		(32)		(9)		(9)		(3.1)		(41)		(26.53)	
Mean	143	111.81		25.64		6		6		2.4		26.25		13.28	
S. Dev.	3.79	13.68		3.10		0.97		0.93		0.5		5.48		6.40	
CV	2.65	12.24		12.09		15.42		15.93		20.4		20.86		48.21	
LSD	1	5		1		0		0		0.2		2		2	

Table 2. Some important features of characterized germplasm in T. Aman 2022-23.

Growth duration (day)		Days to 50% flowering		Plant height (cm)		Panicle length (cm)		Effective tiller (%)		Filled grain/panicle		1000-grain weight (g)		Yield/hill (g)	
Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries
≤135	12	≤104	4	≤93	15	≤23	15	≤87	6	≤87	23	≤23	20	≤13	24
136-142	35	105-109	20	94-114	15	24-28	34	88-93	35	88-118	25	24-32	29	14-23	23
≥149	3	≥113	26	≥135	20	≥33	1	≥99	9	≥149	2	≥41	1	≥33	3
Shortest (128)	IR11N202	Shortest (100)	IR11N202	Shortest (73.40)	IR98430-B-B-B-B-11	Shortest (19.80)	Hori dhan	Lowest (82.50)	Kjallail	Lowest (56.40)	Hori dhan	Lowest (14.00)	Shak-korkhana	Lowest (3.15)	Goti Swarna dhan
Longest (149)	IR10M210 IR99107-B-B-B-B-27 IR16A3524	Longest (113)	Goti Swarna dhan	Longest (134.80)	Chini Gura	Longest (31.40)	ChiniGura	Highest (98.70)	Khoiadhan	Highest (147.10)	Shak-korkhana	Highest (40.82)	Khoiadhan	Highest (32.03)	Shak-korkhana
Mean	137.36		108.28		104.20		24.33		90.58		88.71		27.61		14.46

S. Dev.	4.08	3.25	17.97	2.05	3.61	18.78	7.39	5.95
CV	2.97	3.00	17.25	8.43	3.98	21.17	26.76	41.17
LSD	1.13	0.90	4.98	0.57	1.00	5.21	2.05	1.65
SE	0.58	0.46	2.54	0.29	0.51	2.66	1.04	0.84

Table 3. Some important features of characterized germplasm in Boro 2022-23.

Growth duration (day)		Plant height (cm)		Panicle length (cm)		No. of tiller/hill		Days to 50% flowering		Grain Length Breadth Ratio		1000-grain weight (g)		Yield/hill (g)	
Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries	Range	No. of entries
<135	0	<110	30	<20	16	<10	28	<116	3	>3.0	12	<15	4	<5	0
135-145	18	110-130	24	20-25	33	10-15	28	116-120	47	2.1-3.0	44	15-19	22	5-10	5
>145	38	>130	2	26-30	7	>15	0	>120	6	1.1-2.0	0	20-23	24	>10	51
				>30	0					<1.1	0	24-27	6		
												>27	0		
Short-est (142)	(Murali, Bitla) Acc. 4513, Acc. 4517	Short-est (67)	(Malairri) Acc. 4528	Short-est (16.8)	(Baurash, Thakur Sail) Acc. 4392, Acc. 4531	Lowest (5)	(Gorchhi Sail) Acc. 4381	Lowest (115)	(Murali, Bitla, Begun Bitchi) Acc. 4513, Acc. 4517, Acc. 4519	Low-est (2.02)	(Chenger Boro) Acc. 4389	Low-est (11)	(Chengash) Acc. 4393	Lowest (9.08)	(Dhola Boro) Acc. 4396
Longest (152)	(Chenger Muri) Acc. 4402	Longest (135)	(Kaliajira) Acc. 4540	Longest (28.8)	(Baurash) Acc. 4385	Highest (11)	(Maratona) Acc. 4514	Highest (124)	(Chenger Muri) Acc. 4402	Highest (4.60)	(Shaihimala) Acc. 4527	Highest (27)	(Ayenamiah) Acc. 4523	Highest (28.42)	(Ratna Boro) Acc. 4388
Mean	147		105		21.65		9.00		118.48		2.85		19.61		17.12
Std. Dev.	2.08		16.43		3.01		1.41		2.02		0.50		3.40		5.22
CV	1.42		15.62		13.90		15.71		1.70		17.45		17.33		30.47
LSD	0.54		4.30		0.79		0.37		0.53		0.13		0.89		1.37

In case of panicle length, 16 germplasm had short (<20 cm), 33 had medium (20-25 cm) and seven germplasm had long (26-30 cm) panicle. Again, 28 germplasm possessed intermediate (<10) and the rest 28 had high (10-15) number of tillers per hill. For TGW, four had very low (<15 g), 22 had medium (15-19 g) and six had high (24-27g) grain weights. Five germplasm possessed moderate (5-10 g/hill) and 51 had higher (>10 g/hill) grain

yield. The shortest growth duration (142 days) was observed in Murali (Acc. 4513) and in Bitla (Acc. 4517). The shortest plant height (67 cm) was observed in Malairri (Acc. 4528) and the longest (135 cm) in Kaliajira (Acc. 4540). Chengash (Acc. 4393) had the lowest (11.0 g) and Ayenamiah had the highest (27.0 g) TGW. The highest yield per hill was observed in Ratna Boro (Acc. 4388).



Fig. 2. Pictorial view of characterization of germplasm in Boro 2022-23 season.

In conclusion, the variety having higher yield would be utilized in a crossing programme, if other characters satisfy the breeder's objectives.

Germplasm processing, registration and storage.

In total 2,076 entries of germplasm were processed and conserved with respective accession number in different storages of BRI Genebank during the reporting year. The germplasm were cleaned and dried with a seed moisture content of less than 9% for short-term storage.

In details, a total of 742 entries/ samples from rejuvenated germplasm of Aus 2021-22 season were processed and stored in Genebank of which 655 in short, 38 in medium and 49 in long-term storages during 2022-23. Similarly, in total 1,334 entries of T. Aman 2022-23 season were processed and stored of which 900 in short, 175 in medium and 259 in long-term storages respectively. Finally, a total of 1,555 entries were stores in short, 213 in medium and 308 in long-term storages in Genebank. The rest of the germplasm of Boro 2022-23 season (650+56=706 accessions) are now almost ready

to store. Here, it needs to be mentioned that the harvested fresh seeds of each accession from the previously mentioned experiments entitled 'Morphological characterization of germplasm' of GRS Division were also processed and stored in Genebank. The respective harvested, dried, cleaned and processed seeds of each accession were here treated as the rejuvenated seeds of that respective accession and consequently stored in Genebank for better convenience and use. Apart from this, 173 new germplasm were registered as new accessions (from accession number 8,696 to 8,868) in BRI Genebank during 2022-23.

Viability testing, periodic evaluation and routine monitoring of stored germplasm. The seed viability of the stored germplasm in short-term storage of BRI Genebank was monitored from randomly selected germplasm in three seasons per year. The evaluations of viability (germination %) test are conducted in such a way, so that the monitoring of the whole conserved germplasm of the short-term storage (now 8,868 accessions) will be completed within three years.

One hundred and ten accessions in Aus 2021-22, 200 accessions in T. Aman 2022-23 and 120 accessions in Boro seasons were checked and monitored randomly for viability (germination %) test in short-term storage. Among the randomly selected 430 stored germplasm, 213 acc. had viability between 80-90% and 96 acc. had above 90%. Viability was also monitored in mid- and long-terms storage using five tester varieties namely Dhariyal (Acc. no. 649), Hashikalmi (Acc. 3575), Purbachi (Acc. 6207), Nizersail (Acc.1229) and Patnai-23 (Acc. 52.) to predict the viability of germplasm in respective storages. The viability was measured on six month interval basis as on October 2022 and March 2023 during the reporting year. The germination percentages of the five test samples/testers in the medium-term storages were found ranging from 75 (Purbachi) to 93% (Patnai-23) in October 2022 and 76 (Purbachi) to 95% (Nizersail) in March 2023. Similarly, the germination percentages of the test samples/testers in the long-term storages were found ranging from 80 (Purbachi) to 96% (Nizersail) in October 2022 and 75 (Purbachi) to 95% (Dhariyal, Nizersail and Patnai-23) in March 2023. The germination percentages of the five test samples/testers indicating the probable viability condition of stored germplasm in respective storages.

The seed viability of the germplasm just before storage in the Genebank was also monitored. The germination tests of 250 germplasm just before short-term storage were carried out of which 100 were for Aus 2021-22 and 150 were for T. Aman 2022-23 seasons. Among them, 119 had germination between 80-90% and 80 had above

90%. The germplasm that possessed less than 80% germination will be grown again in the following season for safe keeping. However, the processing of Boro 2022-23 germplasm are now ongoing.

Germplasm distribution and exchange. A total of 2,778 samples were supplied to 48 different users in the reporting year. Among the samples, 2,590 germplasm accessions were supplied to 36 users for research purpose and 188 samples of BRRI invented and recommended rice varieties were supplied to the researchers, Department of Agricultural Extension (DAE) personnel and university students for research, demonstration as well as other purposes.

PI: Mir Sharf Uddin Ahmed and Md Alamgir Hossain.

SEED PRODUCTION AND VARIETY MAINTENANCE

Variety maintenance and nucleus seed production. One hundred nineteen BRRI developed and recommended rice varieties including 15 locally improved varieties (LIVs) were maintained using panicle to row method, implementing time isolation and performing thorough roguing (Table 4 and Fig. 3). After harvest, both the intact panicles and nucleus seed of each variety were stored (20°C with 40% RH) for variety maintenance and distribution to researchers, DAE personnel and students respectively.

PI: Ebna Syod Md Harunur Rashid and Tonmoy Chakrabarti (T. Aman) and Mir Sharf Uddin Ahmed and Ebna Syod Md Harunur Rashid (Boro).

Table 4. List of BRRI developed and recommended rice varieties maintained during 2022-23.

Season	Type	Number	Variety
T. Aman	MV	54	BR4, BR5, BR10, BR11, BR21, BR22, BR23, BR24, BR25, BRRI dhan27, BRRI dhan30, BRRI dhan31, BRRI dhan32, BRRI dhan33, BRRI dhan34, BRRI dhan37, BRRI dhan38, BRRI dhan39, BRRI dhan40, BRRI dhan41, BRRI dhan42, BRRI dhan43, BRRI dhan44, BRRI dhan46, BRRI dhan48, BRRI dhan49, BRRI dhan51, BRRI dhan52, BRRI dhan53, BRRI dhan54, BRRI dhan56, BRRI dhan57, BRRI dhan62, BRRI dhan66, BRRI dhan70, BRRI dhan71, BRRI dhan72, BRRI dhan73, BRRI dhan75, BRRI dhan76, BRRI dhan77, BRRI dhan78, BRRI dhan79, BRRI dhan80, BRRI dhan82, BRRI dhan83, BRRI dhan85, BRRI dhan87, BRRI dhan90, BRRI dhan91, BRRI dhan93, BRRI dhan94, BRRI dhan95, BRRI dhan98
	LIV	10	Nizersail, Latisail, Rajasail, Kalijira, Kataribhog, Basmati-D, Patnai23, Tilockkachari, DA29, DA31

Boro	MV	47	BR1, BR2, BR3, BR6, BR7, BR8, BR9, BR12, BR14, BR15, BR16, BR17, BR18, BR19, BR26, BRRI dhan28, BRRI dhan29, BRRI dhan35, BRRI dhan36, BRRI dhan45, BRRI dhan47, BRRI dhan50, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan60, BRRI dhan61, BRRI dhan63, BRRI dhan64, BRRI dhan65, BRRI dhan67, BRRI dhan68, BRRI dhan69, BRRI dhan74, BRRI dhan81, BRRI dhan84, BRRI dhan86, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, BRRI dhan97, BRRI dhan98, BRRI dhan99, Bangabandhu dhan100, BRRI dhan101, BRRI dhan102
	LIV	8	Hbj Boro II, Hbj Boro IV, Hbj Boro VI, Hbj Boro VIII, Purbachi, IR8, IR20, IR64
Total		119	



Fig. 3. Pictorial view of variety maintenance and nucleus seed production at West Baid, BRRI HQ in Boro 2022-23 season.

Nucleus seed stock for breeder seed production.

Seventy-one BRRI bred rice varieties of which 46 in T. Aman and 25 in Boro were grown following panicle to row method to produce nucleus seed stocks as panicles for breeder seed production. The objective for nucleus seed production was to maintain genetic purity and homogeneity of morphological characteristics of each variety and subsequently to produce and maintain the seed standard of breeder seed.

‘Panicle to row’ method was used to maintain nucleus seed stock, where the intact panicles were sown instead of threshed seeds of each variety. If off-type plant was identified in a row, then the whole

row was discarded or rogued out for maintaining the varietal purity. At maturity, the panicles from ‘true to type’ plants of all the varieties were harvested and the intact panicles for both BRRI HQ, Gazipur and as well as all BRRI regional stations were stored in controlled temperature (20°C with 40% RH).

Breeder seed production and distribution. GRS Division, Farm Management Division and nine regional stations of BRRI were engaged in breeder seed production as per national demand. ‘Panicle to row’ method was also used to produce all the breeder seeds, where the intact panicles were sown instead of threshed seeds for each variety. Off-type plants were identified and rogued out in every

growth stage. After harvesting of a variety, the seeds were separately threshed, dried, cleaned and stored in controlled temperature (20°C with about 40% RH) at BRRI HQ, Gazipur. The harvested seeds then offered as seed lot for getting green 'breeder seed tag' from Seed Certification Agency (SCA) for its distribution.

In total 273.86 tons of breeder seed with tags of which 173.28 tons of 21 Boro varieties, 32.48 tons of nine Aus varieties and 68.1 tons of 36 T. Aman varieties were produced during 2022-23 (Tables 5, 6, 7 and Fig. 4). At the same time, in total 259.765 tons of breeder seed with tags of which 169.454

tons of 21 Boro varieties, 31.063 tons of nine Aus varieties and 59.248 tons of 36 T. Aman varieties were distributed among 696 partners (GO, NGO and PS) of BRRI 'Rice Seed Network'. Again, in total 7,257 kg of 7 varieties of TLS were collected from different BRRI regional stations during 2022-23 and 1,451 kg of 11 varieties of seeds were distributed as TLS with cash and 9,663 kg of 22 varieties of seeds were distributed as free of cost to farmers and different users on T. Aman 2022-23 season (Table 8).

PI: Md Adil Badshah and Mir Sharf Uddin Ahmed (T. Aman) and Ebna Syod Md Harunur Rashid (Boro).

Table 5. Production and distribution of rice breeder seed on Boro 2022-23.

Variety	Production(with tag) (kg)		Distribution (kg)	
	Favourable variety	Stress tolerant variety	Favourable variety	Stress tolerant variety
BR16	480		510	
BR26	1920		1945	
BRRI dhan28	27980		27281	
BRRI dhan29	19050		19244	
BRRI dhan36		60		50
BRRI dhan47		990		130
BRRI dhan50	4050		4044	
BRRI dhan58	3040		3160	
BRRI dhan63	320		780	
BRRI dhan67		10620		7857
BRRI dhan74	17270		17556	
BRRI dhan81	7710		6290	
BRRI dhan84	4280		3505	
BRRI dhan86	140		190	
BRRI dhan88	5120		5390	
BRRI dhan89	29410		30237	
BRRI dhan92	20700		22116	
BRRI dhan96	3590		3813	
BRRI dhan97		3400		2460
BRRI dhan99		210		241

Bangabandhu dhan100	12940		12655	
Total	158,000	15,280	158,716	10,738
Grand total	173,280		169,454	

Table 6. Production and distribution of rice breeder seed on Aus 2022-23.

Variety	Production (with tag) (kg)	Distribution (kg)
BR26	140	83
BRR I dhan42	60	03
BRR I dhan43	50	03
BRR I dhan48	14790	14764
BRR I dhan65	140	133
BRR I dhan82	1450	1390
BRR I dhan83	570	540
BRR I dhan85	1520	277
BRR I dhan98	13760	13870
Total	32,480	31,063

Table 7. Production and distribution of rice breeder seed on T. Aman 2022-23.

Variety	Production (with tag) (kg)		Distribution (kg)	
	Favourable variety	Stress tolerant variety	Favourable variety	Stress tolerant variety
BR10	2270		2200	
BR11	4840		4840	
BR22	3720		3480	
BR23	3850		3610	
BRR I dhan30	470		500	
BRR I dhan32	200		200	
BRR I dhan33	490		480	
BRR I dhan34	4050		4080	
BRR I dhan39	350		350	
BRR I dhan41		170		170
BRR I dhan44	40		40	
BRR I dhan46	280		280	
BRR I dhan49	8620		8720	
BRR I dhan51		4390		4510
BRR I dhan52		4050		4020
BRR I dhan56		120		110

BRRi dhan57		80		80
BRRi dhan62	120		70	
BRRi dhan66		70		40
BRRi dhan70	50		45	
BRRi dhan71		320		320
BRRi dhan72	2120		220	
BRRi dhan73		120		80
BRRi dhan75	4300		4330	
BRRi dhan76	1300		390	
BRRi dhan77	10		10	
BRRi dhan78		60		60
BRRi dhan79	30		30	
BRRi dhan80	150		100	
BRRi dhan87	12220		9153	
BRRi dhan90	890		900	
BRRi dhan91		50		50
BRRi dhan93	1930		1880	
BRRi dhan94	1780		1480	
BRRi dhan95	4540		2370	
Nizersail	50		50	
Total	58,670	9,430	49,808	9,440
Grand total	68,100		59,248	

Table 8. List of collection of TLS (from BRRi regional stations) and distribution of seed as TLS and as free of cost on T. Aman 2022-23.

Variety	Collection of TLS (kg)	Distribution of seed as TLS (kg) (from TLS/ unsold BS)	Distribution of seed as free of cost (kg) (from unsold BS/ TLS)
BR10			100
BR23	1000		50
BRRi dhan34	3480	397	397
BRRi dhan49		66	193
BRRi dhan51	680	275	438
BRRi dhan56			16
BRRi dhan57			11
BRRi dhan70			16

BRRi dhan71		10	
BRRi dhan72		20	1743
BRRi dhan73			10
BRRi dhan75			25
BRRi dhan76			726
BRRi dhan79			03
BRRi dhan80		10	02
BRRi dhan87		155	2834
BRRi dhan90	550	120	408
BRRi dhan91			17
BRRi dhan93	300	01	197
BRRi dhan94	300	36	246
BRRi dhan95		116	2041
BRRi dhan103	425	255	180
Total	7,257	1,451	9,663



Fig. 4. Pictorial view of BS production at West Baid, BRRi HQ in Boro 2022-23 season.

Sending SMS to SeedNet partners for breeder seed distribution. Text messages (SMS) with variety name and allotted quantity of breeder seed were sent through software to 372, 34 and 211 partners before Boro 2022-23, Aus 2022-23 and T. Aman 2022-23 seasons, respectively for distributing breeder seed through BRRi ‘Rice Seed Network’.

PI: Armin Bhuiya.

Monitoring seed production plots and farms. Breeder seed production plots of BRRi regional stations (RSs) at Rangpur, Rajshahi, Cumilla, Barishal, Sonagazi and Habiganj along with foundation seed production farms of BADC at Bangladesh Agricultural University (BAU),

Mymensingh and Shibaloy, Manikganj were visited (Figs. 5 and 6). During the visit, no major insect-pest damage, varietal impurity (<1%) and no obnoxious weeds were observed. Isolation

distances and crop conditions were satisfactory. The seed producers were advised for thorough roguing by themselves for one more time before harvesting.

PI: Md Adil Badshah, Mir Sharf Uddin Ahmed and Md Alamgir Hossain.



Fig. 5. Pictorial views of monitoring the BS plots in BRRI regional stations at Rangpur, Barishal and Sonagazi during T. Aman 2022-23 season.



Fig. 6. Pictorial view of FS plot of BADC at BAU farm, BAU, Mymensingh in T. Aman 2022-23 season.

EXPLORATORY AND GENETIC STUDIES

Regional yield trial (RYT) of Balam rice germplasm. Balam (acc. 516) rice germplasm along with BRRI dhan80 as the standard check variety were evaluated as the regional yield trial (RYT) at BRRI HQ, Gazipur and BRRI RS, Barishal in T. Aman 2022-23. The unit plot size was 25 hills x 6 rows of 20 x 20 cm² spacing between plants and

rows in BRRI HQ. The yield of Balam germplasm (Fig. 7) was 3138.8 g per plot in BRRI HQ, which was equivalent to 5.23 ton/ha. Finally, Acc. 516 will be more purified at BRRI HQ, Gazipur in T. Aman 2023-24 season before conducting any advance yield trials.

PI: Mir Sharf Uddin Ahmed.



Fig. 7. Pictorial views of brown rice and dehusked grains of Balam (Acc. no. 516) germplasm.

Regional yield trial (RYT) of Sada Mota and Lal Mota rice germplasm. Sada Mota (acc. 7888) along with BRRI dhan77 as the standard check variety were evaluated as regional yield trial (RYT) at BRRI HQ, Gazipur and BRRI RS, Barishal in T. Aman 2022-23. The unit plot size was 25 hills x 6 rows of 20 x 20 cm² spacing between plants and PI: Mir Sharf Uddin Ahmed.

rows in BRRI HQ. The yield of Sada Mota (acc. 7888) germplasm (Fig. 8) was 2,258.8 g per plot in BRRI HQ, which was equivalent to 3.76 ton/ha. Finally, Acc. 7,888 will be more purified at BRRI HQ, Gazipur in T. Aman 2023-24 before conducting any advance yield trials.



Fig. 8. Pictorial views of brown rice and dehusked grains of Sada Mota (Acc. no. 7888).

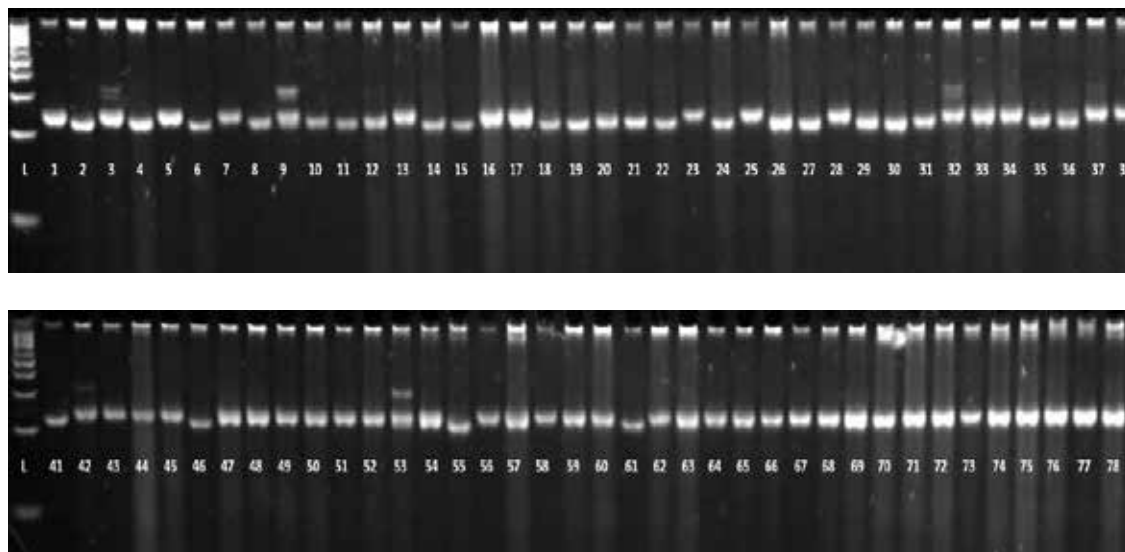
DNA finger printing of Binni group of germplasm. Eighty Binni rice germplasm accessions were characterized for DNA finger printing using 60 SSR markers well distributed within 12 chromosomes (<http://www.gramene.org>). Among the 60 primers, three primers (RM273, RM223 and RM282)

were used for evaluating aroma and four primers (RM170, RM190, RM253 and RM314) were used for evaluating amylose. Three weeks old leaves were used for DNA extraction in the experiment. DNA was extracted from three weeks old leaves following the quick DNA extraction protocol of

Ferdous *et al.* (2012). PCR analysis was performed in 10 µl reaction sample containing 3 µl of DNA template, 4.5 µl of Master Mix (Promega), 1.5 µl of Nuclease-Free Water, 0.5 µl each of 10 µM forward and reverse primers using a GeneAtlas G (Astec, Japan) 96-well thermal cycler. After initial denaturation for five minutes at 94°C, each cycle comprised 30 sec denaturation at 95°C, 30 sec annealing at 55°C, and 25 sec extensions with a

final extension for five min at 72°C at the end of 32 cycles. The 2.5 µl PCR products were mixed with bromophenol blue gel loading dye and were analyzed by electrophoresis on 8% polyacrylamide gel using mini vertical polyacrylamide gels for high throughput manual genotyping (CBS Scientific Co. Inc., CA, USA). Data analysis is in process. Figure 9 presents the DNA profiles of 80 Binni accessions with SSR marker RM314.

PI: Armin Bhuiya.



Legends: L=Ladder, 1=Kaisha Binni (Acc. 204), 2=Kaisha Binni (Acc. 205), 3=Kaisha Binni (Acc. 206), 4=Kaisha Binni (Acc. 207), 5=Koha Binni (Acc. 208), 6=Lal Binni (Acc.), 7=Lal Binni (Acc.), 8=Kala Binni (Acc. 236), 9=Kaika Binni (Acc. 1874), 10=Sail Binni (Acc. 1974), 11=Netha Binni (Acc. 1987), 12=Aguinya Binni (Acc. 4473), 13=Kuichcha Binni (Acc. 4474), 14=Pura Binni (Acc. 4475), 15=Garo Binni (Acc. 4476), 16=Binni (Acc. 4477), 17=Leda Binni (Acc. 4478), 18=Binni (Acc. 4479), 19=Kakoiya Binni (Acc. 4480), 20=Chandan Binni (Acc. 4481), 21=Dudhmethi (Acc. 4482), 22=Atha Binni (Acc. 4483), 23=Atha Binni (Acc. 4484), 24=Gouhati Binni (Acc. 4485), 25=Nedra Binni (Acc. 4486), 26=Ranga Binni (Acc. 4487), 27=Sona Binni (Acc. 4700), 28=Kaisa Binni (Acc. 4701), 29=Netha Binni (Acc. 4705), 30=Binni (Acc. 4707), 31=Kaisa Binni (Acc. 4720),

32=Sada Binni (Acc. 4726), 33=Lata Binni (Acc. 4727), 34=Panga Binni (Acc. 5032), 35=Chysa Binni (Acc. 5954), 36=Chidira Binni (Acc. 7074), 37=Binni Dhan (Acc. 7253), 38=Kala Binni (Acc. 7258), 39=Kutkutta Binni (Acc. 7261), 40=Horin Binni (Acc. 7268), 41=Ranga Binni (Acc. 7276), 42=Binni (Red) (Acc. 7487), 43=Binni (Acc. 7488), 44=Binni (Black) (Acc. 7489), 45=Horina Binni (Acc. 7493), 46=Ayla Binni (Acc. 7666), 47=Lal Binni (Acc. 7691), 48=Ranga Binni (Acc. 7693), 49=Binnisada (Acc. 7730), 50=Kangiri Binni Dhan (Acc. 7738), 51=Sada Binni (Acc. 7746), 52=Patri Binni (Acc. 7747), 53=Binnilangmeno (Acc. 7767), 54=Bak Binni (Acc. 7768), 55=Laxmi Binni (Acc. 7781), 56=Khoiya Binni (Acc. 7784), 57=Jhum Binni (Acc. 7796), 58=Uscha Binni (Acc. 7804), 59=Lal Binni (Acc. 7819), 60=Binnidhan (Redesh) (Acc. 7832), 61=Binni (Red) (Acc.

7834), 62=Binnidhan (Sadamota) (Acc. 7981), 63=Banor Bini Dhan (Acc. 8166), 64=Longapura Binni (Golden) (Acc. 8170), 65=Cholokka Binni (Acc. 8176), 66=Nola Binnidhan (Acc. 8181), 67=Lokkhi Binni (Acc. 8188), 68=Lonka Pora Binni (Acc. 8581), 69=Meme Black Binni (Acc. 8582), 70=Lamnu Binni (Acc. 8583), 71=Long Mona Binni (Acc. 8584), 72=Sundori Binni (Acc. 8793), 73=Laxmi Binni (Acc. 736), 74=Aus Gara Binni (Acc. 2091), 75=Lal Binni (New Collection, NC), 76=Binni Dhan (NC), 77=Kalo Binni (NC), 78=Sada Binni (NC), 79=Binni Dhan (NC), 80=Morta Dhan (Binni) (Acc. 7426).

Fig. 9. DNA profile of 80 Binni accessions with SSR marker RM314.

Evaluation of photosensitive rice germplasm collected from northern districts of Bangladesh.

A total of 12 photosensitive germplasm along with three checks were grown late (transplanting 15

September) in T. Aman 2022-23 season to identify germplasm suitable for late transplanting after flood in northern region of Bangladesh (Bogura, Kurigram, Lalmonirhat, Gaibandha, Rangpur and Jamalpur). One Rosul Bhog (Acc. 5071), one Malshira (Acc. 299) and, one Ganjia (Acc. 287) accession showed better performance on the basis of their morpho-agronomic traits among the tested entries (Table 9). Grain weights per hill of RosulBhog (Acc. 5071), Malshira (Acc. 299) and Ganjia (Acc. 287) germplasm were 30.8 g, 30.0 g and 25.0 g, respectively. L/B ratio of RosulBhog was very high (4.62). Longer panicle length (24 to 26 cm), higher number of filled grain per panicle (117 to 173) and medium growth duration (116 to 124 days) were observed in selected three local germplasm and will be tested further in Rangpur region in the next T. Aman 2023.

PI: Ebna Syod Md Harunur Rashid.

Table 9. Performance of twelve photosensitive T. Aman rice germplasm from BRRI Genebank.

Acc. no.	Name	Effect tiller per hill	Culm length (cm)	PL (cm)	DTM	TGW (g)	FG/panicle	UFG/panicle	Grain weight per hill (g)	DGL (mm)	DGW (mm)	L/B ratio
285	BindiPakri	10.8	93.0	24.73	117	17	148.8	20.6	27.6	6.46	2.18	2.96
287	Ganjia	11.2	96.1	26.13	124	19	117.8	18.53	25.0	5.61	2.21	2.54
299	Malshira	10.9	87.8	24.66	117	23	122.4	37.53	30.0	5.64	2.34	2.41
360	Malshira	10.9	84.6	25.33	116	21	106.0	11.93	25.0	5.42	2.38	2.28
520	Ganjia	10.2	88.1	26.2	123	20	79.2	12.2	16.0	5.74	1.91	3.01
531	Ganjia	11.0	98.6	26.2	120	18	98.7	11.73	19.8	5.32	2.10	2.53
545	Malshira	10.4	95.9	27.46	119	21	100.8	18.6	24.0	6.1	2.37	2.57
3661	Indur Sail	10.9	93.9	25.2	115	25	87.7	12.6	24.0	6.68	2.44	2.74
4810	BindiPakri	10.2	92.4	27.46	120	22	82.5	12.13	19.7	5.58	2.16	2.58
5969	Joy Sail	11.4	89.5	26.46	120	24	85.8	12.6	23.0	6.64	2.38	2.79
338	RosulBhog	11.0	93.8	27.6	115	20	114.2	13.46	26.0	6.18	2.08	2.97
5071	RosulBhog	11.2	100.0	25.6	116	16	173.6	18.53	30.8	5.5	1.19	4.62
-	BR22 (ck)	9.6	81.2	25.13	122	22	118.9	20.93	26.0	5.69	2.41	2.36
-	BR23 (ck)	11.1	91.7	25.33	120	17	121.6	26.73	20.4	5.66	2.36	2.40
-	Nizersail (ck)	10.9	87.9	26.53	122	19	115.4	16.4	26.0	5.61	2.11	2.66
	CV	3.91	4.64	3.11	2.01	10.98	15.58	36.96	13.50	6.78	6.32	8.60
	LSD (5%)	0.26	2.67	0.50	1.49	1.39	10.91	4.09	2.05	0.24	0.08	0.12

Identification and selection of sticky rice from Jhum rice germplasm. Seventy-five Binni rice germplasm were grown in the field at BRRRI HQ, Gazipur and after harvest the seed were sent to GQN (Grain Quality and Nutrition) Division for measuring Amylose content. A total of 14 Binni rice germplasm viz Binni, Atha Binni, Nedra Binni,

Ranga Binni, Panga Binni, Patri Dhan, Banor Bini Dhan, Lonka Pora Binni, Meme Black Binni, Binni Long Mon, Sundori Binni, Kalo Binni, Sada Binni and Binni Dhan were found containing very low amylose % (5.71-9.04) (Table 10).

PI: Armin Bhuiya.

Table 10. Apparent amylose content (AAC) % of 75 Binni rice during 2022-23.

Name	AAC%	Name	AAC%	Name	AAC%
Kaisha Binni	21.79	Ranga Binni	8.89	Lakmi Binni	24.35
Kaisha Binni	20.79	Sona Binni	20.89	Khoiya Binni	24.03
Kaisha Binni	21.58	Kaisa Binni	21.63	Jhum Binni	24.61
Kaisha Binni	21.74	Nethabinni	21.89	Uscha Binni	24.42
Koha Binni	21.63	Binni	19.79	Binni Dhan (Redesh)	24.68
Lal Binni	21.63	Kaisa Binni	25.00	Binni (Red)	23.64
Lal Binni	20.53	Sada Binni	25.05	Binni Dhan (Sadamota)	24.87
Kala Binni	10.95	Lata Binni	21.83	Banor Bini Dhan	8.59
Kaika Binni	20.63	Panga Binni	7.75	Longapura Binni(Gold-en)	11.50
Sail Binni	21.26	Chysa Binni	11.69	Cholokka Binni	14.41
Netha Binni	20.74	Chidira Binni	22.48	Nola Binni Dhan	25.00
Aguinya Binni	18.11	Binnidhan/ Ching-nu	23.13	Lokkhi Binni Dhan	12.09
Kuichcha Binni	9.68	Kala Binni	22.35	Lonka Pora Binni	6.54
Pura Binni	19.95	Kutkutta Binni	21.64	Meme Black Binni	8.30
Garo Binni	20.68	Horin Binni	23.45	Lamnu Binni Dhan	9.18
Binni	7.68	Ranga Binni	22.87	Binni Long Mona	5.88
Leda Binni	12.21	Binni (Red)	23.97	Sundori Binni	5.71
Binni	20.89	Binni	17.64	Laksmi Bini	15.28
Kakoiya Binni	18.53	Ayla Binni	23.51	Aus Gara Binni	22.58
Chandan Binni	14.54	Ranga Binni	18.60	Lal Binni	22.14
Dudhmethi	21.37	Binni Sada	23.39	Binni Dhan	10.17
Atha Binni	12.58	Sada Binni	23.19	Kalo Binni	7.64
Atha Binni	7.53	Patri Dhan	9.04	Sada Binni	8.19
Gouhati Binni	13.89	Binni Langmeno	25.13	Binni Dhan	7.97
Nedra Binni	7.21	Bak Binni	23.71	Morta Dhan (Binni)	19.34

Characterization of Badshabhog group of germplasm. For protecting from biopiracy and establishment of IPR (Intellectual Property Right) related issues, 19 Badshabhog rice germplasm along with five standard check varieties viz BR5, BRRI dhan34, BRRI dhan90 and GI marked Bangladesh Kalijira (Acc. 247) and Dinajpur Kataribhog (Acc. 4791) were grown in T. Aman 2022 season at GRSD germplasm experimental plot, BRRI HQ. The experiment was enacted with Randomized Complete Block Design (RCBD). The row-to-row and plant-to-plant distance was 20 × 20 cm with 60 m² plot. There were 30 hills for each germplasm in each replication. Entries were repeated three times. Fertilizer doses were 60:20:40 kg NPK/ha. The recommended agronomic practices were maintained throughout the growing period.

Besides, the mentioned 24 germplasm were also characterized in the Molecular Laboratory of GRSD, BRRI HQ. In T. Aman 2022, 61 SSR marker well distributed within 12 chromosomes were used (<http://www.gramene.org>) and all markers were identified as polymorphic for afterward analysis. DNA extraction, PCR amplification, PCR cycles, Electrophoresis and visualization of amplified products were as same as mentioned in the previous molecular study experiment entitled 'DNA finger printing of Binni group of germplasm'. For Allele scoring and diversity data analyses, Alpha Ease FC 4.0 and Power Marker V3.25 (Liu and Muse 2005) software were used and genetic distance based unrooted neighbour-joining tree was constructed using MEGA 5.1 software (Tamura *et al.*, 2011).

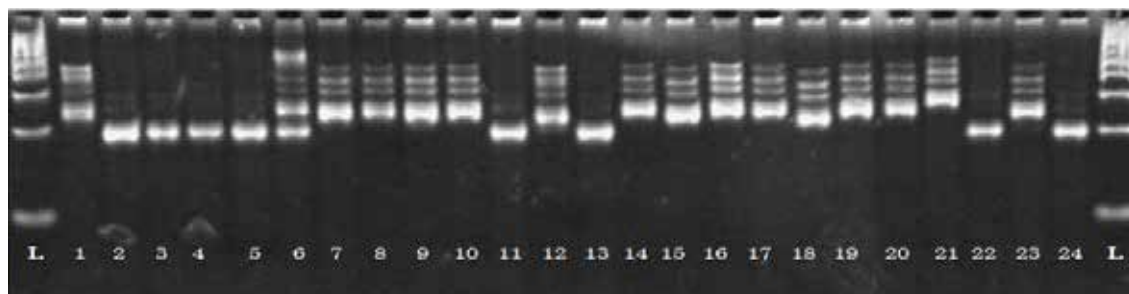
The morphological characterization revealed that high differences in genotypic and phenotypic variances were present for all the studied traits except for ligule length, flag leaf width, panicle length, flowering duration, growth duration, thousand grain weight, grain length, grain width, dehulled rice length, dehulled rice width, dehulled rice length breadth ratio due to less influenced by environment. The highest genotypic and phenotypic

coefficient of variation was found for ligule length, flag leaf width and yield. The high heritability was observed for all traits except for flag leaf length, flag leaf width, culm diameter, effective tiller. The high heritability along with genetic advance (GA) and genetic advance in percent of mean (GAM) were observed for plant height, ligule length, culm length, panicle length, thousand grain weight, dehulled rice length breadth ratio and yield as are controlled by multiple genes with high additive gene action.

In total 182 alleles were detected at 61 SSR (Simple Sequence Repeats) markers across 24 rice germplasm. The highest amplicon size was produced by RM144 (263 bp) and the lowest by RM413 (70 bp). The number of alleles per locus ranged from 2 to 9 alleles, with an average of three alleles across the 61 loci. The PIC values ranged from 0.08 (RM125) to 0.70 (RM474) with an average of 0.42. The higher value of PIC indicates higher diversity of materials. Primer RM474 had the highest PIC value (0.70) and this primer is detected as the highest level of polymorphism. Therefore, it is confirmed that RM474 was the best marker for characterizing the studied 24 rice germplasm. The frequency of the most common allele at each locus ranged from 29.17% to 95.83%. On average, 69.59% of the 24 rice germplasm shared a common major allele at any given locus. Figure 10 shows the DNA profile of 24 rice germplasm with SSR marker RM474.

The genetic distance-based results seen in the unrooted neighbour-joining tree revealed that the 24 rice germplasm were grouped into four major clusters (Fig. 11). The highest number of germplasm (16) was found in cluster II, followed by clusters I (5) and the lowest in cluster IV (1). Badsha Bhog TAPL-53 as B4 and Badsha Bhog TAPL-54 as B5 is very much close and almost no genetic distance in cluster II.

PI: Tonmoy Chakrabarty.



Legend: L= Ladder 50 bp., 1. Badsha Bhog-DA27 (Acc. 3), 2. Badsha Bhog (Acc. 1110), 3. Badsha Bhog TAPL-52 (Acc. 2481), 4. Badsha Bhog TAPL-53 (Acc. 2482), 5. Badsha Bhog TAPL-54 (Acc. 2483), 6. Badsha Bhog TAPL-55 (Acc. 2484), 7. Badsha Bhog TAPL-56 (Acc. 2485), 8. Badsha Bhog TAPL-58 (Acc. 2486), 9. Badsha Bhog TAPL-59 (Acc. 2487), 10. Badsha Bhog TAPL-60 (Acc. 2488), 11. Badsha Bhog TAPL-61 (Acc. 2489), 12. Badsha Bhog TAPL-62 (Acc. 2490), 13. Badsha Bhog TAPL-63 (Acc. 2491), 14. Badshabhog (Colored) (Acc. 4355), 15. Badshabhog (Jirabhog) (Acc. 4364), 16. Badsha Bhog (Acc. 4827), 17. Badshabhog (Acc. 5349), 18. Badsha Bhog (Acc. 7554), 19. Badsa Bogh (Acc. 7870), 20. BR5, 21. BRRI dhan34, 22. BRRI dhan90, 23. Bangladesh Kalijira (Acc. 247) and 24. Dinajpur Kataribhog (Acc. 4791).

Fig. 10. DNA finger print of 19 Badshabhog rice germplasm and five check varieties with SSR marker RM474.

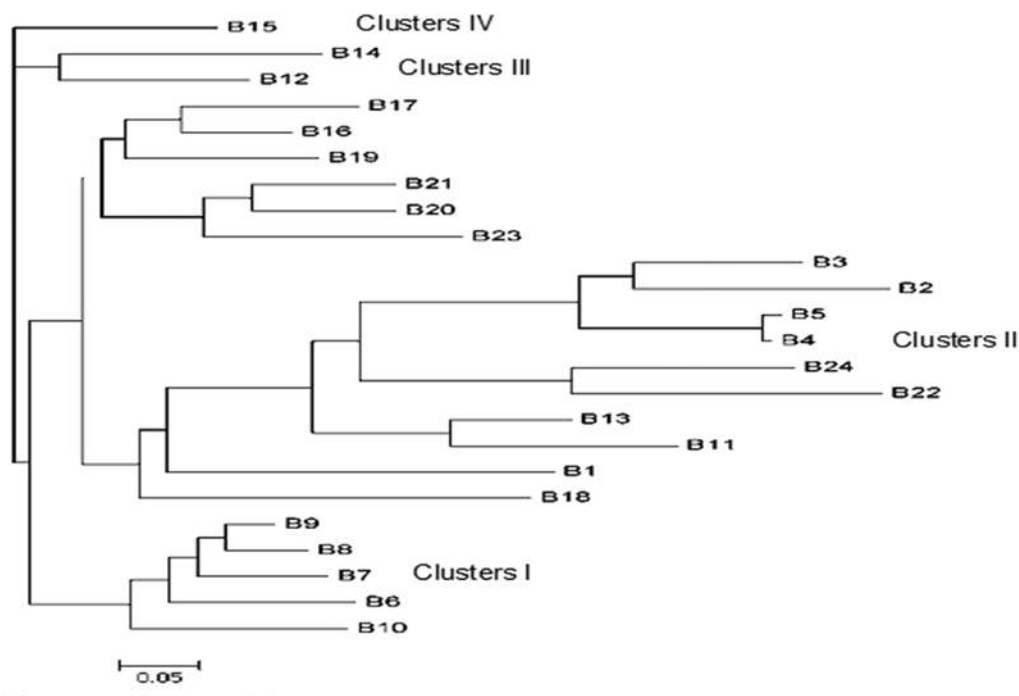


Fig. 11. Unrooted neighbour-joining tree showing the genetic relationships among the 19 Badshabhog rice germplasm and five check varieties by using 61 SSR markers.

Grain Quality and Nutrition Division

60	Summary
61	Grain Quality Character
63	Nutritional Quality Assessment Of Rice
63	Grain Quality Parameters For Consumer Preference
66	Commercial Rice Based Products

SUMMARY

A total of 630 breeding lines were analyzed, among them 59 had more than 70% milling outturn, 134 had more than 60% head rice recovery, 26 have shown less than 10% chalky grain, 325 had long grain, 190 had more than 3.0 L/B ratio, 283 had more than 25.0% amylose content, 268 had between the range of 3.1-5.9 alkali spreading value, 113 had more than 9.0% protein content, 32 had more than 1.5 elongation ratio, 219 had between the range of 4.0-5.0 volume expansion ratio and 15 had high aroma. Some of the promising lines were identified for higher milling and head rice recovery, size and shape, amylose content, protein content, elongation ratio and acceptable other physicochemical properties.

A total of 4,329 lines were evaluated for grain quality properties for superior quality. Based on the performance of grain quality, we recommended total 45 lines and among them 16 lines for submergence tolerance T. Aman 2021 (PYT), eight lines for salinity tolerance, Boro 2021-22 (PYT), nine lines for insect resistant rice (BPH), Boro 2021-22 (AYT), 12 for advancing as breeding lines BRRI RS, Barishal 2021-22.

Six newly released BRRI HYVs were characterized by antioxidant, minerals, amino acid, and fatty acid composition profiling at Rice Analytical Laboratory (RAL) in association with GQN Division of BRRI. Our analytical data revealed BRRI dhan91 as a superior quality HYV in terms of nutraceutical enriched properties including antioxidant, superior quality amino acid, and fatty acid profiling among all the tested BRRI HYVs in this study.

In the point of view of the panelist for sensory evaluation, well milled rice (10%) in highly acceptable, over milled rice (15%) in moderately acceptable, under milled rice (5%) in slightly acceptable and brown rice (0%) is not acceptable cooked rice of BRRI dhan92 were recognized. Similar result has shown in the taste of cooked rice of BRRI dhan92 at different degree of milling. Results of Pearson correlation matrix for relationships ascertained that excellent and good taste of BRRI dhan92 both have not any significant relationship

with physicochemical and other sensory properties of BRRI dhan92 at different degree of milling. Very good taste is significant and positively correlated with elongation ratio. It is positively correlated with amylose content but negatively correlated with protein content. Tasteless is highly significant and positively correlated with fair appearance of cooked rice. It is significant and positively correlated with cooking time but significant and negatively correlated with alkali spreading value.

Studies on the expression of genes in different rice cultivars and tissues revealed that pigmented rice had greater transcript levels of flavonoid biosynthesis genes than non-pigmented rice. Therefore, higher expression of genes involved in the biosynthesis of flavonoids can be linked to pigmented rice's higher amounts of phenolics, flavonoids, anthocyanins, and antioxidant capacity. Additionally, this offers a functional explanation for expression variations across various pigmented rice cultivars and the colorlessness of non-pigmented endosperms. With respect to specific genes, tissues, and rice cultivars, expression patterns varied. Although the PAL gene was expressed more in the root, shoot and leaf than the grain. CHS, the gene downstream of PAL, was expressed more in the shoots, leaf than the grain and ANS was expressed more in the grain (mainly black rice) than roots, shoots and leaf. Although a consistent tissue-level expression pattern could not be determined in the current study, transcript levels were consistently greater in pigmented rice tissues (primarily black rice) than in non-pigmented tissues. As a result, it is concluded that flavonoid genes are independently regulated, and additional research in this field would help to shed more light on the actual mechanism regulating the pattern of gene expression for flavonoid biosynthesis.

Puffed, popped and flattened rice were produced from BRRI varieties to evaluate the quality of products. Comparing a few parameters (fully puffed rice, length, and breadth increased percentage) with BR16 (Std), it is ascertained from the results that BR23 and BRRI dhan52 are better in producing whole puffed rice followed by BRRI dhan28, BRRI dhan39, and BRRI dhan58. Considering physical parameters, BRRI dhan89 and BRRI dhan87 show excellent performance for whole, partially popped,

broken, unpopped, and volume of popped rice. On the other hand, three BRRI varieties such as BRRI dhan58, BRRI dhan74, and BR23 are found highly promising in producing flattened rice. According to the performance criterion such as weight of whole and broken flattened rice, BRRI dhan58 performed better than the other tested varieties. However, considering other criteria such as partially flattened rice, length of flattened rice, increased percentage of flattened rice, 1000 flattened rice weight as well as 50 g flattened rice volume, BRRI dhan74 showed a better performance compared to the other varieties.

The market survey highlights the persistent appeal and cultural relevance of rice-based value-added products such as puffed, popped, and flattened rice, “moa” produced from puffed and flattened rice, and rice-based patties in Bangladesh. The products’ accessibility, cultural relevance, and potential nutritional benefits make them an important component of the local food environment. “Moa” and rice-based patties show the cultural and culinary richness of diverse parts of Bangladesh. These rice-based value-added items are more than just snacks; they symbolize heritage, flavour, and the essence of Bangladeshi food culture. With the right strategies, they can continue to thrive and adapt while remaining true to their heritage.

GRAIN QUALITY CHARACTER

Determination of physicochemical and cooking properties of breeding lines

PI: MAS; CI: MAH, SSD, NF, TKS, HBS, SH and RA

After yield, grain quality of rice is important parameters for researchers and consumers. Consumer acceptance of rice depends on its physicochemical quality. Physical parameters were measured by milling outturn, head rice recovery as well as size and shape. Cooking quality was determined by cooking time, elongation ratio and volume expansion ratio. Chemical parameters were determined by amylose content, protein content and alkali spreading value. New high yielding rice varieties have better benefits than the existing ones and will be more accepted if their characteristics are in accordance with consumers’ preferences

(Zen, 2007). For high quality rice uniform shape, whiteness and translucency are major factors defining market value of rice (Fitzgerald *et al.* 2008). Rice is a very rich source of carbohydrate followed by protein.

A total of 630 samples were provided from different divisions of BRRI and outside of BRRI to find out the desirable characteristics. In Bangladesh, long slender type translucent grains preferred by consumers as premium quality rice with higher price. But medium bold type grains are most suitable for milling. Out of 350 samples, 59 had more than 70% milling outturn, 220 had between the range of 68.0-70.0% milling outturn but 134 had more than 60% head rice recovery and 146 had between the range of 50.0-60.0% head rice recovery. Out of 336 samples, 26 have shown less than 10% chalkiness, 93 have shown between the range of 10.0-20.0% chalkiness and 217 have shown more than 20% chalkiness. There is no translucent (Tr) grain that means 0% chalkiness and opaque grain that means 100% chalkiness. Out of 623 samples, 325 had long grain, 238 had medium grain and 60 had short grain. Among these samples, 190 had more than 3.0 L/B ratio, whereas 409 had between the ranges of 2.1-3.0 L/B ratio. Out of 353 samples, 6 samples had more than 30.0 g 1000-grain wt. (TGW), 40 had between the ranges of 25.1-30.0 g TGW, 145 had between the range of 21.0-25.0 g 1000-grain TGW., 85 had between the range of 15.0-20.0 g TGW and 77 had less than 15 g TGW (Table 1).

Amylose is the most important trait for eating quality, which indicates the texture of cooked rice and also volume expansion. Out of 630 samples, 283 had more than 25.0% amylose content, 307 had between the range of 20.0-25.0% amylose content and 40 had less than 20% amylose content. Alkali spreading value inversely related to gelatinization temperature. Higher gelatinization temperature indicates lower alkali spreading value. Out of 350 samples, 12 had between the range of 1-3, 268 had between the range of 3.1-5.9 and 70 had the range of 6-7 alkali spreading value. Nutritional quality is measured by protein content. Out of 350 samples, 113 had more than 9.0% protein content, 234 had between the range of 7.0-9.0% protein content but only three had less than 7.0% protein content.

Less than 7% protein content in brown rice, which is not normally recommended for variety release. Grain with high gelatinization temperature is not desirable. Out of 355 samples, 42 had more than 20 min. cooking time, 232 had between the range of 15-20 min. cooking time but only 81 had less than 15 min. cooking time. The samples, having more than 20 min. cooking time may give comparatively hard cooked rice. Among 355 samples, 32 had more than 1.5 elongation ratio, 309 had between the range of 1.3-1.5 elongation ratio and only 14 had less than 1.3 elongation ratio. More than 1.5 elongation ratio is desirable. High volume expansion of cooked rice is still considered to be a good quality for the working class people who do not care whether the expansion is lengthwise or crosswise. Among these samples, 354 had between the range of 3.5-4.0 imbibition ratio but only one had less than <3.5 imbibition ratio. Among 231 samples, 15 had highest aroma, 15 had moderate aroma, 17 had the lowest aroma and 184 had no aroma (Table 2).

Some of the promising samples were identified for higher milling outturn, head rice recovery, amylose content, protein content, elongation ratio and acceptable other physicochemical properties (Table 3).

Determination of physicochemical and cooking properties of Transforming Rice Breeding (TRB) lines

PI: SSD CI: MAS

Grain quality is an important component for consumer's preference and profitability. For the Transforming Rice Breeding project on rice grain quality screening, 4,329 lines were received, processed and analyzed for grain quality parameter.

Among them 3,446 were OYT (Favourable and cold tolerant Boro and cold tolerant Boro, insect resistant rice, Salinity tolerant, Boro, Submergence tolerant, disease resistant rice, salinity tolerant T. Aman) lines, 78 were long slender (LS), followed by 1,148 long bold, 2 were medium slender, 2,158 were medium bold, 8 were medium round, 42 were short bold, 8 were short round and 2 were short. Apparent amylose content of 3,446 of OYT lines, 2,520 were high followed by 870 intermediate and 56 was low (Table 4).

Among 883 PYT lines, 404 lines had more than 70% and 343 had 68-70% total milled rice percentage. One hundred thirty-six (136) had less than 68% milling outturn. Less than 68% milled rice is not desirable. Two hundred ten (210) lines had more than 57% followed by 374 had within 48-56.9% , 197 had within 39-47.9%, 80 lines had within 30-38.9% and 22 had less than 30% head rice recovery percentage. Out of 883 lines, none was translucent. Appearance or colour of milled rice is one of the important physical properties to attract consumer's attention. All of the lines were brown in colour. The consumers in our country prefer long and medium slender grain. Grain length and length to breadth ratio determines the grain size and shape. Out of 883 PYT lines, 30 were long slender, followed by 493 were long bold, 360 were medium bold. In Bangladesh, medium slender and medium bold grains are suitable for milling. But long slender rice is sold at high price in the market (Table 5).

Rice contains two types of starch namely amylose and amylopectin. Amylose content of rice grain determines the hardness and stickiness of cooked rice. More than 25% amylose content provides nonsticky cooked rice; 20-25% amylose containing rice gives soft and comparatively sticky cooked rice. Out of 883 lines, 457 were more than 25.0% amylose, 389 lines were with amylose content between the range of 20.0-25.0 % and 110 lines had less than 20.0% amylose. Protein content is measured for the nutritional value of rice. Two hundred fifty-seven lines had high (>9%) and 606 lines had intermediate 7.0-9.0% protein content. Generally, a variety, having less than 7% protein content in brown rice is not recommended for release as a variety. About 748 lines had cooking time between the range of 15-20 minutes. Imbibition ratio (Volume expansion) is one of the important parameters for rice quality. It shows the value of expansion of rice after cooking. Hard working people of our country prefer rice having more volume expansion. All 883 PYT lines, volume expansion ratio were less than 3.5. The elongation ratio is one of the important parameters for cooked rice. Elongation ratio is responsible for fine or coarse cooked rice. If elongation of cooked rice is more in length, it gives a finer appearance, but if expands in breadth, gives a coarse look. Long

slender and medium slender rice should elongate more in length, as they are consumed mostly by peoples having comparatively a higher income. The elongation ratio of most of the lines (818) varied between 1.3-1.5. Among the 883 breeding lines 66 had alkali spreading value ranging 6.0-7.0 and 553 had 3.1-5.9. Grain with high gelatinization temperature is not desirable (Table 6).

This study identified 45 of the promising lines for high milling and acceptable other physicochemical properties (Tables 7, 8, 9 and 10).

NUTRITIONAL QUALITY ASSESSMENT OF RICE

Nutraceutical characterization of newly released BRRi varieties

PI: HBS CI: MAS and MAH

Rice is an important source of energy, naturally hypoallergenic, easily digested, provides protein with higher nutritional quality, and has versatile functional nutraceutical properties. Rice has an important role in the relationship between diet and health. The nutrient content of rice varies depending on rice soil, and the conditions they grow. A better understanding of the intrinsic factors that contribute to the overall rice grain quality will set the foundation for developing new breeding and selection strategies for combining high grain quality, with higher yield and nutritional value. Rice-producing countries have the potential to generate higher export revenues by meeting the ever-increasing global demand for high-quality rice specially nutraceutical-enriched premium-quality rice. In quest of a better understanding of the intrinsic factors of nutraceutical properties of rice, six newly released BRRi HYVs were characterized by antioxidant, minerals, amino acid, and fatty acid composition profiling at Rice Analytical Laboratory (RAL) in an association with Grain Quality and Nutrition Division of BRRi. Our analytical data revealed that BRRi dhan91 is found to be a superior quality HYV in terms of nutraceutical enriched properties including antioxidant, superior quality amino acid, and fatty acid profiling among all the tested BRRi HYVs in this study.

Materials and Method. Six BRRi HYVs namely BRRi dhan90, BRRi dhan91, BRRi dhan92, BRRi

dhan93, BRRi dhan94, and BRRi dhan95 were collected from GRS Division, BRRi. Shimadzu LCMSMS 8050 was used for amino acid profiling. Intradat Amino Acid (3.0mm I.D. x 50mm, 3µm, Imtakt Corporation, Kyoto, Japan) column was used in this regard. Shimadzu GCMS-QP-2020 and Shimadzu ICP-OES 9820 were used for fatty acid and mineral profiling of zinc (Zn), iron (Fe), calcium (Ca), phosphorus (P), arsenic (As) respectively. Antioxidant parameters such as ferric reducing antioxidant power (FRAP), total phenolic compound (TPC) and total antioxidant capacity (TAC) were measured by Shimadzu UV-Vis 1900i of the spectrophotometric method.

Results and Discussion. Antioxidant properties of rice grains such as FRAP, TPC, and TAC parameters were measured for selected BRRi HYVs. FRAP of HYVs was not found any difference among the tested HYVs. The TPC and TAC of BRRi dhan91 were found the highest among all the tested HYVs which are 4.15 mM GAE and 80.29 µM AAE respectively. TPC and TAC are expressed by gallic acid equivalent (GAE) and ascorbic acid equivalent (AAE) respectively. Among all the tested HYVs BRRi dhan94 had shown the highest level of Zn (21.5 ppm) and Fe (6.1 ppm) (Table 11).

BRRi dhan91 had shown the highest quality of protein and amino acid profiling among all the tested HYVs in terms of Aspartic Acid, Threonine, Serine, Glutamic Acid, Glycine, Alanine, Valine, Methionine, Isoleucine, Leucine, Tyrosine, Histidine, Lysine, Arginine at 0.58, 0.21, 0.32, 1.20, 0.38, 0.44, 0.52, 1.44, 0.35, 0.73, 0.30, 1.60, 0.21, 0.59 % respectively (Table 12).

BRRi dhan91 had contained the highest quality of fatty acid profiling among all the tested HYVs in terms of the lowest saturated fatty acid (SFA%) and the highest polyunsaturated fatty acid (PUFA%) at 18.91 and 43.28 % respectively (Table 13).

GRAIN QUALITY PARAMETERS FOR CONSUMER PREFERENCE

Evaluation of palatability of BRRi dhan92 at different degree of milling based on physicochemical properties and sensory evaluation

PI: NF; CI: MAH

Milling properties. In the case of milling outturn, head rice recovery, L/B ratio and thousand grain weight of BRRRI dhan92, all have decreasing trend with increasing degree of milling. Whereas, bran and milling time both have increasing trend with increasing degree of milling (Fig. 4).

Chemical properties. In the case of chemical properties, alkali spreading value has shown increasing trend with increasing trend of degree of milling; protein content of brown rice (0%) has shown the decreasing trend with increasing trend of degree of milling as well as amylose content has shown the decreasing trend at under milled rice (5%) but increasing trend at well milled rice (10%) and over milled rice (15%) (Fig. 5).

Cooking properties. In case of cooking properties, elongation ratio (ER) has shown almost similar but increasing trend. In the case of cooking properties, volume expansion ratio (IR) has shown the highest value for under milled rice (5%) but the lowest value for brown rice (0%) as well as well milled rice (10%) and over milled rice (15%) both have decreasing trend from under milled rice (5%). In case of cooking properties, cooking time has shown the highest cooking time for brown rice (0%) followed by under milled rice (5%), well milled rice (10%) and over milled rice (15%) (Fig. 6).

Appearance of cooked rice: In the case of excellent appearance, well milled rice (10%) has shown the highest value followed by over milled rice (15%), under milled rice (5%) and brown rice (0%). In the case of Very good appearance, over milled rice (15%) has shown the highest value followed by well milled rice (10%) but under milled rice (5%) and brown rice (0%) both have shown the same value. In the case of good appearance, under milled rice (5%) has shown the highest value followed by well milled rice (10%), brown rice (0%) and over milled rice (15%). In the case of fair appearance, brown rice (0%) has shown the highest value (Fig. 7).

Taste of cooked rice: In the case of excellent taste, well milled rice (10%) has shown the highest value but over milled rice (15%), under milled rice (5%) and brown rice (0%) all have shown the same

value. In the case of Very good, taste over milled rice (15%) has shown the highest value followed by well milled rice (10%), under milled rice (5%) and brown rice (0%). In the case of good taste, under milled rice (5%) has shown the highest value followed by well milled rice (10%), brown rice (0%) and over milled rice (15%). In the case of tasteless, brown rice (0%) has shown the highest value but over milled rice (15%), well milled rice (10%) and under milled rice (5%) all have shown the same value (Fig. 8).

Texture of cooked rice: In the case of texture of cooked rice of BRRRI dhan92, over milled rice (15%) and well milled rice (10%) both have shown the highest level for soft and sticky cooked rice whereas over milled rice (15%) and well milled rice (10%) both have shown the lowest level for hard and fluffy cooked rice (Fig. 9).

Aroma of cooked rice: In the case of high aroma, over milled rice (15%), well milled rice (10%) and under milled rice (5%) all have negligible aroma but brown rice (0%) has no aroma. In the case of medium aroma, over milled rice (15%) has highest aroma followed by well milled rice (10%), brown rice (0%) and under milled rice (5%). In the case of less aroma, under milled rice (5%) has highest aroma followed by well milled rice (10%), over milled rice (15%) and brown rice (0%). In the case of no aroma, brown rice (0%) has shown the highest level followed by under milled rice (5%) but well milled rice (10%) and over milled rice (15%) both have shown the same level (Fig. 10).

Acceptance of cooked rice: In the case of highly acceptable cooked rice of BRRRI dhan92, well milled rice (10%) has shown the highest ranking followed by over milled rice (15%), brown rice (0%) and under milled rice (5%). In the case of moderately acceptable cooked rice, over milled rice (15%) has shown the highest ranking followed by well milled rice (10%), under milled rice (5%) and brown rice (0%). In the case of slightly acceptable cooked rice, under milled rice (5%) has shown the highest ranking followed by same ranking of well milled rice (10%) and under milled rice (5%) as well as over milled rice (15%). In the case of not acceptable cooked rice, brown rice (0%) has

shown the highest ranking followed by over milled rice (15%) as well as well milled rice (10%) and under milled rice (5%). Over milled rice (15%) in moderately acceptable and under milled rice (5%) in slightly acceptable both have shown the highest ranking in the acceptance of cooked rice of BRRI dhan92 at different degree of milling (Fig. 11).

Cluster analysis of BRRI dhan92: Dendrogram among physicochemical properties and sensory evaluation of BRRI dhan92 at different degree of milling like brown rice (0%), under milled rice (5%), well milled rice (10%) and over milled rice (15%) based clustering provided 4 clusters: two cluster at level below 5, one cluster at level below 15 and another cluster at level 25. In BRRI dhan92 at different degree of milling, well milled rice (10%) and over milled rice (15%) both are similar to each other than under milled rice (5%) and brown rice (0%) (Fig. 12).

Pearson Correlation of BRRI dhan92: Results of Pearson correlation matrix for relationships ascertained that excellent taste of BRRI dhan92 at different degree of milling is positively correlated with excellent appearance (0.794) followed by softness (0.505), stickiness (0.487), amylose content (0.271), Very good appearance (0.238), alkali spreading value (0.227), IR (0.197) and ER (0.016). Whereas excellent taste of BRRI dhan92 at different degree of milling is negatively correlated with hardness (-0.505) followed by fluffiness (-0.487), cooking time (-0.374), fairness (-0.367), protein content (-0.238) and good appearance (-0.099).

Results of Pearson correlation matrix for relationships ascertained that Very good taste of BRRI dhan92 at different degree of milling is significant and positively correlated with ER ($r=0.982$, $p<0.5$). It is positively correlated with Very good appearance (0.946) followed by stickiness (0.883), softness (0.872), alkali spreading value (0.865), amylose content (0.843), excellent appearance (0.594) and IR (0.081). Whereas Very good taste of BRRI dhan92 at different degree of milling is negatively correlated with protein content (-0.948), followed by fluffiness (-0.883), hardness (-0.872), cooking time (-0.773), good appearance (-0.330) and fairness (-0.627).

Results of Pearson correlation matrix for relationships ascertained that good taste of BRRI dhan92 at different degree of milling is significant and positively correlated with good appearance ($r=0.984$, $p<0.5$). It is positively correlated with IR (0.806) followed by fluffiness (0.559), hardness (0.323) and protein content (0.253). Whereas good taste of BRRI dhan92 at different degree of milling is negatively correlated with amylose content (-0.841) followed by very good appearance (-0.691), ER (-0.640), stickiness (-0.559), softness (-0.323), excellent appearance (-0.116), cooking time (-0.76) and alkali spreading value (-0.26).

Results of Pearson correlation matrix for relationships ascertained that tasteless of BRRI dhan92 at different degrees of milling is highly significant and positively correlated with fairness ($r=0.997$, $p<0.1$). It is also significant and positively correlated with cooking time ($r=0.987$, $p<0.5$). It is positively correlated with protein content (0.872) followed by hardness (0.830) and fluffiness (0.655). Whereas tasteless of BRRI dhan92 at different degree of milling is significant and negatively correlated with alkali spreading value ($r=-0.956$, $p<0.5$). It is negatively correlated with softness (-0.830) followed by excellent appearance (-0.794), IR (-0.764), stickiness (-0.655), ER (-0.539), very good appearance (-0.537), good appearance (-0.374) and amylose content (-0.327) (Table 14).

Differential expression of flavonoid biosynthetic genes in different tissues of pigmented and non-pigmented rice cultivars of Bangladesh

PI:SH CI: MAH and HBS

Rice (*Oryza sativa* L.) is generally categorized into red, black, and white cultivars by caryopsis colour at harvest time, which is determined by the composition of flavonoids such as anthocyanin. A number of studies have found that anthocyanins help to prevent chronic and degenerative diseases such type 2 diabetes, cardiovascular disease, and cancer. Further, black rice pigment fraction markedly reduced oxidative stress and improved lipid profile in animal models. The phenolic structure of anthocyanin is responsible for their antioxidant activity; i.e., ability to scavenge reactive oxygen species (ROS). In Bangladesh,

rice provides more than 70% of daily caloric consumption. Since its founding, BRRI has released 113 high yielding rice varieties that grow in three distinct seasons. Bangladesh is currently third in the world for rice production. Considering the amount of rice consumed, it is important to study the extra nutritional components present in our rice cultivars. Bangladesh has several wild type rice cultivars, among them seven red rice cultivars Binni, Lalmota, Khama, Laxmi Digha, Balam, Tola Beruin, Dadkhani, Hijol Digha, BRRI dhan 84, three white rice varieties BRRI dhan28, BRRI dhan34, RC (plant purple but grain white) were collected from GQN Division of BRRI and black rice were collected mainly from hilly areas BK-8 (GQN Division), BK-9 (Sylhet), BK-10 (Khagrachori) and BK-11(Bandorban) were studied in this research.

Total RNA was extracted from roots, leaf, sheath, grain of pigmented and non-pigmented rice cultivars. RNA was extracted from roots, leaf, sheath using a PureLink® RNA Mini Kit (Invitrogen, Thermofisher), (Qiagen, Valencia, CA, USA) and stored the purified RNA at -80°C. Large quantities of lipids, storage proteins, polysaccharides, and polyphenols that are normally present in dry seeds, which are essential components for gene expression analysis, reduce RNA production and quality (Tai *et al.*, 2004). The new procedure was used for total RNA isolation from dry and germinating rice seeds for gene expression studies developed by Vergara *et al.* 2008. Thermo Scientific Verso cDNA Synthesis Kit (#AB-1453/A) was used for the synthesis of cDNA from RNA. SYBR® Green Jump Start^{Taq} Ready Mix™ S4438 was used for RT PCR of the three gene including PAL (X16099), CHS (X89859), and ANS (Y07955) by Quant studio 5 (Applied biosystem). The Actin gene was used as a housekeeping gene in the RTPCR experiment and the comparative threshold (Ct, cycle value) method was used to determine relative expression levels. (Livak and Schmittgen, 2001).

The expression of major three flavonoid biosynthetic genes phenylalanine ammonia (PAL) chalcone synthase (CHS) and Anthocyanidin synthase (ANS) in various tissues of pigmented and non-pigmented rice varieties were analyzed and

the results demonstrated higher gene expression in pigmented varieties as compared to non-pigmented varieties. Based on the chosen gene, the tissue, and the kind of rice, different flavonoid biosynthesis gene transcript levels were observed. Expression of three important gene PAL, CHS and ANS from different tissue (Roots, Shoots, Leaf and Grain) were evaluated. The expression was higher in black rice followed by red, and least in non-pigmented white rice. The PAL gene, which catalyzes the initial stage of the phenylpropanoid pathway, was shown to have different transcript levels depending on the tissue and type of rice. Expression level for PAL was higher in roots. PAL is the first enzyme in phenyl propionate pathway and its expression is the highest in white rice followed by red and black rice cultivars. The CHS gene catalyzes the first committed step towards flavonoid synthesis. However, in the present study, higher CHS expression was observed in roots and shoots of red rice. The highest CHS gene transcript levels were observed in the root tissues of all rice varieties, followed by the shoot, leaf, and grain. In shoot, similar high expression of PAL was observed but in black rice cultivars have higher expression of CHS and ANS was also seen. As the shoot of the black rice cultivars are pigmented, our results support the phenotype of the plants. CHS and ANS gene expression is higher in leaf of pigmented rice, especially in the black rice cultivars, than non-pigmented rice. And interestingly, in the leaf of the RC variety, CHS and ANS are highly expressed, which matches the appearance of the plant. In case of grain higher expression of ANS and CHS gene was observed from black rice grain. Surprisingly RC from Cumilla had high ANS and CHS expression in leaf, root and shoot but very low in grain. This explains the reason why the grain of the RC cultivar appears white. A correlation between anthocyanin accumulation and the expression of genes involved in its biosynthesis is supported by the finding that the level of ANS genes is the highest in black rice grain and the lowest in white rice grain (Figs.13 and 14).

COMMERCIAL RICE BASED PRODUCTS

Determination of physicochemical properties and quality of puffed, popped, and flattened rice from newly released BRRI varieties

PI: MAH; **CI:** NF, TKS, HBS and MAS

Physical properties viz length, breadth, thickness, increased length and breadth, and volume of rice products such as puffed, popped and flattened rice were determined. This study aims to screen out the BRRI-released varieties that are suitable for popular snack food products: puffed, popped, and flattened rice for instance. BR16 is used as the standard for all the products of puffed, popped, and flattened rice.

Compared to the standard variety, it is ascertained from the results that BR23 and BRRI dhan52 are better in producing fully puffed rice 80.50% and 80.21% respectively followed by BRRI dhan58 (56.32%), BRRI dhan39 (62.25%) and BRRI dhan28 (62.04%) in terms of weight of fully puffed rice. Considering overall parameters, BR23 and BRRI dhan52 yielded better results: puffed rice length =13.80 mm and 11.44 mm; increased percentage of puffed rice length= 109.67% and 95.83%; and 50 g puffed rice volume = 497 ml and 513 ml followed BRRI dhan28 (puffed rice length =12.63 mm, increased percentage of length =93.90%, volume = 500.00 ml), BRRI dhan39 (puffed rice length=12.29 mm, increased percentage of length =95.83%, volume =513.00 ml) and BRRI dhan58 (puffed rice length =13.10 mm, increased percentage of length =107.84%, volume = 557.00 ml) respectively (Table 15). Results of correlation matrix for relationships ascertained that puffed rice length is significant and positively correlated with fully puffed rice wt. ($r=0.634$, $p<0.5$) as well as highly significant and positively correlated with milled rice length ($r=0.742$, $p<0.1$). Puffed rice length increase is highly significant and positively correlated with fully puffed rice wt. ($r=0.784$, $p<0.1$) as well as significant and positively correlated with puffed rice length ($r=0.678$, $p<0.5$). Puffed rice breadth is significant and positively correlated with milled rice breadth ($r=0.612$, $p<0.5$). Puffed rice breadth increased is significant and positively correlated with puffed rice length increased ($r=0.637$, $p<0.5$). 1000 Puffed rice wt. is highly significant and positively correlated with milled rice breadth ($r=0.721$, $p<0.1$). 50 gm puffed rice volume is highly significant and positively correlated with puffed rice length increase ($r=0.862$, $p<0.1$). Whereas, it is significant and positively correlated with fully puffed rice wt. ($r=0.663$, $p<0.5$), puffed rice length ($r=0.605$, $p<0.5$) and puffed rice breadth

increased ($r=0.586$, $p<0.5$) (Table 16).

In the case of popped rice, BRRI dhan89 and BRRI dhan87 show excellent performance followed by BRRI dhan83 and BRRI dhan98 considering total popped rice percent, fully popped rice percent, partial and broken popped rice percent. On the other hand, in terms of increased popped rice length and volume of 50 g popped rice, BRRI dhan89 (110.99% and 916.67 ml) performed better than BRRI dhan87 (101.44% and 880.33 ml). However, BRRI dhan89 (122.98%) and BRRI dhan87 (124.27%) showed the highest potential in increasing breadth percent and fully popped percent (86.73% and 84.16%) respectively after being popped (Table 17). Results of the correlation matrix for relationships ascertained that the length of popped rice is significant and positively correlated with the percent of broken wt. ($r=0.728$, $p<0.05$). It is also significant and positively correlated with an increased percent of popped rice length ($r=0.607$, $p<0.05$). The breadth of popped rice is significant and positively correlated with an increased percent of popped rice breadth ($r=0.636$, $p<0.05$). Percent of total popped rice is highly significant and positively correlated with the volume of 50g popped rice ($r=0.753$, $p<0.01$) (Table 18).

Similarly, physical properties such as whole, partial, and broken flattened rice were considered. Comparing the varieties selected from screening, it is revealed from the results that in terms of weight of whole, partial, and broken flattened rice BRRI dhan58 showed the best performance followed by BRRI dhan74 and BR23 (Table 19). However, the results demonstrated that BRRI dhan74 showed higher potential in producing flattened rice considering the flattened rice length increased percent, the thickness of the flattened rice, 1000 flattened rice weight, and the volume of the 50 g sample. It is ascertained from the study that brown rice length and breadth are not or insignificantly correlated with the flattened rice length and breadth. Results of the correlation matrix for relationships (Table 20) ascertained that the flattened rice length increase is highly significant and positively correlated with flattened rice length ($r=0.715$, $p<0.1$) but significant and negatively correlated with brown rice length ($r=-0.663$, $p<0.5$). Flattened rice breadth is highly significant and positively correlated with brown rice breadth ($r=0.841$,

$p < 0.1$). Flattened rice breadth increase is significant and positively correlated with flattened rice breadth ($r = 0.635$, $p < 0.5$). 50 gm flattened rice volume is highly significant and positively correlated with flattened rice length ($r = 0.736$, $p < 0.1$) and 1000 flattened rice wt. ($r = 0.783$, $p < 0.1$) but, only significant and positively correlated with flattened rice length increased ($r = 0.641$, $p < 0.5$).

Survey on rice-based value-added products available in the market

PI: MAH; CI: TKS

The survey aims to investigate the market's diversity and prevalence of rice-based value-added products. The study examines the rice-based goods that are available and popular in Bangladesh's Khulna, Dhaka, and Gazipur regions. The study identified various rice-based products such as puffed, popped, and flattened rice, snacks made from puffed and flattened rice, and rice-based patties, shedding light on their consumption and availability in the market through surveys, observations, and visits to different wholesale markets, bakery and confectionary, and sweetmeat shops. The products available in the market are described in the following section:

Puffed, popped, and flattened rice. Puffed, popped, and flattened rice have cultural and culinary significance in every part of Bangladesh. Puffed rice, also known as “Muri,” is a popular snack and traditional dish because of its lightness and adaptability. “Khoi,” or popped rice, adds a crisp taste to a variety of dishes. Flattened rice, or “Chira,” is a staple in breakfasts and celebratory delights, serving as a blank canvas for both sweet and savoury creations. These rice forms demonstrated in Figure 1 showcase the country's culinary diversity, enriching dishes and celebrations with unique textures and flavours. Furthermore, these products are available throughout the country.

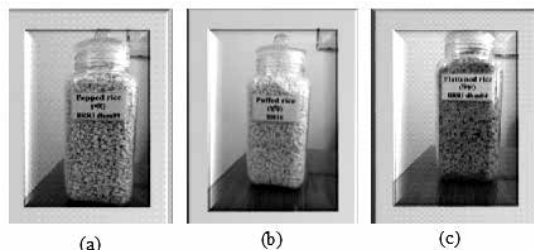


Fig. 1, Popped (a), puffed (b), and flattened rice (c)

Rice-based value-added product: “Moa” is a traditional Bangladeshi snack crafted from puffed and flattened rice (Fig. 2). “Moa” holds a special place in Bangladeshi culture and is often associated with festive occasions and celebrations. Its consumption is deeply rooted in tradition, with the snack being a popular treat during festivals like Pohela Boishakh (Bengali New Year). “Moa” enjoys widespread popularity and is abundantly available in local markets even in the small village shops, sweet shops, and roadside stalls across the study areas. However, its demand varies based on season and time. According to consumers' preference, production, and consumption is higher than at any other time of the calendar. Thus, its accessibility and cultural significance contribute to its consistent demand.

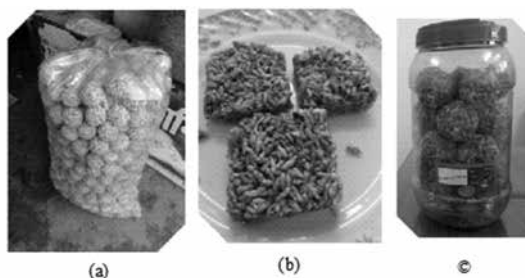


Fig. 2, “Moa” crafted from puffed and flattened rice: muri moa (a), chira moa (b) chira moa (c).

Rice-based patties. Rice-based patties, designated popularly as “pithas,” are another integral part of Bangladeshi cuisine. According to culture and hereditary succession, a diverse form of patties (Fig. 3) is popular in a particular region. These savoury or sweet delicacies are primarily made of rice flour and come in a variety of shapes and sizes, such as puli, vapa, chittoi, etc. in common. Rice-based patties are popular among consumers because of their rich flavours and historic backgrounds. Their accessibility in markets and stalls contributes to their popularity, particularly during the festival time. People from all walks of life love having these food items as part of their traditional food habit and culture. Nevertheless, a range of patties are very popular as street food expanded from capital city to typical rural village.

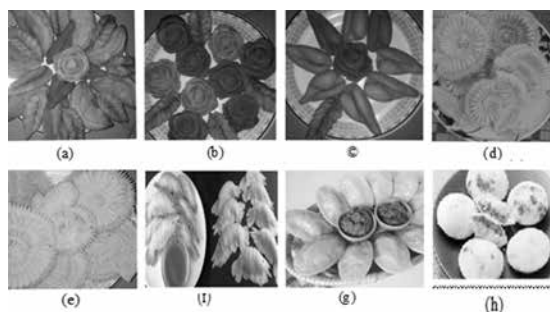


Fig. 3, Rice-based patties: puli pitha (a), ful pitha (b), jhinuk pitha (d), nokshi pitha (d) and (e), chingri pitha (f), chittoi pitha (g), and vapa pitha (h).

Conclusion. Rice-based products with added value, such as puffed, popped, flattened rice, ‘moa’, and patties, play an important role in Bangladesh’s culinary landscape. They reflect the country’s diverse cultural traditions while also offering consumers easy, nutritional, and tasty options.

Embracing innovation, addressing challenges, and capitalizing on opportunities will be important to the industry’s long-term success.

Recommendation. This study covers only three districts of Bangladesh. A comprehensive market survey in different parts of the country is necessary for a better insight into value-added rice-based products available in a particular region. Furthermore, to promote consumption, it is needed to raise consumer awareness about the nutritional benefits and culinary applications of rice-based value-added products. In addition, it is also required to improve processing procedures to boost product quality, shelf life, and safety. Continued research into new rice-based products should be pursued in order to increase market diversity and demand. Moreover, it is needed to investigate options to export these items, which would benefit the economy and showcase Bangladesh’s culinary tradition.

Table 1. Physical properties of breeding lines.

Range	Sample no.	
		Milling outturn (%) (Total sample no. 350)
>70.0	59	
68.0-70.0	220	
<68.0	71	
		Head rice recovery (%) (Total sample no. 350)
>60.0	134	
50.0-60.0	146	
<50.0	70	
		Chalkiness (%) (Total sample no. 350)
0 (Tr)	0	
<10.0	26	
10.0-20.0	93	
>20.0	217	
		Length (mm) (Total sample no. 623)
>6.0	325	
5.0-6.0	238	
<5.0	60	
		L/B ratio (Total sample no. 623)

>3.0	190
2.0-3.0	409
<2.0	24
1000-grain wt. (g) (Total sample no. 353)	
>30.0	6
25.1-30.0	40
21.0-25.0	145
15.0-20.0	85
<15.0	77

Table 2. Chemical and cooking properties of breeding lines

Range	Samples No.
Amylose content (%) (Total sample no. 630)	
>25.0	283
20.0-25.0	307
<20.0	40
Alkali spreading Value (Total sample no. 350)	
1-3	12
3.1-5.9	268
6-7	70
Protein content (%) (Total sample no. 350)	
>9.0	113
7.0-9.0	234
<7.0	3
Cooking time (mim.) (Total sample no. 355)	
>20	42
15.0-20	232
<15.0	81
Elongation ratio (Total sample no. 355)	
>1.5	32
1.3-1.5	309
<1.3	14
Imbibition ratio (Total sample no. 355)	
>4.0	-
3.5-4.0	354
<3.5	1

Aroma (Total sample no. 231)

+++	15
++	15
+	17
-	184

Table 3. Physicochemical properties of promising breeding lines.

Variety/Line	Milling outturn (%)	Head rice recovery (%)	Size & shape	1000 grain wt. (g)	Amylose (%)	Protein (%)	ER	IR
BR12236-5R-6	71	48	LS	21.9	26.8	8.7	1.3	3.6
BR12266-5R-22	69	50	LS	23.0	26.6	8.8	1.4	4.3
BR10757-2B-9-26	67	49	LS	20.5	27.3	6.8	1.4	3.9
BR11716-4R-105	71	46	LS	24.9	25.6	8.0	1.4	4.0
BR10458-20-2-3-1-3	70	61	LS	25.1	25.4	8.8	1.4	4.5
BR10482-1-2-3-1-3	69	57	LS	20.9	25.5	8.4	1.3	3.7
BR12261-5R-46	71	49	LS	20.2	26.3	8.0	1.4	3.7
BR12266-5R-22	69	50	LS	23.0	25.6	8.1	1.4	5
SVIN647	70	54	LS	23.6	26.5	8.3	1.3	3.9
Ranqui	69	55	LS	22.2	27.7	8.1	1.4	4.5
BR11224-7-9-4-3	71	66	MS	16.7	28	12.5	1.5	3.7
BR11768-10-4-7	70	67	SB	9.4	25	9.4	1.4	4.5
BR10458-20-2-3-1-3	70	61	LS	25.1	25.4	8.8	1.4	4.5

Table 4. Physicochemical properties of transforming Rice Breeding (OYT) rice lines.

Parameter and total no. of samples	Classification	Number of sample
Size and shape (Milled Rice) (Total sample no. 3446)	Long slender	78
	Long bold	1148
	Medium slender	2
	Medium bold	2158
	Medium round	8
	Short bold	42

	Short round	8
	Short short	2
Amylose content (%) (Total sample no. 3446)	High	2520
	Intermediate	870
	Low	56

Table 5. Physical properties of Transforming Rice Breeding (PYT, SYT and AYT) rice sample.

Range	Properties and sample no.
	Milling outturn (%) (Total sample no. 883)
>70.0	404
68.0-70.0	343
<68.0	136
	Head rice recovery (%) (Total sample no. 883)
>60.0	-
50.0-60.0	210
<50.0	673
	Length (mm) (Total sample no. 883)
>6.0	523
5.0-6.0	360
<5.0	-
	L/B ratio (Total sample no. 883)
>3.0	30
2.0-3.0	853
<2.0	-
	Chalkiness (%) (Total sample no. 883)
(0) Tr	-
<10	35
10.0-20.0	250
>20.0	598
Opaque	-

Table 6. Chemical and cooking properties of Transforming Rice Breeding (PYT, SYT, and AYT) rice samples.

Range	Properties and sample no.
	Amylose content (%) (Total sample no. 883)

>25.0	457
20.0-25.0	389
<20.0	37
Protein content (%) (Total sample no. 883)	
>9.0	257
7.0-9.0	606
<7.0	20
Alkali spreading value (Total sample no. 883)	
1.0-3.0	264
3.1- 5.9	553
>6.0	66
Cooking time (min.) (Total sample no. 883)	
>20	25
15-20	748
<15	110
Elongation ratio (Total sample no. 883)	
>1.5	13
1.3-1.5	818
<1.3	52
Imbibition ratio (Total sample no. 883)	
>4.0	-
3.5-4.0	-
<3.5	883

Table 7. Promising genotypes for submergence tolerant T. Aman rice 2021.

Genotype	Head rice recovery (%)	Size & shape	Apparent amylose content (%)	Elongation ratio
BR11690-5R-349	64.3	MB	26.2	1.5
BR11690-5R-345	58.2	MB	26.2	1.6
BR11690-5R-351	68.2	MB	25.5	1.5
BR11694-5R-125	54.1	MB	25.5	1.5
BR11694-5R-32	62.8	MB	25.4	1.5
BR11686-5R-173	65.8	MB	26.5	1.5
BR11686-5R-11	68.0	MB	25.9	1.5
BR11686-5R-179	53.9	MB	25.9	1.6
BR11686-5R-172	62.5	MB	25.5	1.5
BR11686-5R-1	70.2	MB	27.4	1.5

BR11693-5R-274	65.0	MB	25.7	1.5
BR11686-5R-23	64.6	MB	25.2	1.6
BR11690-5R-87	64.3	MB	25.5	1.5
BR11690-5R-316	61.2	MB	24.9	1.5
BR11691-5R-128	57.5	LB	26.8	1.5
IR15F1886-P1	53.3	MB	28.3	1.5

Table 8. Promising genotypes for salinity tolerant (PYT), Boro 2021-22.

Genotype	Head rice recovery (%)	Size & shape	Apparent amylose content (%)	Elongation ratio
BR11276-4R-139	54.2	MB	27.2	1.5
BR11718-4R-178	50.1	MB	24.8	1.5
BR11276-4R-210	49.0	LB	24.9	1.5
BR11276-4R-196	51.5	MB	24.9	1.5
BR11718-4R-46	51.4	MB	26.1	1.5
BR11722-4R-398	48.5	LB	24.8	1.5
BR11714-4R-322	47.2	LB	25.0	1.85
IR18T1137	53.4	MB	24.7	1.5

Table 9. Promising genotypes of insect resistant rice (BPH) (PYT) Boro, 2021-22.

Genotype	Head rice recovery (%)	Size & shape	Apparent amylose content (%)	Elongation ratio
BR12177-5R-6	55.9	MB	28.2	1.4
BR12177-5R-20	63.0	LB	27.9	1.3
BR12177-5R-169	57.2	LB	27.4	1.4
BR12180-5R-1	65.1	LB	27.7	1.4
BR12180-5R-10	49.7	MB	26.9	1.5
BR12180-5R-73	57.0	MB	25.4	1.3
BR12180-5R-74	60.6	MB	25.2	1.3
BR12208-5R-286	45.5	MB	24.5	1.5
BR12208-5R-403	55.3	MB	24.9	1.3

Table 10. Promising genotypes of advance breeding lines, BRRI RS, Barishal 2021-22.

Genotype	Head rice recovery (%)	Size & shape	Apparent amylose content (%)	Elongation ratio
NGR 521-2	60.0	MB	26.3	1.4
NGR 522-1	61.2	MB	25.2	1.3
NGR 721-2	62.4	LB	26.3	1.4
NGR 796-2	65.5	MB	27.2	1.3
NGR 680-2	60.6	MB	23.9	1.4

NGR 593-1	60.2	MB	27.5	1.4
NGR 710-1	61.3	MB	28.1	1.4
NGR 857-1	55.0	MB	27.3	1.5
BRBa23-8-2-3-2-P1	56.1	MB	27.1	1.5
BRBa12-21-2-3-2	44.1	MB	29.4	1.5
BRBa12-42-1-1-4	52.8	MB	28.8	1.5
BRBa16-28-2-1-6	47.9	MB	27.7	1.5

Table 11, Antioxidant and mineral profiling of BRRI HYVs (BRRI dhan90 to BRRI dhan95).

HYVs	FRAP $\mu\text{M AAE}$	TPC mM GAE	TAC $\mu\text{M AAE}$	Zn ppm	Fe ppm	Ca ppm	P gKg^{-1}	As ppm
BRRI dhan90	0.594	2.01	73.15	16.2	3.4	32.6	2.1	<0.01
BRRI dhan91	0.593	4.15	80.29	15.8	5.2	23.3	1.9	<0.01
BRRI dhan92	0.593	2.19	61.77	20.6	5.9	33.1	2.6	<0.01
BRRI dhan93	0.593	2.25	36.4	15.3	4.1	24.8	2.5	<0.01
BRRI dhan94	0.599	2.99	39.97	21.5	6.1	32.1	3.1	<0.01
BRRI dhan95	0.602	3.36	37.71	13.5	4.2	21.8	2.8	<0.01

Table 12, Amino acid profiling of BRRI HYVs (BRRI dhan90 to BRRI dhan95) in percentage.

Amino Acid	BRRI dhan90	BRRI dhan91	BRRI dhan92	BRRI dhan93	BRRI dhan94	BRRI dhan95
Aspartic acid	0.47	0.58	0.45	0.49	0.47	0.46
Threonine	0.19	0.21	0.15	0.18	0.17	0.16
Serine	0.25	0.32	0.22	0.27	0.25	0.25
Glutamic acid	0.97	1.20	0.81	1.00	0.98	0.96
Glycine	0.33	0.38	0.26	0.32	0.30	0.30
Alanine	0.36	0.44	0.32	0.36	0.35	0.34
Valine	0.43	0.52	0.36	0.43	0.41	0.41
Methionine	1.19	1.44	1.02	1.19	1.16	1.15
Isoleucine	0.29	0.35	0.24	0.29	0.28	0.27
Leucine	0.62	0.73	0.52	0.60	0.59	0.58
Tyrosine	0.24	0.30	0.24	0.25	0.25	0.24
Histidine	1.30	1.60	1.15	1.35	1.29	1.26
Lysine	0.21	0.21	0.12	0.19	0.18	0.17
Arginine	0.47	0.59	0.44	0.50	0.48	0.48

Table 13, Fatty acid composition of BRRI HYVs (BRRI dhan90 to BRRI dhan95) in percentage.

FAC	BRRI dhan90	BRRI dhan91	BRRI dhan92	BRRI dhan93	BRRI dhan94	BRRI dhan95
SFA%	22.7	18.91	19.7	20.53	25.9	22.94
Myristic acid%	0.24	-	0.17	0.25	0.13	0.35
Palmitic acid%	20.34	16.75	17.72	18.28	23.02	20.09

Stearic acid%	2.12	1.82	1.71	1.55	2.11	1.79
Arachidic Acid%	-	0.33	0.1	0.44	0.63	0.7
MUFA%	40.5	37.79	39.97	38.63	41.12	39.39
Palmitoleic Acid%	-	-	0.02	0.07	-	-
Oleic acid%	40.5	37.79	39.94	38.55	41.12	39.39
PUFA%	36.78	43.28	40.31	40.82	31.97	37.66
Linoleic acid%	35.88	42.63	39.45	40.05	31.95	36.55
Linolenic Acid%	0.9	0.65	0.86	0.77	1.02	1.1

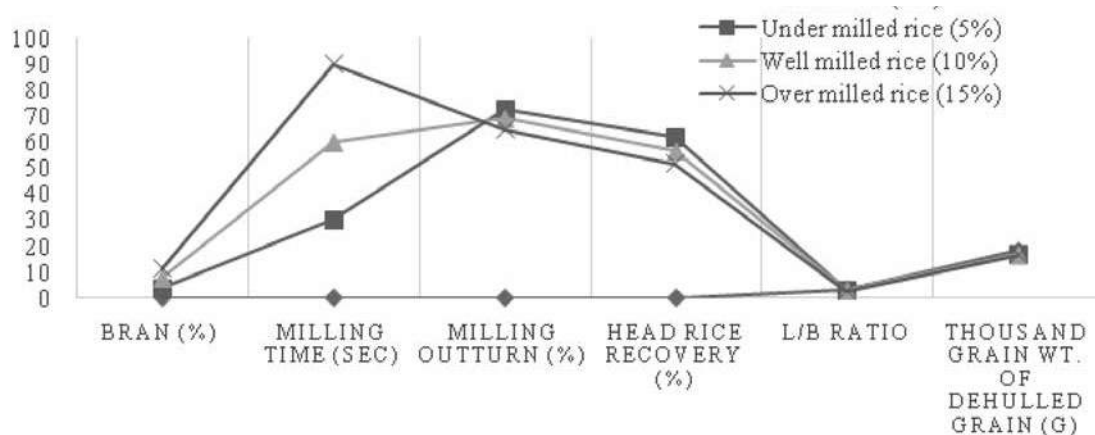


Fig.4, Milling properties of BRRI dhan92 at different degrees of milling.

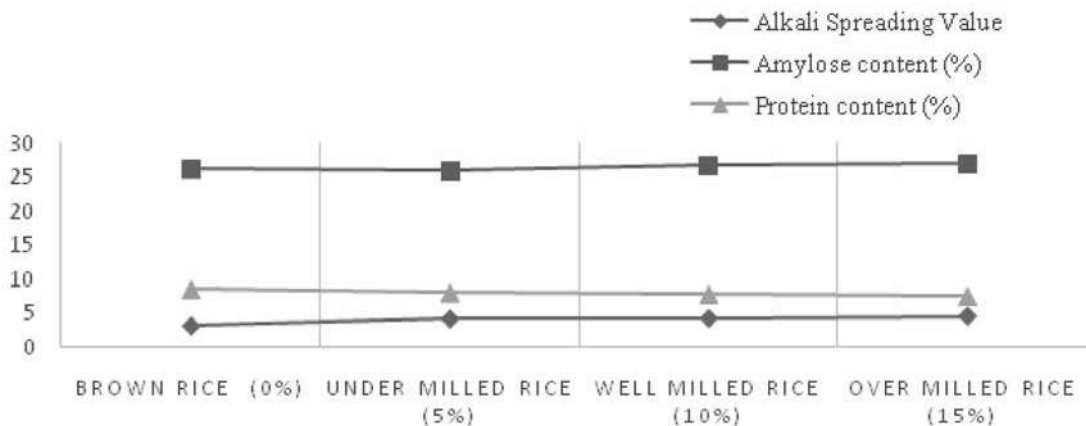


Fig. 5, Chemical properties of BRRI dhan92 at different degrees of milling.



Fig. 6, Cooking properties of BRR1 dhan92 at different degrees of milling.



Fig. 7, Appearance of cooked rice for BRR1 dhan92 at different degrees of milling.

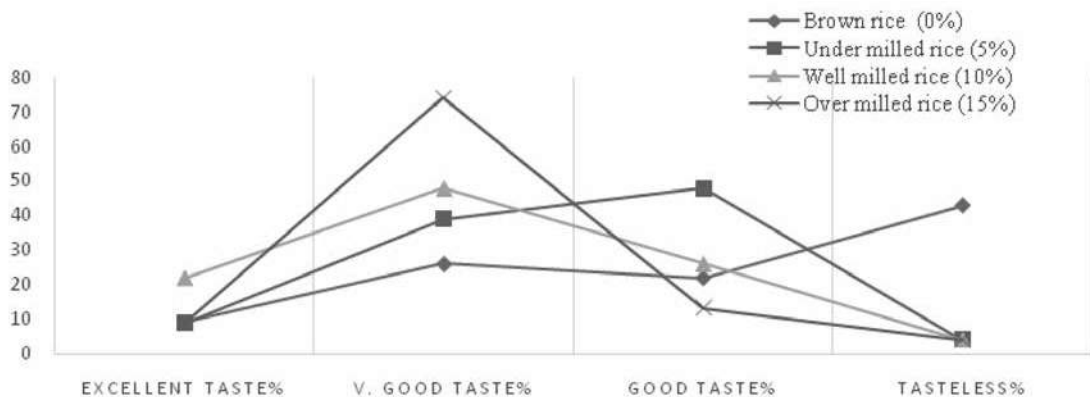


Fig. 8, Taste of cooked rice for BRR1 dhan92 at different degrees of milling.



Fig. 10, Aroma of cooked rice for BRRI dhan92 at different degrees of milling.

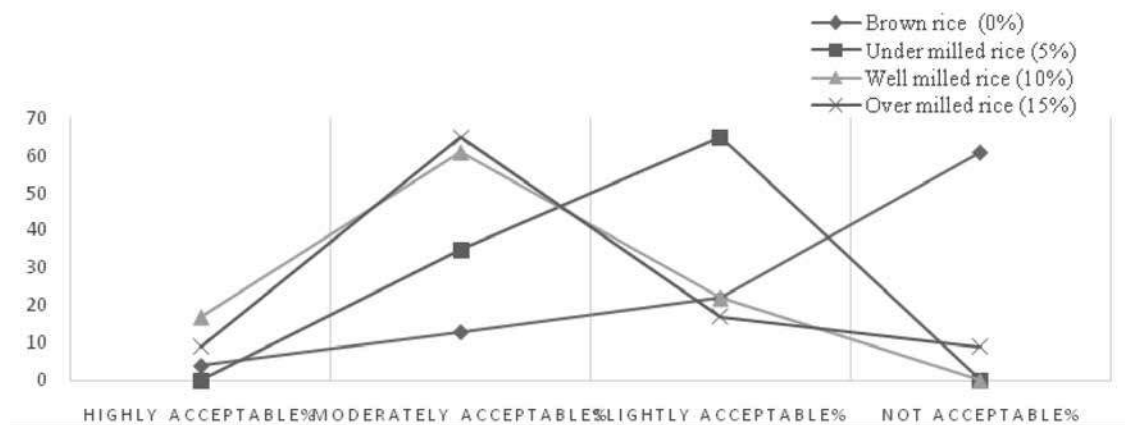


Fig. 11, Acceptance of cooked rice for BRRI dhan92 at different degrees of milling.

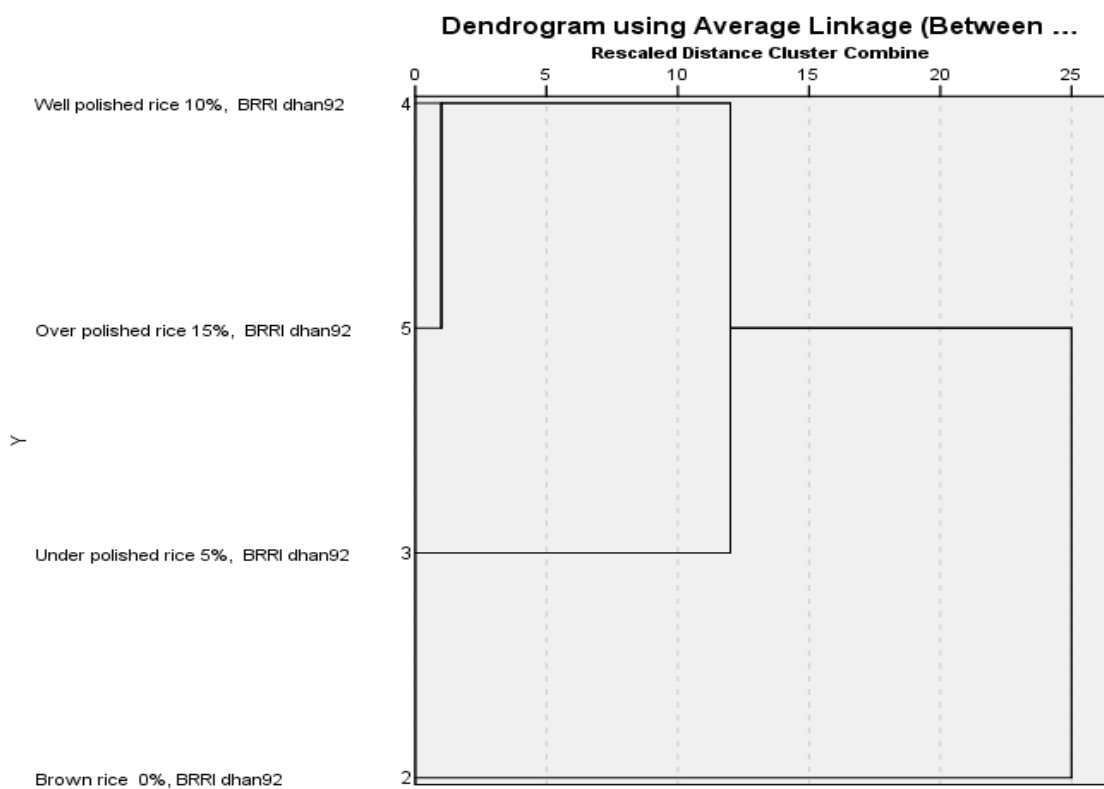


Fig. 12, Dendrogram of BRR1 dhan92 at different degrees of milling.

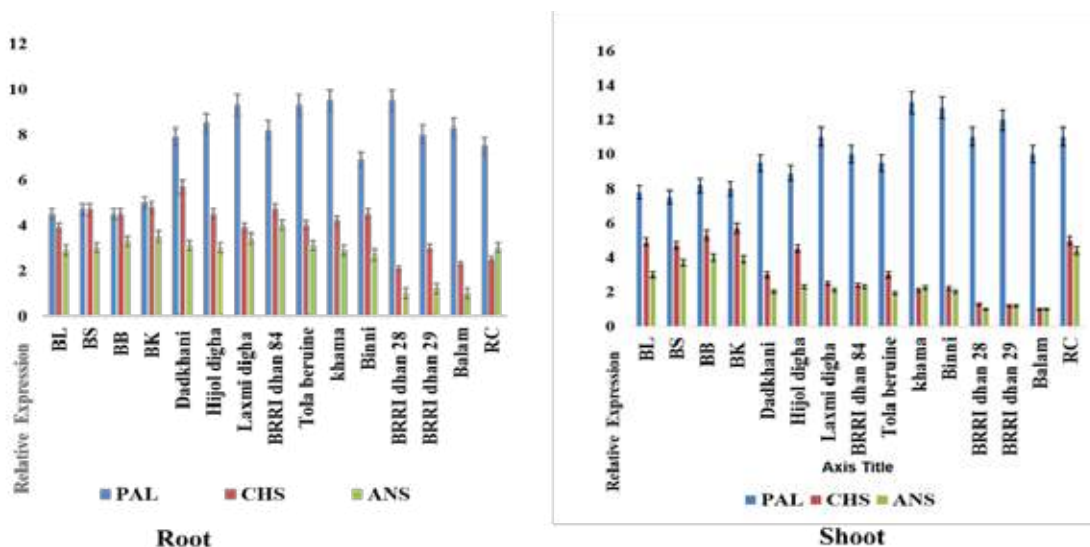


Fig.13. Gene expression in root and shoot of pigmented and non-pigmented rice.

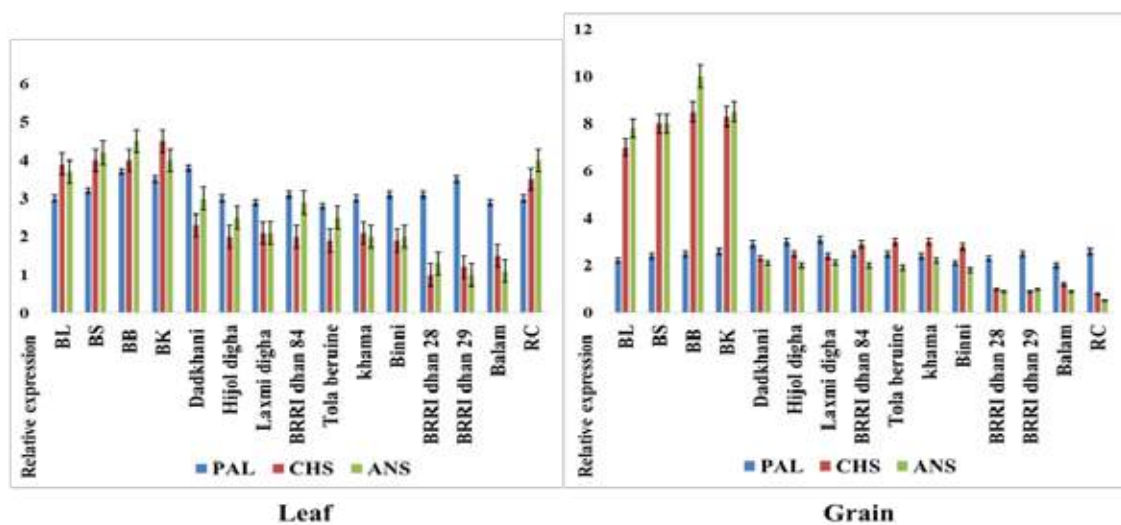


Fig.14. Gene expression in leaf and grain of pigmented and non-pigmented rice.

Table 14, Correlation among the physicochemical properties and sensory evaluation for BRR1 dhan92 at different degrees of milling.

Parameter	Correlation														
	Alkali Spreading Value	Amylose content (%)	Protein content (%)	ER	IR	Cooking time (min.)	Excellent appearance%	V. good appearance%	Good appearance%	Fat%	Excellent taste%	V. good taste%	Good taste%	Tastiness%	Hard%
Amylose content (%)	.552														
Protein content (%)	-.973*	-.727													
ER	.759	.912	-.880												
IR	.560	-.357	-.358	-.106											
Cooking time (min.)	-.982*	-.476	.934	-.652	-.651										
Excellent appearance%	.769	.572	-.774	.522	.424	-.847									
V. good appearance%	.739	.968*	-.874	.972*	-.133	-.664	.656								
Good appearance%	.134	-.752	.096	-.496	.876	-.218	-.044	-.568							

Fair%	-.933	-.273	.837	-.478	-.801	.976*	-.798	-.484	-.422										
Excellent taste%	.227	.271	-.238	.016	.197	-.374	.794	.238	-.099	-.367									
V. good taste%	.865	.843	-.948	.982*	.081	-.773	.594	.946	-.330	-.627	.041								
Good taste%	-.026	-.841	.253	-.640	.806	-.076	-.116	-.691	.984*	-.291	-.056	-.488							
Tasteless%	-.956*	-.327	.872	-.539	-.764	.987*	-.794	-.537	-.374	.997**	-.333	-.682	-.235						
Hard%	-.909	-.780	.955*	-.820	-.296	.909	-.911	-.884	.198	.804	-.505	-.872	.323	.830					
Soft%	.909	.780	-.955*	.820	.296	-.909	.911	.884	-.198	-.804	.505	.872	-.323	-.830	-1.000**				
Fluffy%	-.792	-.913	.896	-.880	-.034	.769	-.843	-.958*	.450	.619	-.487	-.883	.559	.655	.965*	-.965*			
Sticky%	.792	.913	-.896	.880	.034	-.769	.843	.958*	-.450	-.619	.487	.883	-.559	-.655	-.965*	.965*	-1.000**		

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Table 15, Physical properties of puffed rice of BRRI developed modern varieties.

Variety	Fully puffed rice wt. (%)	Partial puffed rice wt. (%)	Milled rice length (mm)	Milled rice breadth (mm)	Puffed rice length (mm)	Puffed rice length increased (%)	Puffed rice breadth (mm)	Puffed rice breadth increased (%)	1000 Puffed rice wt. (g)	50 gm Puffed rice volume (ml)
BR16	55.03C	44.87E	6.73	2.19	13.21B	96.23C	4.70B	101.07AB	17.55D	490DE
BR11	54.02C	45.92E	5.72	2.67	11.23G	96.39BC	4.40DE	75.90F	17.54D	480F
BR23	80.50A	19.23G	6.58	2.4	13.80A	109.67A	4.69B	95.18C	17.73D	497CD
BRRI dhan28	62.04B	37.89F	6.51	2.19	12.63C	93.90CD	3.90H	78.23EF	15.67E	500C
BRRI dhan32	55.15C	44.66E	5.75	2.32	11.05G	92.17D	4.59C	97.7BC	14.66H	453G
BRRI dhan33	20.89FG	79.0AB	5.56	2.62	9.37I	68.46F	4.26F	62.60H	16.65E	372I
BRRI dhan39	62.25B	37.37F	6.38	2.33	12.29D	92.58CD	3.86H	67.0G	15.44E	417H
BRRI dhan51	32.33E	67.58C	5.41	2.22	10.83H	100.18B	4.49D	102.1A	13.95I	500C
BRRI dhan52	80.21A	24.69G	5.84	2.71	11.44F	95.83CD	5.12A	88.93D	19.60B	513B
BRRI dhan58	66.32B	33.58F	6.29	2.19	13.10B	107.84A	3.94H	79.91E	14.42H	557A
BRRI dhan67	39.98D	59.94D	6.18	2.14	12.13D	96.33BC	3.75I	75.10F	15.18G	483EF

BRRI dhan68	16.50G	83.44A	6.7	2.48	11.67E	74.13E	4.36E	75.67F	18.06C	416H
BRRI dhan74	24.35F	75.58B	6.47	2.56	11.14G	69.32F	4.15G	62.24H	19.96A	416H
Range	16.50-80.50	19.23-83.44	5.41-6.73	2.14-2.71	9.37-13.80	68.46-109.67	3.75-5.12	62.24-102.1	13.95-19.96	372-557
Mean±SD	49.97±21.42	50.29±20.92	6.16±0.45	2.39±0.20	11.83±1.19	91.77±13.20	4.32±0.40	81.66±14.05	16.65±1.94	468.74±50.97
SE	2.5	3.3	0	0	0.09	1.9	0.04	1.71	0.12	4.51
CV%	6.11	7.98	0	0	0.99	2.54	1.17	2.58	0.86	1.18

Table 16. Correlation among the physical properties of puffed rice of BRRI developed modern varieties.

Correlations									
Parameter	Fully puffed rice wt. (%)	Partial puffed rice wt. (%)	Milled rice length (mm)	Milled rice breadth (mm)	Puffed rice length (mm)	Puffed rice length increased (%)	Puffed rice breadth (mm)	Puffed rice breadth increased (%)	1000 puffed rice wt. (g)
Partial puffed rice wt. (%)	-.998**								
Milled rice length (mm)	.134	-.152							
Milled rice breadth (mm)	-.101	.136	-.300						
Puffed rice length (mm)	.634*	-.657*	.742**	-.532					
Puffed rice length increased (%)	.784**	-.798**	.012	-.474	.678*				
Puffed rice breadth (mm)	.286	-.253	-.349	.612*	-.177	.126			
Puffed rice breadth in-creased (%)	.414	-.414	-.099	-.361	.343	.637*	.515		

1000 Puffed rice wt. (g)	-.026	.058	.316	.721**	-.041	-.419	.466	-.235	
50 gm Puffed rice volume (ml)	.663*	-.661*	.044	-.414	.605*	.862**	.143	.586*	-.250

** . Correlation is significant at the 0.01 level (2-tailed). * . Correlation is significant at the 0.05 level (2-tailed).

Table 17. Physical properties of popped rice of BRRI developed modern varieties.

Variety	Total Popped rice (%)	Total waste (%)	Fully popped rice wt. (%)	Partial wt. (%)	Broken wt. (%)	Popped rice length (mm)	Popped rice length increased (%)	Popped rice breadth (mm)	Popped rice breadth increased (%)	1000 Popped rice wt. (gm)	50 gm Popped rice volume (ml)
BR16	40.97DE	41.29BC	86.78BCD	12.52BCD	0.60C	13.83BC	95.89D	5.01A	117.68ABC	20.48A	711.67E
BRRI dhan80	45.4BC	38.06E	86.43BCD	11.31CDE	2.03A	13.83BC	95.62D	4.94AB	128.86A	20.33A	775.00C
BRRI dhan81	42.96CD	41.96B	81.79CDE	16.64BC	1.50B	14.68A	98.33CD	3.53F	84.03E	17.53CD	765.00CD
BRRI dhan82	39.53E	47.51A	81.32DE	18.29AB	0.30CD	11.88F	100.73BC	4.37D	73.41E	17.77C	638.67G
BRRI dhan83	46.92B	38.4DE	85.68BCD	15.37BCD	0.46CD	13.14D	99.00CD	4.77AB	101.41D	20.37A	646.67G
BRRI dhan84	34.92F	42.83B	76.69E	22.95A	0.25CD	12.53E	86.41E	4.50CD	108.57CD	17.23D	598.00H
BRRI dhan85	46.1BC	38.73DE	87.58ABC	12.31CD	0D	12.36E	86.66E	4.44D	115.70BC	15.83E	678.33F
BRRI dhan86	45.41BC	39.43CDE	93.03A	5.607E	1.30B	14.42A	104.83B	4.03E	110.07CD	17.35D	863.33B
BRRI dhan87	50.34A	30.34F	84.16BCD	15.12BCD	0.61C	13.96B	101.44BC	4.70BC	124.27AB	18.25B	880.33B
BRRI dhan88	44.4BC	40.64BCD	89.90AB	9.55DE	0.37CD	11.72F	76.99F	4.25DE	107.32CD	16.04E	746.67D
BRRI dhan89	50.68A	30.11F	86.73BCD	12.41BCD	0.73C	13.50C	110.99A	4.88 AB	122.98AB	17.55CD	916.67A
Mean±SD	44.33±4.6	39.027±5.09	85.462±4.41	13.825±4.62	0.7406±0.61	13.258±1.01	96.081±9.53	4.4942±0.44	108.57±17.00	18.067±1.65	747.3±105.43
SE	1.5402	1.1502	2.8083	2.864	0.2536	0.1618	2.3219	0.1206	5.6122	0.1537	13.617
CV%	4.26	3.61	4.02	25.37	41.93	1.49	2.96	3.29	6.33	1.04	2.23

Table 18. Correlation among the physical properties of popped rice of BRRI developed modern varieties.

Correlation										
Parameter	Total popped rice (%)	Total waste (%)	Fully popped rice wt. (%)	Partial wt. (%)	Broken wt. (%)	Popped rice length (mm)	Popped rice length increased (%)	Popped rice breadth (mm)	Popped rice breadth increased (%)	1000 Popped rice wt. (gm)
Total waste (%)	-.849**									
Fully popped rice wt. (%)	.574	-.301								
Partial wt. (%)	-.555	.302	-.983**							
Broken wt. (%)	.184	-.118	.203	-.346						
Popped rice length (mm)	.326	-.379	.171	-.262	.728*					
Popped rice length increased (%)	.435	-.405	.073	-.103	.360	.607*				
Popped rice breadth (mm)	.215	-.404	.035	.004	-.153	-.126	.134			
Popped rice breadth increased (%)	.477	-.731*	.379	-.405	.168	.250	.011	.636*		
1000 Popped rice wt. (g)	.043	-.063	-.050	.041	.399	.417	.365	.579	.199	
50 gm Popped rice volume (ml)	.753**	-.760**	.520	-.593	.463	.585	.556	.010	.477	-.056

** . Correlation is significant at the 0.01 level (2-tailed). * . Correlation is significant at the 0.05 level (2-tailed).

Table 19. Physical properties of flattened rice of BRRI developed modern varieties.

Variety name	Fully flattened rice (%)	Partial flattened rice (%)	Broken flattened rice (%)	Brown rice length (mm)	Brown rice breadth (mm)	Flattened rice length (mm)	Flattened rice length increased (%)	Flattened rice breadth (mm)	Flattened rice breadth increased (%)	Flattened rice thickness (mm)	1000 flattened rice wt. (g)	50 gm flattened rice volume (ml)
BR11	74.94BC	6.44DE	18.58F	6.17	2.66	9.86H	59.86G	4.34B	63.15CD	0.86B	18.87C	100.0D
BR23	77.02B	5.73DEFG	17.39F	7.28	2.5	11.10DE	52.51I	3.75E	50.00F	0.84BC	17.55E	90.0E
BRRI dhan28	60.22D	18.88B	20.84EF	6.9	2.2	11.06DE	60.33G	3.22H	46.36F	0.68E	18.53CD	100.0D
BRRI dhan32	52.72EF	12.69C	34.48C	6.2	2.24	10.66F	71.99E	3.82DE	70.68B	0.58F	17.83DE	100.0D
BRRI dhan51	41.59G	25.35A	33.01C	6.11	2.37	13.07A	113.90A	3.89D	63.99C	0.73D	18.77C	120.0B
BRRI dhan52	71.90C	2.44H	25.58D	6.22	2.8	11.17D	79.58D	4.61A	64.64C	0.73D	20.58B	123.3B
BRRI dhan55	44.80G	6.85D	48.18A	7.57	2.3	10.98E	45.08J	3.19H	38.54G	0.98A	20.02B	110.0C
BRRI dhan58	91.33A	3.83FGH	4.78G	6.84	2.21	10.55F	54.19HI	3.52F	59.42DE	0.51G	17.11E	100.0D
BRRI dhan60	71.88C	4.10EFGH	23.95DE	7.23	2.27	12.20C	68.69F	4.06C	79.00A	0.80C	21.58A	120.0C
BRRI dhan64	55.42E	1.92H	42.56B	5.84	2.69	11.14DEb	90.75B	4.25B	57.99E	0.82BC	17.04E	113.3C
BRRI dhan67	49.32F	5.78DEF	44.83AB	6.6	2.26	10.28G	55.70H	3.38G	49.70F	0.83BC	17.55E	100.0D
BRRI dhan74	77.19B	3.36GH	19.29F	6.73	2.72	12.61B	87.41C	4.30B	57.96E	0.83BC	22.04A	140.0A
Range	41.59-91.33	1.92-25.35	4.78-48.18	0	0	9.86-13.07	45.08-113.90	3.19-4.61	38.54-79.00	0.51-0.98	17.04-22.04	90.0-140.0
Mean±SD	64.028±1.35	8.1142±11.54	27.79±5.06	6.6408±3.43	2.435±1.22	11.224±0.57	69.999±0.67	3.8611±1.09	58.453±1.55	0.7667±2.14	18.955±1.63	109.72±0.16
SE	2.089	1.1579	2.1006	0	0	0.0811	1.2591	0.0501	1.9931	0.0191	0.4227	1.9245
CV%	4	17.48	9.26	0	0	0.89	2.2	1.59	4.18	3.05	2.73	2.15

Table 20, Correlation among the physical properties of flattened rice of BRRI modern varieties

Parameter	Correlations										
	Fully Flattened rice (%)	Partial Flattened rice (%)	Broken Flattened rice (%)	Brown rice length (mm)	Brown rice breadth (mm)	Flattened rice length (mm)	Flattened rice length increased (%)	Flattened rice breadth (mm)	Flattened rice breadth increased (%)	Flattened rice Thickness (mm)	1000 flattened rice wt. (g)
Partial Flattened rice (%)	-.545										
Broken Flattened rice (%)	-.885**	.093									
Brown rice length (mm)	.180	-.150	-.130								
Brown rice breadth (mm)	.261	-.439	-.067	-.443							
Flattened rice length (mm)	-.152	.341	-.010	.045	.109						
Flattened rice length increased (%)	-.277	.375	.120	-.663*	.386	.715**					
Flattened rice breadth (mm)	.335	-.356	-.200	-.574	.841**	.230	.550				
Flattened rice breadth increased (%)	.249	-.042	-.273	-.410	.117	.272	.456	.635*			
Flattened rice Thickness (mm)	-.294	-.256	.493	.292	.362	.070	-.132	.061	-.399		
1000 flattened rice wt. (g)	.135	-.161	-.073	.289	.302	.548	.181	.381	.259	.359	
50 gm flattened rice volume (ml)	-.008	-.115	.070	-.152	.478	.736**	.641*	.541	.305	.191	.783**

** . Correlation is significant at the 0.01 level (2-tailed). * . Correlation is significant at the 0.05 level (2-tailed).

Abbreviation: MAS: Muhammad Ali Siddiquee; MAH: Md Anwarul Haque; SSD: Sharifa Sultana Dipti; NF: Nilufa Ferdous; TKS: Tapash Kumar Sarkar; HBS: Habibul Bari Shozib; SH: Shakir Hosen; RA: Rubel Akanda

Hybrid Rice Division

88	Summary
89	Development Of Parental Materials
90	Evaluation Of Parental Lines And Hybrids
100	Seed Production Of Parental Lines And Hybrids

SUMMARY

In T. Aman season 2022, a total of 74 test crosses and 430 ($A \times R$) crosses were made from source nursery. Eighty test crosses (F_1 s) were evaluated for their pollen fertility status of which two entries have been found heterotic over the check varieties. Pollen parent of this combination was regarded as suspected restorer and selected for fertility restoration ability with other CMS lines in the next season. Two entries were found completely sterile and their corresponding male parents were regarded as suspected maintainer line. Twenty-one backcross entries were advanced as new CMS lines. Other backcross generations were advanced to next generations except four BC_6 generations which were found unstable in terms of pollen sterility and hence discarded. Ninety-four CMS lines along with their respective maintainer lines were maintained by hand crossing.

A total of 91 test crosses and 513 ($A \times R$) crosses were made using 14 CMS lines in Boro season 2022-23. Eighty-three test crosses (F_1 s) were evaluated for their pollen fertility status. Among them two entries showed complete sterility and immediately backcrossed with their corresponding male parents for conversion. On the other hand, four entries have been selected for their high yielding ability compared to the check varieties. Six BC_6 generations were advanced as new CMS lines and shifted to CMS maintenance and evaluation nursery. The other entries were advanced for next generations except three BC_2 and one BC_1 generations due to pollen fertility fluctuation. One hundred forty-six CMS lines along with their respective maintainer lines were maintained by hand crossing in CMS maintenance and evaluation nursery for their genetic purity.

In T. Aman, out of 205 test hybrids under observational trials, ten hybrid combinations were selected based on yield, duration and grain type and expressed more than 15-18% yield advantage over check variety BRRI hybrid dhan6, 9-12% over AZ7006 and 6-9 % over Dhanny Gold. The heritability obtained from growth duration and grain yield were 87%, and 82% respectively, indicating high level of precision in this experiment. In Boro,

out of 135 test hybrids 17 hybrid combinations were selected based on yield, duration and grain type. The selected hybrid combinations expressed 4-21% yield advantage over BRRI hybrid dhan5, 7-24% over SL8H and 15-34% over Tej Gold, 4-21% over Heera and BRRI hybrid dhan8. The heritability obtained from growth duration and grain yield was 94% and 75% respectively, indicating high level of precision in this experiment.

Under parental line improvement programme ($B \times B$ and $R \times R$) seven $B \times B$ and 11 $R \times R$ crosses were confirmed based on different cyto-sources and amylose content in T. Aman 22 and seven $B \times B$ and 10 $R \times R$ crosses were made based on different cyto-sources, grain type and amylose content in Boro 2022-23. Under field rapid generation advancement programme 30,986 F_3 , F_4 and F_5 progenies of $B \times B$, $R \times R$ and $A \times R$ were advanced in T. Aman 22 and 59,256 progenies of F_2 , F_4 , F_5 and F_6 generations of $B \times B$, $R \times R$ and $A \times R$ crosses were advanced in Boro 2022-23.

In T. Aman preliminary yield trials, two hybrids were selected out of 15 and showed yield advantage 3-25 % over BRRI hybrid dhan6, 6-20 % over AZ7006 and 3-14 % over Dhanny Gold. In T. Aman under multi-location trials one hybrid out of eleven produced 29% yield advantage over BRRI hybrid dhan6, 27% over AZ7006 and 19% over Dhanny Gold under Set-I. In set-II, one hybrid out of 10 hybrids produced 21% yield advantage over BRRI hybrid dhan6 and AZ7006 and 13% over Dhanny Gold. In Boro, under preliminary yield trials, thirteen hybrids were evaluated along with four hybrids as check variety. Out of 13 hybrids two hybrids were selected that produced 4-6% yield advantage over BRRI hybrid dhan5, 14-18% over SL8H, 24-28% over Heera-2 and 11-14% over check variety Tej Gold. In Boro, multi-location yield trials comprised of 14 hybrids with four checks. Three hybrids were selected based on average yield of five locations over check varieties and expressed 6-10% yield advantage over BRRI hybrid dhan5, 18-23 % over SL8H, 12-16% over Heera-2 and 18-23% over Tej Gold.

Adaptability under saline condition of BRRI developed and popular company hybrids along with

popular saline tolerant inbred checks BRRI dhan 67 and locally cultivated rice IT was done at two coastal locations of Satkhira (Debhata and Kaliganj). None of the tested entries performed well at kaliganj and Debhata of Satkhira due to very high-water salinity (13.81 ds/m and 9.4 ds/m, respectively). We found that the top highest yielding genotypes were BRRI hybrid dhan3 (5.88 t ha⁻¹), BRRI hybrid dhan6 (5.65 t ha⁻¹), BRRI hybrid dhan2 (4.61 t ha⁻¹) followed by BRRI hybrid dhan67 (4.53 t ha⁻¹), BRRI hybrid dhan7 (4.44 t ha⁻¹), Heera (4.30 t ha⁻¹). Therefore, we can conclude that BRRI hybrid dhan3, BRRI hybrid dhan6, BRRI hybrid dhan2 and BRRI dhan67 can be cultivated profitably in areas where water salinity level of the paddy field remains 3.77 ds/m to 9.4 ds/m.

Eleven CMS lines including promising and released hybrids were multiplied during Boro 2022-23 and got total seed yield of 3.7 metric tons. It was ranging from 2.8 kg to 1352 kg/plot equivalent to 0.3 to 1.99 t/ha. Experimental F₁ seed production was made using twelve CMS with five different restorer lines and seed yield was ranging from 0.5 to 60 kg/plot from selected promising hybrid combinations in T. Aman 2022 which was equivalent to 0.03 to 1.9 t/ha. Sixty-four experimental hybrids were evaluated in augmented design during Boro 2022-23 and selected 12 hybrids expressed more than 5% yield advantages over the highest yielding check varieties. In Boro 2022-23, a total of 208 kg (1.04 t/ha) from BRRI hybrid dhan5 and 295 kg (1.5 t/ha) from BRRI hybrid dhan6, 370 kg (1.5 t/ha) from BRRI hybrid dhan7 and 325 kg (1.63 t/ha) from BRRI hybrid dhan8 were obtained. From production side (Ishwardi and Barishal) 962 kg (0.96 t/ha) from BRRI hybrid dhan2, 7,150 kg (1.5 t/ha) from BRRI hybrid dhna3, 1,500 kg (1.5 t/ha) from BRRI hybrid dhan4, 3,628 kg (1.05 t/ha) from BRRI hybrid dhan5, 5,700 kg (2.04 t/ha) from BRRI hybrid dhan6, 4,620 kg (2.31 t/ha) from BRRI hybrid dhan7 and 3872 kg (1.94 t/ha) of BRRI hybrid dhan8 F₁ seeds were obtained.

In T. Aman 2022, Hybrid Rice Division supplied 8,446 kg of parental lines and F₁ seeds to 90 farmers, 13 seed companies, scientists, extension people, projects and staffs of BRRI. In Boro 2022-23, Hybrid Rice Division supplied 21,606 kg of

parental lines and F₁ seeds to 130 farmers, 24 seed companies, scientists, extension people, projects and staffs of BRRI. In T. Aus 2022, 4,370 kg F₁ seeds of BRRI hybrid dhan7 were distributed free of cost among farmers through different regional stations of BRRI and the Department of Agricultural Extension. Twenty-three stake holders produced more than 334 MT F₁ seeds using BRRI developed hybrid rice parental lines during Boro 2022-23.

DEVELOPMENT OF PARENTAL MATERIALS

Source Nursery

Seventy-four test crosses and 430 (A × R) crosses were made during T. Aman season 2022. Ninety-one test crosses and 513 (A × R) crosses were made using 14 CMS lines during Boro season 2022-23.

Test cross nursery

In Aman 2022, eighty test crosses (F₁s) were evaluated for their pollen fertility status of which two entries have been found heterotic over check varieties. Pollen parents of those combinations were regarded as suspected restorers and selected for fertility restoration ability with other CMS lines in the next season. Two entries were found completely sterile and their corresponding male parents were regarded as suspected maintainer lines.

In Boro 2022-23, eighty-three test crosses (F₁s) were evaluated for their pollen fertility status. Among them two entries showed complete sterility and immediately backcrossed with their corresponding male parents for conversion. On the other hand, four entries have been selected for their high yielding ability compared with check varieties.

Back cross nursery

In T. Aman 2022, twenty-one backcross entries were advanced as new CMS lines. Other backcross generations were advanced to next generations except four BC₆ generations which were found unstable in terms of pollen sterility and hence discarded. In Boro 2022-23, six BC₆ generations were advanced as new CMS lines and shifted to CMS maintenance and evaluation nursery. Other entries were advanced for next generations except three BC₂ and one BC₁ generations due to pollen fertility fluctuation.

CMS maintenance and evaluation nursery

Ninety-four CMS lines were maintained by hand crossing for seed increase and genetic purity in T. Aman 2022 and in Boro 2022-23, 146 CMS lines were maintained through hand crossing for seed increase and genetic purity.

EVALUATION OF PARENTAL LINES AND HYBRIDS

In T Aman 2022 T. Aman, out of 205 test hybrids under observational trials, ten hybrid combinations were selected based on yield, duration and grain type and expressed more than 15-18% yield advantage over check variety BRRI hybrid dhan6, 9-12% over AZ7006 and 6-9 % over Dhanny Gold. The heritability obtained from growth duration and grain yield were 87%, and 82% respectively, indicating high level of precision in this experiment

(Table 1). Upon commercial seed production feasibility of these selected hybrid combinations and grain quality assessment it will be tested under preliminary yield trial (PYT) and multi-location yield trials (MLT). Upon satisfactory yield advantage over check variety it is subjected to registration under national hybrid rice yield trial (NHRYT) for releasing as new hybrid rice of BRRI. In Boro, out of 135 test hybrids 17 hybrid combinations were selected based on yield, duration and grain type. The selected hybrid combinations expressed 4-21% yield advantage over BRRI hybrid dhan5, 7-24% over SL8H and 15-34% over Tej Gold, 4-21% over Heera and BRRI hybrid dhan8. The heritability obtained from growth duration and grain yield was 94% and 75% respectively, indicating high level of precision in this experiment (Table 2).

Table 1. List of experimental hybrids found heterotic over check variety during T. Aman, 2022.

Designation	DTM	GSS	Plot Yield (kg/plot)	Yield (t/h)	Heterosis (%)		
					Ck-1	Ck-2	Ck-3
BRRI99A/BRRI32R	104	LS	1.5	7.5	15	9	6
BRRI109A/IR86526-11-9-1-1-1-1R	104	LS	1.5	7.5	15	9	6
BRRI109A/IR86515-19-1-2-1-1-1-1R	109	MS	1.5	7.5	15	9	6
IR102758A/BRRI55R	111	MS	1.5	7.5	15	9	6
BRRI110A/208R	118		1.5	7.5	15	9	6
IR102758A / IR86526-15-10-1-1-2-1-1R	121	LS	1.52	7.6	16	10	8
BRRI110A/EL220R	115	MS	1.54	7.7	18	12	9
BRRI110A/EL32R	111	MS	1.52	7.6	16	10	8
BRRI110A/BRRI50R	112		1.54	7.7	18	12	9
IR102758A/IR86404-8-1-1-1-1R	121		1.54	7.7	18	12	9
BRRI hybrid dhan6 (ck-1)	108	MS	1.31	6.6			
AZ7006 (ck-2)	120	MS	1.38	6.9			
Dhanny Gold (ck-3)	122	MS	1.41	7.1			
Heritability	0. 87	-		0.82			
LSD _(0.05)	10.5	-		3.7			

Yield data counted from 30 hills per entry, spacing was 20cm×15cm (R × P)

DS: 14 Jul 2022; DT: 10 Aug 2022

Legend: DTM = Days to maturity; GSS= Grain size and shape

Table 2. List of the hybrid combinations found heterotic from observational nursery during Boro season 2022-23.

SL no	Designation	DTM	GSS	P Y (kg)	Yield (t/h)	Ck-1	Ck-2	Ck-3	Ck-4	Ck-5
OT-5	BRR111A/EL-40	140	MB	2.21	11.04	4	7	15	4	4
OT-6	BRR111A/EL-203	137	MB	2.50	12.48	18	21	30	18	18
OT-21	BRR197A/BRR142R	139	LS	2.53	12.65	20	22	32	19	19
OT-22	BRR197A/BRR144R	140	MS	2.50	12.51	18	21	31	18	18
OT-24	BRR197A/BRR156R	138	MS	2.42	12.08	14	17	26	14	14
OT-25	BRR197A/EL175R	140	MS	2.57	12.84	21	24	34	21	21
OT-35	BRR199A/CHH67R	139	MS	2.56	12.79	21	24	34	21	20
OT-44	BRR199A/IR90928-15-4-1-1-1R	144	LS	2.44	12.18	15	18	27	15	15
OT-54	BRR1109A/Getco17R	135	LS	2.54	12.72	20	23	33	20	20
OT-56	BRR1109A/CHH56R	141	LS	2.41	12.05	14	17	26	14	13
OT-60	BRR1109A/BRR156R	137	MS	2.39	11.93	13	15	25	13	12
OT-72	BRR1110A/BRR137R	141	LS	2.27	11.34	7	10	19	7	7
OT-76	BRR1110A/BRR144R	145	MS	2.46	12.29	16	19	28	16	16
OT-93	BRR1110A/IR86522-12-12-2-1-1-1-1R	136	MS	2.41	12.06	14	17	26	14	14
OT-115	IR105688A/BRR144R	142	SS	2.48	12.40	17	20	30	17	17
OT-125	IR102758A/GoldR	139	MS	2.51	12.55	19	21	31	18	18
OT-132	IR102758A/IR85503-3-3-A-1-1-1-1-1R	142	MS	2.44	12.20	15	18	27	15	15
ck-1	BRR1 hybrid dhan5	143	LB	2.11	10.57					
ck-2	SL8H	141	MB	2.07	10.34					
ck-3	Tej Gold	138	LS	1.91	9.57					
ck-4	Heera	144	MB	2.12	10.60					
ck-5	BRR1 hybrid dhan8	145	LS	2.12	10.62					
Heritability		0.94		0.75						
LSD _(0.05)		5.24		3.71						

DS: 11 Dec 2022; DT: 14 Jan 2023; Plot size: 2 m²

Legend: DTM = Days to maturity; GSS= Grain size and shape

Preliminary yield trials of promising hybrids

Under preliminary yield trials, two hybrids were selected out of 15 and showed yield advantage 3-25 % over BRR1 hybrid dhan6, 6-20 % over AZ7006 and 3-14 % over Dhanny Gold in T. Aman 2022 (Table 3). In Boro, under preliminary yield trials,

13 hybrids were evaluated along with four hybrids as check variety. Out of 13 hybrids two hybrids were selected and produced 4-6% yield advantage over BRR1 hybrid dhan5, 14-18% over SL8H, 24-28% over Heera-2 and 11-14% over check variety Tej Gold (Table 4).

Table 3. Results of preliminary yield trials in T. Aman 2022.

Designation	PHT (cm)	GD (day)	GSS	SF (%)	Amy (%)	Yield (t/h)	Heterosis (%)		
							ck-1	ck-2	ck-3
IR102758A/IR77498-45-1-2-2R	112	116	MS	78.3	23.4	7.8	19.0	13.9	7.6
BRR199A/IR86526-11-6-2-1-1-1-1R	110	111	S	76.2	23.3	6.79	2.6	-	-
IR105688A/BRR146R	105	103	S	75.5	23.4	6.50	-	-	-
BRR197A/BRR146R	107	105	S	77.6	24.1	7.43	12.2	8.5	2.5
BRR199A/BRR146R	111	107	S	76.5	23.7	7.22	9.0	5.4	-
BRR1110A/BRR142R	110	110	S	83.3	23.7	6.64	0.3	-	-
IR79156A/BRR142R	115	118	S	77.6	23.5	7.39	11.6	7.9	1.9
IR58025A/BRR142R	112	120	S	80.2	22.8	8.06	21.8	17.7	11.2
IR105688A BRR137R	106	104	S	76.3	23.6	6.60			
IR78369A BRR137R	113	112	S	75.4	23.3	6.75	2.0	-	-
IR58025A/BRR137R	111	111	S	74.4	22.8	6.10	-	-	-
IR79156A/BRR136R	115	110	S	74.0	24.0	5.80	-	-	-
IR105687A/BRR136R	104	106	S	73.6	23.3	5.75	-	-	-
IR79125A/BRR143R	110	122	S	80.6	24.0	8.25	24.6	20.4	13.8
IR78369A/BRR143R	112	121	MS	76.8	23.5	7.35	11.0	7.3	1.4
BRR1 hybrid dhan6	109	113	S	76.0	24.0	6.62			
AZ7006	112	130	S	76.5	-	6.85			
Dhanny Gold	108	133	MS	77.1	-	7.25			
Mean	110.1	114.0		77.0	23.5	7.0			
CV (%)	2.9	7.5		3.2	1.7	10.2			
LSD (0.05%)	1.9	5.2		1.5	0.2	0.4			

DS: 14 Jul 2022; DT: 05Aug 2022; Plot size=10 m²; PHT (cm) = Plant height (cm); GD = Growth duration; GSS= Grain shape and size; S=Slender, M=Medium, MS=Medium slender; SF (%) = Spikelet fertility; Amy (%) = Amylose.

4. Result of preliminary yield trial (PYT) during Boro 2022-23.

Designation	PHT (cm)	GD (day)	GSS	AC (%)	Yield (t/h)	Heterosis (%)			
						ck-1	ck-2	ck-3	ck-4
BRR197A/EL86R	105.4	141	MS	23.3	10.78	2.08	12.87	22.50	9.59
BRR199A/EL86R	112.2	144	MS	22.8	10.75	1.79	12.56	22.15	9.25
BRR1109A/EL86R	109.1	143	MS	23.5	10.67	1.04	11.72	21.25	8.43
BRR1125A/BRR138R	109.0	141	S	24.0	11.24	6.43	17.70	27.73	14.23
IR79156A/BRR142R	103.3	142	S	23.4	10.93	3.50	14.45	24.20	11.08
IR105687A/BRR142R	95.8	139	S	23.3	10.42	-	9.11	18.40	5.89
IR102758A/BRR142R	107.5	147	S	24.1	10.60	0.38	10.99	20.45	7.72
BRR148A/BRR132R	110.6	147	S	23.4	10.64	0.76	11.41	20.90	8.13
BRR197A/BRR132R	110.8	145	S	23.6	9.73	-	-	10.57	
IR79156A/BRR132R	111.9	144	S	24.2	9.50	-	-	7.95	
BRR197A/IR85551-9-1-1-1-2-1-1-1R	92.4	146	S	23.3	10.40	-	-	18.18	5.69

Designation	PHT (cm)	GD (day)	GSS	AC (%)	Yield (t/h)	Heterosis (%)			
						ck-1	ck-2	ck-3	ck-4
BRR199A/IR85551-9-1-1-1-2-1-1-1R	102.3	145	S	22.8	10.51	-	10.05	19.43	6.81
IR58025A/IR85551-9-1-1-1-2-1-1-1R	104.5	146	S	23.4	10.53	-	10.26	19.65	7.01
BRR1 hybrid dhan5 (ck-1)	110.7	144	S	24.0	10.56	-	10.57	20.00	7.31
SL8H(ck-2)	108.4	147	S		9.55				
Heera-2(ck-3)	109.3	145	S		8.80				
Tej Gold (ck-4)	113.8	146	S		9.84				
LSD (0.05)	3.16	2.82			0.53				
Heritability	0.99	0.98			0.91				

DS: 08 Dec 2022; DT: 14 Jan 2023; Plot size: 20 m²

Legend: PH=Plant height (cm), GD= Growth duration (days), AC (%) = Amylose content, GSS= Grain size and shape, MS= Medium slender, LS = Long slender, SS= Short slender, MB = Medium bold, LB= Long bold

Multi-location yield trials of promising hybrids

In T. Aman 2022, under multi-location trials one hybrid out of 11 produced 29% yield advantage over BRR1 hybrid dhan6, 27% over AZ7006 and 19% over Dhanny Gold under Set-I. In set-II, one hybrid out of 10 hybrids produced 21% yield advantage over BRR1 hybrid dhan6 and AZ7006 and 13% over Dhanny Gold. (Tables 5 and 6). In

Boro 2022-23, multi-location yield trials comprised of 14 hybrids with four checks. Three hybrids were selected based on average yield of five locations over the check varieties and expressed 6-10% yield advantage over BRR1 hybrid dhan5, 18-23 % over SL8H, 12-16% over Heera-2 and 18-23% over Tej Gold. (Table 7).

Table 5. Results of multi-location yield trials during T. Aman 2022 (Set-I).

Hybrid	PH (cm)	DTM	Yield (t/ha)						SF (%)	GSS	Amy (%)	Aver yield advantage over ck (%)		
			Gaz	Ish	Bari	Ran	Son	Av				ck-1	ck-2	ck-3
IR79156A/BRR146R	108	111	7.4	7.6	5.8	7.4	5.8	6.8	76.3	S	24.2	8	6.3	-
BRR197A/BRR153R	110	110	7.2	7.0	8.9	6.4	5.6	7.02	78.6	MS	23.4	11.4	9.7	3.2
IR79156A/BRR153R	106	113	5.9	7.3	7.4	6.9	6.3	6.8	76.0	S	23.2	8	6.3	-
IR105688A/BRR153R	104	110	6.1	6.9	7.4	6.04	5.8	6.4	75.2	S	23.5	1.6	-	-
BRR197A/BRR142R	107	114	6.8	8.7	8.4	7.7	6.7	7.7	80.3	MS	23.6	22.2	20.3	13.2
BRR199A/BRR142R	111	115	8.3	9.2	8.5	7.3	7.0	8.1	84.5	MS	24.2	28.6	26.6	19.1
BRR199A/BRR137R	110	110	6.0	7.9	6.9	7.2	6.3	6.9	77.8	MS	23.4	9.5	7.8	1.5
IR102758A/BRR136R	109	114	6.5	7.1	6.12	6.32	5.8	6.4	75.0	MS	23.4	1.6	-	-
BRR197A/BRR143R	107	110	6.1	7.5	7.3	7.1	6.3	6.9	77.6	S	24.0	9.5	7.8	1.5

	BRR199A/BRR143R	111	118	7.4	8.8	7.8	7.05	7.0	7.6	79.8	S	23.7	20.6	18.8	11.8
	IR79156A/BRR143R	113	119	6.7	8.4	7.2	7.4	6.8	7.3	78.7	MS	23.6	15.9	14.1	7.4
ck-1	BRR1 hybrid dhan6	112	116	5.8	7.3	5.8	6.4	6.2	6.3	75.0	S	24.0			
ck-2	AZ 7006 (ck-2)	116	123	5.6	7.8	6.2	6.9	5.4	6.4	75.1	S				
ck-3	Dhanny Gold (ck-3)	118	127	6.3	7.0	7.8	7.4	5.6	6.8	75.8	S				
Mean		110.1	115.0	6.6	7.8	7.3	7.0	6.2	7.0	77.6					
CV (%)		3.5	4.6	11.7	9.7	13.8	7.1	8.7	7.8	3.5					
LSD (0.05%)		2.6	3.6	0.5	0.5	0.7	0.3	0.4	0.4	1.9					

DS: 07 Jul 2022; DT: 26 Jul 2022; Unit plot size: 30 m²

Legend: PH (cm) = Plant height; DTM= Days to maturity; SF (%) = Spikelet fertility; GSS= Grain size and shape; Amy (%) = Content of amylose in percentage; Gaz = Gazipur; Ish = Ishwardi; Bari = Barishal; Ran = Rangpur; Son = Sonagazi

Table 6. Results of multi-location yield trials during T. Aman 2022 (Set-II).

	Hybrid	PH (cm)	DTM	Yield (t/ha)						SF (%)	GSS	Amy (%)	Aver yield advantage over ck (%)		
				Gaz	Ish	Bari	Ran	Son	Av				Ck-1	Ck-2	Ck-3
	IR58025A/BRR146R	111	120	7.4	7.8	8.1	6.4	5.8	7.1	78	S	23.2	12.7	12.7	6.0
	IR102758A/BRR153R	110	116	7.2	7.7	7.9	5.8	5.6	6.8	77.5	MS	23.5	7.9	7.9	1.5
	IR79125A/BRR153R	114	119	6.8	6.4	7.4	6.4	5.8	6.6	76	S	24.2	4.8	4.8	-
	IR78369A/BRR153R	116	123	6.1	7.5	7.4	6.2	5.8	6.6	75.6	M	23.5	4.8	4.8	-
	IR102758A/BRR142R	107	114	6.8	8.7	7.4	6.6	6.7	7.4	75.8	MS	23.6	17.5	17.5	10.4
	IR78369A/BRR142R	111	115	6.3	7.0	7.5	6.2	5.8	6.6	79.1	M	24.2	4.8	4.8	-
	IR58025A/BRR136R	110	118	6.0	7.9	6.9	6.0	5.8	6.5	75.1	S	22.4	3.2	3.2	-
	IR105688A/BRR143R	109	114	6.5	7.1	6.12	6.32	5.8	6.4	75	MS	23.4	1.6	1.6	-
	IR102758A/BRR143R	112	118	8.1	7.9	8.3	7.4	6.3	7.6	79.4	S	24.0	20.6	20.6	13.4
	IR58025A/BRR143R	111	118	5.8	7.1	6.7	6.5	5.7	6.4	75.1	S	22.7	1.6	1.6	-
ck-1	BRR1 hybrid dhan6	112	116	6.3	7.0	5.8	6.0	6.2	6.3	74.8	S	24.0			
ck-2	AZ 7006 (ck-2)	116	124	5.6	7.5	6.2	6.7	5.6	6.3	77.3	S				
ck-3	Dhanny Gold (ck-3)	118	128	6.3	7.6	7.0	6.8	5.8	6.7	78	S				
Mean		112.1	118.7	6.6	7.5	7.1	6.4	5.9	6.7	76.7					
CV (%)		2.8	3.5	10.6	7.6	10.8	6.5	5.3	6.1	2.1					
LSD (0.05%)		2.2	3.0	0.5	0.4	0.6	0.3	0.2	0.3	1.2					

DS: 08 Jul 2022; DT: 27 Jul 2022; Unit plot size: 30 m²

Legend: PH (cm) = Plant height; DTM= Days to maturity; SF (%) = Spikelet fertility; GSS= Grain size and shape; Amy (%) = Content of amylose in percentage; Gaz = Gazipur; Ish = Ishwardi; Bari = Barishal; Ran = Rangpur; Son = Sonagazi

Table 7. Results of multi-location yield trials during Boro 2022-23.

	Hybrid	PH (cm)	DTM	Yield (t/ha)						SF (%)	GSS	AC (%)	Aver yield Advantage over ck (%)			
				Gaz	Ish	Bari	Ran	Son	Av				ck-1	ck-2	ck-3	ck-4
	BRR125A/EL86R	108	146	11.0	11.5	11.5	9.7	10.5	10.8	87.3	S	23.6	10.2	22.7	16.1	22.7
	IR105687A/EL86R	110	139	9.2	9.6	8.9	8.5	8.3	8.9	82.6	MS	23.4	-	1.1	-	1.1
	BRR197A/BRR138R	108	113	8.9	9.3	8.4	7.9	9.0	8.7	79.6	MS	23.2	-	-	-	-
	BRR1109A/BRR138R	104	147	10.7	11.4	11.3	9.7	10.1	10.6	85.2	S	24.0	8.2	20.5	14.0	20.5
	BRR197A/BRR142R	107	144	8.8	9.7	8.4	7.7	9.7	8.9	81.3	MS	23.6	-	1.1	-	1.1
	BRR199A/BRR142R	111	145	10.7	11.2	11.0	9.6	9.4	10.4	84.5	S	24.2	6.1	18.2	11.8	18.2
	BRR111A/BRR132R	110	146	9.0	9.6	8.9	9.2	9.4	9.2	83.2	MS	23.4	-	4.5	-	4.5
	BRR125A/BRR132R	109	144	8.9	10.1	9.7	8.5	8.8	9.2	83.0	S	23.4	-	4.5	-	4.5
	IR105687A/BRR132R	107	140	8.1	8.5	9.3	8.1	8.3	8.5	77.6	S	24.0	-	-	-	-
	BRR1109A/IR85551-9-1-1-1-2-1-1-1R	111	143	8.4	8.8	9.7	8.1	9.0	8.8	79.8	S	23.7	-	-	-	-
	BRR1110A/IR85551-9-1-1-1-2-1-1-1R	113	147	9.7	9.4	10.2	7.4	7.8	8.9	80.7	MS	23.6	-	1.1	-	1.1
	BRR125A/IR85551-9-1-1-1-2-1-1-1R	112	144	8.5	9.1	9.2	8.2	7.8	8.6	78.1	M	23.3	-	-	-	-
	IR105687A/IR85551-9-1-1-1-2-1-1-1R	107	139	8.7	9.5	9.3	8.4	8.7	8.9	81.0	MS	23.4	-	1.1	-	1.1
	IR102758A/IR85551-9-1-1-1-2-1-1-1R	110	144	9.6	10.0	10.3	8.6	8.9	9.5	84.6	M	23.6	-	8.0	2.2	8.0
	BRR1 hybrid dhan5 (ck-1)	108	145	10.3	10.5	9.7	9.4	9.3	9.8	86.3	MS	24.0	-	11.4	5.4	11.4
	SL8H (ck-2)	108	143	9.3	8.8	9.4	8.2	8.4	8.8	80.4	MS					
	Heera-2 (ck-3)	113	148	9.6	9.4	10.4	8.6	8.5	9.3	83.6	M					
	Tej Gold (ck-4)	115	141	8.4	9.3	8.8	8.2	9.4	8.8	79.7	S					
	Mean	109.5	142.1	9.3	9.7	9.7	8.6	9.0	9.3	82.1	-	23.6				
	CV (%)	2.47	5.44	9.33	9.13	10.07	7.77	8.17	7.55	3.38	-	1.26				
	LSD (0.05%)	1.65	4.71	0.53	0.54	0.60	0.40	0.44	0.43	1.69	-	0.18				

DS: 04 Dec 2022; DT: 07 Jan 2023; Unit plot size: 30 m²

Legend: PH (cm) = Plant height (cm); DTM= Days to maturity; SF (%) = Spikelet fertility (%); GSS= Grain shape and size; S=Slender; MS= Medium Slender; M=Medium; AC (%) = Amylose (%)

Development of maintainer and restorer lines through (B×B) and (R×R) crosses

Under parental line improvement programme (B×B and R×R) seven B×B (Table 8) and 11 R×R (Table 9) crosses were confirmed based on different cyto-sources and amylose content in T Aman 22 and seven B×B (Table 10) and 10 R×R (Table 11) crosses

were made based on different cyto-sources, grain type and amylose content in Boro 2022-23. Under field rapid generation advancement programme 30,986 F₃, F₄ and F₅ progenies of B×B, R×R and A×R were advanced in T. Aman 22 (Table 12) and 59256 progenies of F₂, F₄, F₅ and F₆ generations of B×B, R×R and A×R crosses were advanced in Boro 2022-23 (Table 13).

Table 8. F₁ Confirmation for (B x B) improvement, T. Aman 2022.

Genotype	Amount of F ₂ seed harvested (5 panicles)
IR75596B × IR102571B	18 g
BRR1111B × BRR1126B	23g
BRR129B × BRR112B	20 g
BRR12B × BRR1 25B	23 g
IR80154B × BRR1125B	33 g
IR80156B × IR77809B	20 g
IR80154B × BRR112B	30 g

DS: 12 Jul 2022; DT: 29 Jul 2022

Table 9. F₁ Confirmation for (R x R) improvement, T. Aman 2022.

Genotype	Amount of F ₂ seed harvested (5 panicles)
IR 85593-23-2-1-3-1-2-1-1-1 × RFSR	35 g
IR 86612-12 -10-1 -1 -2-1R × BRR130R	18 g
IR86522-11-1-1-3-1R × BR6723-1-1-2R	23 g
BRR129R × LP70R	26 g
IR86526-14-3-2-2-1-1-1-1R × BRR129R	30 g
IR69712-154-2-3-1-3R × IR86522-29-10-1-1-1-1-1-1R	24 g
IR86522-29-10-1-1-1-1-1-1R × IR 86403-5-5-2-1-1-1-1-1R	33 g
IR85553-18-2-1-14-1-1-1R × IR86522-29-10-1-1-1-1-1-1R	22 g

Genotype	Amount of F ₂ seed harvested (5 panicles)

IR85503-3-3-A-1-1-1-1-1R × BRR150R	33 g
IR86522-29-10-1-1-1-1-1-1R × SL8R	24 g
IR90928-15-4-1-1-1-1R × BRR131R	21 g

DS: 12 Jul 2022; DT: 29 Jul 2022

Table 10. F₁ Confirmation of (B×B) crosses, Boro 2022-23.

Cross combination	Code	Amount of harvested F ₂ seeds
BRR196B × BRR194B	77 CMSB x 75 CMSB	200g
IR68886B × BRR194B	1 CMSB x 75 CMSB	200g
BRR197B × BRR191B	78 CMSB x 72 CMSB	200g
BRR197B × IR68886B	78 CMSB x 1 CMSB	200g
Z.S 97B × BRR145B	7 CMSB x 40 CMSB	200g
BRR191B × BRR196B	72 CMSB x 77 CMSB	200g
BRR189B × Z.S 97B	70 CMSB x 7 CMSB	200g

DS: 8 Dec 2022; DT: 10 Jan 2023

Table 11. F₁ confirmation of (R×R) crosses Boro 2022-23.

Cross combination	Code	Amount of harvested F ₂ seeds
Chachua5R (N) × IR96479-81-7-1-1-B-1-1-1-1R	EN 279R x HRDC32R	200g
BAU521R × IR86522-29-4-2-1-1-1-1-1-1-1-1	EN 110R x HRDC37R	200g

IR86522-15-2-1-1-1-1-1R×IR86526-21-2-2-1-1-1-1-1R	HRDC55R x HRDC77R	200g
Collected from India× EL220R	EN 281R x EN 165R	200g
IR 86612-31-3-2-1-1-1-1-1R×IR86526-10-6-1-1-1-1-1-1R	HRDC48R x HRDC78R	200g
EL220R×IR86612-13-1-1-1-1-1R	EN 165R x HRDC80R	200g
IR86612-13-1-1-1-1-1R× LP108R	HRDC11R x EN 93R	200g
IR 86522-25-3-1-1-1-1-1-1R× LP70R	HRDC10R x EN 91R	200g
IR73971-87-1-1-1-1-1R (IR01N200) × F2277	HRDC20R x EN 75R	200g
Collected from India × IR06N126R	EN 281R x HRDC61R	200g

DS: 8 Dec 2022; DT: 10 Jan 2023

Table 12. Progenies selected through Field RGA during T. Aman 2022.

Cross Type	No. of Crosses			Transplanted	Harvested
	F	F	F		
B×B	14	15	5	72574	30986
R×R	7	6	13		
A×R	22	-	-		
Total		82			

DS: 12 Jul 2022; DT: 17 Aug 2022

Table 13. Progenies selected through Field RGA, during Boro 2022-23.

Cross Type	No. of Crosses				Transplanted	Harvested
	F ₂	F ₄	F ₅	F ₆		
B×B	7	14	15	5	90895	59256
R×R	11	7	6	13		
A×R	-	22	-	-		
Total			100			

DS: 11 Dec 2022; DT: 17 Jan 2023

Generation advancement of parental lines having multi stress genes (HRDC materials) at restorer (R) and maintainer (M) background

In T. Aman 2022, thirty-four F₆ progenies from 10 crosses were evaluated and 36 progenies were selected from pedigree generations based on the better performance with phenotypic acceptability,

insect and disease reaction, grain type and growth duration (Table 14). In Boro 2022-23, a total of 43 progenies were selected from F₇ generation, among them 15 progenies were harvested as a single plant basis and 28 progenies bulked through pedigree method (Table 15).

Table 14. Selected progenies for the development of restorers and maintainers having multi stress gene/s.

Pedigree	No. of selected progenies	Gene/s								
		SKC	Sub1	Xa5 Xa7 Xa13Xa21	Pita	Bph3Bph18	hd1	Rf3Rf4	GW2 GW8	Chalk5 alk GS3 GS5 WX
IR126044	4 progenies	√	-	√	-	-	√	√	-	√
IR126055	4 progenies	√	√	√	√	-	√	√	-	√
IR126066	4 progenies	√	-	-	√	Bph18	-	Rf4	-	√
IR126069	5 progenies	√	√	-	√	-	√	√	-	√
IR126072	5 progenies	√	√	-	-	-	√	RF3	-	√
IR126076	2 progenies	√	√	-	√	-	√	Rf3	-	√
IR127275	3 progenies	√	-	-	-	-	√	Rf4	-	√
IR127278	4 progenies	√	-	Xa13 Xa21	-	-	√	√	-	√
IR127270	3 progenies	-	-	-	-	Bph18	√	Rf4	-	√
IR126037	2 progenies	√	√	-	-	Bph18	√	Rf4	GW2	√
Total	36 progenies									

DS: 07 Jul 2022; DT: 30 Jul/2022

Legend: √- Gene/s Present; Salinity tolerance (SKC); Submergence (Sub1); Bacterial leaf blight (Xa21, Xa13, Xa7 and xa5); Brown plant hopper (Bph3, Bph18); Blast (Pita); Gelatinization temperature (alk); Grain chalkiness (Chalk5); Grain width (GW8); Grain width (GW2); Grain shape (GS3, GS5); Heading date (hd1); waxy (wx); Fertility restorer (Rf3, Rf4)

Table 15. List of harvested F₈ population of restorers and maintainers having multi stress gene/s during Boro 2022-23.

Pedigree	No. of harvested progenies
IR 126044	4 progenies
IR 126055	4 progenies
IR 126066	4 progenies
IR 126069	5 progenies
IR 126072	5 progenies
IR 126076	2 progenies
IR127275	3 progenies
IR127278	4 progenies
IR127270	3 progenies
IR 126037	2 progenies
Total	43 progenies

DS: 05 Dec 2022;2DT: 08 Jan 2023

Screening of rice hybrid parental lines against blast disease and genome wide association study (GWAS) using diverse panel of hybrid rice parental lines against differential isolates of blast pathogen.

Out of 383 parental lines 51 (30 maintainer and 21 restorer) showed moderate (5) to resistant (3) scores under 12 ds/m at seedling stage.

Assessment of specific and general adaptability for selection of suitable rice hybrids under saline prone areas for Boro season

Adaptability under saline condition of BRRI developed and popular company hybrids along with popular saline tolerant inbred checks BRRI dhan 67

and locally cultivated rice IT was done at two coastal locations of Satkhira (Debhata and Kaliganj). None of the tested entries performed well at Kaliganj and Debhata of Satkhira due to very high-water salinity (13.81 ds/m and 9.4 ds/m, respectively). We found that the top highest yielding genotypes were BRRI hybrid dhan3 (5.88 t ha⁻¹), BRRI hybrid dhan6 (5.65 t ha⁻¹), BRRI hybrid dhan2 (4.61 t ha⁻¹) followed by BRRI hybrid dhan6 (4.53 t ha⁻¹), BRRI hybrid dhan7 (4.44 t ha⁻¹), Heera (4.30 t ha⁻¹). Therefore, we can conclude that BRRI hybrid dhan3, BRRI hybrid dhan6, BRRI hybrid dhan2 and BRRI dhan7 can be cultivated profitably in areas where water salinity level of the paddy field remains 3.77 ds/m to 9.4 ds/m (Table 16 and Fig. 1).

Table 16. Yield and agronomic performance of twelve genotypes from adaptive trial in Boro 2022-23.

Genotype	GD (day)	PH (cm)	Yield (t/ha)			SF (%)	PAcp	
			Debhata	Kaliganj	Average		Veg	Mat
BRRI hybrid dhan2	136	88	4.61	4.01	4.31	84	5	5
BRRI hybrid dhan3	138	90	5.88	4.21	5.04	76	5	5
BRRI hybrid dhan5	134	91	2.57	4.03	3.30	63	3	3
BRRI hybrid dhan6	141	97	5.65	2.42	4.03	71	3	3
BRRI hybrid dhan7	142	95	4.53	2.68	3.60	83	3	3
BRRI hybrid dhan8	140	94	4.44	2.04	3.24	54	3	3
Heera	137	87	3.70	3.73	3.71	55	3	3
Tejgold	136	88	4.30	3.50	3.90	93	5	5
SL-8	138	90	3.63	1.90	2.76	67	3	3
BRRI dhan67	131	88	4.19	1.91	3.05	76	3	3
IT	130	92	3.03	*	3.03	60	3	3
Tia	132	77	2.95	*	2.95	86	3	3
LSD (0.5) %	3.46	12	1.26	0.49		31		
CV (%)	0.73	2.42	18.09	9.39		1		
Heritability (%)	0.94	0.50	0.82	0.97		0.50		

DS: 12 Dec 2022; DT: 21 Jan 2023

Legend: GD=Growth duration (day), PH=Plant height (cm), SF=Spikelet fertility (%), PAcp = Phenotypic acceptability *=All the entries died,

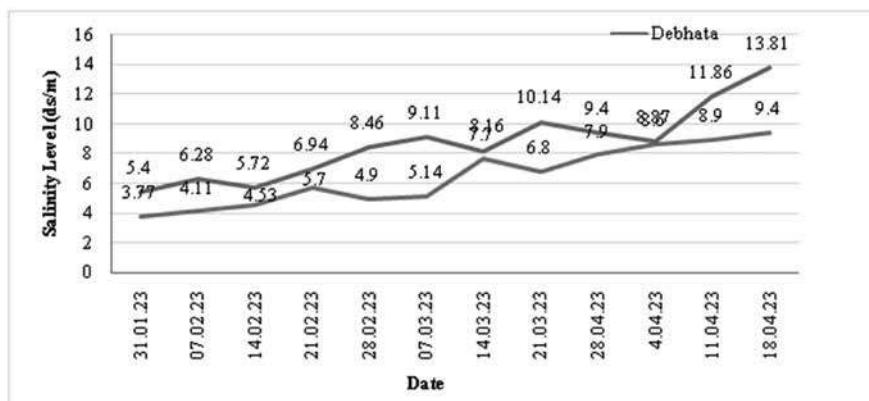


Fig. 1. Water salinity levels of different experimental plots in Boro 2022-23 at Debhata and Kaliganj upazila in Satkhira district.

SEED PRODUCTION OF PARENTAL LINES AND HYBRIDS

CMS line multiplication of released hybrids

Seed yield of 470 kg/plot (0.94 t/ha), 315 kg/plot (0.93 t/ha), 10.3 kg/plot (1.03 t/ha) and 7.8 kg/plot (1.3 t/ha) were obtained from BRRI11A, IR79156A, BRRI74A and BRRI120A respectively in T. Aman season 2022 (Table 17). Seed yield was very poor due to pollen was washed out for continuous heavy rain during supplementary pollination period.

On the other hand, in Boro 2022-23, CMS seed yield of 58 kg (0.45 t/ha), 598 kg (1.40 t/ha), 244

kg (1.16 t/ha), 419 (1.23 t/ha), 1,352 kg (1.99 t/ha) and 421 (1.91 t/ha) were obtained from BRRI10A, BRRI11A, IR58025A, BRRI7A, IR79156A and BRRI99A, respectively (Table 18). Seed yield was poor due to high temperature at flowering time.

Table 17. CMS lines multiplication of BRRI11A, IR79156A, BRRI74A and BRRI120A in T. Aman 2022.

Combinations	Plant height (cm)		50% flowering date		PER (%) kg /plot	OCR (%) (t/ha)	Yield		Remark
	A line	B line	A line	B line					
BRRI11A/B	90	94	82	80	78	30	470	0.94	Poor seed yield due to rainfall during supplementary pollination
IR79156A/B	93	97	85	83	79	31	315	0.93	
BRRI74A/B	98	103	80	77	80	33	10.3	1.03	
BRRI120A/B	97	100	79	77	80	32	7.8	1.30	

DS: B₁=08 Jul 2022, A/B₂=11 Jul 2022, B₃=14 Jul 2022; DT: = 01 Aug 2022

DS: B₁= 03 Jul 2022, A/B₂=06 Jul 2022, B₃=09 Jul 2022; DT: = 27 Jul 2022

DS: B₁= 05 Jul 2022, A/B₂=08 Jul 2022, B₃=11 Jul 2022; DT: = 29 Jul 2022

DS: B₁= 15 Jul 2022, A/B₂=18 Jul 2022, B₃=21 Jul 2022; DT: =14 Aug 2022

PER=Panicle exertion rate, OCR= Out crossing rate.

Table 18. CMS multiplication of BRRI hybrid dhan2, BRRI hybrid dhan3, BRRI hybrid dhan4, BRRI hybrid dhan5 and BRRI hybrid dhan6 during Boro 2022-23.

Designation	Plant height (cm)		50% flowering (days)		PER (%)	OCR (%)	Plot area (m ²)	Yield (kg/ plot)	Seed yield (t/ha)
	A line	B line	A line	B line	A line	A line			
BRRI10A/B	86	88	125	122	78.0	38.0	1300	58	0.45
BRRI11A/B	95	99	120	118	82.34	39.9	4000	598	1.40
IR58025A/B	84	87	123	120	77.3	38.0	1500	244	1.16
BRRI7A/B	94	97	120	117	78.0	38.3	3400	419	1.23
IR79156A/B	88	91	123	121	83.0	43.5	6800	1352	1.99
BRRI99A/B	85	89	126	123	84.3	42.4	2200	421	1.91

DS: B₁ = 02 Dec 2022; A/B₂ = 05 Dec 2022; B₃ = 08 Dec 2022; DT: = 13 Jan 2023; DS: B₁ = 07 Dec 2022; A/B₂ = 10 Dec 2022; B₃ = 13 Dec 2022; DT: = 11 Jan 2023; DS: B₁ = 05 Dec 2022; A/B₂ = 08 Dec 2022;

B₃ = 11 Dec 2022; DT: = 08 Jan 2023; DS: B₁ = 30 Nov 2022; A/B₂ = 03 Dec 2022; B₃ = 06 Dec 2022; DT: = 05 Jan 2023; DS: B₁ = 10 Dec 2022; B₂/A = 13 Dec 2022; B₃ = 16 Dec 2022; DT: = 17 Jan 2023; PER = Panicle Exertion Rate, OCR = Out Crossing Rate.

F₁ seed production of BRRI hybrid dhan5 and BRRI hybrid dhan7 in Boro 2022-23

A total of 208 kg (0.800 t/ha) from BRRI hybrid dhan5 and 370 kg (1.40 t/ha) from BRRI hybrid dhan7 (Table 19). Seed set was poor due to high temperature (> 37°C) at flowering time hampered

pollination. Seed yields were obtained 295 kg/plot (1.18 t/ha) and 313 kg/plot (1.30 t/ha) from IR79156A /BRRI20R and BRRI99A/BRRI37R combinations (Table 20). Seed yield was poor due to high temperature at flowering time (>37°C) hampered pollination.

Table 19. F₁ seed production of BRRI hybrid dhan5 and BRRI hybrid dhan7 during Boro 2022-23.

Hybrid	Plant height (cm)		50% flowering date		PER (%)	OCR (%)	Yield	
	A line	R line	A line	R line			kg/plot	t/ha
BRRI hybrid dhan5	87	98	123	139	80	28	208	0.80
BRRI hybrid dhan7	90	100	124	131	87	27	370	1.40

DS: R₁ = 16 Nov 2022; R₂ = 23 Nov 2022; A = 12 Dec 2022; DT: R = 21 Dec 2022; A = 12 Jan 2023.

DS: R₁ = 27 Nov 2022; R₂ = 30 Nov 2022; A = 06 Dec 2022; DT: R and A = 06 Jan 2023

PER (%) = panicle exertion rate, OCR (%) = Out crossing rate

Table 20: F₁ seed production of BRRI hybrid dhan6 and BRRI hybrid dhan8, Boro 2022-23.

Combination	Plant height (cm)		50% flowering date		PER (%)	OCR (%)	Yield		
	A line	R line	A line	R line			kg/plot	Plot size (m ²)	t/ha
IR79156A/BRRI20R	98	102	18	130	77	40	295	2500	1.18
BRRI99A/BRRI37R	97	102	119	129	81	47	313	2400	1.30

DS: R₁ = 28 Nov 2022; R₂ = 03 Dec 2022; A = 12 Dec 2022; DT: R = 04 Jan 2023; A = 14 Jan 2023

DS: R₁ = 27 Nov 2022; R₂ = 02 Dec 2022; A = 07 Dec 2022; DT: R = 03 Jan 2023; A = 07 Jan 2023

F₁ seed production through contract growers

We had F₁ seed production programme in Ishwardi and Barishal through contract growers during Boro 2022-23. We got 962 kg (0.96 t/ha) of BRRI hybrid dhan2, 3,510 kg (1.3 t/ha) of BRRI hybrid dhan3, 1,500 kg (1.5 t/ha) of BRRI hybrid dhan4, 2,728 kg (0.97 t/ha) of BRRI hybrid dhan5, 5,700 kg (2.04 t/

ha) of BRRI hybrid dhan6, 4,620 kg (2.31 t/ha) of BRRI hybrid dhan7 and 3,872 kg (1.94 t/ha) seeds of BRRI hybrid dhan8 from Ishwardi, Pabna (Table 21). From Barishal 3,640 kg (1.82 t/ha) of BRRI hybrid dhan3 and 900 kg (1.13 t/ha) of BRRI hybrid dhan5 seeds were received (Table 22).

Table 21. F₁ seed production of BRRI developed hybrids through contract grower during Boro 2022-23.

Combination	Contract grower	Location	Seed yield (kg)	Area (m ²)	Seed yield (t/ha)	Remark
BRRI hybrid dhan2	AUS Bangla Agro	Ishwardi	962	10000	0.96	Less seed due to high temperature at flowering stage & shattering for hail storm
BRRI hybrid dhan3	AUS Bangla Agro	Ishwardi	3510	28000	1.25	Less seed due to high temperature at flowering stage & shattering for hail storm
BRRI hybrid dhan4	AUS Bangla Agro	Ishwardi	1500	10000	1.50	Good
BRRI hybrid dhan5	AUS Bangla Agro	Ishwardi	2728	28000	0.97	Less seed due to high temperature at flowering stage & shattering for hail storm
BRRI hybrid dhan6	AUS Bangla Agro	Ishwardi	5700	28000	2.04	Good
BRRI hybrid dhan7	AUS Bangla Agro	Ishwardi	4620	20000	2.31	Good
BRRI hybrid dhan8	AUS Bangla Agro	Ishwardi	3872	20000	1.94	Good
Total=			22892	144000 (36 Acre)		

Table 22. F₁ seed production of BRRI developed hybrids through contract grower during Boro 2022-23 from Barishal.

Combination	Contract grower	Location	Seed Yield (kg)	Area (m ²)	Seed yield (t/ha)	Remark
BRRI hybrid dhan3	Md Jalal Akand	Babuganj, Barishal	3640	20,000	1.82	Less seeds due to high temperature at flowering stage
BRRI hybrid dhan5	Md Jalal Akand	Babuganj, Barishal	900	8,000	1.13	
Total =			4,540	28,000 (7 Acre)		

Dissemination of Hybrid rice technology

In T. Aman 2022, Hybrid Rice Division supplied 8,446 kg of parental lines and F₁ seeds to 90 farmers, 13 seed companies, scientists, extension people, projects and staffs of BRRI (Table 23). In Boro 2022-23, Hybrid Rice Division supplied 21,606 kg of parental lines and F₁ seeds to 130 farmers, 24 seed companies, scientists, extension

people, projects and staffs of BRRI (Table 24). In T. Aus 2022, 4,370 kg F₁ seeds of BRRI hybrid dhan7 was distributed free of cost among farmers through different regional stations of BRRI and the department of Agricultural Extension. Twenty-three stakeholders produced more than 334 MT F₁ seeds using BRRI developed hybrid rice parental lines during Boro 2022-23 (Table 25).

Table 23. Amount of parental line and hybrid seeds supplied to different organization during T. Aman 20

	Recipient	No.	F ₁ (kg)	A line (kg)	B line (kg)	R line (kg)
	Seed Companies	13	800	80	-	30
	Farmers	90	1510	-	-	-
	BRRI scientists + staffs	25	1250	-	-	-
	BRRI, R/S (5)+DAE	27	4886	-	-	-
Total		155	8446	80	-	30
Aus 2022						
01	BRRI, RS (5)+DAE		4370			
Grand Total			12916 Kg			

Investigator: All staff of Hybrid Rice Division.

Table 24. Amount of parental line and hybrid seeds supplied to different organizations.

Recipient	Nos.	F ₁ (kg)	A line (kg)	B line (kg)	R line (kg)
Seed Companies	24	1250.0	3290	-	1222
Farmers	130	1500.0	130	-	35
BRRI Scientists + staffs	19	2000.0	-	-	-
BRRI R/S (5) +DAE	6	12000.0	-	-	-
Total	179	16750	3420	0.00	1257
Grand Total		21606.0			

Investigators. All staff of Hybrid Rice Division.

Table 25. Seed production activities of BRRI developed hybrids during Boro 2022-23 both at private and public sectors.

Name of the organization/ person	Location	Var	Supplied Parental lines (Kg)		Area (acre)	Yield achieved (ton)	Remark
			A Line	R Line			
JF Agro Private Ltd. Savar, Dhaka. Md. Jama- luddin, Chairman. Mob. 0196877336	S h e r p u r , Bogura	BHD3	120	45	15	12.0	Experienced
		BHD5	100	30	10	7.0	
		BHD6	100	30	10	9.0	
Seed Care Crop Science Pro- prietary: Md Juwel, D-09, Bank Colony, Savar Mob. 01968773337	Sherpur Bogura	BHD3	40	15	05	4.0	Experienced
		BHD5	50	15	05	3.5	
		BHD6	50	15	05	4.3	
Babylon Agro & Dairy Ltd. 2B/1, Darussalam Road, Mirpur, Dhaka-1216. Mob. 01710327720	Ishwardi, Pabna	BHD3	400	150	50	45	Experienced
		BHD7	10	03	01	0.7	
Supreme Seed Company	Muktagasha, Mymensingh	BHD5	50	15	05	3.5	Experienced
American advanced Agro Ltd. Proprietor Kbd Kamrul Haque Mouchak Tower, Malibagh Mob. 01720053768	Muktaghacha, Mymensingh	BHD3	100	45	15	12.0	Experienced
		BHD6	200	75	25	25.5	
		BHD7	50	18	06	6.5	
M/S Agriculture crop seeds. Tatalpur, Sherpur Proprietor: Md Moklesur Rahman	Muktaghacha, Mymensingh	BHD3	20	06	02	1.5	Experienced
		BHD4	16	06	02	1.4	
		BHD5	20	06	02	1.5	
M/S Champion Seeds Md Alimul Raji; Sreebordi; Sherpur. Mob. 01710257702	Madhapur	BHD3	20	06	02	1.5	Experienced
		BHD4	16	06	02	1.4	
		BHD5	20	06	02	1.5	
Bagro Company Ltd. House No# 17, R#09, Uttra Proprietor: M R Ibne Aziz Managing Director Mob. 01711479884	Muktaghacha, Mymensingh	BHD6	200	70	25	23.5	Experienced
Thailand Agro Seeds Vite Proprietor: Md Alamin Ho- que. Kandi, Fulpur, Mymens- ingh Mob. 01719464815	Muktaghacha, Mymensingh	BHD2	45	15	5	4.5	Experienced
Abdur Rahman Agro Compa- ny. Muktagasha Proprietor: Md Abdur Barek Mob.01978424141/ 01766688323	Muktaghacha, Mymensingh	BHD3	80	30	10	9.0	Experienced
		BHD6	120	45	15	13.5	
		BHD2	24	09	03	2.5	
Mirtika Agro Vision Proprietor: Mirthonjoy Roy Executive Director Rangpur. Mob. 01752084181	Sherpur, Bogura	BHD3	40	15	05	4.2	Experienced
Aus Bangla Agro Gohail Road, Mission gate, Bogura. Kbd. Mosharrof Hossain, PM Mob. 01716444502	Ishwardi, Pabna	BHD3	160	60	20	18.0	Experienced

Name of the organization/ person	Location	Var	Supplied Parental lines (Kg)		Area (acre)	Yield achieved (ton)	Remark
			A Line	R Line			
Bangladesh Agricultural De- velopment Corporation	Meherpur Chaudanga	BHD7	240	90	30	27.3	Experienced
		BHD5	50	21	07	3.2	
Ahasan seeds & Agrotech Gaffargaon, Mymensingh Mob. 01734414647	Muktaghacha, Mymensingh	BHD2	18	06	02	1.5	Experience
		BHD3	18	06	02	2.2	
		BHD4	09	03	01	0.5	
		BHD6	150	45	15	13.5	
		BHD7	09	03	01	0.8	
Usha Agro Ltd. Proprietor: Md A Khaleque	Muktaghacha, Mymensingh	BHD3	40	15	05	3.0	Experimental
Raja Seed Company Md Aminul Islam Razzak Pirghacha, Rangpur Mob. 01713792560	Rangpur	BHD2	09	03	01	0.7	Experimental
		BHD6	09	03	01	0.8	
Mr Jalal Akand Babuganj Mob. 01770674655	Babuganj Barishal	BHD3	40	15	05	3.6	Experienced
		BHD5	18	06	02	0.9	
Monjil Seed Company Ishwardi, Pabna Mob. 01733137743	Ishwardi Pabna	BHD3	80	30	10	6.5	Experienced
		BHD5	80	30	10	6.0	
Aus Bangla Agro Gohail Road, Mission gate, Bogura. Mob. 01716444502 Contract growers	Patirajpur, Ishwardi, Pabna	BHD2	20	08	2.5	0.96	Experienced
		BHD3	56	21	07	3.5	
		BHD4	20	08	2.5	1.5	
		BHD5	56	21	07	2.7	
		BHD6	56	21	07	5.7	
		BHD7	40	15	05	4.6	
		BHD8	40	15	05	3.9	
		BHD5	07	03	0.6	0.2	
Hybrid Rice Division, BRRI	Gazipur	BHD6	07	03	0.3	0.3	Experienced
		BHD7	07	03	0.3	0.3	
		BHD8	07	03	0.4	0.4	
Explore Business Ltd. Proprietor: Kbd. Md. Abbas Ali. H#16, R#04, B#B, Kaderabad Housing, Moham- madpur. Mob. 01713041395	Sherpur Bogura	BHD6	80	30	10	8.0	Experienced
Metal Seeds Ltd. PBL Tower; Gulshan, Circle-2, Dha- ka-1212	Sreepur, Gazipur	BHD6	24	09	03	2.5	Experienced
		BHD7	80	30	10	8.0	
Aftab Bhumukhi Farms Ltd. Banani, Dhaka Mob. 01755532275	Bazitpur Kishoreganj	BHD3	08	03	01	0.7	Experienced
		BHD5	08	03	01	0.6	
		BHD7	08	03	01	0.8	
Wazuddin, Chokoria, Cox's Bazar. Mob. 01300041321	Chokoria	BHD3	24	09	03	2.5	Experienced
Total l=			3369	1220	405.6	334.66	

Legend: BHD1= BRRI hybrid dhan1, BHD2 = BRRI hybrid dhan2, BHD3 = BRRI hybrid dhan3, BHD4 = BRRI hybrid dhan4, BHD5 = BRRI hybrid dhan5, BHD6 = BRRI hybrid dhan6, BHD7= BRRI hybrid dhan7

AGRONOMY DIVISION

108	SUMMARY
108	Planting Practices
118	Soil Health Improvement
120	YIELD MAXIMIZATION GOOD AGRICULTURAL PRACTICE (GAP)
121	WEED MANAGEMENT
124	SOIL MICROBIOLOGY AND MANAGEMENT
126	Molecular Trait Management

SUMMARY

To achieve a significant yield advantage submergence tolerance genotype IR16F1148 should preferably be transplanted from 20 July to 5 August. When BRRI dhan88 and BRRI dhan89 are transplanted after 5 January the average daily yield losses are 86 and 93 kg ha⁻¹, respectively. So BRRI dhan88 and BRRI dhan89 should preferably be transplanted on 5 January. Additional use of crop residue (30 cm) and vermicompost (2 t ha⁻¹) increases microbial population, nitrogen mineralization, and grain yield in rice. BRRI dhan87 and BRRI dhan95 produced the highest grain yield 5.51 tha⁻¹ and 5.10 tha⁻¹ on STB + 20% and STB treatment, respectively. On the other hand, in Boro season, BRRI dhan92 and BRRI dhan96 produced the highest grain yield 7.66 and 6.97 t ha⁻¹ on STB + 10% and STB treatment, respectively. In 65 mM salinity level BRRI dhan49 produced 16.3% higher yield with 250 ppm chitosan spray. Exogenous application of chitosan significantly improved the growth, and ameliorated the adverse effects of salt stress on rice by decreasing the Na⁺/K⁺ ratio and 45% higher yield of BRRI dhan67 in response to salt stress. In T. Aman season N @ 120 kg ha⁻¹ applied in basal (25%) +AT (25%) +MT 25% + BPI 25%) produced higher grain yield (6.67t ha⁻¹) in BRRI hybrid dhan6. But in Boro season, 150 kg N ha⁻¹ with basal (20%) +AT 30% +MT (30%) +booting stage (20%) produced the highest grain yield (8.53 t ha⁻¹) in BRRI hybrid dhan5. T. Aus, T. Aman-Potato-Mungbean cropping pattern showed a higher number of total bacterial population (3.05×10⁶ cfu/g dry soil over the Boro-fallow-T. Aman cropping pattern. So, crop diversification increases soil fertility when proper agronomic management was given. The highest grain yield was observed in BRRI dhan100×GAPs (8.02 t ha⁻¹) followed by BRRI hybrid dhan5 with

GAPs. Different weed species in weed seed bank was higher in 0-5 and 5-10 cm depth in September and October. The cyperaceous family was the dominant species. Herbicide treatment and tillage before flowering of weeds slightly reduces the density of weeds. New molecule herbicide showed better weed control efficiency (>80%) in both T. Aman and Boro season. The herbicides Penoxulam control Azolla at first stage but later stage 2,4-D Amine performed better to control azolla. The bacterial isolates Sat-2, Sat-4, Sat-5 and Sat-6 are potential salt-tolerant PGPR strains found in Satkhira district. Among the four tested bacterial strains only Sat-2 could be considered a salt-tolerant strain which can significantly contribute to reducing the salinity stress of rice at the seedling stage.

Scientific Information

PLANTING PRACTICES

Effect of planting time on the yield of submergence tolerance PVT genotype

The experiment was conducted at the BRRI farm, Gazipur during the T. Aman, 2022 season. One PVT genotype (IR16F1148) along with two check varieties (BRRI dhan71 and BINA dhan11) were used as test materials. The 20-day-old rice seedlings were transplanted in the field at six scheduled times (20 June, 5 July, 20 July, 5 August, 20 August, and 5 September). The tested materials yielded low transplanted on 20 June due to severe bird damage (**Table 1**). The PVT genotype IR16F1148 produced higher grain yield than the tolerant check BINA dhan11 in all the transplanting dates except 20 August and 5 September. IR16F1148 yielded the highest with 121 days growth duration as transplanted on 20 July. In conclusion, to achieve an appreciable better yield, IR16F1148 should preferably be transplanted on 20 July to 5 August.

Table 1. Effect of planting time on the yield of submergence tolerance PVT genotype

Variety	Date of transplanting											
	20 Jun		5 Jul		20 Jul		5 Aug		20 Aug		5 Sep	
	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (tha ⁻¹)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)	Yield (t/ha)	GD (Day)
IR16F1148	1.09	128	4.98	121	6.51	121	6.25	119	5.78	112	4.58	115
BRRI dhan71(ck)	1.63	125	5.65	119	5.94	116	6.40	113	6.33	107	5.32	111

BINA dhan11(ck)	0.61	119	3.13	112	5.02	112	5.49	108	5.99	106	5.12	110
LSD _(0.05)	1.52	7.27	2.18	2.26	0.86	1.30	1.13	0.17	1.16	1.30	0.95	1.30
CV (%)	21.0	2.6	15.7	0.9	6.60	0.5	8.40	0.0	8.50	0.5	8.40	0.5

Yield Loss Assessment of rice under late planting condition

The experiment was conducted at BRRI farm, Gazipur during Boro season 2022-23. The 35-day-old seedlings of BRRI dhan88 and BRRI dhan89 were transplanted in the field on eight scheduled times at a 15-day interval, starting on 20 November 2022. It was a factorial experiment conducted in a split-plot design with three replications. Planting time significantly influenced the grain yields, and the highest yields of both the varieties were observed as transplant on 5 January (**Table 2**). **Fig. 1** shows the crop growth duration response to mean seasonal temperature. The growth duration

of BRRI dhan88 and BRRI dhan89 decreased by 16 and 11 days, respectively, per 1°C temperature rise. Elevated temperatures directly affected the grain yield of BRRI dhan88 and BRRI dhan89. A strong relationship was found between the number of days exposed to high temperatures (>30°C) and grain yield. The highest grain yield was found when BRRI dhan88 and BRRI dhan89 exposed to high temperatures (>30°C) for 53 and 74 days, respectively (**Fig. 2**). A clear relationship was observed between later plantings and reduced yields. When BRRI dhan88 and BRRI dhan89 are transplanted after 5 January the average daily yield losses are 86 and 93 kg ha⁻¹, respectively (**Fig. 3**).

Table 2. Effect of planting time on the yield of BRRI dhan88 and BRRI dhan89.

Variety	Grain Yield (t/ha)							
	Date of transplanting							
	20 Nov	5 Dec	20 Dec	5 Jan	20 Jan	5 Feb	20 Feb	5 Mar
BRRI dhan88	3.46	4.47	6.58	7.61	5.96	4.35	3.36	2.41
BRRI dhan89	4.34	5.70	7.38	8.45	6.49	5.10	4.17	2.59
LSD _(0.05)	3.51	0.99	1.89	0.44	1.50	1.89	0.82	3.57
CV (%)	12.5	5.6	7.8	1.6	7.0	11.6	6.3	11.2

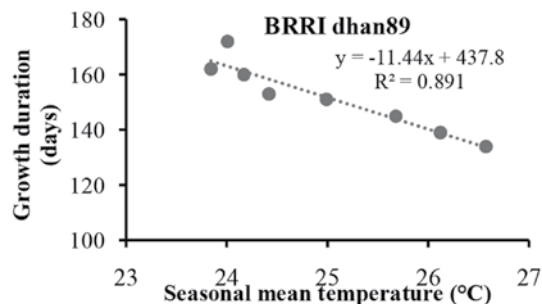
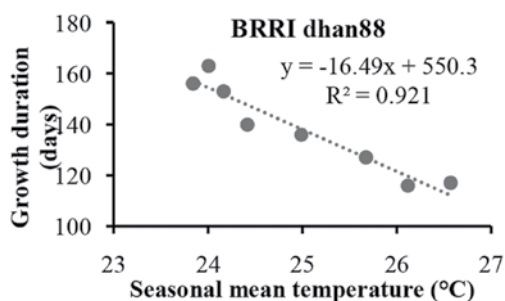


Fig. 1. Relationship between seasonal mean temperature and growth duration of BRRI dhan88 and BRRI dhan89.

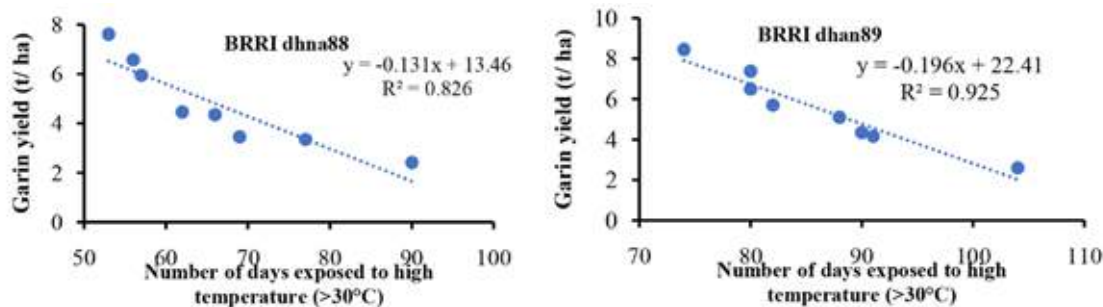


Fig. 2. Relationship between number of days exposed to number of days exposed to high temperature (>30°C) and grain yield of BRRi dhan88 and BRRi dhan89.

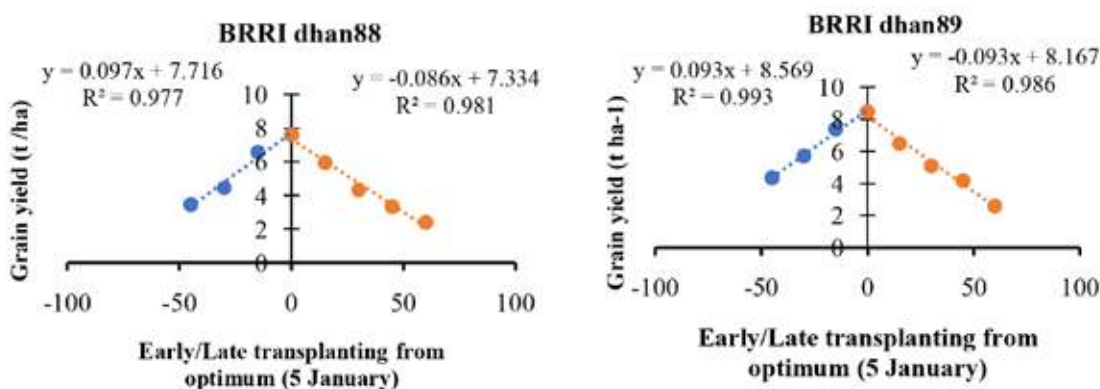


Fig. 3. Relationship between grain yields of BRRi dhan88 and BRRi dhan89 to early/late transplanting.

FERTILIZER MANAGEMENT **Effect of organic and inorganic source of nutrients on nitrogen mineralization, microbial population and rice yield**

The experiment was conducted in the Boro season, 2022-23 at Bangladesh Rice Research Institute (BRRi) farm, Gazipur to find out the best organic material management practice to improve soil health and rice yield. The treatments were i) BRRi recommended dose (BRD), ii) BRD + Crop residue- 30 cm (CR), iii) BRD + Vermicompost- 2 t ha⁻¹ (VC) and iv) BRD + Crop residue- 30 cm (CR) + Vermicompost- 2 t ha⁻¹. Total bacteria and fungus were found the highest in number in the treatment

BRD + CR + VC. The treatment BRD + VC gave higher microbial population than BRD + CR (Fig. 4). Ammonium and nitrate content in soil also found higher where vermicompost and crop residue were applied with BRRi recommended dose (Table 3). The treatment BRD + CR + VC produced 8.3% and 8.1% higher panicle m⁻² and grain yield than BRD, respectively (Table 4). Integrated nutrient management involving conjunctive use of organic, inorganic and crop residues improve the soil productivity. Additional use of crop residue (30 cm) and vermicompost (2 t ha⁻¹) increases microbial population, nitrogen mineralization and also grain yield in rice.

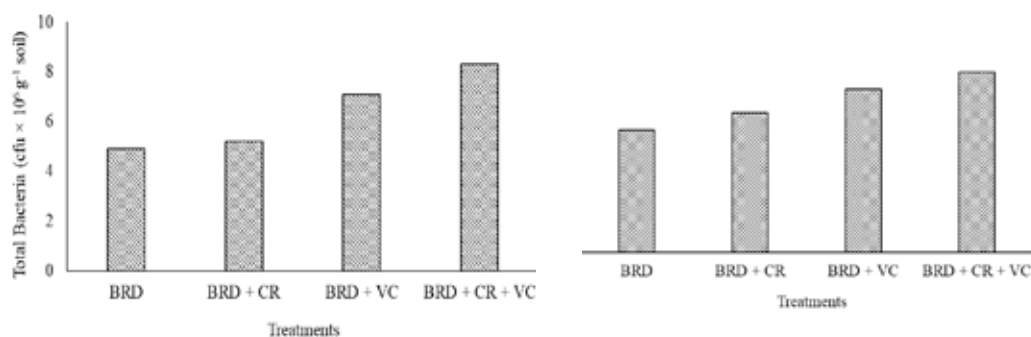


Fig. 4. Effect of organic and inorganic source of nutrients on total bacteria and fungus in soil
BRD=BRRI Recommended dose, CR = Crop residue (30cm), VC = Vermicompost (2 t ha⁻¹)

Table 3. Effect of organic and inorganic source of nutrients on NH₄⁺ and NO₃⁻ content in soil in Boro 2022-23, BRRI, Gazipur.

Treatment	NH ₄ ⁺ content (mg kg ⁻¹)	NO ₃ ⁻ content (mg kg ⁻¹)
BRD	36.2	11.2
BRD + CR	39.1	12.1
BRD + VC	42.4	12.5
BRD + CR + VC	45.3	13.4
LSD _(0.05)	5.14	1.13
CV%	2.92	1.03

Table 4. Effect of organic and inorganic source of nutrients on yield and ancillary characters of rice in Boro 2022-23, BRRI, Gazipur.

Treatments=	Panicle m ⁻²	Grain panicle ⁻¹	1000 GW (g)	Yield (t ha ⁻¹)
BRD	217	118	23.8	5.94
BRD + CR	229	119	23.8	6.27
BRD + VC	219	120	23.9	6.20
BRD + CR + VC	235	116	24.1	6.42
LSD _(0.05)	7.91	NS	NS	0.17
CV%	1.76	2.97	0.58	1.38

Effect of N levels and growth stage-based N application on growth, yield and nitrogen use efficiency in rice

The experiment was conducted at BRRI HQ farm, Gazipur, during T. Aman 2022 to find out the influence of growth stage-based nitrogen application on growth and rice yield. The treatments were; A: Nitrogen level (kg ha⁻¹): N₁: STB (78 kg ha⁻¹), N₂: BRRI recom. (92 kg ha⁻¹), N₃: STB + 10% (86 kg ha⁻¹), N₄: STB + 20% (94 kg ha⁻¹), T₅: Control (0 N);

and B. Varieties: V₁: BRRI dhan87 and V₂: BRRI dhan95. During Boro season the treatments were; A: Nitrogen level (kg ha⁻¹): N₁: STB (V₁=147 kg ha⁻¹, V₂=118 kg ha⁻¹), N₂: BRRI recom. (V₁=138 kg ha⁻¹, V₂=120 kg ha⁻¹), N₃: STB + 10% (V₁=161 kg ha⁻¹, V₂=130 kg ha⁻¹), N₄: STB + 20% (V₁=176 kg ha⁻¹, V₂=141 kg ha⁻¹), T₅: Control (0 N) and B.

Varieties: V₁: BRRi dhan92 and V₂: BRRi dhan96. Urea was applied 1st top dress at 1st tillering; 2nd top dress at mid tillering and 3rd top dress before PI stage. BRRi dhan87 and BRRi dhan95 produced the highest grain yield 5.51 t ha⁻¹ and 5.10 t ha⁻¹ on STB + 20% and STB treatment, respectively (Table 5). It is observed from Table 6 that the highest N

uptake was in STB + 10% and BRRi recommended dose treatment of BRRi dhan92 and STB + 10% treatment of BRRi dhan96 in both grain and straw. BRRi dhan92 and BRRi dhan96 produced the highest grain yield 7.66 t/ha and 6.97 t ha⁻¹ on STB + 10% and STB treatment, respectively (Table 6). BRRi dhan92 required more nitrogen than BRRi recommended dose.

Table 5. Effect of nitrogen levels on yield of BRRi dhan87 and BRRi dhan95 during T. Aman 2022 at BRRi farm, Gazipur.

Variety	Nitrogen rate	Panicle m ⁻²	Grain yield (t ha ⁻¹)
BRRi dhan87	STB	228	4.63
	BRRi recom. dose	250	5.31
	STB + 10%	216	4.97
	STB + 20%	255	5.51
	N ₀	164	2.98
BRRi dhan95	STB	234	5.10
	BRRi recom. dose	227	4.76
	STB + 10%	229	4.86
	STB + 20%	225	4.82
	N ₀	187	3.39
LSD _(0.05)		12.24	0.53
CV(%)		3.22	6.78

Table 6. Effect of Nitrogen levels on yield of BRRi dhan92 and BRRi dhan96 during Boro, 2022-23 at BRRi farm, Gazipur.

Treatment	N rate	Panicle m ⁻²	Grain yield(t ha ⁻¹)
BRRi dhan92	STB	275	7.17
	BRRi recom. dose	268	6.92
	STB + 10%	289	7.66
	STB + 20%	264	6.77
	N ₀	193	3.59
BRRi dhan96	STB	294	6.97
	BRRi recom. dose	283	6.71
	STB + 10%	280	6.64
	STB + 20%	276	6.54
	N ₀	191	3.34
LSD _(0.05)		20.12	0.70
CV(%)		4.48	6.58

Effect of foliar application of chitosan on growth, yield and physio-biochemical characteristics of rice under salinity stress

A pot experiment was conducted at rain-out shelter of Agronomy Division, BRRI, Gazipur in T Aman 2022. The pots were set as split-split design with three replications. The main plots represented two salinity levels; i. 0 mM NaCl, ii. 65 mM NaCl. Sub-plots represented two concentrations of chitosan; i. 0 ppm, ii. 250 ppm. Sub-sub-plots represented two variety of rice; i. BRRI dhan49 (salt sensitive), ii.

BRRI dhan73 (salt tolerant). Chitosan was sprayed two times at active tillering and at heading stages. Fig. 5 shows the sodium and potassium ratio of selected rice varieties in grain and straw. The ratio was lower in chitosan treated rice varieties in both grain and straw. The grain wt. was lower in both the varieties and Chitosan application did not influence the grain wt. (Table 7).

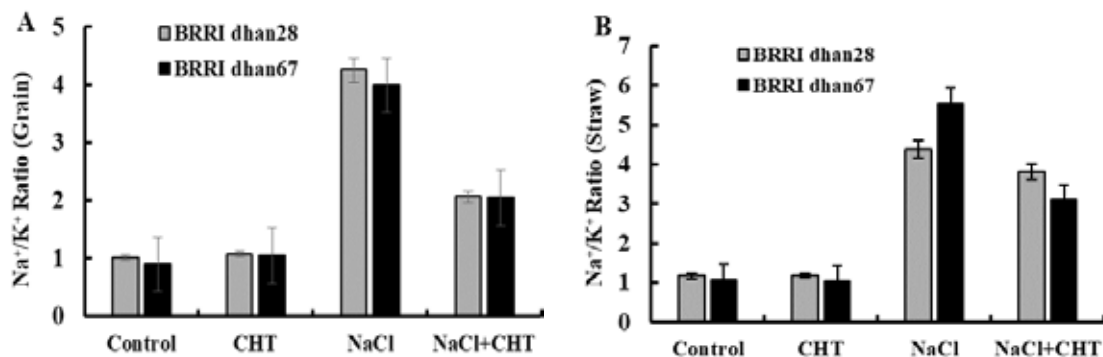


Fig. 5. Na⁺/K⁺ ratio in grain and straw (A, B) at maturity stage in the two rice cultivars under salinity stress. Vertical bars represent LSD_(0.05)

Table 7. Effect of salinity and Chitosan spray on growth and yield components of BRRI dhan49 and BRRI dhan73 in T. Aman 2022, BRRI, Gazipur.

Salinity level	Chitosan spray	Variety	Panicle hill ⁻¹	Grains panicle ⁻¹	1000 GW (g)	Yield (g ⁻¹ pot)
0 mM	0 ppm	BRRI dhan49	23	131	18.2	55.2
		BRRI dhan73	16	167	20.6	54.3
	250 ppm	BRRI dhan49	22	141	17.1	52.2
		BRRI dhan73	18	166	20.2	55.6
65 mM	0 ppm	BRRI dhan49	17	99	18.6	34.4
		BRRI dhan73	10	104	21.1	27.0
	250 ppm	BRRI dhan49	23	114	18.2	43.4
		BRRI dhan73	18	123	19.5	38.2
LSD _(0.05)			3.80	21.8	NS	8.29
CV%			11.5	9.4	10.2	10.4

Application of chitosan to improve salt tolerance of rice in the Boro season

A pot experiment was conducted at rain-out shelter of Agronomy Division, BRRI, Gazipur in Boro 2022-23. The pots were set as split-split design with three replications. The main plots represented two salinity levels; i. 0 mM NaCl, ii. 65 mM NaCl. Sub-plots represented two concentrations of chitosan; i. 0 ppm, ii. 250 ppm. Sub-sub-plots represented two

variety of rice; i. BRRI dhan28 (salt sensitive), ii. BRRI dhan67 (salt tolerant). Chitosan was sprayed two times at active tillering and at heading stages. Significant increases in Na⁺/K⁺ ratio in grain and straw of both the varieties were observed in response to salt stress. On the contrary, chitosan application showed a significant decrease in grain Na⁺/K⁺ ratio

in both the varieties' response to salt stress (Fig. 6). In saline condition, yield reduction was found in both the varieties. Higher sterility (48%) was

found in BRRI dhan28 than BRRI dhan67 for all treatment combinations. In 65 mM salinity level BRRI dhan67 produced 45% higher yield with 250 ppm chitosan spray than without spray (Table 8).

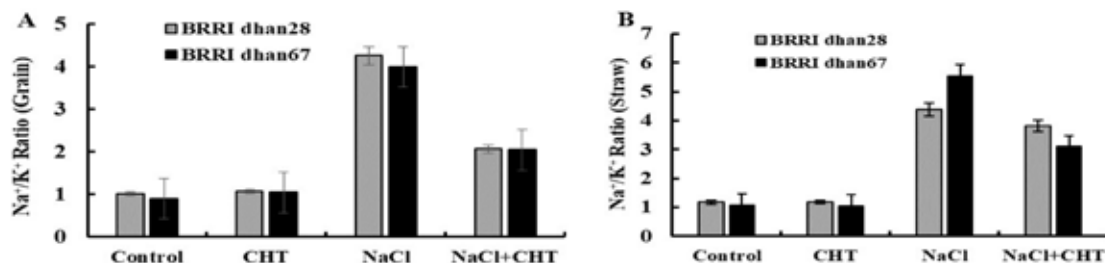


Fig. 6. Na⁺/K⁺ ratio in grain and straw (A, B) at maturity stage in the two rice cultivars under salinity stress. Vertical bars represent LSD_(0.05).

Table 8. Effect of salinity and chitosan spray on growth and yield components of BRRI dhan28 and BRRI dhan67 in Boro 2022-23, BRRI, Gazipur.

Salinity level	Chitosan spray	Variety	Grains panicle ¹	1000 GW (g)	Yield (g pot ¹)	Sterility%
0 mM	0 ppm	BRRI dhan28	119	18.19	53.7	17.9
		BRRI dhan67	128	18.73	52.5	9.2
	250 ppm	BRRI dhan28	108	18.35	49.7	16.6
		BRRI dhan67	136	17.79	48.0	8.8
65 mM	0 ppm	BRRI dhan28	70	12.1	7.24	48.8
		BRRI dhan67	80	14.1	11.2	47.5
	250 ppm	BRRI dhan28	81	16.15	11.7	20.6
		BRRI dhan67	93	19.07	27.7	12.3
LSD _(0.05)			34.1	3.60	8.41	17.6
CV%			18.7	12.1	14.4	43.7

Mitigation of water logging stress in T. Aman through the application of plant protectants coupled with balanced fertilization

A pot experiment was conducted at rain-out shelter of Agronomy Division, BRRI, Gazipur in T Aman 2022. The pots were set as RCB (factorial) design with three replications. Five crop managements were: CM₁ = Recommended. Fertilizer Dose (100%), CM₂ = RDF 100% + 10 μM ABA + Waterlogging stress, CM₃ = RDF 100% + 10 μM H₂O₂ + Water stress, CM₄ = RDF 100% + 5 mM GSH + Waterlogging stress, CM₅ = RDF 100% +

5 mM Proline + Waterlogging stress. BRRI dhan51 (submergence tolerant) and BRRI dhan87 were used as variety. Water logging stress were given for seven days at 25, 45, 65 and 85 DAT. Plant protectants were sprayed three times at active tillering, maximum tillering and heading stages. Higher yield was observed in BRRI dhan87 in CM₂ (RDF+ ABA with water stress) followed by CM₁ in BRRI dhan51 (Table 9). CM₁ treatment has higher N, P, K uptake at maturity stage (114, 22.3, 109 kg ha⁻¹) in BRRI dhan87 followed by BRRI dhan51 (109, 17.7, 98.6 kg ha⁻¹) (Fig. 7).

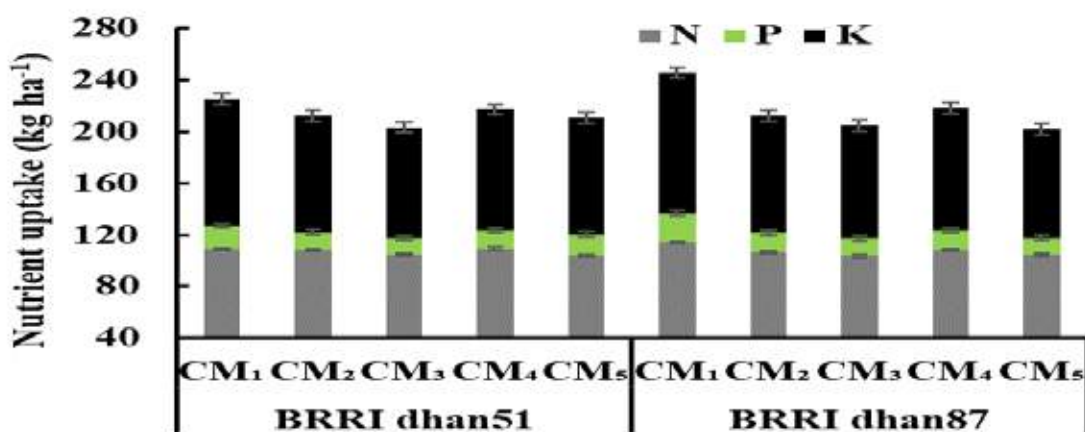


Fig. 7. Total nutrient uptake (kg ha^{-1}) of BRRI dhan51 and BRRI dhan87 influenced by different crop management, Vertical bars represent standard error (SE).

Table 9. Yield and yield components of BRRI dhan51 and BRRI dhan87 as affected by crop management at BRRI farm, Gazipur.

Variety	Crop management	Panicle hill ⁻¹	Grain panicle ⁻¹	1000 GW (g)	Yield (g pot ⁻¹)
BRRI dhan51	CM ₁	27	164	17.3	75.5
	CM ₂	25	165	16.8	69.6
	CM ₃	21	148	16.7	52.7
	CM ₄	24	151	17.2	69.8
	CM ₅	23	171	17.4	63.2
BRRI dhan87	CM ₁	25	136	20.4	55.8
	CM ₂	26	146	21.4	82.8
	CM ₃	22	109	21.1	49.6
	CM ₄	24	95	21.3	52.1
	CM ₅	20	91	20.5	37.4
LSD _(0.05) for V×CM		2.16	36.4	0.75	16.17
CV (%)		5.2	15.3	2.3	15.4

Growth stage-based nitrogen management for yield maximization of Hybrid rice in T. Aman and Boro season

To investigate hybrid rice response to different nitrogen levels and timing of application at different growth stages the experiment was conducted at BRRI farm Gazipur with the variety BRRI hybrid dhan5 (Boro) and BRRI hybrid dhan6 (T. Aman). The N Rates (Kg ha^{-1}) were 0, 50, 100, 150 and 200 for the Boro season and 0, 40, 80, 120, and 160

for the T. Aman season, respectively. In T. Aman season It is observed that (Table 10.) N applied in basal (25%) +AT (25%) + MT 25% + BPI 25%) with 120kg N ha^{-1} produced higher grain yield (6.67t ha^{-1}). Differentiating the quadratic equation of yield response with respect to applied different N doses the optimum N rate appeared as 100kg , and

109 kg ha⁻¹ and 91 kg ha⁻¹ for BRRI hybrid dhan6 with corresponding GSBNM practices, respectively (Fig. 8). In Boro season Table 11 indicates significant effect of GSBNM × N rate on the grain yield of BRRI hybrid dhan5. Among the N rates 150 kg N ha⁻¹ with basal (20%) +AT 30% +MT (30%)

+BS (20%) observed highest grain yield (8.53 t ha⁻¹). Differentiating the quadratic equation of yield response with respect to applied different N doses the optimum N rate appeared as 146, 143 and 137 kg ha⁻¹ for BRRI hybrid dhan5 with corresponding GSBNM practices, respectively (Fig. 9).

Table 11. Effect of growth stage-based N management and N rate on grain yield, straw yield and harvest index of BRRI hybrid dhan6 during T. Aman 2022 at BRRI farm, Gazipur.

Nitrogen rate (kg ha ⁻¹)	N management	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	HI
N ₀	NT ₁	3.43	4.34	0.45
N ₄₀		5.43	6.94	0.45
N ₈₀		5.72	6.17	0.47
N ₁₂₀		6.67	6.05	0.53
N ₁₆₀		5.11	5.97	0.46
N ₀	NT ₂	3.28	4.37	0.43
N ₄₀		5.13	5.65	0.47
N ₈₀		5.34	5.86	0.47
N ₁₂₀		6.02	5.74	0.51
N ₁₆₀		5.28	6.78	0.46
N ₀	NT ₃	3.37	3.96	0.46
N ₄₀		5.48	5.68	0.49
N ₈₀		5.60	5.62	0.50
N ₁₂₀		5.84	5.98	0.51
N ₁₆₀		4.50	5.97	0.43
LSD for GSBNM		ns	0.28	ns
LSD for N rate		0.38	0.37	0.26
LSD for N × GSBNM		ns	ns	ns
CV(%)		7.5	6.7	5.7

Table 12. Effect of growth stage-based N management and N rate on grain yield of BRRI hybrid dhan5 during Boro 2022-23 season at BRRI, Gazipur.

Nitrogen rate (kg ha ⁻¹)	Growth stage-based N management	Grain yield (t ha ⁻¹)
0	Basal (25%) +Active tillering stage (25%) +Mid tillering stag (25%) +Before panicle initiation (BPI) (25%)(NT1)	3.86
50		6.39
100		7.29
150		8.15
200		7.39

0	Basal (20%) +Active tillering stage (30%) +maximum tillering stage (30%) +Booting (20%) (NT2)	3.57
50		6.82
100		7.86
150		8.53
200		7.84
0	Basal (20%) +Active tillering stage (30%) +maximum tillering stage 35% + during flow- ering (15%)(NT3)	3.83
50		7.11
100		7.87
150		7.85
200		7.53
LSD for GSBNM		ns
LSD for N rate		0.38
LSD for N × GSBNM		0.58
CV(%)		5.2

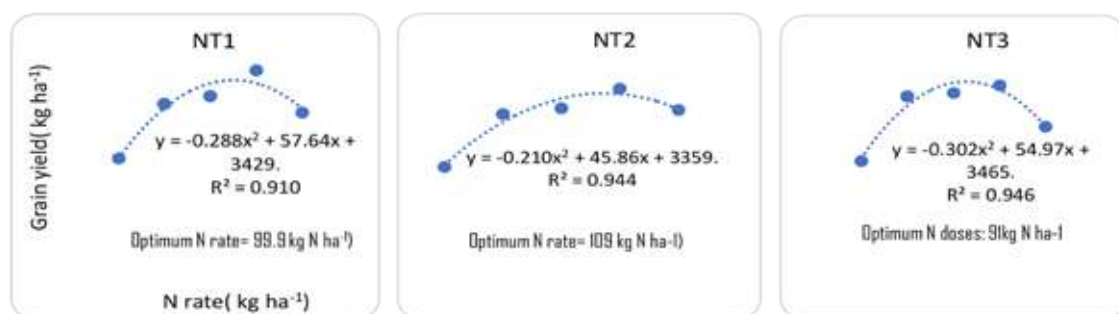


Fig. 8. Grain yield responses to growth stage-based N management and N fertilization rate and determination of optimum N doses in BRRI hybrid dhan6.

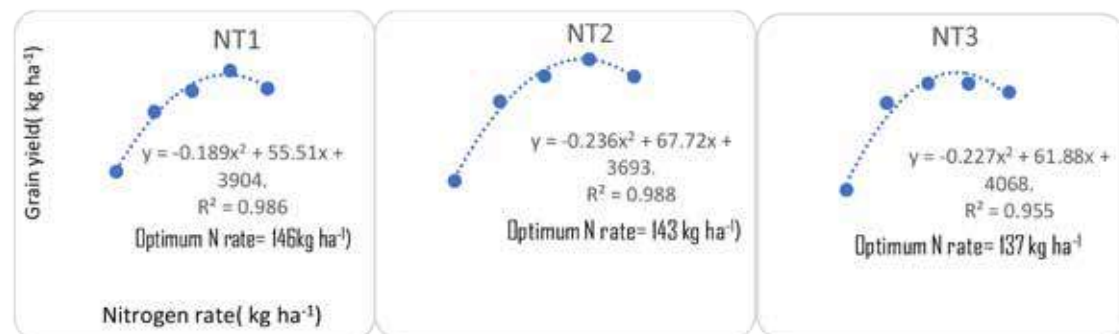


Fig. 9. Grain yield responses to growth stage-based N management and N fertilization rate and determination of optimum N doses in BRRI hybrid dhan5.

SOIL HEALTH IMPROVEMENT

Improvement of soil health in four crops pattern through agronomic management

A long-term study was under taken from 2017-18 to 2022-23 at east byde (Agronomy research field) of BRRI farm, Gazipur with the four crops cropping pattern: T. Aus (BRRI dhan48)-T. Aman (BRRI dhan87)-Potato (BARI Alu41)-mungbean (BARI Mung-6). Agronomic management was: 1. Incorporation of mungbean stubble with soil before T. Aus; 2. Incorporation of compost @ 2.0 t ha⁻¹ (dry wt. basis) with soil before potato sowing and 3. Recommended dose of chemical fertilizers was applied for all crops as per schedule. Table 12 presents the crop yield of T. Aus 2022, T. Aman 2022 and Potato. The results indicated that the yield of BRRI dhan48 (T. Aus) and BRRI dhan87 (T. Aman) are satisfactory. The potato yield was lower (21.5 t ha⁻¹) compared to previous year (2021-22). It was mainly due to a poor irrigation system, the

soil was not properly level. It was not possible to harvest mungbean because of poor germination and uneven flowering. However, the mungbean plant was incorporated with soil at flowering stage. The rice equivalent yield (REY) was 29.28 t ha⁻¹ (21.5 t ha⁻¹ potato = 19.35 t ha⁻¹ rice, Rice = Tk 20 kg⁻¹, Potato = Tk 18 kg⁻¹), which is still low. In four crops system, the REY should be more than 35 t ha⁻¹ to make it profitable and viable. The results of soil analysis show that there was an increasing trend in soil pH, P, K, S and Zn with few exceptions (Table 13) when compared with the previous year. There was very little change in soil OM and total N%. However, despite of cultivation of four crops in same land, are not harmful in terms of soil fertility the proper agronomic management is given. In T. Aus, T. Aman-Potato-Mungbean cropping pattern showed higher number of total bacterial population (3.05×10^6 cfu/g dry soil over the Boro-fallow-T. Aman cropping pattern (Fig. 10).

Table 13. Yield of different crops in four crops systems BRRI farm, Gazipur, 2022-23\

Crop	Field duration	Variety	Yield (t ha ⁻¹)	Remark
T. Aus	11 May to 06 Aug 2022	BRRI dhan48	4.68	-
T. Aman	10 Aug to 6 Nov 2022	BRRI dhan87	5.25	-
Potato	20 Nov 19 to 19 Feb 2023	BARI Alu41	21.50	REY=19.35 t ha ⁻¹
Mungbean	1 Mar 2023 (Sowing)	BARI mung6	-	Poor germination

(1 kg rice= Tk 20, 1kg potato= Tk 18)

Table 14. Comparison of initial soil status of experimental plots in four crops system, 2021-22 and 2022-23, BRRI, Gazipur.

Crop	pH		OM		Total N		P (ppm)		K (meq/100 g)		S (ppm)		Zn (ppm)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2021-22	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T. Aus	7.41	7.58	2.15	2.18	0.13	0.14	8.9	14.35	0.14	0.19	11.8	13.2	1.63	1.97
T. Aman	7.25	7.64	2.03	2.09	0.12	0.13	9.6	15.32	0.15	0.21	9.7	13.0	1.51	1.61
Potato	7.22	7.57	2.22	2.07	0.14	0.13	11.9	14.09	0.20	0.21	6.7	12.8	1.19	1.39
Mungbean	7.02	7.31	2.12	2.13	0.13	0.13	15.3	13.36	0.21	0.20	13.3	12.7	1.16	2.20



(a)



(b)

Fig. 10. Total bacterial population counted in soil collected from (a) four crops and (b) 2 crops cropping pattern.

Effect of agronomic factors for maximizing yield of BRRI developed Long Slandered Premium Quality Fine Rice-BRRI dhan70 (*Katarivog type*) through developing sustainable production management protocol in T. Aman season

The experiment was conducted at the BRRI farm, Gazipur to develop agronomic management protocol of BRR dhan70 for higher grain yield. The treatments of the experiment were as follows: Factor A: Two time of crop establishment (T): T_1 = 1 July seeding and T_2 = 15 July seeding. Factor B: Two age of seedling (A): A_1 = 15 day and A_2 = 30 day.

Factor C: Two Population density or spacing (S): S_1 = 25×25 cm (16 hill m^{-2}) and S_2 = 20×20 cm (25 hill m^{-2}). Factor D: Two fertilizer management (F): F_1 = BRRI recommended fertilizer management, F_2 = Soil test based high yield goal targeted fertilizer management. The result showed that there was significant grain yield difference in different agronomic management factor-based treatments (Fig. 11). The highest grain yields were obtained from the agronomic based treatment combination of $F_2S_1A_1T_2$ (5.89 t ha^{-1}) followed by $F_2S_1A_2T_1$ (5.16 t ha^{-1}) than $F_2S_1A_2T_2$ (4.16 t ha^{-1}).

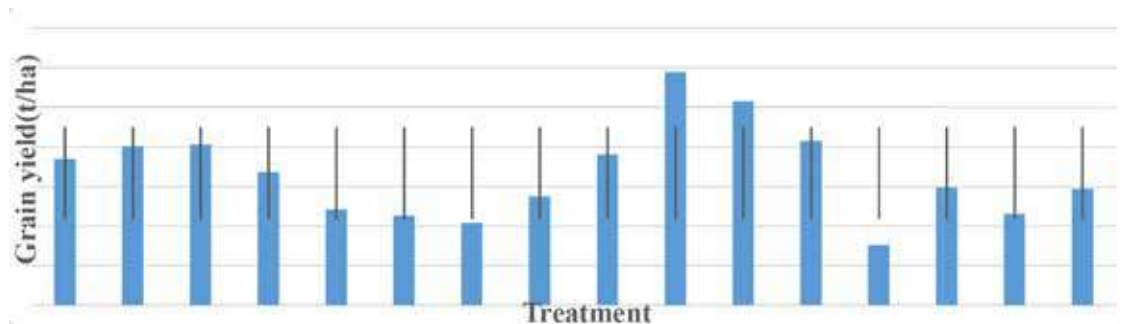


Fig. 11. Effect of different agronomic factor on the yield maximization of BRRI dhan70 (*Katarivog type*) through developing sustainable production management protocol in T. Aman season.

Maximizing yield of BRRI developed Boro varieties through influencing some agronomic critical factors

The experiment was conducted at the BRRI HQ farm, Gazipur to develop agronomic critical factor-based management packages of short, medium and long duration Boro rice varieties for higher grain yield. Different agronomic critical factors were considered as Factor A: such as M_1 = BRRI recommended practices, Agronomic critical factors based proposed three treatments M_2 , M_3 and M_4 . BRRI developed three varieties with different growth duration were considered as Factor B, such as: V_1 = Short duration (BRRI dhan88), V_2 = Long duration (BRRI dhan89) and V_3 = Check variety (BRRI dhan29). In 2022-23, the highest grain yield was observed by long duration varieties BRRI

dhan29 and BRRI dhan89 in agronomic factor based proposed M_2 , M_3 and M_4 management treatments followed by M_1 . Shorter duration BRRI dhan88 produced lower yield than the tested long duration varieties in all management treatments. BRRI dhan88 produced similar yield in all management treatments compared to the existing recommended practice. For obtaining higher yield from long duration Boro varieties, it may recommend from the obtained result (Table 15) that seeding would be done on last week of December, younger seedling (15 to 25-day old) may transplant following wider spacing (25 × 25 cm) within 3rd week of December with 1 or 2 seedling per hill. Upper soil stirring would be done on 20 and 35 DAT. STB fertilizer management would be followed and additionally 1% MoP solution to be sprayed on 30 and 45 DAT.

Table 15. Effect of some agronomic critical factors on yield of different growth duration Boro varieties at BRRI farm Gazipur during Boro 2022-23 season.

Management	V_1 =BRRI dhan88	V_2 =BRRI dhan89	V_3 =BRRI dhan29
M_1	6.35	6.96	7.36
M_2	6.24	7.80	7.79
M_3	6.35	7.75	7.54
M_4	6.25	7.90	8.14
, LSD _(0.05) for $V \times M$ = 0.786, LSD _(0.05) for V = 0.393, LSD _(0.05) for M = 0.454, CV% = (Management*Variety) = 6.4			

YIELD MAXIMIZATION GOOD AGRICULTURAL PRACTICE (GAP)

Few GAP components were evaluated on three varieties: BRRI hybrid dhan5, BRRI dhan100, and BRRI dhan96. Here we considered good agricultural practice (GAP) and BRRI recommended management (BRM) of GAPs were a. Balanced fertilizer application (N,P,K,S, Zn) (soil test based) b. Alternate wetting and drying (AWD) c. BRRI weeder fb 1 HW at 45 DAT d. Integrated insect and disease management and e. Maintaining planting

depth 2-3cm. BRRI recommended management (BRM) were: a. BRRI recommended fertilizer and cultural practices b. Normal irrigation practice, c. Herbicide fb 1HW d. Insect and disease management by applying pesticides. The experiment followed a factorial RCB design with three replications at BRRI farm Gazipur. Results showed that varieties × management differed significantly on grain yield, straw yield, and harvest index (Table 16). The highest grain yield was observed in BRRI dhan100×GAPs (8.02 t ha⁻¹) followed by BRRI hybrid dhan5 with GAPs. Lower HI of BRM

indicates a scope to increase grain yield to increase economic yield rather than straw yield by practicing intensive GAPs. The estimated net change in profit due to the adoption of GAPs techniques over BRP worked out using partial budgeting technique was

found to be significantly higher. The net change in the profit obtained by the GAPs techniques was observed to be 808 Tk ha⁻¹ for BRRI hybrid dhan5, Tk 23,383 ha⁻¹ for BRRI dhan100 and Tk 11,608 ha⁻¹ for BRRI dhan96.

Table 16. Yield and yield characters of BRRI varieties as affected by two management practices at BRRI farm, Gazipur during Boro 2020-21.

Variety(V)	Management (M)	GY (t ha ⁻¹)	SY (t ha ⁻¹)	HI
BRRI hybrid dhan5	GAP	7.63	7.85	0.49
	CRM	7.61	8.69	0.47
BRRI dhan100	GAP	8.02	7.71	0.51
	CRM	7.30	7.92	0.48
BRRI dhan96 GAP				0.48
6.95 7.64				
	CRM	6.56	7.52	0.47
LSD _(0.05) for V		0.45	ns	ns
LSD _(0.05) for M		ns	ns	ns
LSD _(0.05) for V × M		0.51	ns	ns
CV (%)		4.0	7.5	3.2

GAP=Good agricultural practices; CRM= Conventional BRRI recommended management

WEED MANAGEMENT

Reduce weed seed in weed Seed Bank of soil in long-term fallow management and herbicide uses in Rice- Rice Cropping System

Two-factor treatments were considered to evaluate the study. Weed management before soil sampling considered factor A:1. Kill weed seedlings by tillage or herbicide (W₁), 2. Tillage after flowering of weeds (W₂), 3. Weed management by herbicide fb 1 HW (W₃), 4. Weed management by HW (W₄) and 5. Control (No weeding) (W₅). After imposed weed management treatment before transplanting soil sample were collected before land preparation (Factor B). A soil auger was used to take soil samples to a depth up to 15 cm from three depths i.e. 0-5 cm, 05-10 cm and 10-15 cm. Soil samples were taken by using PVC probe of 2.5 cm diameter for each method from each replication. Weed seedlings that emerged were identified, counted, and removed at 30 days intervals throughout the four months

(August, September, October and November of T. Aman 2022) emergence period.

Weed management treatment with herbicide and stale seed bank techniques showed lower weed seed banks in different soil depths. October and November counted a lower number of weed seeds compared to August and November. The significant reduction in weed seed in the seed bank in herbicide and stale seedbed techniques indicates the effective control of weeds in the field. Species seed bank relative importance was differed significantly by different weed control methods. The Cyperous *difformis*, *Scirpus maritimus*, *Echinochloa crus-galli*, *Fimbristylis miliaceae* and *cynodont dactylon* showed comparatively higher dominance/ importance value in soil seed bank at all three upper, middle and lower soil depths. The Shannon index for diversity of the weed seed bank ranged from 0.48 to 1.35, depending on the soil sampling depths in different weed management treatments

(Table 17). In different weed management methods, Shannon's index of weed seeds diversity was high in middle depth in September having 1.35 value which indicates higher number of species found at this depth and it was followed by upper depth having a 1.30 index value whereas, minimum index value

0.48 was recorded at lower depth which indicates that under deeper layer of soil, the seeds of different weed species may be decomposed with time which has less longevity of seeds. It was minimum in the lowest depth (0.48) in August, while it was higher at 0.90 and 0.78 at the upper and middle depth.

Table 17. Shannon's index of diversity value of weed species under three soil depths in different weed management treatments determined over different months during Boro season.

Aug	Soil depth (cm)			Sep	Soil depth (cm)			Oct	Soil depth(cm)			Nov	Soil depth(cm)		
WM	0-5	5-10	10-15	WM	0-5	5-10	10-15	WM	0-5	5-10	10-15	WM	0-5	5-10	10-15
W ₁	0.87	0.85	0.55	W1	1.14	1.20	0.70	W1	1.12	1.10	0.90	W1	1.18	1.11	0.78
W ₂	0.90	0.78	0.60	W2	1.14	1.35	0.72	W2	1.15	1.16	0.93	W2	1.23	0.90	0.70
W ₃	0.79	0.70	0.50	W3	1.12	0.86	0.67	W3	0.95	0.94	0.77	W3	0.90	0.80	0.70
W ₄	0.68	0.66	0.48	W4	1.10	1.20	0.67	W4	0.95	0.80	0.75	W4	0.80	0.75	0.75
W ₅	0.88	1.23	0.69	W5	1.36	1.30	1.10	W5	1.27	1.38	0.80	W5	0.98	0.88	0.77

Effect of herbicide on Azolla infestation in rice field

The experiment was conducted at the BRRI farm, Rangpur, during T. Aman 2022 to find out the effect of herbicide on azolla infestation in rice. The treatments were: T₁: Remove water from the plot (Farmers' practice), T₂: Herbicide (Penoxsulam), T₃: Herbicide (Bispyribac sodium), T₄: Herbicide (2,4-D Amine), T₅: Incorporation of Azolla after full mat formation in the field); and T₆: Control (un-weeded) The treatments were distributed in

RCB design with three replications. The highest grain yield 5.39 t/ha was found in T₅ treatment and consequently panicle m⁻² and grains panicle⁻¹ were also found the highest in this treatment (Table 18). The highest Azolla dry wt. found in the control treatment at seven DAS (Days after spray), 14 DAS and 21 DAS. Herbicide 2,4-D Amine treated plot showed that at seven DAS Azolla was similar to the control plot but after that, it gradually decreased. Penoxulam control Azolla at first stage but later stage 2,4- D Amine performed better to control.

Table 18. Effect of herbicide on Azolla infestation in rice field, T. Aman, 2022 BRRI RS farm, Rangpur.

Treatment	Panicle number/ m ²	Grains/ panicle	1000 g wt. (g)	Grain yield (t/ha)	weed dry wt. (g)	Dry wt. 7 DAS (g)	Dry wt. 14 DAS (g)	Azolla dry wt. 21 DAS (g)
T ₁	216	103	24.56	5.02	14.66	20.00	1.24	5.93
T ₂	223	101	24.86	5.03	6.70	5.07	7.33	9.13
T ₃	202	88	24.23	4.55	10.70	5.86	15.73	25.73
T ₄	238	105	24.66	5.33	5.13	23.96	10.93	2.76
T ₅	240	106	24.97	5.39	6.26	21.20	0.00	0.00
T ₆	198	100	24.16	3.57	13.80	24.13	25.73	20.93
LSD _{0.05}	23.45	16.82	1.75	0.66	5.06	4.29	4.59	3.66
CV (%)	5.9	9.2	3.9	7.6	16.1	14.1	15.4	17.3

Evaluation of candidate herbicide for weed control efficiency in T. Aman and Boro season

Field trials were conducted at the BRRI HQ Farm, Gazipur from T. Aman 2022, and Boro 2022-23, seasons. Most of the herbicides performed more than 80% weed control efficiency in different weed populations observed in the field (Table 19). Only *cynodont dactylon* cannot be controlled >80% by some herbicides in most cases. Among 20 groups of herbicides, most of the groups were post-emergence and early post-emergence. Among the herbicides,

four herbicides did not control weed effectively and their weed control efficiency was less than 80%. Table 19 shows that post-emergence herbicide coming dominant and most of the herbicide contains combination chemicals which indicates to be more effective. Four herbicides eg. Pyrazosulfuron ethyl 10% + Bispyribac 20% WP, Triasulfuron, Metsulfuran methyl 10% + Chlorimuron ethyl 10%, Bispyribac sodium 40% SC, etc. did not control weed effectively, where the weed control efficiency of this herbicide was less than 80%. Other groups of herbicides were more than 80% weed control efficiency.

Table 19. Herbicide chemical name, dose and weed control efficiency of different herbicide evaluated during T. Aman 2020 and Boro 2020-2021 at BRRI farm, Gazipur.

Chemical name	Dose ha ⁻¹	Season	Weed Control Efficiency (%)					Remark
			<i>Cynodon dactylon</i>	<i>Echinochloa crus-galli</i>	<i>Monochoria vaginalis</i>	<i>Scirpus maritimus</i>	<i>Cyperus difformis</i>	
Bispyribac sodium 18%+ Bensulfuronmethyl 12%	150 g	Aman	82.50	81.50	85.00	82.88	80.80	Postemergence satisfactory
		Boro	75.50	80.00	84.85	76.65	81.08	
Quizalofop ethyl 15% +ethoxysulfuron 15%	50g	Aman	80.50	83.0	85.40	82.78	84.75	Post emergence Satisfactory
		Boro	78.10	80.85	82.44	82.30	81.70	
Atrazine + Mesotrione	600ml	Aman	78.82	80.50	80.45	80.20	80.50	Late post-emergence; very sensitive, over dose may destroy rice plant.
		Boro	80.54	82.00	83.50	81.90	82.84	
Pretilachlor 15 %+ Oxyfluorfen 12 %+ Oxadiazon 7 %	1.0L	Aman	78.70	84.00	86.00	82.50	81.55	Post-emergence Satisfactory
		Boro	70.80	83.50	80.60	82.80	81.70	
Pretilachlor + Pyrazosulfuran Ethyl	800 g	Aman	82.70	81.80	82.10	80.28	80.80	Post-emergence. Satisfactory
		Boro	85.00	83.40	85.55	81.80	77.25	
Bispyribac sodium 40% SC	150ml	Aman	81.50	80.50	82.50	45.75	80.55	Early Post-emergence Satisfactory
		Boro	81.60	80.07	80.80	82.70	82.50	
Pyrazosulfuron ethyl 10% + Bispyribac 20% WP	150g	Aman	70.60	72.95	72.00	75.75	70.00	Post emergence not Satisfactory
		Boro	77.50	71.60	74.00	77.70	78.96	

SOIL MICROBIOLOGY AND MANAGEMENT

Characterization of salt-tolerant PGPR isolated from coastal saline soil in Bangladesh

The experiment was conducted at the soil microbiology laboratory, Agronomy division during the season of T. Aman 2022. The soil was collected from the Satkhira district under the Upazila of Ashashuni (N-22°31.585'; E-089°12.381') and Shayamnagar (N-22°22.519'; E-089°06.319'). Initially, 20 bacteria were isolated from the collected soil. Five bacterial strains were screened out through a preliminary test on salinity tolerance and plant growth-promoting characteristics. They were further allowed to test for various salinity tolerance characteristics which include bacterial growth in saline media. The considerable populations of Sat-2 (6.90), Sat-4 (6.65) and Sat-6 (6.45) were measured at 1.5M of NaCl concentrations (Fig.

12). The floc yield of the tested bacterial strains was increased gradually with the increase of NaCl concentrations showing a maximum value at 1.5M of NaCl concentrations. The bacterial strain Sat-2 (16.90g/L) was ranked first following Sat-4 and Sat-6 (Fig. 13). The exopolysaccharide production of the tested bacterial strains gradually increased with the increase of NaCl concentrations showing the highest peak at 1M of NaCl concentrations. The strain Sat-6 followed by Sat-2 produced the highest exopolysaccharide at 1M of NaCl concentrations (Fig. 14). The highest uptake of sodium was measured by the strain Sat-4 followed by Sat-2 at 1.5M of NaCl concentrations (Fig. 15). Among the six bacterial strains, Sat-4, Sat-5 and Sat-6 were enabled to fix atmospheric nitrogen. On the other hand, Sat-1, Sat-2 and Sat-4 showed phosphate solubilization ability. Further, Sat-2 was the highest IAA (69 ppm) producer (Table 20).

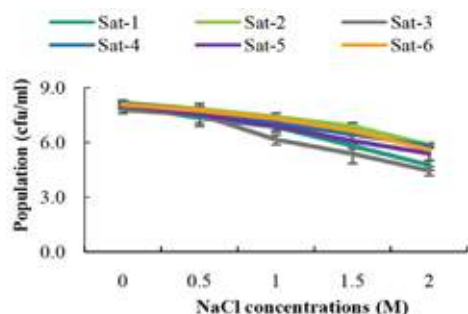


Fig. 12. The effect of NaCl concentrations on bacterial growth under TSB medium.

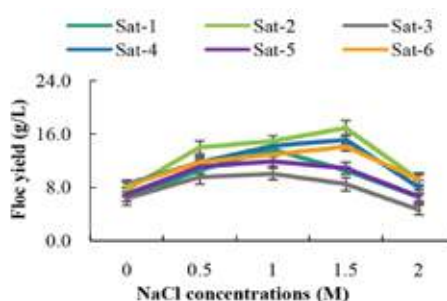


Fig. 13. The effect of NaCl concentrations on bacterial floc yield production under TSB medium.

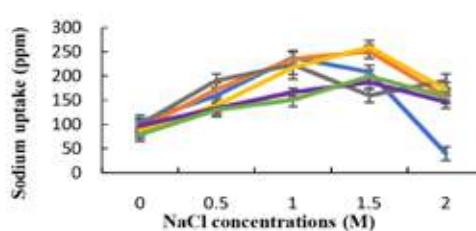
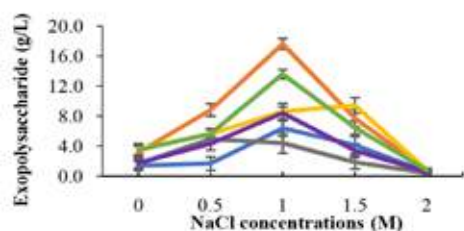


Table 20. Plant growth-promoting traits of the selected bacterial strains.

Bacteria	N ₂ fixation	P solubilization	IAA (ppm)
Sat-1	-	+	22
Sat-2	-	++	69
Sat-3	-	-	2
Sat-4	+++	+	28

Sat-5	++	++	27
Sat-6	+	-	13

Note: '+' positive; '-' Negative

Effect of salt-tolerant PGPR inoculation on the growth of rice seedlings under salt-stress condition

The experiment was conducted at the rainout shelter, Agronomy Division during the season of Boro 2022-23. The treatments were comprised as six bacterial inoculum (no inoculum, UPMRB9, Sat-2, Sat-4, Sat-5, Sat-6) and three salinity levels (0, 6, 8 dSm⁻¹). The plants were cultured in a hydroponic system following the protocol of Yoshida *et al* (1976). Sodium chloride (NaCl) was added at the rate of 3 and 4 g/L to the nutrient solution to reach the desired electrical conductivity (EC) of 6 and 8 dSm⁻¹, respectively (Gregorio, 1997). The trays were filled up with 7L of culture solution to ensure optimal nutrient uptake by the roots. A portable pH meter was used to measure the pH of the saline nutrient solution and pH 5 was adjusted to each day by incorporating KOH and HCL. The pails were

arranged in a Randomized Complete Block Design following three replications. The shoot dry weight of rice plants inoculated with five bacterial strains was not varied significantly under non-saline conditions. However, the values significantly differed under salt-stress conditions. At 6 dSm⁻¹ of salinity, significantly the highest shoot dry matter was produced by UPMRB9 inoculated plants (26.62 g) followed by Sat-2 (24.75 g) and Sat-4 (23.24 g). Further, at 8 dSm⁻¹ of salinity, UPMRB9 was the highest contributor (14.28 g) followed by Sat-2 (11.16 g) (Fig. 16a). On the other hand, a significant variation in root dry weight was measured regardless of salinity concentration. The bacterial strain UPMRB9 was the major contributor to the highest dry matter production (11.93 g) followed by Sat-2 (11.07 g) under non-stress conditions. The consistent contribution of these two strains was also measured under the salt-stress condition which was 8.44 g and 7.62 g at 6 dSm⁻¹ and 7.30 g and 6.09 g at 8 dSm⁻¹ respectively (Fig. 16b)

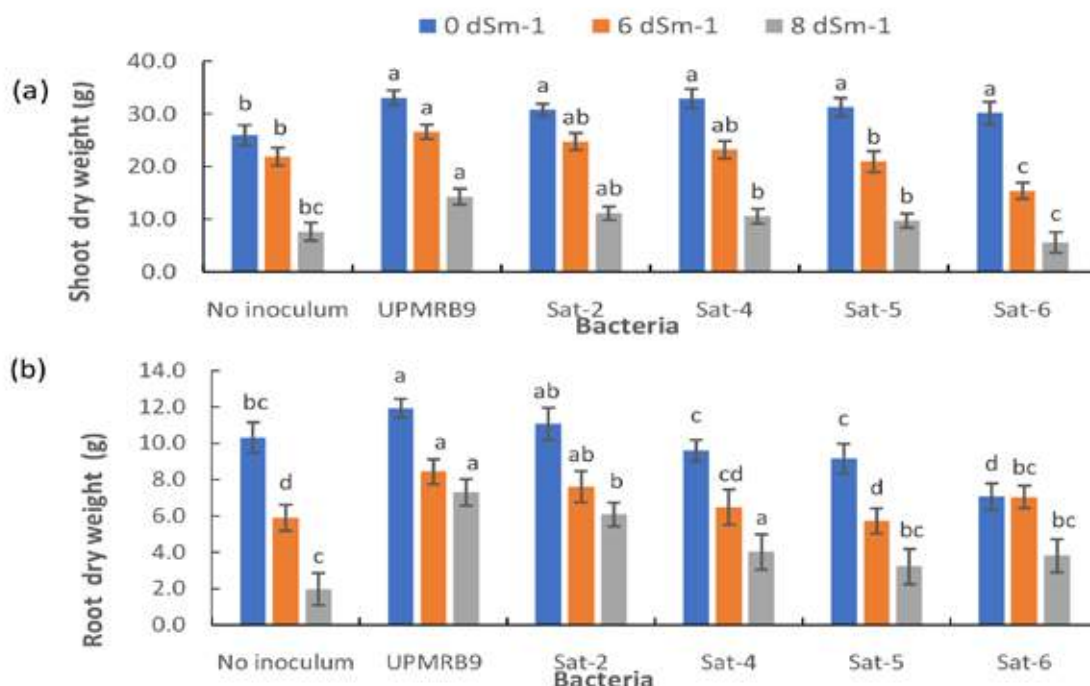


Fig. 16. Effect of bacterial inoculation on the shoot dry weight (a) and root dry weight (b) of rice seedlings under the salt-stress condition.

MOLECULAR TRAIT MANAGEMENT

Physiological, biochemical and molecular mechanisms of salinity tolerance in rice

This study was conducted from April to June 2023 in a rain-out shelter, Agronomy Division, BRR, Gazipur. Six rice varieties (BRRI dhan47, BRRI dhan67, BRRI dhan73, BRRI dhan78, BRRI dhan88, and BRRI dhan99) were tested at seedling stage using pot culture. Two different salinity level viz 0 and 12 dSm⁻¹ were considered as salinity treatment. The trial was set up in a complete randomized design using three replicates with 10 plants per trial unit. Salt was added 14 days after planting to measure the visual symptoms of salt toxicity. The results showed that BRRI dhan47

and BRRI dhan99 are tolerant¹; BRRI dhan67 and BRRI dhan73 are moderately tolerant; and BRRI dhan78 is susceptible at 12 dSm⁻¹ (Fig. 17). The ratio of Na: K varied significantly at 0 and 12 dSm⁻¹ among the tested rice cultivars (Fig. 18). The lower amount of Na: K was measured from rice cultivars BRRI dhan47 and BRRI dhan99 followed by BRRI dhan73 > BRRI dhan67 > BRRI dhan78 > BRRI dhan88 at 12 dSm⁻¹ salinity level. Without NaCl stress, no significant difference in proline content was observed among the genotypes. Under salt stress condition, BRRI dhan67 and BRRI dhan99 had significantly higher proline content followed by BRRI dhan47, BRRI dhan73, BRRI dhan78, and BRRI dhan88.

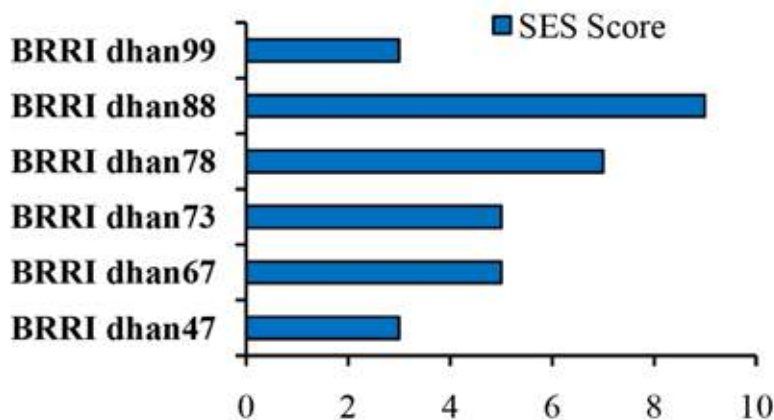


Fig. 17. SES score of rice seedlings grown in 12 dSm⁻¹ salt stress for 10 days.

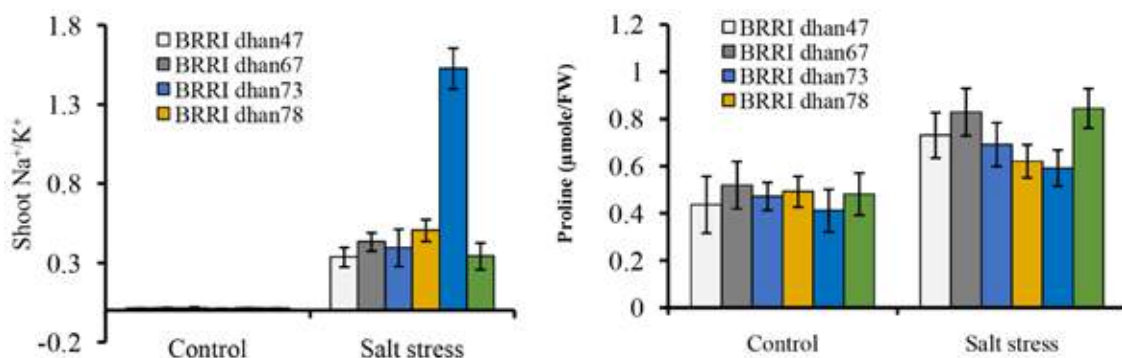


Fig. 18. Shoot Na⁺/K⁺ and proline content of the tested rice varieties grown with or without salt stress.

Soil Science Division

128	Summary
134	Identification And Management Of Nutritional Disorder
137	Integrated Nutrient Management
140	Soil And Environmental Problems
149	Soil Microbiological Studies

SUMMARY

The optimum nitrogen doses for the submergence tolerant advanced line IR16F1148, drought tolerant advanced lines BR10538-2-1-3 and BR10540-4-1-2-4-1, were 55, 60 and 51 kg N ha⁻¹, respectively for T. Aman season.

High N dose at potassium deficient conditions adversely affects rice yield, while at N deficient conditions, increasing rates of K fertilizer did not influence rice yield in both T. Aman and Boro seasons. Therefore, maintaining an appropriate N:K ratio is crucial for MV rice production. The optimum N and K rates at BRRI farm Gazipur for achieving the maximum grain yield were 50 and 50 kg/ha, respectively, for BRRI hybrid dhan6 in T. Aman, while for BRRI hybrid dhan3 in Boro season, the rates were 150 kg N and 150 kg K/ha.

The calculated economically optimum N dose for BRRI dhan95 in T. Aman season was 80 kg ha⁻¹ and in Boro season for BRRI dhan92 it was 175 kg ha⁻¹.

Liquid nano urea might save 33% of the recommended urea fertilizer without sacrificing the rice yield in Boro season at BRRI farm, Gazipur. However, multi-location studies in different seasons are needed to draw a conclusion and confirm the present findings.

Intensive rice cropping with NPKSZn resulted in the highest annual yield of rice compared to the other fertilizer treatments. On the other hand, when the fertilizer control plot was reversed with complete fertilization after a long time resulted in yield similar to fertilized treatments which indicated that complete fertilization could recuperate soil productivity even after a long period of rice cultivation.

Application of Zn and Cu fertilizer showed positive effect on rice yield.

Rice yield increased sharply due to P fertilizer application as the soil is very deficient in available P. Better grain yield obtained in TSP fertilized plots than DAP fertilizer alone. The combination of TSP and DAP application gave lower grain yield than TSP alone.

The combinations of 50-75% reduced doses of inorganic fertilizer with PM 1-2 t ha⁻¹ showed better growth and yield performance followed by CD 2-3 t ha⁻¹ with inorganic fertilizer 50-75%. The sole application of 100% inorganic fertilizer or sole application of organic manure using CD and oil cake produced almost similar grain yield.

STB dose and 50% STB + MM fertilizer produced significantly higher grain yield than farmers' practice and cumulative yield of triple rice cropping was always higher than double rice cropping pattern. Grain yield were non-significant in three BRRI farms irrespective of treatment. But added vermicompost with soil test based fertilizer performed good in Gazipur and Cumilla while 20% more K with soil test based fertilizer performed good in Rangpur.

Application of biochar had positive impact on growth and yield of rice. In this study, single application of 4 t ha⁻¹ biochar in Boro-Fallow-T. Aman cropping pattern performed the best on rice yield.

AWD irrigation reduced about 38-42% of total CH₄ flux and 36-40% of GWP than continuous standing water (CSW) at different locations in Bangladesh.

In T. Aman season, rainfed condition reduced 12-18% GWP than the other irrigation system.

In Boro season, if reduced about 15% of GWP by AWD irrigation system than continuous standing water (CSW) system. In T. Aman, rain fed water management one of the key technique for reducing total CH₄ emission, and GWP and GHG intensity without sacrificing rice yield. In Boro season, AWD is the important irrigation system for reducing GHG, GWP but not significant different of grain yield than CSW irrigation system.

Vermicompost (VC) organic fertilizer is a good technique for reduction of about 18% of global warming potential (GWP), 17% of emission factor (EF) of GHG (green house gas) and 22% of GHG intensity compared to cowdung organic fertilizer during T. Aman season. In Boro rice cultivation, the VC reduced about 14% of GWP, 15% of EF and 17% of GHG intensity compared to cowdung treated plot.

About 44-1,380 kg CO₂ ha⁻¹ are absorbed under Jute-T. Aman cropping system with different fertilizer management practices. Therefore, we conclude that Jute-T. Aman cropping pattern is one of the important environment friendly cropping pattern.

CO₂ absorption rates were about 1121-4057 kg CO₂ ha⁻¹ under Wheat-Rice cropping system with different fertilizer management.

Application of BRRI-organic fertilizer 2 t ha⁻¹ (dry weight basis) saved 30% N and 100% TSP fertilizer in rice production and improved 8.5 % grain yield over chemical fertilizer in Boro season.

Bio-coated urea improved N fertilizer use efficiency (NUE) and crop yield in both favourable and unfavourable (saline soil) ecosystems. Application of bio-coated urea improved yield and saved 25 to 50% prilled urea in rice cultivation.

Bacillus spp. is the dominant bacteria that found in nine tested AEZ's soil. There is a relationship ($r^2=0.74$) found for soil organic matter and soil biomass C of the tested soil. The expected N use efficient populations were identified as AUS 175, AUS 328, AUS MURALI, BAWOI, BROWN GORA S.B.92, DESHI BORO, DJ 24, KALI AUS, KALI BORO 138-2, KALI BORO 704, LALI BORO, PURANUKA, SAITA BORO, SADA BORO, SONA MUKHI.

SOIL FERTILITY AND PLANT NUTRITION

Determining N requirement of drought tolerant ALART materials. N requirement as N is the most limiting nutrients for rice production. Field trial was conducted at BRRI HQ farm, Gazipur in T. Aman 2022 season to determine the N requirement of drought tolerant rice advanced line. Two drought tolerant advanced lines BR10538-2-1-3-2 and BR10540-4-1-2-4-1 were compared with two check varieties. BRRI dhan71 and BRRI dhan75 in T. Aman. Six N rates (kg ha⁻¹): N₀, N₂₀, N₄₀, N₆₀, N₈₀ and N₁₀₀ were applied for the experiment following split-plot design with three replications, where N rates were assigned in main-plot and rice genotypes in sub-plot.

Grain yield and N requirements. Grain yield of most genotypes increased with the increasing of N rates up to 60 kg ha⁻¹ and then decreased. The drought tolerant line BR10538-2-1-3-2 produced comparatively higher grain than the other line BR10540-4-1-2-4-1 and the two check varieties. The calculated economic optimum doses of N for advanced line BR10538-2-1-3-was 60 kg N ha⁻¹, and for BR10540-4-1-2-4-1 the dose was 51 kg N ha⁻¹, respectively.

Determining N requirement of submergence tolerant ALART materials. Field trial was conducted at BRRI HQ farm, Gazipur in T. Aman 2022 season to determine the N requirement of submergence tolerant rice genotypes. The advanced line IR16F1148 was evaluated with two check varieties. BRRI dhan71 and BINA dhan11. Six N rates (kg ha⁻¹): N₀, N₂₀, N₄₀, N₆₀, N₈₀ and N₁₀₀ with recommended doses of P, K, S and Zn were applied in this trial. Quadratic regression model was used to determine optimum N requirement of the tested rice genotypes. Grain yield of all rice genotypes was progressively increased with the increase of N rates up to 60 to 80 kg ha⁻¹. The tested submergence tolerant ALART material IR16F1148 didn't perform better than the two check varieties with the same doses of nitrogen application. The calculated economic optimum N dose of submergence tolerant ALART material was 55 kg N ha⁻¹, and for the check varieties BRRI dhan71 and BINA dhan11 the doses were 76 and 60 kg N ha⁻¹, respectively.

Influence of N and K on the performance of modern rice. The study was conducted to observe the effect of nitrogen (N) and potassium (K) on the yield of modern rice at BRRI HQ farm, Gazipur during T. Aman 2022 and Boro 2022-23 seasons. The experiment was laid out in split-plot design with three replications assigning the rates of K in the main plots and that of N in the subplots. Soil test based flat rates of P and S were applied to all the plots. The application rate of K was 0, 50, 100, 150, and 200 kg ha⁻¹ both in T. Aman and Boro seasons. Nitrogen was applied @ 0, 50, 75, and 100 kg ha⁻¹, in T. Aman season, while in Boro season, the rate of N was 0, 100, 150 and 200

kg ha⁻¹. The test varieties were BRRI hybrid dhan6 and BRRI hybrid dhan3 in T. Aman and Boro seasons, respectively.

Grain and straw yield. The interaction effect of rice yield between N and K was significant in both T. Aman 2022 and Boro 2022-23 (Table 1). In T. Aman 2022, application of 0, 50 and 75 kg N/ha did not show considerable variations in grain yield under K-deficient conditions, but 100 kg N/ha significantly decreased grain yield of BRRI hybrid dhan6. Furthermore, K rates were not responsible for increased grain yield in N-deficient conditions. Application of N @ 50 kg ha⁻¹ with 50 kg K ha⁻¹ produced 5.45 t ha⁻¹ rice grains, which was statistically identical with the highest grain yield of 5.80 t ha⁻¹ achieved with a combination of 100 kg N and 150 kg K ha⁻¹ (Table 1). So, the combination of 50 kg K and 50 kg N is suitable for BRRI hybrid dhan6 cultivation to get optimum yield. In Boro 2023, a combination of 200 kg N and 150 kg K ha⁻¹ produced the highest grain yield (7.54 t ha⁻¹) of BRRI hybrid dhan3, which was statistically identical to the combination of 150 kg N and 150 kg K ha⁻¹. Therefore, combining 150 kg N and 150 kg K ha⁻¹ could be suitable for BRRI hybrid dhan3 achieving optimum grain yield. The interaction effect of K and N on the straw yield of MV rice in T. Aman 2022 and Boro 2022-23 was also significant (Table 2). Similar to the grain yield of BRRI hybrid dhan6 in T. Aman 2022, a combination of 50 kg N and 50 kg K ha⁻¹ was suitable for achieving optimum straw yield. In Boro 2022-23, increasing N rates gradually increased the straw yield of BRRI hybrid dhan3, and the highest straw yield (7.48 t ha⁻¹) was obtained with the combination of 200 kg N and 100 kg K ha⁻¹.

Table 1. Effect of N and K on the grain yield (t ha⁻¹) of MV rice in T. Aman 2022 and Boro 2023 at BRRI HQ farm, Gazipur.

K rate (kg ha ⁻¹)	N rates (kg ha ⁻¹)							
	0	50	75	100	0	100	150	200
	BRRI hybrid dhan6 (T. Aman)				BRRI hybrid dhan3 (Boro)			
0	4.65aA	4.71bA	4.48cA	3.35cB	2.51aC	4.99bAB	5.39dA	4.72cB
50	4.98aB	5.45aA	5.42bA	5.04bB	2.61aB	6.48aA	6.88bcA	6.94bA
100	4.64aB	5.61aA	5.50abA	5.36bA	2.85aC	6.50aB	6.41cB	7.16abA
150	4.72aC	5.34aB	5.80aA	5.80aA	2.87aC	6.65aB	7.34abA	7.54aA
200	4.69aB	5.35aA	5.37bA	5.21bA	2.73aC	6.80aB	7.53aA	7.13abAB
ANOVA (p values)								
Nitrogen (N)	<0.001				<0.001			
Potassium (K)	<0.001				<0.001			
N × K	<0.001				<0.001			

Values followed by the same letter are not significantly different at the 5% level of probability.

Table 2. Effect of N and K on the straw yield (t ha⁻¹) of MV rice in T. Aman 2022 and Boro 2023 at BRRI HQ farm, Gazipur.

K rate (kg ha ⁻¹)	N rates (kg ha ⁻¹)							
	0	50	75	100	0	100	150	200
	BRRI hybrid dhan6 (T. Aman)				BRRI hybrid dhan3 (Boro)			
0	3.60aB	3.52cB	4.59bA	4.06cAB	2.19bC	4.16cB	4.54dAB	4.98cA
50	4.04aB	4.89aA	4.98abA	4.83bA	2.09bD	4.79bC	5.56cB	6.60bA
100	4.23aC	4.74abBC	5.42aA	5.09abAB	2.17bD	4.87bC	6.65aB	7.48aA
150	3.91aB	4.29abB	5.49aA	5.44abA	2.85aC	5.16abB	6.43abA	7.36aA
200	4.17aB	4.20bB	4.97abA	5.52aA	2.18bC	5.47aB	5.96bcB	7.03abA
ANOVA (p values)								
Nitrogen (N)	<0.001				<0.001			
Potassium (K)	<0.05				<0.001			
N × K	<0.05				<0.001			

Values followed by the same letter are not significantly different at the 5% level of probability.

Updating of nitrogen doses for modern rice varieties. The experiment was conducted at the experimental field of Bangladesh Rice Research Institute, Gazipur in T. Aman 2022 and Boro 2022-23 seasons to determine the optimum N requirement of BRRI dhan95 and BRRI dhan92, respectively. The experiment was laid out in a RCB design with three replications. The applied N doses (kg ha^{-1}) for T. Aman was 0, 30, 60, 90, 120, 150 and Boro was 0, 40, 80, 120, 160, 200, respectively, along with flat doses of P, K, S fertilizer. The grain yields of BRRI dhan95 and BRRI dhan92 were significantly influenced by N rates. The calculated economically optimum N dose for BRRI dhan95 in T. Aman season was 80 kg ha^{-1} and in Boro season for BRRI dhan92 it was 175 kg ha^{-1} . However, in case of BRRI dhan92 the grain yield was similar with 120, 160 and 200 kg N ha^{-1} . The slow response to higher N rates might be due to the slow mineralization of N because of low temperature during the growing period.

Effects of liquid nano urea on rice yield in wetland conditions. A field experiment was laid out in a randomized complete block design with three replications to investigate the influence of liquid nano urea on rice yield at BRRI HQ farm, Gazipur, in Boro 2022-23. Four treatments were tested in this study: (i) 66% of the recommended dose of urea (RDU), (ii) 66% RDU with liquid nano urea (LNU), (iii) 100% RDU and (iv) 100% RDU with LNU.

Grain yield. It was observed that application of urea @ 105.6 kg N/ha (66% RDU, T_1) produced the lowest grain of 5.74 t/ha compared to other treatments (Table 3). Spray of LNU with 66% RDU (T_2) significantly increased the grain yield to 6.55 t/ha , which was 14% higher than the T_1 treatment. Moreover, application urea @ 160 kg N/ha (100% RDU, T_3) produced the highest grain of 7.00 t/ha , which was statistically identical to T_2 treatment (66% RDU+LNU). It indicates that LNU may save 34% urea without significant yield reduction. Furthermore, the additional use of LNU to 100% RDU (T_4) reduced grain yield by 7% relative to RDU (T_3). However, further multi-location studies in different seasons are needed to draw a conclusion and confirm the present findings.

Table 3. Effect of liquid nano urea on the grain yield of BRRI dhan89 at BRRI farm, Gazipur, in Boro 2022-23.

Treatment	GY (t/ha)
$T_1 = 66\% \text{ RDU}$	5.74 c
$T_2 = 66\% \text{ RDU+LNU}$	6.55 ab
$T_3 = 100\% \text{ RDU}$	7.00 a
$T_4 = 100\% \text{ RDU+LNU}$	6.48 b
Level of significance	**
CV	3.8

RDU = recommended dose of urea

LNU = liquid nano- urea

Effect of zeba coated urea on growth and yield of Boro rice. Nitrogen requirement of rice varies with the seasons, soil fertility and rice genotype and also varies with N source and application method. Nitrogen release obviously depends on coating and, or placement method. Slow release of nitrogen increases the N use efficiency. A field experiment was conducted in AEZ 28 at BRRI research farm, Gazipur during Boro 2022-23 to evaluate the performance of Zeba coated urea on the growth and yield of rice. Four treatment combinations viz T_1 : 100% N (prilled urea) dose of BRRI recommended, T_2 : 75% N dose of BRRI recommended, T_3 : 100% N (prilled urea) dose of Zeba coated, T_4 : 75% N dose of Zeba coated were evaluated using RCB design with three replications. Application of Zeba coated urea didn't produced higher rice yield than the recommended N fertilizer.

Response of added zinc on BRRI zinc enriched rice varieties. A field experiment was conducted at BRRI HQ farm Gazipur in Boro 2022-23 season to investigate the effect of added Zn on yield and quality of Zn enrich rice. Six different Zn doses and application methods viz T : No Zn fertilizer (Zn control), T : Zn @ 2.0 kg ha^{-1} as basal, T : Zn @ 3.0 kg ha^{-1} as basal, T4: Zn @ 2.0 kg ha^{-1} as basal + one time ZnSO spray (0.5%) at PI stage, T5: Zn @ 3.0 kg ha^{-1} as basal + one time ZnSO spray (0.5%) at PI stage and T : ZnSO spray (0.5%) two times at active tillering and PI stage of rice were

evaluated with two rice varieties viz BRRI dhan74 and BRRI dhan89.

Grain yield. The zinc enriched rice BRRI dhan74 yielded higher in Zn fertilizer sprayed treatments but on the other hand, BRRI dhan89, a non Zn enriched rice, performed better in basal application of Zn fertilizer (**Table 4**).

Table 4. Effect of added Zn on grain yield of BRRI dhan74 and BRRI dhan89 in Boro 2022-23, BRRI, Gazipur.

Treatment	Grain yield (t/ha)	
	BRRI dhan74	BRRI dhan89
T ₁ : No Zn fertilizer (control)	7.13 bc	6.82 b
T ₂ : Zn @ 2.0 kgha ⁻¹ as basal	6.95 c	7.31 a
T ₃ : Zn @ 3.0 kgha ⁻¹ as basal	6.94 c	7.40 a
T ₄ : Zn @ 2.0 kgha ⁻¹ as basal + ZnSO ₄ spray (0.5%)	7.65 a	7.10 ab
T ₅ : Zn @ 3.0 kgha ⁻¹ as basal + ZnSO ₄ spray (0.5%)	7.55 a	7.35 a
T ₆ : Two times ZnSO ₄ spray (0.5%)	7.43 ab	6.87 b
CV (%) : Treatment	2.10	
CV (%) : T X V	1.54	
LSD (0.05): Treatment	0.34	

Depth distribution of soil physicochemical properties with crop residues retention after six cycles of four crops cropping. The experiment was initiated during T. Aus 2016 at BRRI, Gazipur, continued till Boro/Mungbean 2022, then terminated completing six crop cycles to evaluate changes in soil physicochemical properties with crop residues retention. The soil samples were collected from two depths (0-15, 16-30cm) after harvesting Boro/Mungbean, 2022 and analyzed for soil organic C (SOC), total N (TN) and available K. Three fertilizer treatments viz soil test based (STB) fertilizer (T₁), crop residues (CR) + STB fertilizer (T₂) and fertilizer control i.e. native soil nutrients (T₃) were tested under Mustard-Boro-T.

Aus-T. Aman (CP-1) and Mustard-Mungbean-T. Aus-T. Aman (CP-2) patterns. Experimental design was RCB with three replicates. In both the cropping patterns, the overall soil OC and TN contents were greater in surface (0-15cm) than sub (16-30cm) soil. In contrast, available K content was greater in sub soil (16-30cm) than in the surface (0-15cm) soil. The significant differences in SOC and TN contents between the fertilizer treatments only existed in surface soil layer. In CP-1, surface SOC increased by 0.18 to 0.41% in all the three fertilizer treatments over its initial value. While in CP-2, the surface SOC increased (by 0.33%) in crop residues incorporated treatment, T₂ only than initial surface SOC. In both the cropping patterns, the surface SOC was significantly ($p < 0.01$ to < 0.05) greater in crop residues incorporated treatment (T₂) than that in no fertilizer applied treatment (T₃). Alike SOC, the surface soil TN increased by 0.01 to 0.06% in all the three fertilizer treatments of CP-1 over initial surface soil TN. While this was the case for crop residues incorporated treatment, T₂ in CP-2. The surface soil TN in crop residues incorporated treatment (T₂) was significantly ($p < 0.01$) greater than that in T₃ (in both CP-1 and CP-2) and T₁ (in CP-1). The extent of sub soil available K rise over surface soil was greater in CP-1 (0.08-0.13 meq 100g⁻¹ soil) than that in CP-2 (0.01- 0.03 meq 100g⁻¹ soil). Irrespective of cropping pattern, soil available K did not differ significantly between the treatments in all depths ($p = 0.422$ to 0.952), except at 0-15cm depth of CP-1, where soil available K in crop residues incorporated treatment (T₂) was significantly ($p < 0.05$) greater than that in T₃. In most cases, incorporation of crop residues with AEZ based or STB chemical fertilizers had positive influence on rice equivalent yield (data not shown), soil OC, TN and available K than chemical fertilizer and no fertilizer applied treatments. This efficacious control was more prominent in CP-1 than CP-2, hence indicating that growing three rice crops and mustard essentially with AEZ based or STB chemical fertilizers and incorporation of crop residues may propose to sustain productivity and maintain soil fertility in terrace paddy field of Gazipur, Bangladesh.

IDENTIFICATION AND MANAGEMENT OF NUTRITIONAL DISORDER

Long-term use of organic and inorganic nutrients in Boro-Fallow-T. Aman rice. A long-term experiment was initiated on a permanent layout at BRRI HQ farm, Gazipur in 1985 Boro season having 12 treatments assigned in RCB design with four replications. The objective of the study was to find the impact of long-term nutrient management on grain yield and soil health. The treatments were revised according to the needs (see BRRI, 2016 and BRRI, 2019). The recent STB doses of NPKSZn were 150-12-80-5-2 kg ha⁻¹ and 100-10-80-5-2 kg ha⁻¹ for Boro and T. Aman rice, respectively. In T. Aman 2022, the variety was BRRI dhan87 and in Boro 2022-23, it was BRRI dhan89.

Grain and straw yield. Full omission of N, P and K decreased rice grain yield significantly compared to the complete fertilizer treatment in both the seasons. Among the organic treatments, applications of CD and PM as IPNS produced slightly higher grain yield as compared to complete fertilizer but VC-IPNS performed the worst (**Table 5**). Increased K rates (kg ha⁻¹) from 40 to 80 have significant impact on grain yield. Sulphur and zinc are not a limiting nutrient yet and shown similar grain yield compared to complete fertilizer in both T. Aman and Boro seasons.

In case of annual yield, organic with IPNS based chemical fertilizer treatment shows an increasing

trend compared to the complete chemical fertilizer treatment (**Fig. 1**).

Table 5. Effect of organic and inorganic amendments on rice grain yield (t ha⁻¹) of BRRI dhan87 and BRRI dhan89 at BRRI HQ, Gazipur, in 2022-23.

Treatment	Grain yield (t ha ⁻¹)	
	T. Aman 2022	Boro 2022-23
T ₁ = NPKSZn@150/100-12/10-80-5-2 kg ha ⁻¹	5.63 ab	7.00 abc
T ₂ = NPSZn (-K)	4.63 c	4.17 d
T ₃ = NKSZn (-P)	4.26 c	2.47 e
T ₄ = PKSZN (-N)	4.28 c	2.54 e
T ₅ = CD (3 t ha ⁻¹) + IPNS	5.54 ab	7.31 a
T ₆ = NPKS (-Zn)	5.51 ab	7.30 a
T ₇ = NPKZn (-S)	5.38 ab	7.15 ab
T ₈ = PM (2 t ha ⁻¹) + IPNS	5.71 a	7.36 a
T ₉ = NPKSZn @150/100-12/10-60-5-2 kg ha ⁻¹	5.54 ab	6.88 bc
T ₁₀ = VC (2 t ha ⁻¹) + IPNS	5.57 ab	6.97 abc
T ₁₁ = NPKSZn@150/100-12/10-40-5-2 kg ha ⁻¹	5.19 b	6.70 c
T ₁₂ = Control (native nutrients)	3.52 d	1.37 f
LSD _{0.05}	0.47	0.41
CV (%)	3.73	3.01

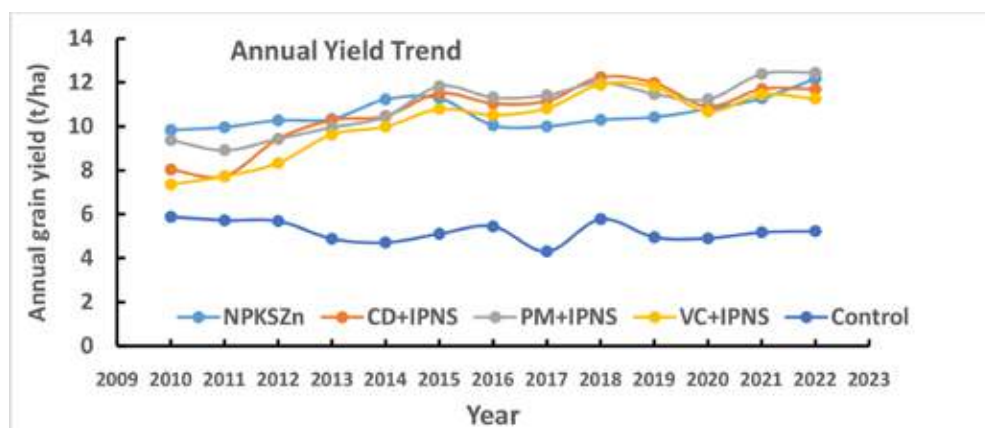


Fig. 1. Annual yield trend of IPNS based treatment compared with complete chemical fertilizer and control treatment, 2022-23, BRRI, Gazipur.

Long term missing element trial at BRRI RS, Rangpur. The experiment was initiated in a permanent layout at BRRI RS farm, Rangpur during Boro 2014-15 combining seven treatments: T₁= Control, T₂= NPKSZn, T₃= PKSZn (-N), T₄= NKSZn (-P), T₅= NPSZn (-K), T₆= NPKZn (-S), T₇=NPKS (-Zn) in RCB design with three replicates. Fertilizer nutrients i.e., N-P-K-S-Zn rate was 95-8-40-12-1 kg ha⁻¹ and 145-10-60-15-2 kg ha⁻¹ in T. Aman and Boro seasons, respectively. Urea-N was applied into three equal splits at final land preparation, active tillering and 5-7 days before panicle initiation (PI) stage. Rest of the

fertilizers were applied at final land preparation. BRRI dhan87 in T. Aman and BRRI dhan89 in Boro season were cultivated as test rice varieties.

Grain yield of T. Aman and Boro. The omission of N in T. Aman and omission of N and P in Boro season from complete fertilizer significantly reduced the rice grain yield at BRRI RS Rangpur farm (**Table 6**). Among the major nutrient elements, omission of N appeared as the most yield limiting nutrient followed by P and K omission for rice in both the seasons. The S and Zn omission have no significant effect on yield reduction at BRRI RS, Rangpur farm yet.

Table 6. Effect of long-term missing element on grain yield of BRRI dhan87 and BRRI dhan89 at BRRI RS farm, Rangpur in Boro 2022-23.

Treatment	T. Aman 2022	(%) Grain yield decreased due to nutrient omission	Boro2023	(%) Grain yield decreased due to nutrient omission
	GY(t/ha)		GY(t/ha)	
T ₁	3.37 c	-	3.04 c	-
T ₂	5.82 a	-	6.71 a	-
T ₃	3.95 b	32	3.54 c	47
T ₄	5.59 a	4	5.10 b	24
T ₅	5.70 a	2	6.32 a	6
T ₆	5.65 a	3	6.51 a	3
T ₇	5.74 a	1.5	6.53 a	2.5
<i>LSD (0.05)</i>	<i>0.40</i>		<i>0.82</i>	
<i>CV (%)</i>	<i>2.72</i>		<i>5.3</i>	

N.B. T₁= Control, T₂= NPKSZn, T₃= PKSZn (-N), T₄= NKSZn (-P), T₅= NPSZn (-K), T₆= NPKZn (-S), T₇=NPKS (-Zn)

Effect of intensive rice cropping on rice yield under continuous wetland condition. The experiment was designed to harvest three rice crops per year with evaluation of the consequences of intensive rice cropping under continuous wet land conditions and to monitor soil fertility changes over time. This experiment was initiated in 1971 in a permanent layout with NPK fertilizer application. Since Boro 2000, the experiment was modified to accommodate six treatments viz control (native nutrient), reverse control (NPKSZnCu), NPK, NPKS, NPKSZn and NPKSZnCu after several revision in 1982, 1984 and 1991. In Boro 2020-

21, the experiment was revised again with the N and K fertilizer from 140 to 160 and 80 to 100 kg ha⁻¹, respectively. The varieties tested in T. Aus, T. Aman and Boro seasons were BRRI dhan48, BRRI dhan87 and BRRI dhan84, respectively. The NPK doses used were 160-25-100, 60-15-80 and 60-10-60 kg ha⁻¹ for Boro, T. Aman and T. Aus, respectively. Sulfur, Zn and Cu were applied at 10, 4 and 1 kg ha⁻¹ in Boro season only.

Grain yield and yield trend. The annual rice production trend from 1981 to 2022 was decreasing because of continuous rice cultivation with no

fertilizer application. However, from 2001 the reverse control treatment produced grain yield almost similar to complete fertilized treatment (Fig. 2). In 2022, annual rice production in control plot was 5.33 t ha⁻¹ while its reversed management (addition of NPKSZnCu fertilizer) resulted in 12.27 t ha⁻¹ grain production, which was close to complete fertilizer treatment (13.29 t ha⁻¹yr⁻¹). It indicates that complete fertilization

can recuperate soil productivity even after a long period of rice cultivation. Results indicate that additional use of Zn and Cu once in a year with NPKS increased annual grain yield by more than 2.0 t ha⁻¹ than the application of NPKS alone. A similar increasing trend was observed in complete fertilizer (NPKSZnCu) treatment of grain yield in Boro season 2022-23.

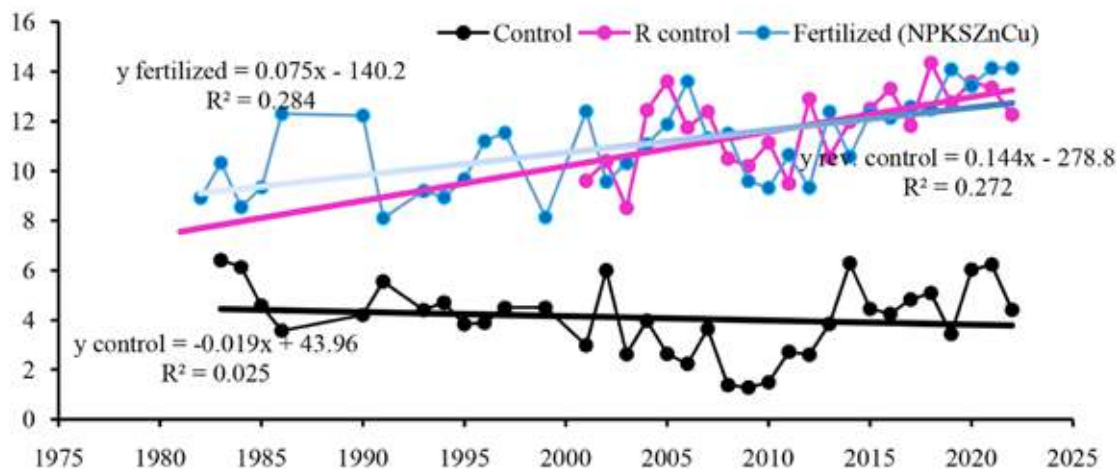


Fig. 2. Annual rice production trend under intensive wetland conditions in BRRI, Gazipur during 1981-2022.

Performance of rice variety under P deficit conditions. Acute P deficiency reduces rice yield depending on internal and/or external mechanisms that allow greater soil P extraction. The experiments were conducted at BRRI HQ farm, Gazipur during T. Aman 2022 and Boro 2022-2023 seasons having deficit soil available P condition. In both the seasons, six P doses 0, 50%, 75%, 100% 125% and 150% of STB P were evaluated with BRRI hybrid dhan4 in T. Aman while BRRI hybrid dhan3 in Boro season. Each plot received a flat dose of N-K-S-Zn (kg ha⁻¹) @ 90-42-10-1 in T. Aman and 60-20-10-2 in Boro season

Grain yield of T. Aman and Boro. Soil P deficit conditions largely influence grain yield of rice in both the seasons Soil available P levels can decrease tremendously if P fertilizer is not applied for a long period of time. Rice yield increased sharply due to P fertilizer application. BRRI hybrid dhan4 in T. Aman and BRRI hybrid dhan3 in Boro season showed better result at 100% of STB P condition (**Table 7**). The economic optimum dose of P for BRRI hybrid dhan4 and BRRI hybrid dhan3 were 29 and 24.5 kg ha⁻¹, respectively. Response of added phosphorus is lower in wet season than in dry season. However, application of recommended dose of P fertilizer might be useful for better rice yield irrespective of season.

Table 7. Response of phosphorus on grain yield of BRRI hybrid dhan4 in T. Aman 2022 and BRRI hybrid dhan3 in Boro 2022-23 BRRI farm, Gazipur.

Treatment	GY(t/ha)	
	T. Aman 2022	Boro 2022-23
T ₁ = P control	3.36 d	1.78 d
T ₂ = 50% STB P	4.46 c	6.67 c
T ₃ = 75% STB P	5.15 b	7.38 b
T ₄ = 100% STB P	5.60 a	8.15 a
T ₅ = 125% STB P	5.63 a	7.96 a
T ₆ = 150% STB P	5.65 a	7.91 a
LSD (0.05)	0.40	0.44
CV (%)	2.84	2.32

N.B. T₁ = 0, T₂ = 11, T₃ = 16.5, T₄ = 22, T₅ = 27.5, T₆ = 33 kg Pha⁻¹, respectively.

INTEGRATED NUTRIENT MANAGEMENT

Integrated nutrient management for double and triple rice cropping. The experiment was initiated in Boro 2008-09 at BRRI HQ farm, Gazipur in a clay loam soil to find the suitable fertilizer management for double and triple rice cropping system and to find out the impact of triple rice cropping on soil health. In Boro-Fallow-T. Aman pattern, BRRI dhan58 and BRRI dhan87 were used. In Boro-T. Aus-T. Aman pattern, BRRI dhan84, BRRI dhan48 and BRRI dhan87 were included as test variety. The fertilizer treatments used were: control, STB dose (NPKS @ 160-25-60-20 kg ha⁻¹ for Boro, 70-12-48-10 kg ha⁻¹ for T. Aus and 84-21-32-06 kg ha⁻¹ for T. Aman), STB (50%) + Mixed manure (MM) (CD @

2 t ha⁻¹ + ash @ 1 t ha⁻¹ oven dried), farmers' practice (FP) (NPKS @ 80-10-20-10 kg ha⁻¹ for Boro, 70-10-15-0 kg ha⁻¹ for T. Aus and 70-10-15-0 kg ha⁻¹ for T. Aman). The experiment was laid out in RCB design with three replications. Fig. 3 presents the annual grain yield of double rice cropping pattern from 2008 to 2022. Similar increasing trend of grain yield of 100% STB fertilization and 50% STB with mixed manure were observed from the beginning to upto date. But control and farmers' Practices (FP) showed decreasing trend with the increment of time. Almost similar pattern was observed in triple rice cropping pattern except FP (Fig. 4). Cumulative yield of triple cropping was always higher than double rice cropping pattern irrespective of treatment.

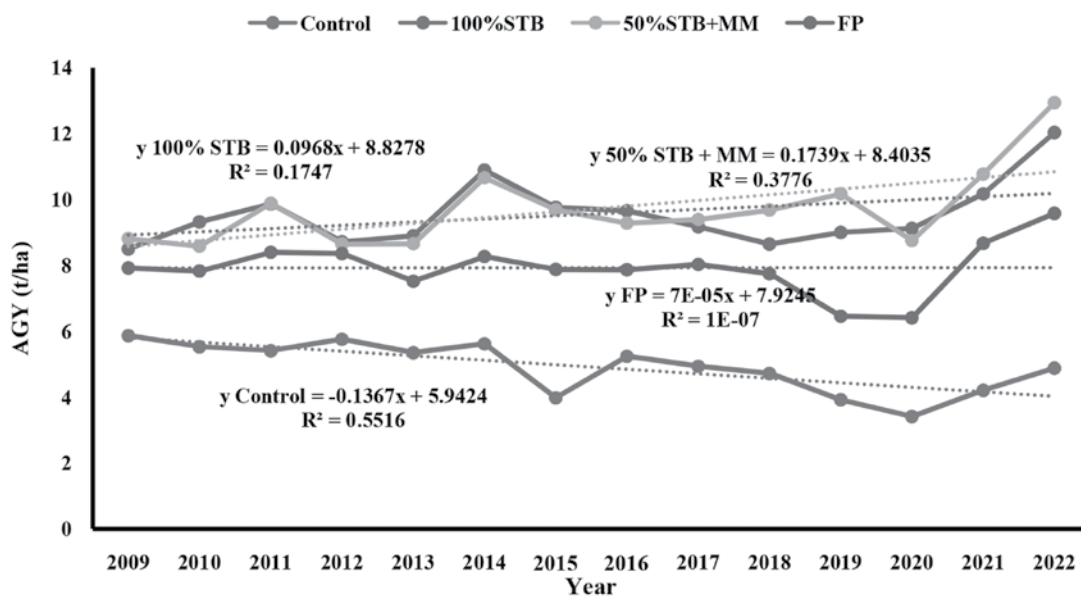


Fig. 3. Annual rice production trend under integrated nutrient management for double rice cropping for maximizing productivity during 2009-2022 in BRRI HQ, Gazipur.

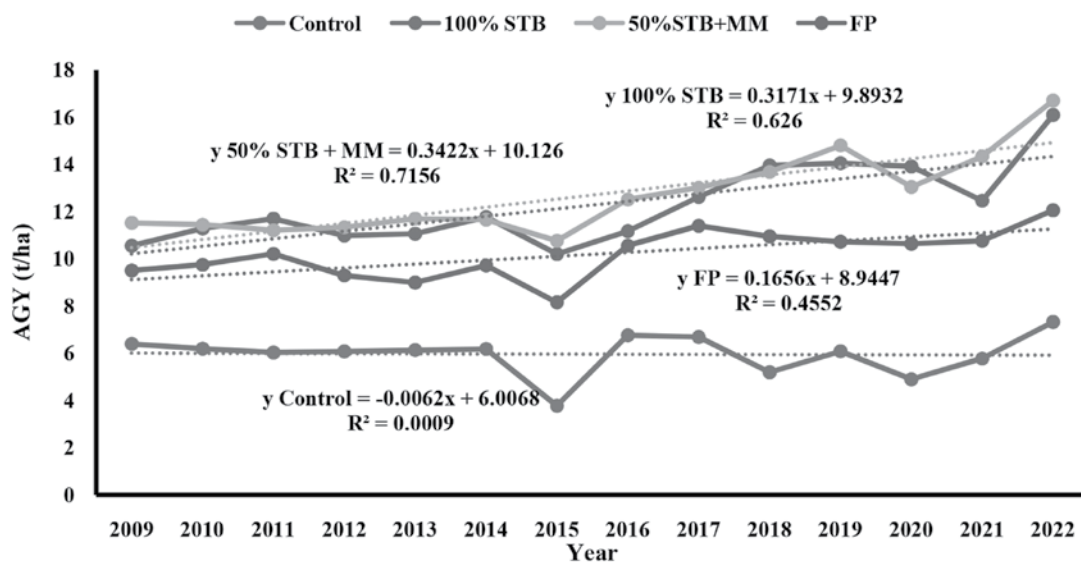


Fig. 4. Annual rice production trend under integrated nutrient management for triple rice cropping for maximizing productivity during 2009-2022 in BRRI HQ, Gazipur.

Soil management to maximize the yield of newly released rice varieties. The experiment was conducted in Boro 2022-23 at BRRI HQ farm,

Gazipur, as well as BRRI RS farms Cumilla and Rangpur to find out the best soil management to maximize rice yield with organic and inorganic

amendment with maintaining soil health. Before the initiation of the experiment, soil samples were collected and analyzed for calculating soil test based fertilizer recommendation in each sites. Treatments were T_1 = soil test based fertilizer application, T_2 = soil test based fertilizer plus 20% more nitrogen T_3 = soil test based fertilizer plus 20% more potassium and T_4 = soil test based fertilizer with available organic matter (2 t/ha). Soil test based

nutrient recommendation for Boro season 2022 in Gazipur, Cumilla and Rangpur 179:17:71:8:2; 173:18:61:12:1.5 and 167:17:71:11:2 kg/ha respectively. Grain yield were non significant in three BRRI farms irrespective of treatment. But added vermicompost with soil test based fertilizer performed good in Gazipur and Cumilla; 20% more K with soil test based fertilizer performed well in Rangpur.

Table 8. Grain yield under different soil management practices for double rice cropping for maximizing productivity of newly released BRRI rice varieties in BRRI Gazipur, Cumilla and Rangpur, Boro 2022-23.

Treatment	BRRI HQ, Gazipur			BRRI RS, Cumilla			BRRI RS, Rangpur		
	BRRI dhan89	BRRI dhan92	BRRI dhan96	BRRI dhan89	BRRI dhan92	BRRI dhan96	BRRI dhan89	BRRI dhan92	BRRI dhan96
STB	6.86	6.78	5.79	8.16	8.21	6.27	7.90	7.01	6.38
STB+20%N	6.97	6.28	6.44	8.13	7.81	6.19	6.96	7.78	6.67
STB+20% K	6.91	6.55	5.90	8.01	7.37	5.99	8.10	8.41	7.12
STB+VC	7.07	6.81	6.41	8.19	8.61	6.14	7.89	7.10	7.29
LSD _{0.05}	NS			NS			NS		
CV%	6.53			6.71			9.88		

Increase of rice yield through vermicompost (VC) amendments in coastal land. The experiments were initiated at three farmers' fields- each of Dumuria, Khulna and Amtali, Borguna, Bangladesh in T. Aman (wet) season in 2021 to find out the effect of VC on grain yield improvement. The treatments were @ 0, 1, 2 t ha⁻¹ (oven dry basis) VC with full dose of chemical fertilizer (FRG,

2018). Grain yield was significantly increasing due to vermicompost added at the rate of 1 and 2 t ha⁻¹ in Dumuria, Khulna in T. Aman 2021 but insignificant in Boro 2021-22. In Amtali, Borguna site vermicompost added at the rate of 1 and 2 t/ha with a full dose of chemical fertilizer significantly increased grain yield both in T. Aman 2021 and Boro 2021-22 seasons (Table 9).

Table 9. Yield performance of BRRI rice varieties under vermicompost amendments with recommended chemical fertilizer in coastal land, 2021-22.

Treatment	Grain yield (t/ha)			
	Dumuria, Khulna		Amtali, Borguna	
	T. Aman 2021 (BRRI dhan87)	Boro 2021-22 (BRRI dhan28)	T. Aman 2021 (BRRI han87)	Boro 2021-22 (BRRI dhan67)
Vermicompost @ 0 t/ha	6.44b	6.21	6.12b	5.41a
Vermicompost @ 1 t/ha	6.92a	6.57	6.65a	6.41b
Vermicompost @ 2 t/ha	7.14a	6.9	6.60a	6.63b
CV(%)	5.96	7.06	6.60	4.54

Nutrient management under conservation agriculture (CA) in double rice cropping system.

This experiment was initiated at Paba, Rajshahi, in Boro 2018-19 seasons with the objectives to determine the nutrient requirement of rice in Boro-Fallow-T. Aman cropping pattern, and to improve soil health under conservation agriculture practices. Two crop establishment methods (unpuddled and puddled) in the main plot, two residue management practices (straw retained and straw removed) in the sub plot and four fertilizer doses as recommended

fertilizer (RD) 100%, 125% of RD. Again 75% of RD, and 50% of RD were assigned in split-split plot design with three replications.

Grain yield. In Boro 2020-21 and T. Aman 2021, grain yields were insignificant among puddled and unpuddled cultivation, but rice straw incorporation significantly increased the rice yield (Table 10). FRG recommended (100%) fertilizer application was enough for the grain yield of rice irrespective of residue management and crop establishment method in both the seasons.

Table 10. Effect of crop establishment methods (EM), rice straw incorporation (RS) and fertilizer rates (FR) on grain yield (t ha⁻¹) of Boro and T. Aman rice, Paba, Rajshahi, 2021.

EM	Grain yield (t ha ⁻¹)							
	Boro 2020-21	T. Aman 2021	Rice straw	Boro 2020-21	T. Aman 2021	Fertilizer FRG	Boro 2020-21	T. Aman 2021
Unpuddled	4.28a	4.54a	Yes	4.31a	4.64a	125%	5.14a	4.76b
Puddled	4.22a	4.66a	No	4.18b	4.57b	100%	5.17a	5.50a
						75%	4.38b	4.45c
						50%	2.30c	3.70d

SOIL AND ENVIRONMENTAL PROBLEMS

Effects of rice cultivars and fertilizer management on rice yield and greenhouse gas emissions.

The field experiments were conducted in BRRI RS farm, Satkhira and BRRI HQ farm, Gazipur. Four rice varieties were used including BRRI dhan50, BRRI dhan67, BRRI dhan92, and BRRI hybrid dhan3 in both the locations. Two fertilizer treatment practices were tested: (i) recommended N rate @ 150 kg/ha and (ii) (PU) at 128 kg N ha⁻¹. The experiment was laid out in factorial RCB with three replications. Nutrients viz P, K, S k and Zn were used as basal at the recommended rate to all plots and the rates were 15 kg P/ha, 70 kg K/ha, 15 kg S/ha, and 1 kg

Zn/ha, respectively. PU was applied in three equal splits. The crop was harvested at full maturity of the crops. After harvest, the plot-wise crop was bundled separately and brought to the threshing floor; threshing was done manually. The rice grains were cleaned and weighed. Then, sundry weight of grain was recorded for every plot and the weight in g plot⁻¹ was adjusted at 14% moisture and finally expressed in t ha⁻¹. The sundry weight of straw was also recorded plot-wise and expressed as t ha⁻¹.

CH₄ emissions were measured using a closed gas chamber technique and their emission rates were determined from the slope of the linear regression curves of CH₄ concentration against chamber closer

time. Cumulative CH₄ and N₂O emissions were estimated by summing up the daily emissions. Emission rates between two sampling days were estimated by linear interpolation of two consecutive measurements.

Rice yield and total nitrogen uptake. Rice cultivars and locations had a significant interaction with grain yield and total nitrogen uptake (TNU) in the Boro seasons (Table 11). BRRI hybrid dhan3 significantly increased grain yield compared to the other cultivars in both the locations. At BRRI RS farm, Satkhira, BRRI dhan67 showed a similar grain yield with BRRI hybrid dhan3 and BRRI dhan92, while at BRRI HQ farm, Gazipur, BRRI dhan67 produced a lower yield relative to BRRI hybrid dhan3 and BRRI dhan92 (Table 11). The lower rice yield under BRRI dhan92 and BRRI dhan50 at Satkhira might be correlated

to soil salinity. Similarly, higher rice yield under BRRI dhan92 and BRRI hybrid dhan3 at Gazipur are probably associated with yield potentiality and genetic makeup of these cultivars. Higher TNU was found in BRRI dhan92 and BRRI hybrid dhan3 in both locations. BRRI dhan67 significantly reduced TNU compared to BRRI dhan92 and BRRI hybrid dhan3 at Gazipur, while BRRI dhan67 showed similar TNU with BRRI dhan92 and BRRI hybrid dhan3 at Satkhira. However, no significant variation was observed in rice yield and TNU between the two N rates (Table 11). Across the rice cultivars and N rates, higher rice yield and TNU was observed in BRRI HQ farm, Gazipur compared to BRRI RS farm, Satkhira.

Table 11. Effects of rice cultivars and N rates on rice yield and total nitrogen uptake during Boro season at BRRI HQ farm Gazipur and BRRI RS farm Satkhira.

Rice cultivar	N rate	Grain yield (t/ha)		Straw yield (t/ha)		TNU (kg/ha)	
		Gazipur	Satkhira	Mean of 2 locations		Gazipur	Satkhira
Effects of rice cultivars (means across N rates and locations)							
BRRI dhan50	Mean	5.6c	4.6c	5.2c		66.2c	60.9b
BRRI dhan67		6.1b	6.3ab	6.0b		75.0b	83.8a
BRRI dhan92		7.3a	6.0b	6.6a		86.2a	79.6a
BRRI hybrid dhan3		7.4a	6.6a	6.8a		93.9a	80.2a
Effects of N rates (means across cultivars and locations)							
Mean	PU-N128	6.1a		6.0a		76.3a	
	PU-N150	6.3a		6.2a		80.2a	
Effects of locations (means across cultivars and N rates)							
		Gazipur	Satkhira	Gazipur	Satkhira	Gazipur	Satkhira
Mean	Mean	6.6A	5.8B	6.3A	5.9B	80.3A	76.1B

TNU indicates total nitrogen uptake. * and ns correspond to significant and non-significant at 0.05 level of probability.

Greenhouse gas emission. Across the N rates, BRRI dhan67 and BRRI hybrid dhan3 significantly ($p < 0.05$) reduced cumulative CH₄ emissions compared to BRRI dhan50 and BRRI dhan92 in both the locations of BRRI RS farm, Satkhira and BRRI HQ farm, Gazipur (Fig. 5). The higher CH₄ emissions under BRRI dhan50 and BRRI dhan92 are probably linked to the longer growth duration of rice varieties. However, the higher N rates (N150) significantly ($p < 0.05$) increased cumulative

CH₄ emissions compared to lower the N rates (N128). The presence of high NH₄⁺ concentration from urea hydrolysis can inhibit CH₄ oxidation and enhance CH₄ emissions (Singh et al., 1999). Lower CH₄ emissions were observed in BRRI farm Satkhira compared to BRRI farm, Gazipur due to soil salinity. High salt concentrations in soil adversely affect microbial activities leading to the inhibition of methanogenesis (Fagodiya et al., 2022).

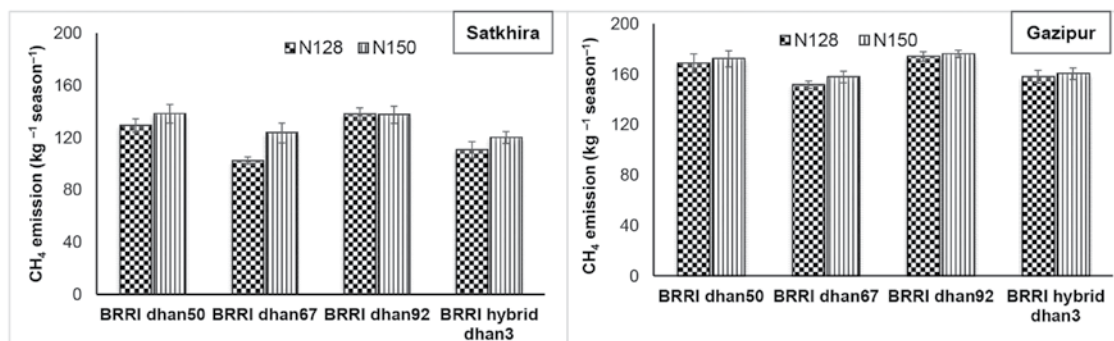


Fig. 5. Effects of rice cultivars and N rates on CH₄ emissions during Boro 2022-23 at BRRI RS farm, Satkhira and BRRI HQ farm, Gazipur.

Management interventions to improve N use efficiency with the least environmental pollution in double rice cropping of Bangladesh.

The experiment was conducted during T. (transplant) Aman 2022 and Boro 2023 at the BRRI Soil Science Division's field to assess the fates of N fertilizer (crop, soil and losses) and N use efficiency (NUE) with minimum environmental harm under various N management practices. The selected rice cultivars were BRRI dhan87 and BRRI dhan89 for T. Aman and Boro, respectively. The experimental design was RCB with seven treatments and four replicates. In T. Aman, the treatments were: T₁: no N fertilizer (N0), T₂: 110 kg N ha⁻¹ from prilled urea (N110PU), T₃: T₂+25% N (N138PU), T₄: T₂-25% N (N83PU), T₅: Cow dung (CD) (2 t ha⁻¹) + IPNS with T₂ (N110 PU+CD), T₆: BRRI Organic Fertilizer (BOF) (2 t ha⁻¹) + IPNS with T₄ (N83 PU+BOF) and T₇: Deep Placed Urea (UDP) alike T₄ (N83 UDP). During Boro, these were: T₁: N0, T₂: N140PU, T₃: T₂+25% N (N175PU), T₄: T₂-25% N (N105PU), T₅: CD (2 t ha⁻¹) + IPNS with T₂ (N140 PU+CD), T₆: BOF (2 t ha⁻¹) + IPNS with T₄ (N105 PU+BOF) and T₇: N105 UDP. The blanket rates of P-K-S-Zn were 20-60-10-1 kg ha⁻¹, resp. in T. Aman and 25-80-10-1 kg ha⁻¹, respectively in Boro for all the treatments except T₅ and T₆, where P and K were adjusted to CD and BOF, respectively. In both the seasons, air samples were collected to analyze CH₄ and N₂O. Locally fabricated lysimeter was installed to analyze NH₄⁺-N and NO₃⁻-N in leachates. NH₃ emission was measured after split application of N fertilizer using closed chamber technique and Boric Acid Trap method. Soil and plant samples were collected at 3-4 events to determine soil NH₄⁺-N and NO₃⁻-N, and plant N uptake. In Boro 2023, aerial vehicle (DRONE) was

used to take digital image, and SPAD readings and N concentrations in 1st leaves (5 readings plot⁻¹) were recorded to detect the relations between measured and predicted leaves N status. Grain yield was recorded by harvesting 5m² area plot⁻¹. In T. Aman, grain yield was statistically identical amongst N fertilizer treatments, all of which were significantly (p<0.01) greater than that in N0 (**Fig. 6**). Compared to N0, grain yield was significantly (p<0.01) greater in all N fertilizer treatments in Boro season with statistically identical grain yield was only obtained from N140PU+CD, N140PU, N175PU, N105 PU+BOF and N105UD (**Fig. 6**). During T. Aman, greater agronomic (AE_N) N use efficiency (kg grain kg⁻¹ N applied) was attained from N83PU (11), N83UDP (10) and N83 (PU+BOF) (9), while the higher recovery (RE_N) N use efficiency was attained from N83UDP (69%), N110PU (49%) and N83PU+BOF (42%) (**Fig. 7**). During Boro, greater AE_N was obtained from N105UDP, N105PU and N105PU+BOF (39, 38 and 37, resp.) whereas greater RE_N was recorded from N105UDP (**Fig. 7**). Relations between SPAD readings and measured N concentrations was moderate and positive (R²=0.64) on 32DAT (Days after transplanting), but very weak or no correlations existed during other three samplings (**Fig. 8**). In all the three splits, peak NH₃ emissions (mg NH₃-N m⁻² d⁻¹) were greater (64, 116 and 52) in higher PU-N rate T₃ (N175PU) than lower PU-N rates (23, 60 and 35 in N140PU, and 20, 52 and 31, in N105PU) (**Fig. 9**). Overall peak NH₃ emissions were comparable between N105PU+BOF (19, 57 and 41) and N140PU+CD (18, 54 and 35). In N105UDP, NH₃-N emission was lower than the other five N fertilizer treatment practices and only one detected during its full application coincided with 1st topdressing (2-21)

(Fig. 9). Therefore, 105 (Boro) or 83 (T. Aman) kg N ha⁻¹ from UDP could be the most suitable N management intervention with second alternative of N105/83 (PU+BOF) to sustain rice production

with least environmental harm from reactive N (Nr) in terrace paddy field of Gazipur, Bangladesh, but requires further verification with ¹⁵N tracing.

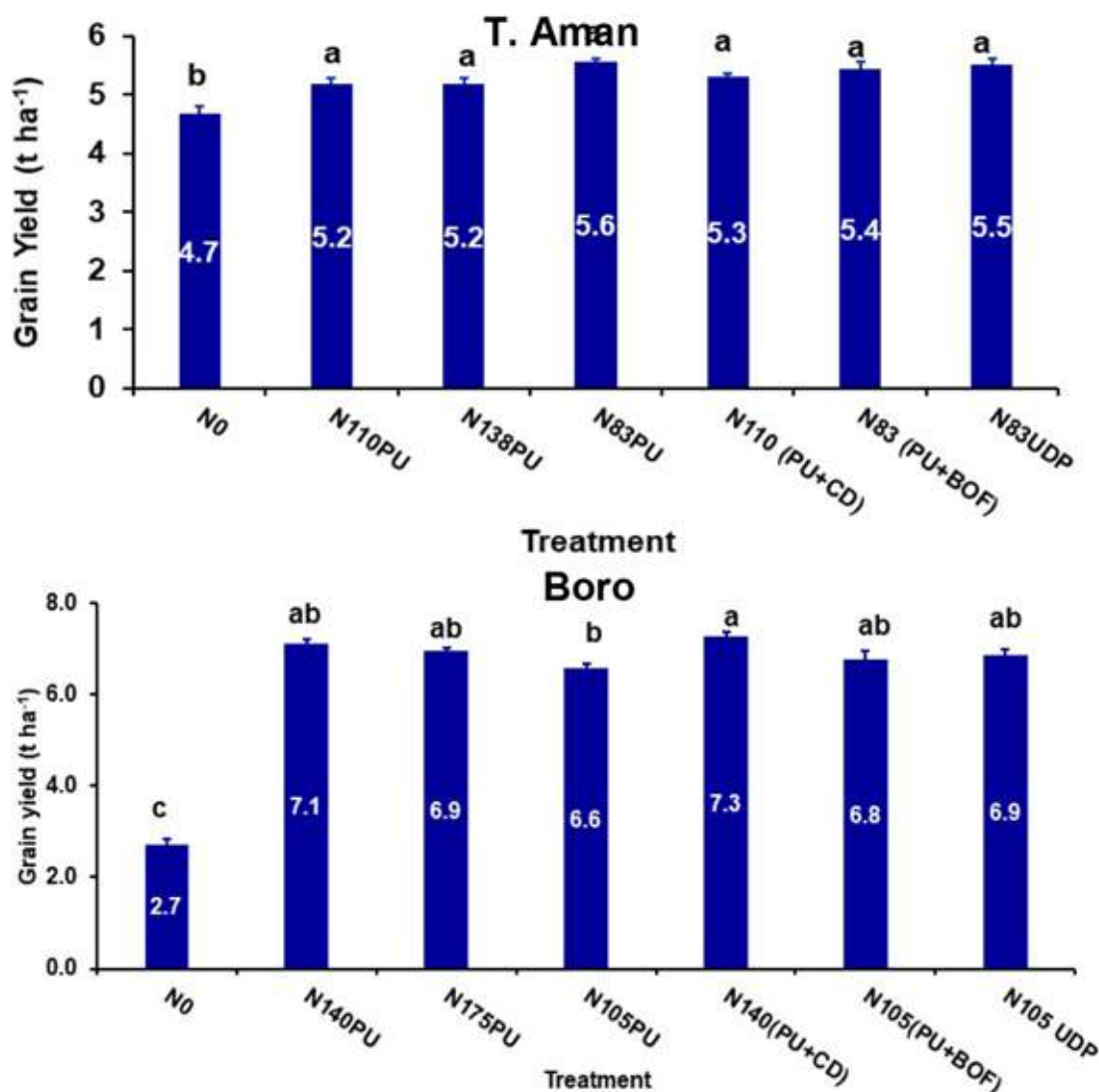


Fig. 6. Grain yield (mean $\pm$ SE, n=4) influenced by different N managements in T. Aman and Boro season rice, 2022-23. Different lower case letters after group mean indicate significant ($p < 0.01$) differences according to Duncan's Multiple Range Post Hoc Test.

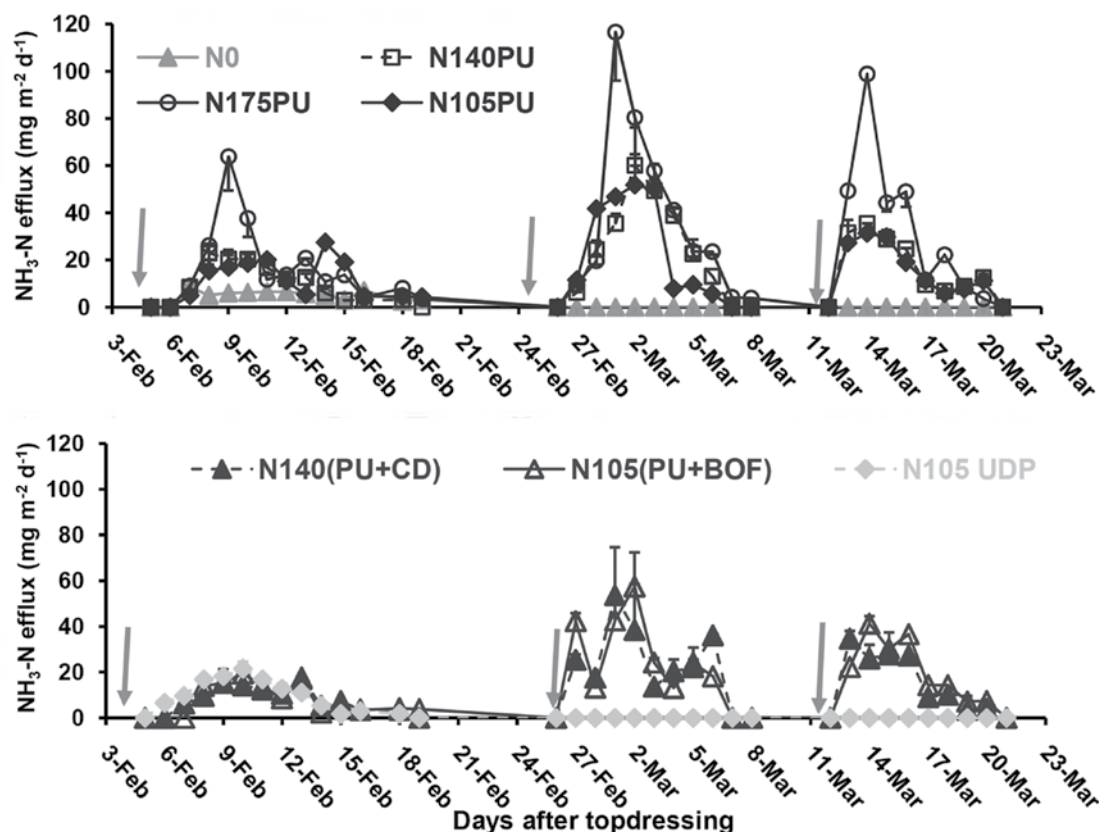


Fig. 9. Daily NH_3 emission fluxes (mean $\pm$ SE; $n = 3$) at different N managements in Boro season rice, 2023; arrow shows the day of split application of urea or UDP.

Effect of water management on mitigating of greenhouse gas emission at Gazipur and Kushtia. The study was undertaken to find out the suitable water management options based on GHG emission and sustainable rice production. The study was conducted in BRRI farm, Gazipur during and farmers' field at Kushtia during Boro 2023. The experiment involved randomized complete block design (RCBD) with four replications. In Boro season, the experiment was carried out with three irrigation management treatments as T_1 = Continuous standing water (CSW), T_2 = AWD (Supplemental irrigation when water level goes 15 cm below ground surface), T_3 = AWD (Supplemental irrigation when water level goes 25 cm below ground surface). The amount of applied irrigation was measured with a flow meter and was documented. We have followed standard

gas sampling techniques for recording N_2O and CH_4 emission patterns. The grain yield and yield contributing parameters of each treatment were recorded for statistical analysis.

Yield in Boro season. Yield of Boro rice varied insignificantly in different water management options at different locations (Table 12). Statistically insignificant grain yield (ranged from 7.16 to 7.43 t ha^{-1} and 7.67 to 7.77 t ha^{-1}) were found among the treatments and location.

GHG and GWP during Boro season. The total CH_4 flux was not significantly different because of two AWD condition at different locations. However, the AWD, 15 cm and AWD, 25 cm treatment reduced about 38-42% and 34-39% of total CH_4 flux than CSW at Gazipur and Kushtia. The GWP reduced about 36-40% and 34-37% by AWD than CSW.

Table 12. Total GHG and GWP under varying irrigation management during Boro 2023.

Treatment	Location							
	Gazipur				Kushtia			
	GHG emission (kg ha ⁻¹)			Grain Yield (t ha ⁻¹)	GHG emission (kg ha ⁻¹)			Grain Yield (t ha ⁻¹)
	CH ₄	GWP	GHGI		CH ₄	GWP	GHGI	
CSW	201	5235	0.70	7.43	205	5908	0.77	7.67
AWD, 15 cm	125	3361	0.45	7.54	136	3924	0.51	7.77
AWD, 25 cm	116	3159	0.44	7.16	125	3700	0.48	7.72
LSD _{0.05}	35	211	0.11	0.21	31	228	0.10	0.15

Effect of greenhouse gas emission under rain fed water management with T. Aman-Boro season in haor region.

The study was undertaken to find out the suitable water management options based on GHG emission and sustainable rice production in hoar region in Bangladesh. The study was conducted at farmers' field, Habiganj during T. Aman and Boro 2022-23. Popular rice cultivar BRRI dhan87 and BRRI dhan92 for T. Aman and Boro were the test varieties. The experiment involved randomized complete block design (RCBD) with three replications. Recommended chemical fertilizer was applied during the study period. During the study period, the experiment was carried out with three irrigation management treatments as T₁ = Rainfed condition, T₂ = AWD (Supplemental irrigation when water level goes 15 cm below ground surface), T₃ = CSW (Continuous standing water). The amount of applied irrigation was measured with a flow meter and was documented. We have followed standard gas sampling techniques for recording CO₂, N₂O and CH₄ emission patterns. The grain yield and

yield contributing parameters of each treatment were recorded for statistical analysis.

Yield in T. Aman season. Yield varied insignificantly in different water management options (Table 13). Sufficient rainfall in the whole growing season created no water stress during 2022. Thus, no supplemental irrigation was applied both in continuous flooding and supplemental irrigation treatments. Statistically insignificant grain yield (ranged from 4,680 to 4,725 kg ha⁻¹) were found among the treatments.

Global warming potential (GWP). It was significantly affected under different water management practices during T. Aman season. About 12-18 % of GWP was reduced by rainfed irrigation system than the other irrigation system.

In Boro season. The GWP was significantly affected under different water management practices during Boro season (Table 13). About 15-25 % of GWP was reduced by rainfed and AWD irrigation system than the continuous flooding system.

Table 13. Total GHG and GWP under varying irrigation management during T. Aman-Boro season 2022-23.

Treatment	Season					
	T. Aman			Boro		
	GWP	GHGI	Yield	GWP	GHGI	Yield
T ₁ (Rainfed)	4466	0.95	4700	5904	0.93	6350
T ₂ (AWD)	5006	1.07	4680	6268	0.94	6640
T ₃ (CSW)	5253	1.11	4725	7379	1.07	6900
LSD _{0.05}	305	0.09	230	420	0.07	380

Global warming potential as influenced by different fertilizer management practices during T. Aman and Boro season at kushtia region.

The objectives of this study were to find out GHG, GWP, GHG intensity and to increase rice yield by incorporating either VC or CD in comparison to other fertilizations. The experiment was assigned in a completely randomized block design with three replications. Unit plot size was 400 x 600 cm. Sole chemical fertilizers (SCF), farmers practice, vermicompost (VC) and cow dung (CD) as integrated plant nutrient system (IPNS) based inorganic fertilizers were tested in the experiment. T. Aman rice (wet season) was transplanted in the last week of July and harvested in the last week of November 2022. Boro was transplanted in the 2nd week of December and harvested in the last week of May 2023. Two to three seedlings of 30-35 day-old in T. Aman season and 40-45 day-old in Boro season were transplanted at 0.2-x 0.2-m spacing. Rice were grown under irrigated conditions and after harvest, the root biomass was incorporated into rice soil. Sole chemical fertilizer used were: 138/100-10-80-5-5 kg ha⁻¹ for Boro and T. Aman season as N from urea, P from triple super phosphate, K from muriate of potash, S from gypsum and Zn from zinc sulphate. Cow dung and VC were applied at two ton per hectare with IPNS based inorganic fertilizations as basal dose. One third of N, total P, K, S and Zn were applied as basal fertilizers before

rice transplanting. The rest of the N fertilizer was applied in two equal splits at active tillering stage and one week before panicle initiation stage. BRRI dhan87 and BRRI dhan92 were used as indicator crop variety in T. Aman and Boro seasons.

Gas sampling and analysis. Carbon dioxide, methane, and nitrous oxide emissions were measured by using static chamber methods during T. Aman and Boro rice cultivation (Haque et al., 2013, 2020).

Grain yield. Vermicompost with IPNS fertilizer application plot showed significantly higher grain yield than CD plot during T. Aman and Boro rice cultivation. Organic fertilization plot increased about 18-25% and 11-15% grain yield than that of farmers fertilizer management during T. Aman and Boro season. Among the treatment, farmers management showed the lowest grain yield than the other fertilization (Table 14).

Greenhouse gas emission. The lowest total CH₄, N₂O, EF, GWP and GHG intensity were found under VC treated plot than CD. About 18% reduction of GWP, 17% of EF and 22% of GHG intensity compared to CD during T. Aman season were observed. During Boro rice cultivation about 14% reduction of GWP, 15% of EF and 17% of GHG intensity. Chemical fertilizer treated plot showed lower GHG intensity, GWP and EF during T. Aman and Boro rice season than farmers and organic management.

Table 14. Grain yield, emission factor, global warming potential and GHG intensity as influenced by organic and inorganic fertilizer application during T. Aman-Boro rice cultivation at Kushtia region in, 2022-23.

Treatment	T. Aman season				Boro season			
	Grain yield (t ha ⁻¹)	EF of CH ₄ (g ha ⁻¹)	GWP (kg ha ⁻¹)	GHGI (kg ha ⁻¹)	Grain yield (t ha ⁻¹)	EF of CH ₄ (g ha ⁻¹)	GWP (kg ha ⁻¹)	GHGI (kg ha ⁻¹)
Farmers' practice	4.95d	1.95c	5305c	1.07c	6.85d	2.14c	6819c	0.99c
NPKSZn	5.30c	1.71d	4467d	0.88d	7.10c	1.95d	6245d	0.88c
Cowdung with IPNS	5.85b	3.23a	8860a	1.51a	7.60b	3.41a	10765a	1.42a
VC with IPNS	6.20a	2.69b	7306b	1.18b	7.88a	2.91b	9220b	1.17b

Global warming potential on Jute- Rice cropping system. To identify of greenhouse gas emission and GWP during jute-rice cropping system in Bangladesh. The experiment were conducted at farmers' field in Kushtia regions. The experiment was laid out in RCBD with four treatments with three replication. The treatments were: farmers' dose chemical fertilizer practice (FP), recommended chemical fertilizer practice (RP), vermicompost (VC), cowdung (CD) with integrated plant nutrient system (IPNS). The recommended dose of chemical fertilizer for Jute was N_{60}, P_{30}, K_{30} kg ha⁻¹ and $N_{100}-P_{10}-K_{80}-S_5-Zn_5$ kg ha⁻¹ for T. Aman rice. Static closed-chamber method (Haque et al., 2015, 2021)

was used to estimate GHG emission rates during Jute-Rice cropping system.

Global warming potential and yield. Among the treatments, the GWP was significantly different during jute and rice cultivation. Research management was reduced about 13% of GWP than farmers management during T. Aman season. About 44-1380 kg CO₂ ha⁻¹ are absorbed under Jute-T. Aman cropping system with different fertilizer management practices. Rice and jute yield also were significantly different with different fertilizer management practices. The lowest yield were found under the farmers practice fertilizer management under both crop cultivations (Table 15).

Table 15. Total global warming potential and yield as influenced fertilizer management under Jute-Rice cropping system 2022-23.

Treatment	GWP (kg CO ₂ eq. ha ⁻¹)			Yield (kg ha ⁻¹)	
	Crops		Cropping pattern	Crops	
	Jute	Rice		Jute (fibre)	Rice (grain)
Farmers practice	-4310	3644b	-665b	4200c	4830c
Research practice	-4567	3187c	-1380a	4350b	5090b
Vermicompost with IPNS	-4618	4449a	-169c	4800a	5990a
Cowdung with IPNS	-4575	4531a	-44d	4810a	5850a

Greenhouse gas emission and absorption under different fertilizer management practices with Wheat-Rice cropping pattern in Kushtia region.

Greenhouse gas emission is mainly associated with aerobic and anaerobic crop culture, which is influenced by different fertilizer management, placement methods, water management systems and different cropping patterns. Organic and inorganic fertilizer practices on greenhouse gas (GHG) emission, net carbon budget (NCB), net global warming potential (GWP) during wheat-rice cultivation is not well documented. Static close chamber were used for estimating CH₄, N₂O and CO₂ emission and absorption from wheat-rice cultivation. The experiment was conducted at farmers field in Kushtia. The treatments were: (i) recommendation chemical fertilizer (RCF), (ii) farmers practice chemical fertilizer (FP), (iii)

cowdung (CD) and (iv) vermicompost (VC). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The recommended dose of commercial fertilizers for wheat cultivation was $N_{150}P_{40}K_{120}S_{20}Zn_{1.5}B_1$ kg ha⁻¹ and were supplied from urea, TSP, MoP, gypsum, zinc sulphate (hepta) and boric acid, respectively. Farmers' chemical fertilizer doses was $N_{170}P_{30}K_{100}S_{20}Zn_1B_1$ kg ha⁻¹. The unit plot size was 6 m x 5 m. Wheat seeds were sown in line continuously from November 2021 with row to row spacing of 20 cm. After that, the first flooded irrigation was applied at 25-27 days after sowing seeds, and the second irrigation was applied at 38-40 DAS. T. Aman rice (wet season) was transplanted in the last week of July and harvested in the last week of November 2022. Sole chemical fertilizer used were: 100-10-80-5-5 kg ha⁻¹ for T. Aman season

as N from urea, P from triple super phosphate, K from muriate of potash, S from gypsum and Zn from zinc sulphate. Cow dung and VC were applied at two ton per hectare with IPNS based inorganic fertilizations as basal dose. One third of N, total P, K, S and Zn were applied as basal fertilizers before rice transplanting. The rest of the N fertilizer was applied in two equal splits at active tillering stage and one-week before panicle initiation stage. BRRI dhan87 was used as indicator crop variety in T. Aman season.

Gas sampling and analyses. The static closed-chamber method (Haque et al. 2013, 2020a, 2021a, b, 2022) was used to estimate CO₂, N₂O and CH₄ emission rates during wheat-rice cultivation. The

following equation are used for calculation of net carbon balance= NPP+fertilizer-CH₄-C- respiration carbon- biomass carbon.

Grain yield. In wheat cultivation, about 3% higher yields were obtained because of VC application than CD uses. The FP showed a lower yield 2980 kg ha⁻¹ than the other treatment. In T Aman season, VC application showed higher grain yield than that of the other treatments (Table 16). On the other hand, wheat cultivation showed significantly higher CO₂ absorption than rice cultivation. The CO₂ absorption rates were about 1,121-4,057 kg ha⁻¹ under wheat-rice cropping system during the study period based on fertilizer management (Fig. 10).

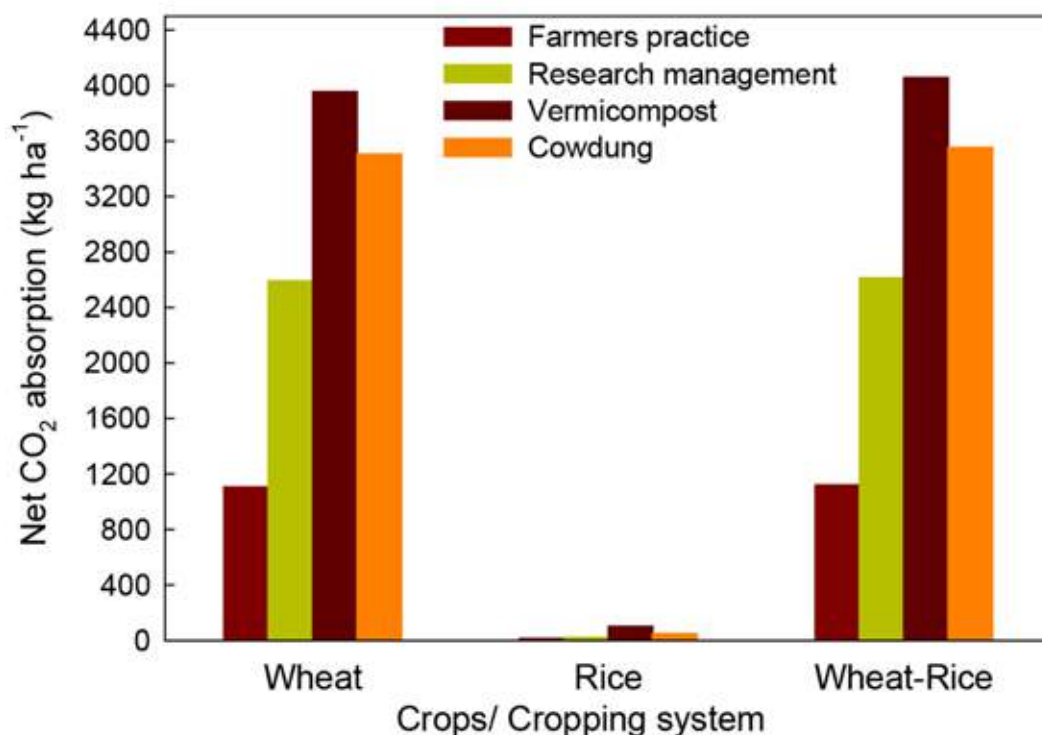


Fig. 10. Net CO₂ absorption as influenced by organic and inorganic fertilizer management under Wheat-Rice cropping pattern, at Kushtia region, 2022-2023.

Table 16. Grain yield as influenced by organic and inorganic fertilizer management under Wheat-Rice cropping pattern, at Kushtia region, 2022-2023.

Treatment	Grain yield (kg ha ⁻¹)	
	Crops	
	Wheat	Rice
Farmers' practice	2980c	4730c
Research practice	3360b	4980b
Vermicompost with IPNS	3880a	5590a
Cowdung with IPNS	3770a	5450a

Effect of biochar on rice yield in the charland.

The study was conducted at BRRI RS, Sirajganj with the objective to determine the effect of biochar on rice growth and yield and soil health in problem soils. The experiment was initiated in Boro 2019-20 and consisted of four treatments: T₁= Control, T₂= Recommended fertilizer (RF), T₃= RF + biochar @ 2 t ha⁻¹ and T₄= RF + biochar @ 4 t ha⁻¹. The treatments were arranged in RCB design with three replications. The biochar was produced from chita dhan (unfilled grain). The recommended dose of N-P-K-S was 100-15-40-10 kg ha⁻¹ in T. Aman and 138-21-75-18 kg ha⁻¹ in Boro season. Biochar was applied only in Boro season and incorporated with soil before seven days of transplanting. In T. Aman season, 30 % fertilizer was reduced from the recommended dose in the biochar treated plots to observe the residual effect of biochar on rice. In T. Aman season, reduction of 30% fertilizer from the recommended dose in the biochar treated plots produced grain yields similar to full dose of recommended fertilizer (5.65 t ha⁻¹) which might be due to the residual effect of biochar. In Boro 2022-23 season, application of biochar @ 4 t ha⁻¹ with recommended fertilizer resulted in the highest yield (6.77 t ha⁻¹) of BRRI dhan89 than the other treatments.

SOIL MICROBIOLOGICAL STUDIES

Field evaluation of BRRI bio-organic fertilizer.

BRRI bio-organic fertilizer was developed with the objectives to reduce synthetic N and P fertilizer use in rice cultivation and to improve soil health. To evaluate its field performance, one field experiment was conducted at BRRI HQ in both the seasons of T. Aman 2021, and Boro 2021-2022. Bio-organic fertilizer (BoF) was used at 2 t ha⁻¹. The treatment combinations were NPKS (100%), BoF + 70% (N) +100% (KS), BoF +100% NPKS and fertilizer control. Recommendation rates of chemical fertilizers for T. Aman and Boro were (kg ha⁻¹) N-P-K-S @ 67-10-41-10 and 140-20-80-10, respectively. BRRI dhan87 at T. Aman and BRRI dhan89 was grown in the Boro season.

Grain yield. Study result proved bio-organic fertilizer (BoF @ 2t ha⁻¹) has potential to supplement 30% N and 100% P requirement for HYV rice without sacrificing yield. In the T. Aman, application of BoF with 70% (N) +100% (KS) produced the highest grain yield of 5.47 t ha⁻¹. Statistically similar grain yield was obtained in 100% NPKS (4.75 t ha⁻¹) and BoF +100% NPKS (4.85) treatment. However, in the Boro season, the highest grain yield was recorded (7.40 t ha⁻¹) in the BoF with 70% (N) +100% (KS) treatment and it was statistically similar with BoF with 100% NPKS application. The significantly lowest grain yield was found at the control treatment.

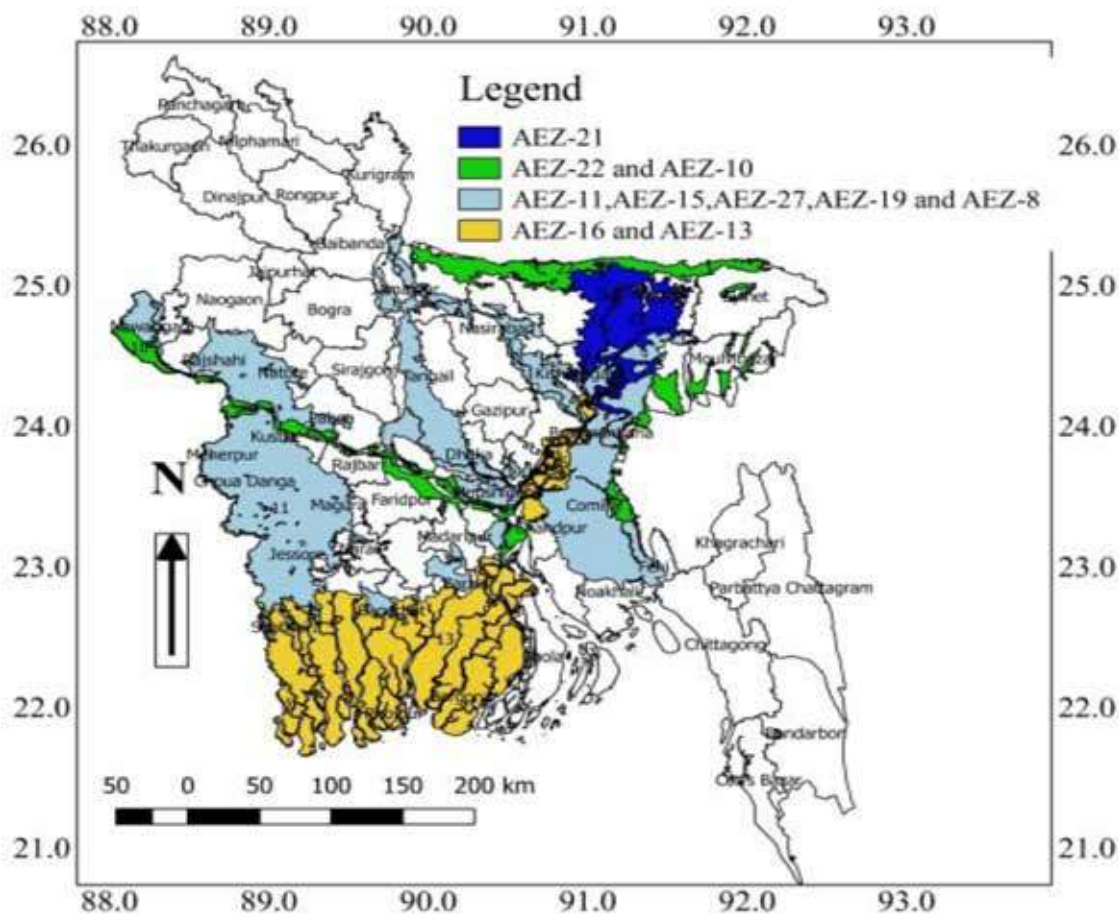
Microbial characterization of different AEZs

soil. Soil biology dictates soil health. Studies were conducted with the aim to determine the soil microbial populations from eight AEZ's of Bangladesh and to characterize the potential free-living N₂ fixing, phosphate solubilizing, and indoleacetic acid producing bacteria and finally prepared a climate smart biofertilizer using the potential bacteria for higher rice productivity. Soil samples (0-15 cm depth) were collected using GPS recording from AEZ-10 (Faridpur), AEZ-11 (Jashore- Rajshahi), AEZ-13 (Satkhira), AEZ-15 (Munshiganj), AEZ-16 (Brahmanbaria- Munshiganj), AEZ-19 (Cumilla- Kishoreganj), AEZ-22 (Moulavibazar- Habiganj) and AEZ-27 (Rangpur- Bogura) and tested for microbial properties, texture, soil pH and organic matter.

Soil bio-physico-chemical properties of different

AEZs. Microbial populations were enumerated on the selective media following 'total plate count' method. Study report showed that the range of total bacteria populations were significantly high in the Decreechar union of AEZ-10 (2×10^6 to 2×10^9 cfu/g soil), Panisara union of AEZ-11 (2×10^7 to 2×10^9 cfu/g soil), and Deorghachi union of AEZ-22 (7×10^6 to 1×10^9 cfu/g soil) (Map). The lowest total bacteria range was found in AEZ-13. Total fungus population range was comparatively lower in the AEZ-10, AEZ-13, AEZ-15, AEZ-16 and AEZ-27. On an average, Actinomycetes populations were low in all the tested AEZs. The populations of free-living N_2 fixing bacteria were higher than the Rhizobium populations. However, populations

of phosphate solubilizing bacteria were higher than free-living N_2 fixing bacteria. Aside soil microbial properties, soil physico-chemical properties such as soil texture, pH, total nitrogen and organic matter content were determined following standard protocol. Among the tested eight AEZs, the highest organic matter (3.90%) and total N (0.21%) was recorded in the Chadnighat union of Moulovibazar Sadar upazila in AEZ-22. In conclusion, among tested eight AEZs, the populations of beneficial bacteria (free-living N_2 fixing, Rhizobium and phosphate solubilizing bacteria), soil organic matter and total N were lower than any healthy agricultural soil. Application of organic matter and biofertilizer is crucial to replenish soil health and sustainable crop production.



MAP showing that highest population found in AEZ-21(10^9 cfu/g soil), AEZ-10 and AEZ-22 (10^8 cfu/g soil), AEZ-11, AEZ-15, AEZ-27, AEZ-19 and AEZ-8 (10^7 cfu/g soil) and AEZ-16 and AEZ-13 (10^6 cfu/g soil)

Biomolecular characteristics of the isolated strains. The dominant potential bacteria from each AEZ were identified and tested for biomolecular characteristics. Among the strains, the highest N_2 fixation (28 ppm NH_4) was recorded by *Bacillus thuringiensis* (B49) isolated from AEZ-27 and *Pseudomonas geniculata* (B61) isolated from AEZ-15. The highest 3746 ppm P was solubilized by the *Stentrophomonas maltophilia* (B53), isolated from Shahjahnpur upazila of AEZ-27. The highest amount of indoleacetic acid (144 ppm) was produced by the *Bacillus sp.* (B59) isolated from Shyamshiddhi union of Sreenagar upazila (AEZ-15).

Formulation of biofertilizer for acid and saline soil. Isolated 15 potential strains were coated

with TSP and urea fertilizer and named as ‘Bio-coated urea’ and ‘Bio-coated TSP’ biofertilizer, respectively. Nutrient mineralization from bio-coated fertilizer and survival of the bacteria during the incubation study were in satisfactory level (Fig. 11a and b). In the glasshouse, pot experiments were conducted for testing the efficacy of the developed biofertilizer in the soil plant system. Study results showed that about 36% grain yield increased in BRRI dhan28 and saved 50% TSP fertilizer by the application of ‘bio-coated TSP’ in acid soil compared to TSP fertilizer only (Table 17). Application of PGPR-coated urea improved grain yield 10.53% of BRRI dhan99 over chemical fertilizer in the saline soil (Table 18).

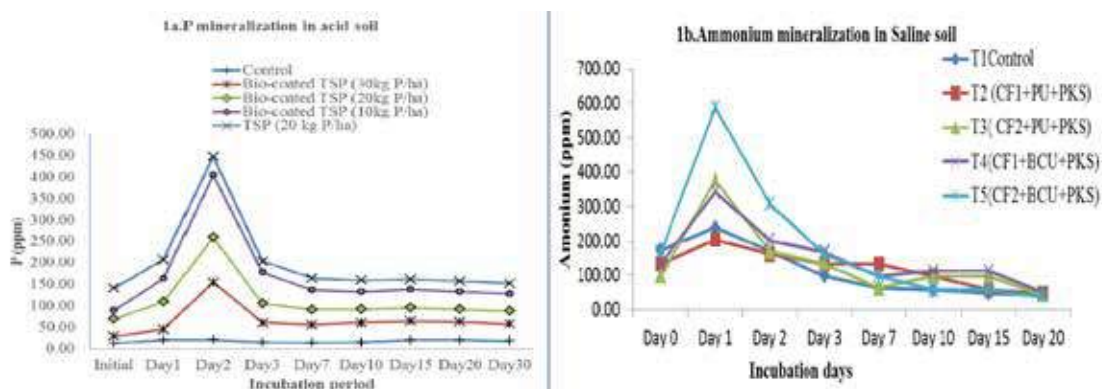


Fig. 11a. Effect of bio-coated TSP and TSP fertilizer on available P mineralization in Acid soil.

Fig. 11b. Effect of Bio-coated urea and urea fertilizer on N mineralization in saline soil.

Here, CF1: NPKS (kg/ha) @ 120-20-50-10, and CF2: NPKS (kg/ha) @ 120-20-120-10, PU: Prilled urea and BCU: bio-coated urea.

Table 17. Effect of bio-coated TSP and TSP fertilizer on growth and yield of BRRI dhan28 and PSB population after harvest.

Treatment	Plant height (cm)	Tiller /hill	Straw weight (g)	Panicle /hill	Yield/ plant (g)	PSB population (cfu/g soil)
Control	67.5 b	6.7	4.9b	5.0c	4.3c	3x10 ³
Bio-coated-TSP (@30 kgP/ha)	68.3 b	7.2	6.7a	7.2a	7.0ab	2x10 ⁶

Bio-coated-TSP (@20 kgP/ha)	73.0 ab	5.8	6.8a	5.8bc	7.0ab	4x10 ⁶
Bio-coated-TSP (@10 kg P/ha)	69.0 ab	6.7	7.0a	6.7ab	7.6a	5x10 ⁶
TSP (@20 kg P/ha)	75.2 b	5.0	5.3b	5.0 c	5.6bc	3x10 ⁴
CV (%)	10.8	32.9	14.9	15.4	21.0	8

PSB; Phosphate solubilizing bacteria. In the column, means followed by the letter were significant at the 5% level of significance.

Table 18. Effect of bio-coated urea on growth and yield of BRRI dhan99.

Treatment	Plant height (cm)	Tiller /hill	Straw weight (g)	Yield/ plant (g)
Control	85.7 b	6 b	18.8 b	13.7 d
NPKS (kg/ha) @ 120-20-50-10, N as prilled urea	88.5 ab	10 a	26.8 ab	15.2 bc
NPKS (kg/ha) @ 120-20-120-10, N as prilled urea	92.7 a	11 a	29.6 a	15.0 c
NPKS (kg/ha) @ 120-20-50-10, N as Bio-coated urea	90.7 ab	11 a	31.7 a	16.6 a
NPKS (kg/ha) @ 120-20-120-10, N as Bio-coated urea	92.8 a	10 a	31.2 a	16.25 ab
CV (%)	25	11.8	27	5.97

In the column, means followed by the letter were significant at the 5% level of significance.

Irrigation and Water Managment Division

154	Summary
155	Water Use Efficiency Improvement In Irrigated Agriculture
158	Land Produtivity Improvement In The Costal Environment
158	Sustainable Management Of Water Resources
159	Utilization Of Renewable Energy
160	Technology Validation In The Farmers' Field

SUMMARY

During 2022-23, Irrigation and Water Management Division reported 13 programmes of basic and applied research as well as two major programmes of technology validation and adaptation in different agroecological zones with a target to generate and extend water efficient technologies in rice water management for increasing land and water productivity, which would lead to sustainable food security and improved livelihood. Automated AWD prototype could measure water level in the rice field with an accuracy of 95 percent. In the hilly region, the location based LULC analysis from satellite images provides the evidence that 5,220 ha surface water bodies in Barkal upazila of Rangamati district and 15,600 ha surface water bodies in Chakaria upazila of Cox's Bazar district are available that could be used for irrigation water source. The case-study based physical assessment discovered that, in total, irrigation coverage could be extended to about 2,000 ha land in Panchari upazila of Khagrachari district, Rajastali upazila of Rangamati district, and Sadar upazila of Khagrachari district. The feasible water management intervention options are constructing cross dam or earthen dam across the creek or stream, constructing rubber dams to conserve canal water, installing solar pumps, introducing modern water distribution systems (i.e., pipe distribution system), developing integrated minor irrigation schemes with low lift pumps (LLP) along with high yielding crop varieties, applying precision irrigation technologies like sprinkler irrigation system or drip irrigation system. During Boro season, six long durations high yielding advanced lines of rice were tested under four water management treatments along with BRRI dhan92 (check variety). The experimental results show that good yield could be achieved from BR11715-4R-186, BR11723-4R-27, BR11723-4R-12, BR11712-4R-218, BR11723-4R-172 and BRRI dhan92 under both CSW and AWD irrigation practice. The experimental results also show that good yield could be achieved from BR11723-4R-27, BR11723-4R-12, BR11712-4R-218, BR11723-4R-172 and BRRI dhan92 under thin irrigation practice. Aman season revealed that,

grain yield and yield contributing characters were not statistically significant for soil amendment practices. About 36.3% yield was increased by compaction over control during Boro season for improving soil-water availability for crop production in Charland by amendment practices. A subirrigation system was designed and installed in BRRI research field to evaluate the performance of system in transplanted rice field during 2022-23 irrigated seasons. No major constraint was marked during the growing seasons except some small technical flaws in the system. The troubleshooting was done immediately when found at the field. The average yield was reported 7.2 t/ha (BRRI dhan89) and the subirrigation system was found 63% efficient compared to conventional flooding irrigation system. A field experiment was conducted at BRRI HQ farm, Gazipur in 2022-23 Boro season aimed at variation in irrigation water requirement in relation to delayed transplanting. Transplanting on 15 and 31 January may need more water but produced the highest yield. Whereas, transplanting on 14 February and 31 January required less irrigation water due to reduced growth duration and increased rainfall but had a lower yield. The study revealed that the latest salt-tolerant rice variety like BRRI dhan97 and BRRI dhan67 can be grown with saline water irrigation up to 4 dS m⁻¹ for getting higher yield potential during the dry season in the saline coastal zone. However, groundwater level depletion was about 44.17 m in last 25 years at BRRI, Gazipur farm, showing an alarming average declining rate of 1.77 m per year. For the sustainable management of water resources, conjunctive use of municipal wastewater with fresh water would be a good irrigation option in Boro season. For computing water use efficiency of BRRI Wets Byde farm, 29.40% of applied water was not used by crop and being wasted by different purposes. Yield of Boro crop of the Haor areas is almost doubled after application of supplementary irrigation at reproductive stage by groundwater development. Solar pump utilization for irrigation purpose at Subornochar upazila of Noakhali district in the Chattogram region is not feasible when the source of water is groundwater. During development of a low-cost brushless DC solar

pump system it is required some modifications to achieve the design rpm and discharge. Based on the research findings in Dacope and Amtali upazilas, farmers expressed their willingness to continue the cultivation of BRRI dhan87 in medium high land and BRRI dhan76 in the medium-low to low land areas due to higher yield, short duration, and unique characters to cope with the environments. These varieties improve the land productivity, net income, and benefit cost ratio (BCR) and also facilitated the cropping intensification in the coastal areas. The performance confirms that the integrated rice/vegetable system was economically viable under the modified vegetable establishment method. Moreover, the high investment for the modified rice/vegetable cropping system identified as a vital bottleneck for large-scale adoption of the technology, in the financial capital scarce coastal region. Govt. had taken some initiative for popularizing this technology in the waterlogged coastal region for enhancing food and nutritional security. All the tested varieties performed well in both the Barishal and Khulna regions over the tested years. But, freshwater availability is the main constraints for cultivation of Boro rice. However, farmers are highly interested to grow Boro rice by conserving fresh water using trapped canal, because the production is less risky compared to the other Rabi crops, which were more vulnerable for uncertain rainfall and cyclonic damage. Cultivation of Boro rice becomes profitable for its safe and higher production. In Aus season, BRRI dhan48, BRRI dhan98 and BRRI hybridhan7 covered 108 hectares including 790 farmers. The yield range was 5.5 – 4.3 t/ha in Barishal and 4.6 – 4.1 t/ha in Khulna. The highest yield was from BRRI dhan87 in all locations during Aman season which varied from 4.2 to 6.4, 5.2 to 6.4 and 5.7 to 7.0 t/ha with an average of 5.4, 6.1 and 6.0 t/ha in Barishal, Khulna and Satkhira, respectively. The average yield of BRRI dhan76 was 3.5 to 5.5 t/ha. BR23 and BR11 also had satisfactory yield which varied from 3.5 to 5.5 t/ha. During Boro season, in Barishal region, the highest yield was obtained from BRRI dhan89, BRRI dhan92 and BRRI Hybridhan5 which ranged from 6.7-11.4 t/ha. Whereas BRRI dhan74 performed well than BRRI dhan67. The range of

yield was 5.8-8.7 t/ha and 5.4-8.4 t/ha for BRRI dhan74 and BRRI dhan67, respectively. In the Khulna region, BRRI dhan81, BRRI dhan58 and BRRI hybridhan5 had higher yield. The yield range of BRRI dhan67, BRRI dhan97 and BRRI dhan99 was 3.2 – 7.8 t/ha, 3.5 – 6.5 t/ha, 4.8 – 6.8 t/ha, respectively. In Satkhira, the yield range of BRRI dhan67 and BRRI dhan81 were 6.3 – 7.4 and 6.4 – 7.2 t/ha, respectively. Overall, Boro yield was much higher in the Barishal region than in Khulna and Satkhira because of the availability of fresh water.

WATER USE EFFICIENCY IMPROVEMENT IN IRRIGATED AGRICULTURE

Development of Automated Alternate Wetting and Drying Irrigation System for

Rice Production

The study is currently ongoing in collaboration with the Department of Computer Science and Engineering, Gazipur University of Engineering and Technology (DUET), Bangladesh. A sensor-based technique has been adopted for applying water efficiently and properly in AWD irrigation system. In Boro 2022-23 season, an ultrasonic sensor based automated AWD unit prototype has been developed. The system could be run by rechargeable batteries powered by solar energy from solar panel. The automated AWD unit was connected to an online server. The real-time water table data along with historic records could be easily accessible through a desktop based app. The AWD unit sent the water level data using a cellular SIM connection. We set up an AWD prototype unit in the BRRI HQ, Gazipur farm. The unit were connected to solar panel to get solar energy in order to supply power to system batteries. The system automatically measured the water level in the pipe using ultrasonic sensors in every six hour, four times a day. Then the measured data were transmitted to the central server. We also installed another AWD pipe near the automated prototype where we measured water level manually every day in the morning at 9:30 am. After the Boro season, we compared the automated module captured data and manually measured data of water level. The results showed that the automated AWD prototype could measure water level in the rice field with an accuracy of 95 percent. The system

would be connected to pump operation in the next irrigation season to control the pumps based on automatic water level measurement.

Problem and potentials for crop productivity improvement through water management in hilly areas

The major challenges of South-Eastern region are water scarcity in dry period, insufficient energy sources for irrigation, lack of sufficient irrigation equipment and water structures, inadequate modern farming knowledge, difficult transport communication and marketing channels, etc. However, this region has a good number of opportunities like rainwater or surface water availability, water structure development for irrigation water conservation, solar energy utilization, orchard or agroforestry farming, crop area expansion through extending irrigation facilities, precision irrigation technologies application and high value crop cultivation. Nationwide the irrigation coverage is about 63% of total cultivable land whereas irrigated areas are only 13%, 15%, 5% and 26% of total cultivable land in Rangamati, Khagrachari, Bandarban and Cox's Bazar districts, respectively. However, this region has potential irrigation water sources from a few major rivers (i.e., Karnafuli, Kassalong, Chengi, Myani, Feni, Sangu or Shonkho, Matamuhuri, Bakkhali, etc.), Kaptai lake, enormous number of creeks (locally know as Jiri or Chora), and ponds as well as canal networks. The location based LULC analysis from satellite images evident that 5,220 ha surface water bodies in Barkal upazila of Rangamati district and 15,600 ha surface water bodies in Chakaria upazila of Cox's Bazar district are available that could be used for irrigation water source. The case-study based physical assessment discovered that, in total, irrigation coverage could be extended to about 2000 ha land in Panchari upazila of Khagrachari district, Rajastali upazila of Rangamati district, and Sadar upazila of Khagrachari district. The feasible water management intervention options are constructing cross dam or earthen dam across the creek or stream, constructing rubber dams to conserve canal water, installing solar pumps, introducing modern water distribution systems (i.e., pipe distribution system), developing integrated minor irrigation

schemes with low lift pumps (LLP) along with high yielding crop varieties, applying precision irrigation technologies like sprinkler irrigation system or drip irrigation system. This region is also a prospective spot to spread agroforestry technologies with the backup of irrigation equipment and power sources. In Cox's Bazar district, 13 promising spots were located where construction of water reservoir by cross dam or rubber dam, installation of pipe distribution system and LLP installation (i.e., integrated minor irrigation system), re-excavation of canal network, replacement of non-functioning sluice gates or regulators could bring huge valley land under crop cultivation.

Performance evaluation of the proposed rice varieties under different water regimes

The experiment was conducted during Boro season 2022-23 at BRRI HQ farm, Gazipur. Six long duration high yielding advanced lines of rice as BR11715-4R-186, BR11723-4R-27, BR11723-4R-12, BR11716-4R-105, BR11712-4R-218 and BR11723-4R-172 were tested under four water management treatments along with BRRI dhan92 (check variety). The cultivars were grown in plots under different water regimes. The treatments included four water management treatments: were: T1 = Maintaining continuous standing water from +1 to +5 cm; T2 = AWD irrigation practice (+5 to -15 cm); T3 = Thin irrigation condition (AWD: +2 to -15 cm) up to booting stage; and T4 = Thin irrigation condition (AWD: +2 to -20 cm) up to the booting stage. The treatments were replicated thrice. The experimental results show that good yield could be achieved from BR11715-4R-186, BR11723-4R-27, BR11723-4R-12, BR11712-4R-218, BR11723-4R-172 and BRRI dhan92 under both CSW and AWD irrigation practice. The experimental results also show that good yield could be achieved from BR11723-4R-27, BR11723-4R-12, BR11712-4R-218, BR11723-4R-172 and BRRI dhan92 under thin irrigation practice. To confirm the study results this experiment will be repeated in the next Boro season.

Improving soil-water availability for crop production in Charland by amendment practices

The study has been carried out in BRRI RS farm

Sirajganj, during Aman 2022 and Boro 2022-23. The objective of the study was to improve soil physical properties, soil water retention capacity of the root zone depth and to identify a suitable soil amendment practice to increase water use efficiency and the crop productivity of the char land. The study consists of five amendment practices as: T1= Compaction with clay soil at the layer of 20-30 cm, T2=Vermicompost added at the top soil (0-10 cm) @ 5 t/ha, T3=top soil (0-10 cm) mixed with 50% of clay soil, T4=Biochar added at the top soil (0-10 cm) @5 t/ha, T5= Cow dung added at the top soil (0-10 cm) @ 5 t/ha and T6= control treatments in randomized complete block design with three replications. Rice seedlings were raised in wet nursery bed and transplanted in experimental plots. BRRI dhan87 and BRRI dhan89 used as a cultivar during Aman and Boro season, respectively. Fertilizer doses were applied as BRRI recommendation. Yield attributing traits and grain yield of rice were recorded. Results of Aman season revealed that, grain yield and yield contributing characters were not statistically significant difference by soil amendment practices (Table1). Higher plant height (132.2 cm) was observed in cow dung added at top layer amendment practices followed by compaction with clay soil at the layer of 20-30 cm. Number of effective tiller per hill (10.73) was observed in vermicompost added in top layer followed by cow dung added in top layer of soil. Compaction, clay soil added, and control treatment produced lower number of sterility % than vermicompost, biochar and cow dung added treatment plot. Higher grain yield (6.38 t/ha) was obtained from vermicompost added at the top layer of soil followed by clay soil added at the top layer of soil. Number of irrigation and amount of irrigation were statistically significant difference by the soil amendment practices (Table 2). Number of irrigations were significantly lower by the soil compaction practices. Similarly amount of irrigation was also lower in the treatment. Higher water productivity (5.61 kg/ha-mm) was obtained from soil compaction treatment followed by cow dung added in the top layer of the soil. Number of irrigation and amount of irrigation was decreased by the compaction treatment over control about 16% and 13.3%, respectively. Plant height, number

of effective tiller and grain yield were influenced by the soil amendment practices (Table 3). The higher plant height (108 cm) was obtained from the compaction treatment followed by biochar added at the top layer of the soil. The lowest plant height (88.6 cm) was found by the control. Similarly, number of effective tillers per hill was obtained from compaction treatment. The highest grain yield (6.55 t/ha) was obtained from the compaction followed by cow dung added at the top layer of the soil. Statistically similar yield was obtained from vermicompost added, biochar added, and cow dung added at the top layer of the soil. Grain yield was increased by compaction over control about 36.3%.

Optimization of Water Use Efficiency Through Subirrigation System in Different Soils of Bangladesh

Subirrigation, a precision irrigation technique, is comparatively a new irrigation method for rice cultivation ever used in Bangladesh. Subirrigation system, basically shallow groundwater table along the soil profile, and it is the reverse process of subsurface drainage. This is the artificial addition of water to the soil profile to moisten the crop root zone. In this system, water applied through perforated pipe beneath the soil surface. Water is allowed to stand for lateral and upward movement by capillarity. This system can optimize water supply to meet crop water requirements as well as increase irrigation water-use efficiency. A subirrigation system was designed and installed in BRRI research field to evaluate the performance of system in transplanted rice field during 2022-23 irrigated seasons. The length of the installed system area was 10 m, and the width was 6 m. The total area of the installed subirrigation system was 60 square meter. For design purposes, the soil physical and hydraulic properties of the selected field were measured. Then, the lateral (drain) spacing and lateral and main (drain) size were determined using available equation and models (Hooghoudt equation, DRAIN CALCULATOR, etc.). The design spacing was found 1.2 m and design depth was found 30 cm from ground surface. For both lateral and main pipe size, 4 in diameter PVC pipe was selected for the subirrigation system. For subsurface irrigation, an overhead tank (1000 L) was installed to supply

adequate irrigation water to crop root zone of the field. A flowmeter (4 in diameter) was set up at the inlet of the system to measure the amount of water supplied to the field. No major constraint was marked during the growing seasons except some small technical flaws in the system. The troubleshooting was done immediately when found at the field. The average yield was reported 7.2 t/ha (BRRI dhan89) and the subirrigation system found 63% efficient compared to conventional flooding irrigation system. This system could be converted to automated and digitized mode with the use of sensors, remote sensing, and artificial intelligence.

Irrigation water requirement and rainfall utilization for delayed transplanting of Boro rice in different locations of Bangladesh

A field experiment was conducted at BRRI HQ farm Gazipur in 2022-23 Boro season aimed at variation in irrigation water requirement in relation to delayed transplanting. The treatments were four transplanting dates (T1 = 15 January, T2 = 31 January, T3 = 14 February, T4 = 1 March) with four replications. Results showed that transplanting on 14 February and 1 March required less water (21-23%) than transplanting on January because of adding rainfall water in the late transplanting (Table 4). However, transplanting on 14 February and 1 March drastically reduced grain yield (22-48% lower yield) relative to transplanting in January. Water productivity was also higher with the early transplanting (6 kg/ha-mm) compared to delayed transplanting (3.5-5.5 kg/ha-mm) (Table 5). Transplanting on 15 and 31 January may need more water but produced the highest yield. Whereas, transplanting on 14 February and 31 January required less irrigation water due to reduced growth duration and increased rainfall but had a lower yield

conducted at the farmer's field at Dacope Upazila in Khulna district in 2022-23 to find out suitable irrigation management options for Boro rice cultivation and the effect of saline water irrigation in response to the growth and yield of rice. The treatments were four saline water irrigation treatments (water salinity < 1 dS m⁻¹, 4 dS m⁻¹, 6 dS m⁻¹, 8 dS m⁻¹ and 10 dS m⁻¹) and two salt tolerant varieties (BRRI dhan67a and BRRI dhan97). The field was arranged with strip plot design and three replications. Both water and soil salinity were influenced by seasonal rainfall. During harvesting, soil salinity was almost double with irrigation water salinity at 8 and 10 dS/m compared to irrigation water salinity at 1 and 4 dS/m (Fig. 1). Soil salinity was at the permissible level when irrigation water was applied at 1 and 4 dS/m. There was a significant difference in rice yield with saline water irrigation treatments but no difference in the varieties (Table 6). Irrigation with 1 dS/m and 4 dS/m had of yield 5.3 and 5.1 t/ha. Whereas rice yield was significantly reduced with increasing salinity levels of irrigation water. The grain yield reductions were 19, 45, and 62% for irrigation treatments 6 dS m⁻¹, 8 dS m⁻¹ and 10 dS m⁻¹ compared to irrigation with 1 dS/m. BRRI dhan97 had a lower yield reduction than BRRI dhan67, indicating that BRRI dhan97 was more salt tolerant than BRRI dhan67. Increasing salinity level of irrigation water also increased unfilled grain and reduced plant height. In conclusion, increasing irrigation water salinity adversely affected Boro rice growth and yield. Salt tolerant rice varieties with irrigation water salinity below 4 dS/m can give potential yield. Therefore, to increase Boro rice cultivation in the coastal area, the maximum volume of less saline irrigation water should be stored in the internal canal after the rainy season.

LAND PRODUCTIVITY IMPROVEMENT IN THE COSTAL ENVIRONMENT

Saline water irrigation strategies for Boro rice cultivation in the coastal saline area

Boro rice cultivation in the coastal saline area is challenging due to the scarcity of fresh water. Using less saline irrigation water can be a strategy to increase rice production. A field experiment was

SUSTAINABLE MANAGEMENT OF WATER RESOURCES

Monitoring of groundwater fluctuation and safe utilization in different geo-hydrological regions

In this study, available water level recorder was used for measuring groundwater fluctuation in BRRI HQ, Gazipur and all regional stations. Data were recorded weekly. Collected weekly records were

calculated to obtain monthly average. In Gazipur, during 2022-23 period, maximum lowering of groundwater (-49.4 m) was observed in January and minimum (-47.4 m) in July (Fig. 2). The fluctuation was more than 2.0 m. The fluctuation was higher than the previous year. In 1998, the minimum groundwater level was about 5.23 m below the ground surface which was 49.4 m in 2023 (Fig. 3). Therefore, the lowering was about 44.17 m in 25 years. During the initial five years (1998-2002) the lowering (3.8 m) was not so high, but during the last five years (2019-2023) the lowering was about 5.18 m. Figure 4 presents monthly groundwater level of BRRI regional stations. Among 10 regional stations, the groundwater level was below the suction limit (> 8 m) during Boro season in Cumilla, Rajshahi and Habiganj.

Conjunctive use of wastewater and freshwater for irrigation in Boro rice cultivation

For determining the suitability of different wastewater treatments, a pot experiment was conducted with five irrigation treatments namely T_1 = Irrigation with freshwater(control), T_2 = Irrigation with municipal wastewater (MWW), T_3 = Irrigation with industrial wastewater (IWW), T_4 = Irrigation with fresh water and industrial wastewater (50% FW and 50% IWW) and T_5 = Irrigation with fresh water and municipal wastewater (50% FW and 50% MWW). Thirty-five-day-old seedling of BRRI dhan89 was transplanted with RCBD and three replications. In total 19 number of irrigation was applied in every pot throughout the growth stages. Yield and yield contributing parameters were recorded. Irrigation with freshwater (control) produced the highest yield(198.3g/pot) followed by irrigation with fresh water and municipal wastewater (50% FW and 50% MWW) (173.6g/pot) (Table 7). So, along with freshwater, municipal wastewater with fresh water is a good option for irrigation practices in the Boro season.

Assessing on-farm Water-use efficiency of BRRI Research Farm, Gazipur

For computing water use efficiency of BRRI West Bye farm, one pump was chosen for this study and the command area was also quantified. After transplanting, operating time of pump and discharge

rate was monitored and calculated. Seepage and percolation and also the evapotranspiration was also measured. Required and supplied amount of water was found 71,485.96 m³ and 1,01,242.1 m³ respectively. The WUE was rated 70.60 %. So, 29.40% of applied water was not used by crop and being wasted by different purposes.

Groundwater use potential for supplemental Irrigation of Boro rice production in the haor areas

Two STWs was installed in the study area for supplying supplementary irrigation water during the water scarcity period in Boro season. Start and end date of irrigation was recorded. The amount of water applied for each supplementary irrigation was recorded regularly. Sample crop-cut were taken from the fields. A comparison of grain yield between plots with and without supplementary irrigation was made. The previous crop yield in STW-1 ranged from 3.5 to 4.5 t/ha. The present yield after supplementary irrigation ranged from 7.00 to 8.50 t/ha. The previous crop yield in STW-2 ranged from 3.5 to 5.0 t/ha. The present yield after supplementary irrigation ranged from 7.00 to 9.00 t/ha. It indicated that crop yield is almost doubled after application of supplementary irrigation by groundwater development. Boro crop of the haor areas experiences water stress during the ripening phase which reduced the yield significantly. The study results show that 2-4 supplementary irrigation from groundwater (STW) sources will increase the yield around two times. So, installation of groundwater irrigation system will be a very important step to ensure food security. Steps will be taken for irrigation expansion of both the STWs in the next year.

UTILIZATION OF RENEWABLE ENERGY

Feasibility assessment of solar pump utilization for irrigation purpose in Chattogram region

In 2022-23, the study was conducted in Subornochar upazila of Noakhali district. The study emphasized on source of irrigation water feasible for solar pump utilization in the Subornochar upazila under the coastal region of Noakhali district. The main source of irrigation water is groundwater. There is

some tidal surface water which are not suitable for irrigation due to high salinity. The lithology of 17 locations of Subornochar upazila has been studied to examine availability and suitability of groundwater for irrigation. Groundwater availability was done by geological formation of aquifer and quality was examined by analyzing various physicochemical parameters (BADC, 2019). These parameters were compared with the drinking and irrigation water quality standards recommended by WHO. Lithological studies show that good aquifers are located at deeper layers from 575-845 ft. From the analysis, it was observed that pH neutral; however, the pH did range from slightly acidic to slightly alkaline (mean 7.5). The electrical conductivity values of the groundwater samples range from 116 to 2,860 $\mu\text{S}/\text{cm}$, which was fall into the acceptable limit for irrigation except Char Clark (Jahura Khatun) union (Fig. 5). Some anions and cations (trace metals) present in the examined groundwater were $\text{Cl}^- > \text{SO}_4^{2-} > \text{NO}_3^-$ and $\text{Fe}^{2+} > \text{As}^{5+}$. The values of alkalinity in the Subornochar upazila of the study region fall within the permissible limit that are being prescribed in WHO (2017) for drinking water. Lithological studies show that good aquifers are located at deeper layers and contain good quality water for irrigation. So solar power operated submersible pump (forced pump) can extract groundwater from deeper layer when more solar panels will be required to generate energy and installation cost will be also higher. Hence, in terms of power source, electricity will be cheaper and suitable than solar power for irrigation when using groundwater. So, solar pump utilization for irrigation purpose at Subornochar upazila of Noakhali district in Chattogram region is not feasible when the source of water is groundwater.

Development of A Low-Cost DC Solar Water Pump for Irrigation in Bangladesh

The initial cost of solar powered irrigation pumps is high. Generally, in solar pumps of Bangladesh, DC system is converted to AC system using pump inverter. Some energy is wasted in this conversion process. As a result, the efficiency of the irrigation pump decreases. To overcome this problem, BRRI has initiated a research programme for the development of a low-cost DC solar powered

irrigation pump. A 1200 W, 3,200 RPM and 48/60 V permanent magnet brushless DC motor which is widely used in auto rickshaws of Bangladesh, collecting from local market. Irrigation pumps with 2-inch suction and delivery have been selected. Rigid coupling was built between the shaft of pump and motor in the workshop. We have used 1,200 W solar power in which each solar panel is 200 W (Fig. 6). The results depicted that design rpm was not achieved due to lower capacity of solar power. The average discharge was obtained 3.5 l/s. On the other hand, rigid coupling produced some heat between the shaft of pump and motor. The DC solar pump discharge was not found up to the mark. It required some modifications to achieve the design rpm and discharge.

TECHNOLOGY VALIDATION IN THE FARMERS' FIELD

Mass demonstration of suitable Aman rice varieties for facilitating Rabi/Boro crops intensification

The yield performance of the promising T. Aman varieties (BRRI dhan87 and BRRI dhan76) were good in both Dacope and Amtali areas. Based on the research findings in both the locations, farmers expressed their willingness to continue the cultivation of BRRI dhan87 in medium high land and BRRI dhan76 in the medium-low to low land areas due to higher yield, short duration, and unique characters to cope with the environments. These varieties improve the land productivity, net income, and benefit cost ratio (BCR) and also facilitated the cropping intensification in the coastal areas. The key insight of the findings is that adoption of modern technologies (variety and agronomic management) not only likely to increase food grain production and farm income but also to reduce risk of the rainfed T. Aman rice cultivation largely. Thus, the wide-scale adoption of the improved agronomic practice and promising cultivars of Aman rice cultivars is highly potential to enhance crop production and farm income in the coastal area substantially.

Growing vegetable crops with rice under waterlogged lowland condition

The integrated rice/vegetable system was not

economically attractive under the initial method (plastic sac with bamboo). But after some modification by introducing durable plastic drum and concrete pillar and galvanized iron wire and synchronizing vegetable production with T. Aman rice, then two to three times vegetable production was possible. Now the farmers were interested to cultivate high value off-season watermelon and get more return compared to the other vegetables. However, the system found to have the potential for ensuring nutritional security and regular cash income for the coastal dwellers. The current years' performance confirms that the integrated rice/vegetable system was economically viable under the modified vegetable establishment method. Moreover, the high investment for the modified rice/vegetable cropping system identified as a vital bottleneck for large-scale adoption of the technology, in the financial capital scarce coastal region. Thus, the policy support for arranging a special credit scheme for the integrated/rice vegetable system in the saline coastal region could transform the area as vegetable surplus from a huge deficit. The government had taken some initiative for popularizing this technology in the waterlogged coastal region for enhancing food and nutritional security.

Block demonstration of Boro rice by using stored surface water in coastal areas for cropping intensification

All the tested varieties performed well in both the Barishal and Khulna region over the tested years. But, freshwater availability is the main constraints for cultivation of Boro rice. However, farmers are highly interested to grow Boro rice by conserving fresh water by trapped canal, because the production is less risky compared to the Rabi crops, which were more vulnerable for uncertain rainfall and cyclonic damage. Cultivation of Boro rice become profitable for its safe and higher production.

Mass block demonstration of Aus, Aman, and Boro rice by using high yielding varieties, improved agricultural practices in the coastal areas to cropping intensification

The demonstrations were setup in farmer's field at Barishal, Khulna and Satkhira district. In Aus

season, BRRI dhan48, BRRI dhan98 and BRRI hybriddhan7 covered 108 hectares including 790 farmers. The yield range was 5.5 – 4.3 t/ha in Barishal and 4.6 – 4.1 t/ha in Khulna. In Aman season, the total demonstration area was 198 ha with 700 farmers. Introducing the high yielding varieties including BRRI dhan76, BRRI dhan75 and BRRI dhan87 along with the farmer's popular variety BR10, BR11 and BR23 were tested in the selected areas. The highest yield was from BRRI dhan87 in all locations which varied from 4.2 to 6.4, 5.2 to 6.4 and 5.7 to 7.0 t/ha with an average of 5.4, 6.1 and 6.0 t/ha in Barishal, Khulna and Satkhira, respectively. The average yield of BRRI dhan76 was 3.5 to 5.5 t/ha. BR23 and BR11 also had satisfactory yield which varied from 3.5 to 5.5 t/ha. In Boro season, high yielding rice varieties BRRI dhan74, BRRI dhan81, BRRI dhan89, BRRI dhan92, BRRI hybriddhan3, BRRI hybriddhan5 and salt tolerant rice varieties BRRI dhan67, BRRI dhan97 and BRRI dhan99 were demonstrated in a block with a range of 10-100 Bigha area in low saline area Barishal and high saline area in Khulna and Satkhira region. In all locations, the total area was 656 ha with 2150 farmers. In Barishal region, the highest grain yield was from BRRI dhan89, BRRI dhan92 and BRRI Hybriddhan5 which ranged from 6.7-11.4 t/ha. Whereas BRRI dhan74 performed well than BRRI dhan67. The range of yield was 5.8-8.7 t/ha and 5.4-8.4 t/ha for BRRI dhan74 and BRRI dhan67, respectively. In the Khulna region, BRRI dhan81, BRRI dhan58 and BRRI hybridhan5 had higher yield. The yield range of BRRI dhan67, BRRI dhan97 and BRRI dhan99 was 3.2 – 7.8 t/ha, 3.5 – 6.5 t/ha, 4.8 – 6.8 t/ha, respectively. In Satkhira, the yield range of BRRI dhan67 and BRRI dhan81 were 6.3 – 7.4 and 6.4 – 7.2 t/ha, respectively. Overall, Boro yield was much higher in the Barishal region than in Khulna and Satkhira because of the availability of fresh water.

Table 1. Effect of different soil amendments practices on yield and yield components of rice at BRRI experimental farms, Sirajganj during Aman 2022.

Treatment	Plant height (cm)	No. of effective Tiller /hill	Sterility%	1000 grain weight (g)	Grain yield (t/ha)
T ₁	131.3	11.2	29.6	21.67	5.48
T ₂	129.1	10.13	25.8	25.67	5.5
T ₃	129.9	10.73	39.6	23.0	6.38
T ₄	129.7	9.63	40.3	24.0	5.37
T ₅	132.2	10.67	41.2	21.33	5.06
T ₆	126.0	9.83	20.0	23.0	5.38
F test	ns	ns	ns	ns	ns
lsd _(0.05)	6.53	1.86	19.7	4.39	1.26
cv (%)	6.3	8.2	18.7	10.4	12.5

Table 2 Amount of irrigation water with number influenced by amendment practices in charland during Boro 2022-23.

Treatment	Number of IR	Amount of IR (mm)	Water productivity (kg/ha-mm)	Number of IR increased over control	Amount of IR increased over control
Compaction	18.3	1168	5.61	15.67	13.29
Clay mixing at top layer	22	1387	3.72	-1.38	-2.97
Vermicompost added	22	1404	3.97	-1.38	-4.23
Biocher added	22	1386	3.96	-1.38	-2.90
Cowdung added	21.7	1402	4.04	0.0	-4.08
Control	21.7	1347	3.10	--	--
lsd _{0.05}	0.79	105.3			
cv%	2	4.3			

Table 3. Effect of different soil amendments practices on yield and yield components of rice at BRRI experimental farms, Sirajganj, during Boro season 2022-23.

Treatment	Plant height (cm)	Number of effective tiller/hill	Grain yield (t/ha)	Grain yield increased over control
T ₁	108.0	11.53	6.55	36.34
T ₂	98.6	9.47	5.16	19.19
T ₃	100.3	9.6	5.57	25.13
T ₄	107.4	10.87	5.49	24.04
T ₅	101.5	10.20	5.66	26.33
T ₆	88.6	8.33	4.17	--

Treatment	Plant height (cm)	Number of effective tiller/hill	Grain yield (t/ha)	Grain yield increased over control
lsd0.05 cv%	**(<0.001) 4.35 2.4	* 1.84 10.1	**(<0.001) 0.75 7.6	

Table 4. Water requirement and water applied for Boro rice in Gazipur in 2021-22.

Treatment	Water requirement (mm)			Water applied (mm)				
	Evapo-transpiration (ET)	Seepage and Percolation (S&P)	Total water required (mm)	Number of irrigation	Water applied in land preparation	Applied irrigation	Rain-fall	Total amount of water used (mm)
T ₁	425	395	820	12	180	800	160	1140
T ₂	418	390	808	11	180	770	185	1135
T ₃	385	348	733	9	180	630	185	995
T ₄	350	315	665	8	180	610	257	1047

Table 5. Yield and water productivity of different transplanting dates of Boro rice in Gazipur in 2021-22 .

Treatment	Growth duration (day)	Total water use including rainfall (mm)	Yield (t/ha)	Water productivity (kg/ha-mm)
T1	141	1140	6.9	6.0
T2	135	1135	6.6	5.8
T3	125	995	5.4	5.4
T4	122	1047	3.6	3.5
<i>P</i> value			0.001	
LSD			0.82	

Table 6. Effect of different saline water irrigation on yield and yield components of BRRI dhan67 and BRRI dhan97 at Dacope, Khulna in 2021-22 season

Treatment	Plant height (cm)	Number of effective tiller/hill	Grain yield (t/ha)	Grain yield increased over control	
Saline water irrigation	Variety	Yield (t ha ⁻¹)	Number of filled grain per panicle	Number of unfilled grain per panicle	Plant height (cm)
I1	V1	5.3	132	13	116
I2		5.1	128	19	109
I3		4.0	109	28	98
I4		2.8	96	37	94
I5		1.9	78	44	87
I1	V2	5.2	128	15	118
I2		5.0	123	22	110
I3		4.5	113	31	101
I4		3.0	102	36	95
I5		2.1	82	40	88
Treatment mean					
I1		5.3	129	14	117
I2		5.1	126	21	109
I3		4.3	111	29	100
I4		2.9	99	36	94
I5		2.0	80	42	87
V1		3.8	107	28	100
V2		4.0	109	29	103
<i>P</i> -values					
Irrigation		0.001	0.001	0.001	0.001
Variety		NS	NS	NS	NS
Irrigation x variety		NS	NS	NS	NS
LSD _{0.05}					
Irrigation		0.27	8.0	7.0	4
Variety		-	-	NS	NS
Irrigation x variety		-	-	-	-

Table 7. Yield and yield contributing parameters of different irrigation treatments during Boro 2022-23.

Treatment	Plant height (cm)	Panicle length (cm)	Tiller/Hill	Panicle/Hill	Yield/Pot (g)
T ₁ = Irrigation with freshwater(control)	100.0a	25.6a	13.1a	12.7a	198.3a
T ₂ = Irrigation with municipal wastewater (MWW)	97.0a	24.0a	9.3b	8.8b	134.3c
T ₃ = Irrigation with industrial wastewater (IWW)	98.3a	25.0a	10.3b	9.6b	146.0bc
T ₄ = Irrigation with fresh water and industrial wastewater (50%FW and 50% IWW)	98.7a	25.2a	18.9a	18.4a	150.0bc
T ₅ = Irrigation with fresh water and municipal wastewater (50%FW and 50% MWW)	99.0a	26.8a	19.0a	18.5a	173.6ab
CV	4.4	5.83	30.24	25.85	5.6

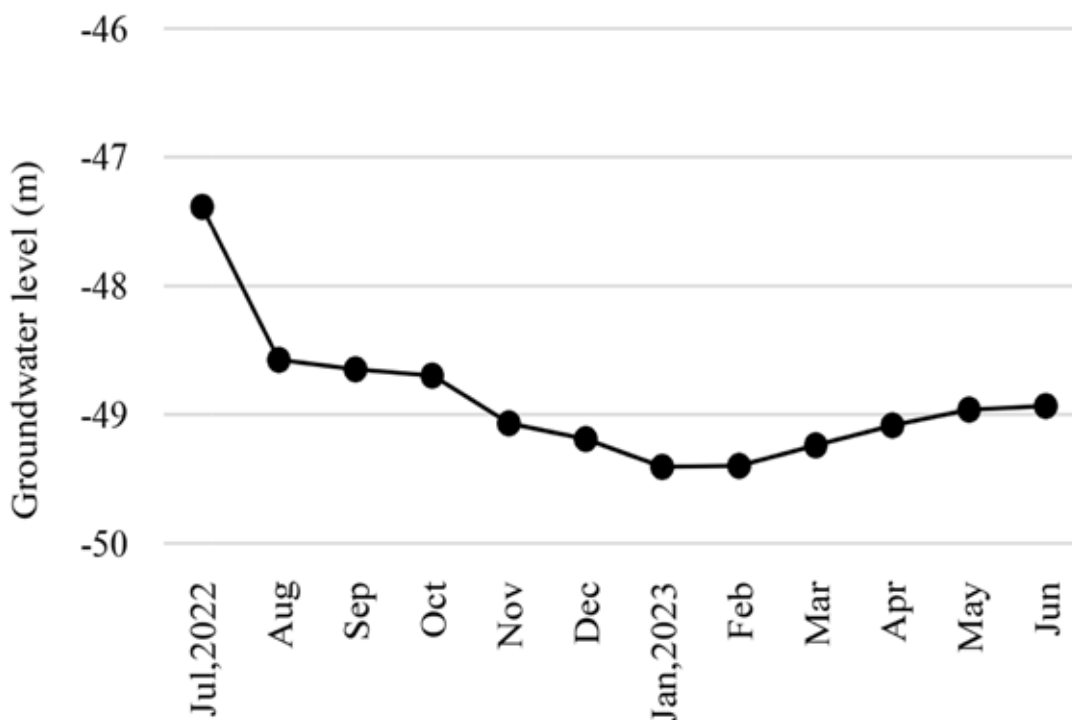


Fig. 1. Soil salinity dynamics at 0-10 cm soil depth with saline water irrigation during the growing season of Boro rice in Dacope Khulna in 2022-23.

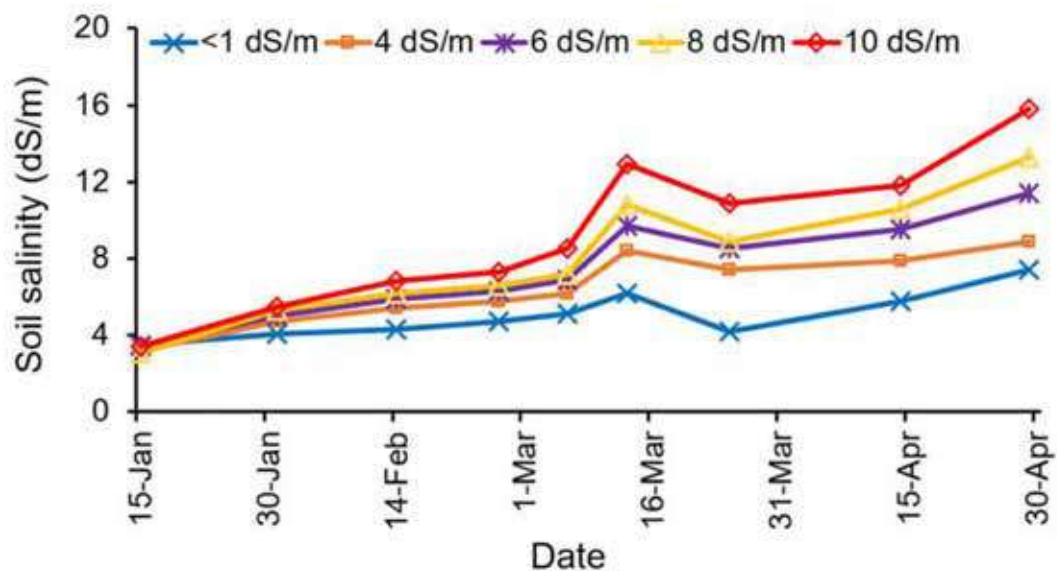


Fig. 2. GW fluctuation (2022-23) at BRRi farm Gazipur.

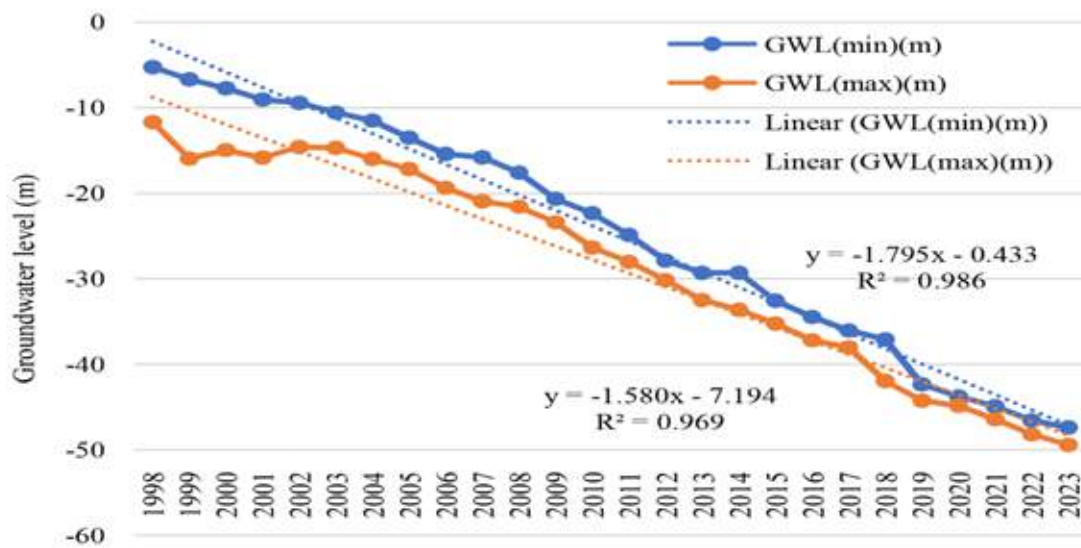


Fig. 3. Long-term GW declination (1998-2023) at BRRi farm Gazipur.

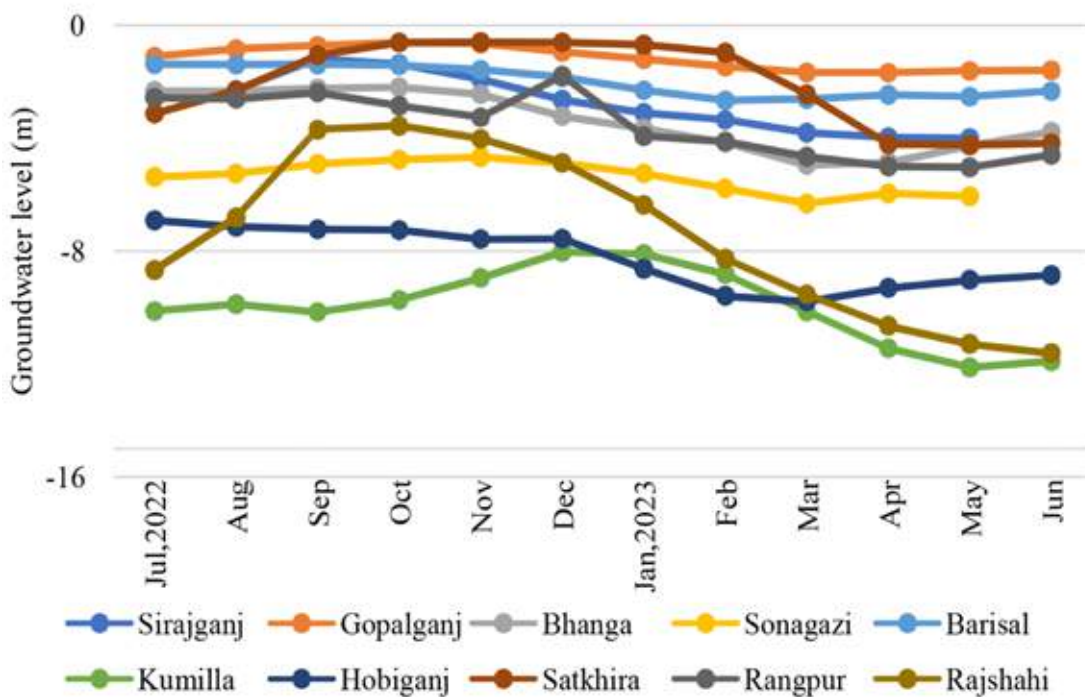


Fig. 4. Yearly GW level fluctuation at different BRRI R/S during 2022-23.

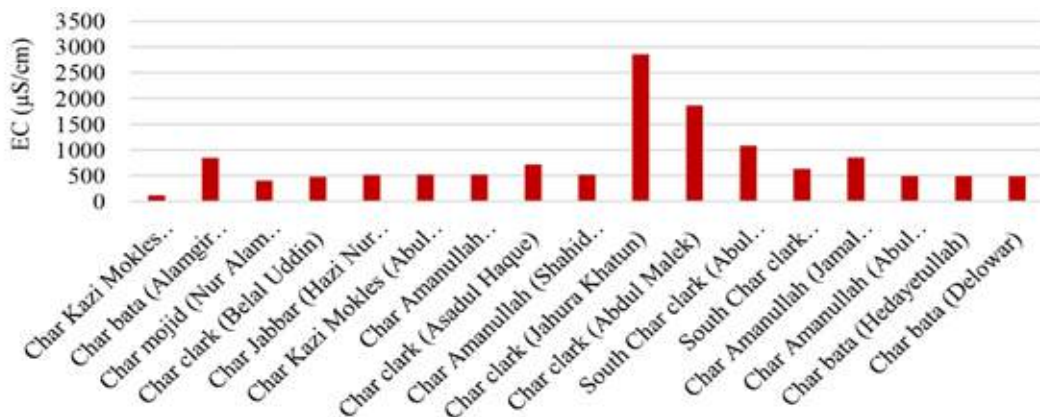


Fig.5: Groundwater salinity of different locations of Subornochar upazila, Noakhhal.



Fig.6: Installation of DC solar irrigation pump.

Plant Physiology Division

170	Summary
171	Salinity Tolerance
172	Submergence Tolerance
173	Drought Tolerance
175	Heat Tolerance
178	Cold Tolerance
181	Growth Studies And Yield Potential
189	Genome Editing
191	C4 Rice Development

SUMMARY

Twenty- six experiments under eight different projects have been carried out during 2022-23 in Plant Physiology Division of BRRI. In salinity stress, around 325 BRRI genebank germplasm, 105 advanced breeding lines, 375 hybrid parent lines and 10 hybrid varieties were characterized of which nine genotypes were found tolerant and 33 genotypes were found moderately tolerant to salinity at seedling stage. Ninety BRRI genebank germplasm were screened for two weeks of complete submergence where no germplasm was found submergence tolerant. Sixty BRRI genebank germplasm were tested for anaerobic tillering ability under water stagnant conditions. Among them, 14 germplasm (BRRI genebank Acc. no. 2098, 2102, 2105, 2116, 2118, 2121, 2124, 2133, 2135, 2139, 2149, 2155, 2156 and 2157) were produced ≥ 10 tillers/hill under water stagnant condition. In drought tolerance, 300 BRRI genebank germplasm were tested of which 40 germplasm were selected for further evaluation. Besides, previously selected 44 BRRI genebank germplasm were studied under control drought condition in the rain-out shelter, acc. no. 2451 yielded the highest followed by acc. no. 2554, 2312, and 2320. The sterility percentage of these genotypes was less than 50. Fifty BRRI genebank germplasm were screened for high temperature tolerance, and out of 50 germplasm, one germplasm (acc. no. 2135) scored 3 with 88% spikelet fertility and five germplasm had SES score 5 with spikelet fertility 51-70%). In order to facilitate breeding for heat tolerance, 34 spikelet fertility QTL introgression lines (22 in the background of BRRI dhan28 and 12 from BRRI dhan29) were evaluated under controlled high temperature (35 ± 3 °C) and high humidity ($75 \pm 5\%$) conditions during flowering. Two introgression lines with moderate heat tolerance and spikelet fertility ranged between 29.30 and 41.13% were chosen for further evaluation. The observational yield trial of high temperature-induced spikelet fertility QTL introgression advanced lines in the background of BRRI dhan28 and BRRI dhan29 were investigated during Boro 2022-23. Out of the 226 introgression

lines, 105 and 89 lines in the background of BRRI dhan28 and BRRI dhan29 respectively, having >0.5 t/ha higher yield advantage were selected for further evaluation. The KASP system has potential as a genotyping tool for use in breeding programmes. A total of 36, 17, 7 BC₁F₁ progenies of BRRI dhna48, BRRI dhan62, and BRRI dhan71 were genotyped. Among the tested progenies, eight from BRRI dhan48 were shown to be heterozygous by using R4M30 (Insertion/Deletion marker), but extra one progeny was discovered when using KASP (Kompetitive Allele Specific PCR) approach. The progenies of BRRI dhan62 displayed a monomorphic band in the gel for R4M30, but KASP showed polymorphic and was able to identify 10 of them as heterozygous. Again, for the progenies of BRRI dhan71, five progenies were identified as heterozygous by R4M30; however, while the population was tested through KASP, all possessed the same SNP as the donor parent N22. Some of 300 BRRI genebank germplasm and 1,563 advanced breeding lines were screened for seedling stage cold tolerance. The acc. no. 2836 showed cold tolerant having the SES score 3 and 27 germplasm showed moderately cold tolerant at seedling stage having the SES score 5. The selected acc. numbers are 2776, 2777, 2778, 2783, 2826, 2828, 2829, 2832, 2834, 2835, 2836 2837, 2843, 2844, 2847, 2855, 2860, 2867, 2868, 2869, 2875, 2884, 2919, 2922, 2971, 2973, 2987, 2998. Among the tested 1,563 advanced breeding lines, the BR12552-3R-179, BR12552-3R-199 and BR11337-5R-29 from favourable Boro and cold tolerant rice showed more than 80% survivability having the SES score 1, and 472 advanced breeding lines and 23 local landrace with SES score 5 and survivability $\geq 50\%$ were selected as moderately cold tolerant. Screening for cold tolerance at reproductive stage, eight advanced breeding lines and three local land races were evaluated in natural field condition using two seeding times 24 October and 1 November. In the first seeding date of early sowing/planting, grain yield of BR11894-R-105 (5.1 t/ha), BR11894-R-R-R-329 (5.20 t/ha) and the check varieties BRRI dhan67 and BRRI dhan89 yielded significantly higher than BRRI dhan28 (3.28 t/ha). Other genotypes BR11894-R-R-R-169 and

BR11894-R-228 had also comparable yield to BRRI dhan67 (5.09 t/ha) and BRRI dhan89 (5.35 t/ha) (Table 5). In 1 November sowing, the advanced line BR11894-R-R-R-169 produced the highest yield (7.13 t/ha) followed by BR11894-R-R-R-110 (7.02 t/ha) which was statistically similar to the check variety BRRI dhan67 (6.26 t/ha) and BRRI dhan89 (6.63 t/ha). Screening for photosensitivity revealed that out of 217 genotypes (201 advanced breeding lines nine BRRI genebank germplasm and seven varieties) 17 genotypes were insensitive, 21 genotypes were strong photosensitive and six varieties were strongly photoperiod sensitive. For lodging tolerance, BRRI dhan47, BRRI dhan58, BRRI dhan61, BRRI dhan81, BRRI dhan89, BRRI dhan96, SVIN109, BR11318-5R-63, IR17A1694 have lodging resistance capacity in various aspect of morphological and anatomical lodging parameters like lower number of air space, highest number of inner vascular bundle. Harvesting time of rice is an important variable which determines the field level yield of rice. It was observed that crop matured earlier in dry season than wet season. A significant yield (about 20-50%) can be reduced due to early harvesting (about 21 to 25 DAF) in wet season and about 12% reduction in field level yield when harvesting was done one week later than optimum time. The phenological development stages obtained from the observation varied for vegetative stage due to shifting seeding date for each variety. Days from sprouting to PI varied from 63 to 68 days, 89 to 93 days and 82 to 85 days for BRRI dhan88, BRRI dhan92 and IR64 respectively with the advancement of seeding time. The numbers of days for attaining different phenological stages differed from cultivar to cultivar. Improving salinity tolerance of rice through CRISPR/cas9 system, guide sequence of *OsRR22* gene was properly cloned into the binary vector pC1300-Cas9. Plants were regenerated through *Agrobacterium*-mediated transformation. Hygromycin phosphotransferase positive plants were identified using HPT primer pair designed from Hygromycin phosphotransferase resistant zone of the Cas9 vector. PCRs amplifications have been performed using primer pairs, which generated an amplicon harboring the target site. The resulting

amplicons have been sequenced using the Sanger method and mutant plant have been identified where deletion of two nucleotides occurred at the target site. Developing male sterile line through CRISPR/cas9 system, guide sequence of *TMS5* gene was properly cloned into the binary vector pC1300-Cas9. Plants were regenerated through *Agrobacterium*-mediated transformation. Hygromycin phosphotransferase positive plants were identified using HPT primer pair designed from Hygromycin phosphotransferase resistant zone of the Cas9 vector. The morphological distinctions between rice and Uri dhan spikelets' green tissues were examined. Uri dhan contains more vascular bundles in the lemma and palea than rice, in comparison. Rice only has five and three vascular bundles in the lemma and palea, compared to 12-15 and 8-12 in the Uri dhan lemma and palea. The application of chlorophyll fluorescence-based imaging to quantify rice submergence tolerance at the seedling stage. FR13A (SUB1 donor), IR42 (standard sensitive check), and BRRI dhan52 (SUB1-HYV) were tested under complete submergence stress for 24, 48, 72, 96, and 120 hours. The chlorophyll fluorescence image was collected following submergence treatments and at seven days of recovery. At two days of complete submergence treatment and six days of recovery, significant variations in maximal quantum yield (Fv/Fm) were identified between the submergence donor and BRRI dhan52 to submergence sensitive.

SALINITY TOLERANCE

Screening of rice germplasm for salinity tolerance at seedling stage

About three hundred rice germplasm were tested for salinity tolerance using method described by Gregorio *et al.*, (1997) at seedling stage in the Plant Physiology Net house, BRRI. The screening was conducted in hydroponic culture of Yoshida solution. Salinity stress was applied at seven days of seedling growth with stress @12dS/m. The experiment was carried out in RCB design following two replications. IR58443 and IR154 were used as tolerant and susceptible check, respectively. Among the 300 BRRI genebank germplasm acc. no. 3870 and 3881 were found tolerant with SES score 3 and

acc. no. 3750, 38667, 3893, 4176 and 4186 were found moderately tolerant to salinity with SES score 5.

Screening of rice advanced breeding lines for salinity tolerance at seedling stage at Boro season

About 105 rice advanced breeding lines were tested for salinity tolerance using method described by Gregorio *et al.*, (1997) at seedling stage in the Plant Physiology Net house, BRRI. The screening was conducted in hydroponic culture of Yoshida solution. Salinity stress was applied at 7 days of seedling growth with stress @12dS/m. The experiment was carried in RCB design following two replications. IR58443 and IR154 were used as tolerant and susceptible check, respectively. Among 105 advanced breeding lines, one line (BR12274-4R-113) was found tolerant with SES score 3 and 21 lines were found moderately salinity tolerant with SES score 5.

Re-evaluation of rice germplasm for salinity tolerance at seedling stage

Twenty-five previously screened salinity tolerant BRRI genebank germplasm were re-evaluated for salinity tolerance using method described by Gregorio *et al.*, (1997) at seedling stage in the Plant Physiology net house, BRRI. The screening was conducted in hydroponic culture of Yoshida solution. Salinity stress was applied at seven days of seedling growth with stress @12dS/m. The experiment was conducted in RCB design following three replications. Six different checks (Tolerant check: IR58443, Pokkali, Horkuch, NonaBokara and Susceptible Check: IR154 and BRRI dhan28) were used. Out of 25 germplasm two germplasm (acc. no. 2779 and 3155) including one check (Nona Bokhra) were found tolerant and 4 germplasm (acc. no. 2780, 3005, 3142 and 3157) including three checks (IR58443, Pokkali and Horkuch) were found moderately tolerant to salinity.

Screening of hybrid parent lines for salinity tolerance at seedling stage

Three hundred seventy-five hybrid parent lines were tested for salinity tolerance using method described by Gregorio *et al.*, (1997) at seedling stage in the Plant Physiology net house, BRRI. The

screening was conducted in hydroponic culture of Yoshida solution. Salinity stress was applied at 12 days of seedling growth with stress @12dS/m. The experiment was conducted in RCB design following two replications. Six different checks (tolerant check: IR58443, Horkuch and susceptible check: IR154 and BRRI dhan28) were used. Out of 375 hybrid parent lines four lines were found tolerant (Namely BHR37, BHR80, BHR259 and BHR260) including the checks IR58443, Pokkali and Horkuch and 78 parent lines were found moderately tolerant to salinity.

Screening of BRRI hybrid rice varieties for salinity tolerance at seedling stage

Six BRRI hybrid rice varieties and four hybrid varieties of different companies were tested for salinity tolerance using method described Gregorio *et al.*, (1997) at seedling stage in the Plant Physiology Net house, BRRI. The screening was conducted in hydroponic culture of Yoshida solution. Salinity stress was applied at 12 days of seedling growth with stress @12dS/m. The experiment was conducted in RCB design following three replications. IR58443 and IR154 were used as tolerant and susceptible check. Among the 10 hybrid varieties BRRI hybrid dhan5 and one company (Lal teer) hybrid dhan (HTM707) were found moderately saline tolerant with SES score 5.

SUBMERGENCE TOLERANCE

Identification of local rice germplasm for two weeks flash flood submergence tolerance

Ninety BRRI genebank germplasms were tested along with tolerant checks (FR13A and BRRI dhan79) and sensitive checks (IR42 and BR5 to identify the tolerant germplasm for two weeks under complete submerged condition at vegetative phase. Twenty-day-old seedlings were transplanted maintaining 20 cm x 20 cm distance in a concrete submergence tank. Two weeks after transplanting plants were submerged completely at one meter water level and kept submerged condition for 14 days. During the submergence period the water of the tank was made turbid twice daily, and the water pH, temperature, dissolve O₂ and turbidity were measured. After 21 days of drain out of water,

recovery or survivability score was taken. Survival scoring was done by following standard evaluation system (SES) (IRRI, 2014). The results showed that most of the germplasms were non-elongating type and percent elongation ranged from 3.30 to 51.68% but did not recover after de-submergence. Out of 90 germplasm 21 (BRRI genebank acc. no. 1737, 1758, 1759, 1775, 1784, 1792, 1799, 1805, 1813, 1817, 1825, 1828, 1859, 1960, 1964, 1972, 2053, 2062, 2063, 2065 and 2069) germplasm were survived after de-submergence, and the percent survivability ranged from 16.67 to 33.33% (SES score 9). Survivability of the tolerant check varieties FR13A and BRRI dhan79 had 100% and 83.33%, respectively whereas susceptible check varieties survived 0%. The average water pH, temperature and dissolve O₂ of the submergence tank were 8.28, 29.95 °C and 5.24 mg/L, respectively. The average turbidity of the water tank was 157.23 and 404.60 FNU (Formazin Nephelometric Units) before and after made turbid, respectively during submergence.

Screening of local germplasms for anaerobic tillering ability under water stagnant condition at T. Aman season

Sixty BRRI genebank germplasms along with two BRRI varieties BR10 and BRRI dhan30 were tested for this study to observe the anaerobic tillering ability of the local germplasm under water stagnant conditions. Twenty-day-old seedlings were transplanted maintaining 20 cm x 20 cm distance in a concrete tank. The water pressure @ 5 cm/week was started from seven days after transplanting and was continued up to 60 cm. The stagnant water was maintained up to maturity. Data of the plant height, tiller number and yield (at 14 % moisture) was taken from average of three hills. The experiment was conducted to observe the anaerobic tillering ability under medium stagnant (60 cm water pressure) conditions. The plant height, tiller/hill, yield/hill and survivability were found to ranges from 89-136 cm, 3.33-14.67 tillers/hill, 2.24-26.52 gm/hill and 100%, respectively. Forty-two germplasm out of 60 produced higher tiller/hill (>6) compared to check varieties BR10 and BRRI dhan30 under water stagnant condition. Among the 42 higher tiller producing germplasm, 14 germplasm (BRRI genebank acc. no. 2098, 2102, 2105, 2116, 2118,

2121, 2124, 2133, 2135, 2139, 2149, 2155, 2156 and 2157) were produced ≥10 tillers/hill under water stagnant condition. Further validation could be done to confirm the above-mentioned germplasm for anaerobic tillering ability.

DROUGHT TOLERANCE

Screening of rice germplasm for drought tolerance at reproductive phase, T. Aman 2022

Three hundred rice germplasm collected from BRRI genebank along with the check varieties BRRI dhan71 and IR64 were tested during T. Aman season 2022 at farmers' field in Alimganj, Paba, Rajshahi following field-managed screening protocol (IRRI, 2008). Thirty-day-old seedlings were transplanted at a spacing of 20 cm x 20 cm. The experiment was laid out in Alpha lattice design with two replications. Standard agronomic management practices were followed. Irrigation was withheld four weeks after transplanting and the field was drained out properly for not allowing any standing water until maturity. Out of 300 germplasm, 40 genotypes showed better performance in relation to yield under rainfed condition at reproductive phase, which were selected for further confirmation under control condition in rainout shelter.

Evaluation of previously selected germplasm under drought stress at reproductive phase in the rain-out shelter

This experiment was conducted in the rain-out shelter, Plant Physiology Division at BRRI HQ, Gazipur during T. Aman 2022 to evaluate previously selected 44 germplasm with the check varieties BRRI dhan71 and IR64. Thirty-day-old seedlings were transplanted in puddled soil at a spacing of 20 cm x 20 cm. Standard agronomic management practices were followed. Weeds were controlled when needed. Four weeks after transplanting, the plots were drained out for inducing drought stress at the reproductive phase. The water table depth was below 1 m and soil moisture was around 20%. Under control drought condition in the rain-out shelter, out of 44 germplasm BRRI Genebank acc. no. 2451 yielded the highest followed by acc. no. 2554, 2312, and 2320. The sterility percentage of these genotypes was less than 50 (Table 1).

Table 1. Observed growth characteristics, yield and yield components of tested 44 genotypes.

BRRI Genebank Acc. no.	Plant height (cm)	Tiller / Plant (no.)	Panicle / Plant (no.)	Panicle Length (cm)	Filled grain /Plant (no.)	Sterility (%)	Grain wt. (g/plant)	HI
2301	133.0	9.5	6.2	20.0	223.00	30.3	4.52	0.21
2312	124.3	10.2	9.3	20.3	355.83	21.0	7.74	0.30
2320	104.0	9.0	10.0	18.4	414.17	17.7	7.42	0.30
2323	112.0	6.0	8.8	18.1	224.00	23.9	4.15	0.24
2330	111.2	7.2	9.3	17.2	209.50	52.8	3.80	0.19
2333	116.2	9.3	8.0	18.1	275.67	20.3	6.45	0.23
2336	106.7	10.3	8.5	18.9	417.33	33.2	5.68	0.28
2346	131.2	9.8	6.2	17.4	201.67	29.6	4.12	0.21
2451	115.7	9.2	8.3	21.5	349.67	26.7	8.64	0.33
2464	103.0	7.0	6.0	21.7	82.50	61.2	1.55	0.06
2479	120.8	7.3	6.7	20.8	211.67	58.0	2.99	0.13
2493	111.5	8.2	7.2	19.5	132.00	65.0	1.47	0.07
2494	113.5	8.0	7.0	21.4	87.67	62.1	1.08	0.05
2495	122.5	7.5	6.7	22.9	139.17	41.1	1.52	0.07
2496	122.2	7.3	7.2	20.8	128.33	47.3	1.43	0.08
2500	122.5	7.8	7.5	21.4	161.83	56.4	1.82	0.09
2509	100.7	5.8	5.7	18.2	85.00	42.8	0.61	0.06
2525	110.5	5.2	5.0	19.2	166.83	32.9	0.40	0.04
2552	136.2	7.3	6.5	18.3	348.83	39.8	6.48	0.22
2553	120.5	8.7	7.3	20.5	113.33	59.5	1.22	0.07
2554	132.8	9.8	9.0	19.3	384.50	15.4	8.06	0.31
2555	118.2	8.0	7.0	20.5	179.17	59.5	1.26	0.06
2575	120.8	6.7	5.2	22.0	74.17	62.4	1.40	0.12
2577	120.7	7.3	5.8	21.6	101.50	41.5	2.11	0.12
2578	128.5	7.5	6.3	23.0	211.50	33.6	4.69	0.19
2579	121.0	8.2	7.0	20.9	145.33	39.2	2.78	0.13
2580	126.0	8.5	7.7	21.8	212.00	41.2	4.57	0.19
2586	126.3	7.5	6.8	22.0	122.50	68.8	2.11	0.09
2600	118.0	6.8	6.2	22.7	292.67	28.4	3.31	0.13
2603	130.7	7.7	6.5	23.7	187.50	62.0	2.88	0.10
2605	131.0	6.8	6.3	22.4	93.33	65.2	1.40	0.07
2607	126.8	6.2	5.3	20.9	53.83	62.0	0.81	0.04
2609	115.5	7.5	6.7	22.1	35.17	69.3	0.61	0.03
2612	120.3	6.2	5.5	21.6	147.50	21.5	2.59	0.20

BRRI Genebank Acc. no.	Plant height (cm)	Tiller / Plant (no.)	Panicle / Plant (no.)	Panicle Length (cm)	Filled grain /Plant (no.)	Sterility (%)	Grain wt. (g/plant)	HI
2630	141.0	6.5	5.8	22.7	46.67	80.3	0.69	0.03
2639	128.0	6.7	4.7	22.1	45.00	50.4	0.60	0.03
2641	118.0	7.8	7.0	20.8	150.83	47.5	2.49	0.11
2649	138.3	7.7	7.7	24.6	211.33	48.7	4.61	0.22
2656	158.8	7.8	6.3	21.9	249.17	34.5	5.92	0.16
2662	125.5	6.5	5.3	21.4	96.00	57.0	1.82	0.07
2672	121.0	6.0	6.0	21.9	143.00	58.9	2.61	0.11
2682	108.8	6.5	5.5	19.5	106.67	26.6	1.95	0.08
2684	108.0	8.0	6.3	17.0	188.00	60.2	2.95	0.11
2689	128.8	9.2	7.8	22.9	321.00	50.5	6.13	0.20
BRRI dhan71	102.2	10.3	9.3	23.2	579.00	23.8	11.59	0.41
IR64	99.2	10.8	10.0	18.8	166.00	61.6	4.18	0.21
	14.4	2.6	2.7	4.0	165.20	27.2	3.00	0.11
	5.9	16.8	19.4	9.5	42.5	29.8	43.6	37.8

HEAT TOLERANCE

Screening of rice germplasm for high temperature tolerance

Fifty BRRI genebank germplasm were evaluated to identify the best germplasm tolerant to high temperature. N22 and BRRI dhan28 was used as tolerant and susceptible check respectively. The plant was grown in earthen pot in natural condition, where each entry has four pots with three plants. Among the four pots the plant of the two pots were transferred at glass house at heading stage for seven days. Where temperature and Relative humidity were maintained to 35 ± 3 °C and 75% respectively. Out of 50 germplasm one germplasm (acc. no. 2135) scored 3 with 88% spikelet fertility and five germplasm had SES score 5 with spikelet fertility 51-70%). The tolerant and susceptible check had 51 and 1% spikelet fertility with SES score 5 and 7 respectively (Table 2).

Table 2. Spikelet fertility and SES score of germplasm tolerant to medium tolerant at control glass house in high temperature condition.

Acc. no.	Spikelet fertility (%)	SES Score
2140	51	5
2141	52	5
2142	59	5
2144	66	5
2116	70	5
2135	88	3
BRRI dhan28	1	7
N22	51	5

High-temperature tolerance of spikelet fertility QTL introgression lines under controlled high-temperature conditions

Rice productivity in tropical and subtropical regions, such as South Asia and Bangladesh, has become seriously threatened by global warming. It was estimated and reported that global rice yields will decrease by 3.2% for every 1 °C increase in global mean temperature. Given the importance of rice to Bangladesh's food security and the detrimental impact of global warming on rice yield, there is an imperative need to breed thermotolerant rice. The development of a new high-temperature tolerant variety with high

yield potential requires the selection of tolerant breeding lines from existing breeding material. In order to facilitate breeding for heat tolerance, 34 spikelet fertility QTL introgression lines (22 in the background of BRRI dhan28 and 12 from BRRI dhan29) were evaluated under controlled high temperature (35 ± 3 °C) and high humidity ($75\pm5\%$) conditions during flowering. Two introgression lines with moderate heat tolerance and spikelet fertility ranged between 29.30 and 41.13% were chosen for further evaluation. However, N22 and Kasalath, two tolerant donors, scored 5 (moderately tolerant) under controlled high temperature and humidity conditions (Table 3).

Table 3. Spikelet fertility (%) under controlled high temperature ($35\pm3^{\circ}\text{C}$) and high humidity ($75\pm5\%$) conditions during flowering of 8 *qHTSF4.1* introgression lines along with parents and checks. Values are the mean $\pm$ SE (n=9)

Line/Parent	Spikelet Fertility under control condition	Spikelet Fertility under HT* stress condition	SES# based on Spikelet Fertility under HT stress
BR12266-3-1	84.51 $\pm$ 2.86	41.13 $\pm$ 12.52	5
BR12266-4-4	61.84 $\pm$ 11.17	29.30 $\pm$ 22.37	7
BR12266-5-1	52.38 $\pm$ 13.36	40.20 $\pm$ 10.85	7
BR12266-10-2	65.19 $\pm$ 7.27	30.76 $\pm$ 2.51	7
BRRI dhan28	73.41 $\pm$ 2.29	12.97 $\pm$ 5.23	9
N22	82.89 $\pm$ 4.65	51.36 $\pm$ 8.87	5
Kachalath	77.39 $\pm$ 10.35	59.26 $\pm$ 4.28	5

*HT = High temperature, #SES = Standard evaluation system.

Observational trial of high temperature-induced spikelet fertility introgression lines in the background of BRRI dhan28 and BRRI dhan29

The observational yield trial of high temperature-induced spikelet fertility QTL introgression advanced lines in the background of BRRI dhan28 and BRRI dhan29 were investigated during Boro 2022-23. Along with the parents, the yield potential of 226 (152 introgression lines from BRRI dhan28 and BRRI dhan74 from BRRI dhan29) was tested in the field. A total of 100 plants per entry were planted in rows of 25 plants $\times$ 4 rows per line during 29 November 2022 sowing and 9 January 2023 planting. Out of the 226 introgression lines, 105 and 89 lines in the background of BRRI dhan28

and BRRI dhan29 respectively, having >0.5 t/ha higher yield advantage were selected for further evaluation.

Marker-assisted introgression of high temperature-induced spikelet fertility QTL (*qHTSF4.1*) in the background of BRRI dhan48 and BRRI dhan62

Bangladesh traditionally experiences more harsh weather, such as droughts, floods, and storms, but in recent years, high temperatures/heat waves/heat shock have become a serious threat to rice production. Rice is vulnerable to high temperatures during the anthesis/flowering period (usually seven days before and after heading). Previously, it was thought that high-temperature stress was only a

problem for Aus season rice; later, it was considered to be a problem for long-duration Boro and late Boro (Boro rice grown after potato harvest) during April to May, and sometimes extended to June/July when rainfall becomes very low or non-existent. However, with the introduction of short-season T. Aman varieties, the problem has extended to T. Aman season rice. Short-duration T. Aman cultivars are vulnerable to high temperature-induced spikelet sterility if rainfall is minimal throughout September and October. In light of this, BRRI dhan48, BRRI dhan62, and BRRI dhan71 were subjected to marker-assisted introgression of high temperature-induced spikelet fertility QTL (*qHTSF4.1*) during the T. Aus and T. Aman seasons. A total of 36, 17, 7 BC₁F₁ progenies of BRRI dhan48, BRRI dhan62,

and BRRI dhan71 were genotyped. Among the tested progenies, eight from BRRI dhan48 were shown to be heterozygous by using R4M30 (Insertion/Deletion marker), but extra one progeny was discovered when using KASP (Kompetitive Allele Specific PCR) approach. However, progenies of BRRI dhan62 displayed a monomorphic band in the gel for R4M30, but KASP showed polymorphic and was able to identify 10 of them as heterozygous (Fig.1). Again, for the progenies of BRRI dhan71, five progenies were identified as heterozygous by R4M30; however, while the population was tested through KASP, all possessed the same SNP as the donor parent N22 (Fig. 2). Based on this evidence, it appears that the KASP system has potential as a genotyping tool for use in breeding programmes.



Fig. 1. PAGE (8%) representing heterozygous (H), recipient (A) and donor (B) alleles segregating at BC₁F₁ of BRRI dhan48/N22 population from SL 1-10, recipient parent (BR48) and donor N22; BRRI dhan62/N22 population from SL 11-19, recipient parent (BR62) and donor (N22) using InDel marker R4M30. L represents ladder.

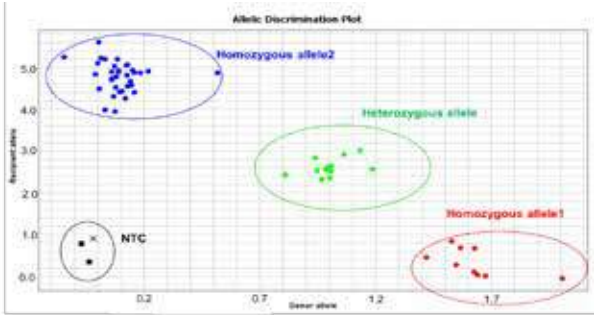


Fig 4: Allelic Discrimination Plot for the backcross populations derived from recipient parent BRRI dhan48, BRRI dhan62, BRRI dhan71 with donor N22

Fig. 2. Allelic discrimination plot of KASP genotyping for the backcross populations derived from recipient parent BRRI dhan48, BRRI dhan62, BRRI dhan71 with donor N22.

COLD TOLERANCE

Screening of rice germplasm for seedling stage cold tolerance

Some 300 BRRI Genebank germplasm along with four check varieties namely BRRI dhan28, BRRI dhan36, Vutan and HbjB-VI were tested for seedling stage cold tolerance in cold water tanks at artificial condition. Seeds were sown in plastic trays (60 cm length x 30 cm breadth x 2.5 cm height) filled with gravels and crop residue free granular soil and allowed to grow until 3-leaf stage. The plastic trays were then placed into cold water tanks adjusted to constant temperature at 13°C. Out of 300 germplasm, BRRI GeneBank acc. number 2836 showed cold tolerance having the SES score 3 and 27 BRRI GeneBank germplasm showed moderately cold tolerance at seedling stage having the SES score 5. The selected BRRI GeneBank Acc. number are 2776, 2777, 2778, 2783, 2826, 2828, 2829, 2832, 2834, 2835, 2836, 2837, 2843, 2844, 2847, 2855, 2860, 2867, 2868, 2869, 2875, 2884, 2919, 2922, 2971, 2973, 2987, 2998. Rest of the genotypes were susceptible to highly susceptible.

Screening of advanced breeding lines for seedling stage cold tolerance

A total of 1,563 genotypes including 1,513 advanced breeding lines and 50 local landrace collected from haor areas along with four check varieties namely BRRI dhan28, BRRI dhan36, Vutan and HbjB-VI were tested for seedling stage cold tolerance in cold water tanks at artificial condition. Methodology was same as previous experiment. Among the tested genotypes, three advanced breeding lines BR12552-3R-179, BR12552-3R-199 and BR11337-5R-29 from favourable Boro and cold tolerant rice showed more than 80% survivability having the SES score 1. However, some total of 695 genotypes have a survivability rate ranging from 50 to 70%. From these lines 191 advanced breeding lines and nine local landraces with SES score 3 and survivability >50% were selected as cold tolerant at seedling stage (Fig. 3). Moreover, 472 advanced breeding lines and 23 local landraces with SES score 5 and survivability $\geq$ 50% were selected as moderately cold tolerant. The check variety BRRI dhan36 and HbjB-VI have the SES score 3. Rest of the 653

genotypes were susceptible to highly susceptible with SES score 7 and 9 respectively (Fig. 3). It is notable that 212 genotypes did not germinate.

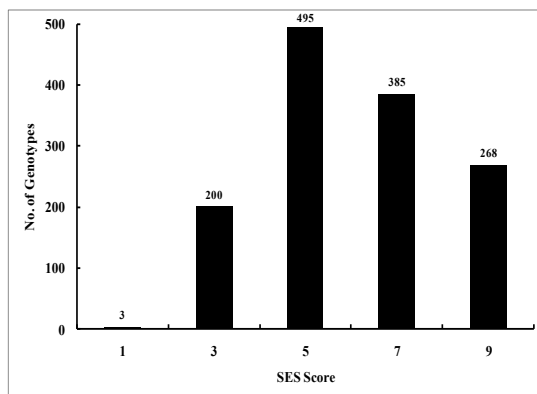


Fig. 3. SES score for seedling stage cold tolerance of tested 1563 rice genotypes.

Evaluation of advanced breeding lines for reproductive stage cold tolerance

Eight advanced breeding lines and three local land races along with BRRI dhan28, BRRI dhan67, and BRRI dhan89 as check varieties were evaluated in natural field condition. There were two seeding times 24 October and 01 November. Thirty-day-old seedlings were transplanted in the main field. Early planting was done with a view to falling rice reproductive phase at cold stress. Cold tolerance of rice genotypes was measured visually based on growth and leaf discolouration score at vegetative phase. For reproductive phase cold tolerance, we mainly focus on spikelet sterility. However, data on date of flowering and maturity, plant height, panicle per hill, panicle length, last internodes length, last leaf sheath length, panicle degeneration and exertion, filled and unfilled grain per panicle, grain yield and yield components were recorded for better understanding of cold tolerance of specific rice genotypes. Changes in different parameters of rice in early planted set due to natural cold temperature were compared last year with normal planting set. This year we observed the degree of performance of these genotypes at early planting. All the rice genotypes of 1st set experienced some cold stress at reproductive phase. But the genotypes experienced very little cold stress at the reproductive phase in second set.

Natural cold stress at reproductive phase of rice genotypes sown on 24 October changed different physiological parameters. Early planted sets of both the sowing dates (24 October and 01 November) caused longer growth duration for all rice genotypes (Table 4). Irrespective of seeding date short plant was observed in both the seeding dates. Scoring for phenotypic acceptability was done at hard dough stage. Among the tested genotypes, phenotypically BR11894-R-R-R-R-169 scored 1.6 and 3.0 in 24 October and 01 November sowing respectively. The advanced line BR11894-R-R-R-R-329 showed fair to good having the score 3.0 to 5.0 (Table 4). The advanced lines BR11894-R-R-R-R-169, BR11894-R-R-R-R-329 and BRRRI dhan67 had complete panicle exertion and scored 1. The panicle exertion of local land race Shubollata was moderately well having the score 3. Others scored 5 where panicle just exerted (Table 5). Irrespective of rice varieties grain yield was significantly higher

in 01 November sowing than 24 October sowing. In 1st seeding date of early sowing/planting, grain yield of BR11894-R-105 (5.1 t/ha), BR11894-R-R-R-R-329 (5.20 t/ha) and check variety BRRRI dhan67 and BRRRI dhan89 was significantly higher than BRRRI dhan28 (3.28 t/ha). Other genotypes BR11894-R-R-R-R-169 and BR11894-R-228 had also comparable yield to BRRRI dhan67 (5.09 t/ha) and BRRRI dhan89 (5.35 t/ha) (Table 5). In 01 November sowing, the advanced line BR11894-R-R-R-R-169 produced the highest yield (7.13 t/ha) followed by BR11894-R-R-R-R-110 (7.02 t/ha) which were statistically similar to the check variety BRRRI dhan67 (6.26 t/ha) and BRRRI dhan89 (6.63 t/ha). However, other genotypes had statistically similar yield to check variety BRRRI dhan28 (5.41 t/ha). Filled grain per panicle was significantly less in 24 October sowing than 1 November. This is due to higher percentage of sterility in 24 October sowing (Table 5).

Table 4. Growth duration, plant height, SES score for phenotypic acceptability (PAcp) and panicle exertion score of tested genotypes.

Genotype	Growth duration (day)		Plant height (cm)		SES score for PAcp		Panicle exertion score	
	24 Oct	01 Nov	24 Oct	01 Nov	24 Oct	01 Nov	24 Oct	01 Nov
BR11894-R-R-R-R-105	172.0	165.0	82.2	92.3	7.0	5.0	5.0	5.0
BR11894-R-R-R-R-169	169.3	164.0	87.6	88.7	3.0	3.0	3.0	1.0
BR11894-R-R-R-R-329	165.0	156.0	77.4	80.9	3.0	5.0	3.0	1.0
BR11894-R-228	159.0	-	78.4	-	5.0	-	5.0	-
BR11646-5R-388	160.0	-	73.4	-	4.7	-	7.0	-
IR18A1859	163.0	-	69.3	-	7	-	9.0	-
BR11894-R-R-R-R-110	-	164.0	-	89.2	-	5.0	-	5.0
BRRRI dhan69-phy1	-	166.0	-	95.9	-	5.6	-	5.0
Zira	-	166.0	-	86.2	-	5.6	-	5.0
Khatobabu	-	164.0	-	81.0	-	5.6	-	5.0

Genotype	Growth duration (day)		Plant height (cm)		SES score for PAcp		Panicle exertion score	
	24 Oct	01 Nov	24 Oct	01 Nov	24 Oct	01 Nov	24 Oct	01 Nov
Shubollata	-	164.0	-	92.7	-	3.6	-	3.0
BRRI dhan28 (ck)	161.6	156.5	80.4	81.4	5.3	6.6	7.0	5.0
BRRI dhan67 (ck)	167.0	163.7	88.5	99.3	3.6	3.0	5.0	1.0
BRRI dhan89 (ck)	169.0	163.3	82.2	82.1	5	3.6	5.0	5.0
LSD (5%)	3.2		9.3		2.2		1.1	
CV (%)	1.2		6.6		26.7		13.2	

Table 5. Grain yield, filled grain number and spikelet sterility (%) of tested genotypes.

Genotype	Grain yield (t/ha)		Filled grain/panicle (no.)		Sterility (%)	
	24 Oct	01 Nov	24 Oct	01 Nov	24 Oct	01 Nov
BR11894-R-R-R-R-105	5.10	5.35	102.9	134.9	28.5	13.1
BR11894-R-R-R-R-169	4.69	7.13	102.9	124.4	21.0	17.6
BR11894-R- R-R-R-329	5.20	5.63	84.1	101.7	33.9	19.7
BR11894-R-228	4.49	-	89.0	-	16.2	-
BR11646-5R-388	3.83	-	89.0	-	31.5	-
IR18A1859	2.81	-	53.4	-	27.8	-
BR11894-R-R-R-R-110	-	7.02	-	124.8	-	30.5
BRRI dhan69-phy1	-	4.96	-	113.1	-	27.7
Zira	-	4.65	-	140.7	-	32.9
Khatobabu	-	5.16	-	148.3	-	8.1
Shubollata	-	5.29	-	142.04	-	15.0
BRRI dhan28 (ck)	3.28	5.41	67.1	107.9	29.3	12.4
BRRI dhan67 (ck)	5.09	6.26	118.3	121.5	16.8	9.6
BRRI dhan89 (ck)	5.35	6.63	122.7	162.0	35.7	14.3
LSD (5%)	1.8		27.5		7.6	
CV (%)	21.7		14.8		20.7	

GROWTH STUDIES AND YIELD POTENTIAL

Photosensitivity test of advanced breeding lines

An experiment was conducted to know the response to photoperiod of 201 advanced breeding lines and three varieties in the east byde, BRRI, Gazipur. Seeds of all the tested with Nizersail as a check variety were directly sown to the well-prepared field beds on 10 April 2022. After emergence the plants were thinned and the experiment was replicated thrice. Ten-hour photoperiodic treatment (7.00 AM to 5.00 PM) was started from seed sowing by using

black cloth cover. One set were grown at natural day length. Observations were made on seeding date and heading date to determine the basic vegetative phase (BVP), photoperiod sensitive phase (PSP) and relative photoperiod sensitivity (RPS). On the basis of RPS (%) Compared to Nizersail, out of 201 advanced lines and three varieties (Gainza, BR22, BR23), 17 lines were insensitive, 12 advanced breeding lines were strong photosensitive and among the three varieties, all were strongly photoperiod sensitive. The other lines showed weakly photoperiod sensitivity (Table 6).

Table 6. BVP, PSP and RPS of some advanced breeding lines and three varieties. Each value is average of three replications. (Sowing date: 10.04.2022)

Designation	Basic vegetative phase (day) $\pm$ SE (n=3)	Photoperiod sensitive phase (day) $\pm$ SE (n=3)	Relative photoperiod sensitivity (%)	Remark
BR 12459-4R -45	14 $\pm$ 0.67	136 $\pm$ 0.67	83	SPPS
BR10212-17-3-2-1	26 $\pm$ 1.2	145 $\pm$ 1.45	88	SPPS
BR10212-17-3-2-2	21 $\pm$ 4.18	74 $\pm$ 8.08	74	SPPS
BR10212-5-5-3	35 $\pm$ 1.33	75 $\pm$ 3.48	75	SPPS
BR10212-7-5-1	17 $\pm$ 0.88	142 $\pm$ 1.33	86	SPPS
BR10820-2-3-3-5-3	47 $\pm$ 2.19	126 $\pm$ 3.00	77	SPPS
BR10821-15-7-8-5*	52 $\pm$ 3.00	129 $\pm$ 3.18	78	SPPS
BR22	17 $\pm$ 1.86	160 $\pm$ 1.53	97	SPPS
BR23	38 $\pm$ 1.45	139 $\pm$ 2.33	85	SPPS
BR8515-8-7-8-2	34 $\pm$ 2.19	139 $\pm$ 1.86	84	SPPS
BR8540-2-4-1-3 (Black)*	45 $\pm$ 0.58	136 $\pm$ 0.88	83	SPPS
BR8540-2-4-1-3*	20 $\pm$ 0.88	163 $\pm$ 0.67	99	SPPS
BR9590-45-4-5-2	19 $\pm$ 2.31	148 $\pm$ 2.03	90	SPPS
Gainza	46 $\pm$ 0.67	132 $\pm$ 0.88	80	SPPS
BR10212-4-3-1	21 $\pm$ 0.67	132 $\pm$ 2.52	80	SPPS
BR10212-10-3-1	17 $\pm$ 0.88	141 $\pm$ 1.31	86	SPPS
Nizersail	19 $\pm$ 0.67	164 $\pm$ 0.67	100	Check
TL Aus-Gaz10-40-5-11*	11 $\pm$ 1.45	170 $\pm$ 2.40	104	SPPS

Note: Values are average of two replications. SPPS= strongly photoperiod sensitive. SE= Standard error (n=Sample number)

Photosensitivity test of local germplasm and four BRRI released varieties

An experiment was conducted with nine local germplasm and four varieties with Nizersail as a check variety were directly sown to the well-prepared field beds during 27 April 2022 in east byde, BRRI, Gazipur. After emergence the plants were thinned and the experiment was replicated three times. Ten-hour photoperiodic treatment (7.00 AM to 5.00 PM) was started from seed sowing by using black cloth cover. One set were grown at natural day length. Observations were made

on seeding date and heading date to determine the basic vegetative phase (BVP), photoperiod sensitive phase (PSP) and relative photoperiod sensitivity (RPS). On the basis of RPS (%) compared to Nizersail out of nine local germplasm and four BRRI released varieties all local varieties were strongly photoperiod sensitive. Among the four BRRI varieties, only BR11 was weakly photosensitive and the other three BRRI released varieties were strongly photoperiod sensitive (Table 7).

Table 7. BVP, PSP and RPS of nine local germplasm and four varieties. Each of the value is average of three replications. (Sowing date: 27.04.2022).

Designation	Basic vegetative phase (day)	Photoperiod sensitive phase (day)	Relative photoperiod sensitivity (%)	Remark
Laxmidigha	27±2.91	129±8.66	89	SPPS
Bashiraj	24±0.33	126±1.76	95	SPPS
Lalmohan	31±1.33	107±1.33	80	SPPS
Dudlucki	4±0.33	143±0.88	107	SPPS
Fulkuri	16±3.8	128±2.03	96	SPPS
Khoyamotor	27±.6	118±0.33	89	SPPS
Shorshoriya	26±1.7	111±2.85	84	SPPS
Malshira	36±5.3	109±2.91	82	SPPS
Biroi	32±3.2	115±2.08	86	SPPS
Nizersail	19± 0.00	133±0.00	100	Check
BR11	32±1.2	62±3.38	47	WPPS
BR22	13±2.0	151±0.33	113	SPPS
BR23	31±2.1	132±0.67	99	SPPS
BRRI dhan54	19±1.5	129±1.15	97	SPPS

Note: SPPS= strongly photoperiod sensitive, WPPS=weakly photoperiod sensitive. SE= Standard error (n=Sample number)

Evaluation of lodging tolerance in BRRI developed T. Aman varieties

Lodging of rice plants is caused mainly by the action of wind. Culm of rice plants becomes weakened under heavy application of nitrogenous fertilizers, dense planting, water lodging, and sunlight deficiency. An experiment was conducted in T. Aman season 2202 in BRRI HQ farm, Gazipur

to determine the lodging characters of five BRRI varieties viz BRRI dhan75, BRRI dhan76, BRRI dhan77, BRRI dhan79 and BRRI dhan80 along with lodging tolerant check variety BR11 and lodging sensitive variety BRRI dhan32. Four sets of seeds were sown on 15 June, 30 June, 15 July and 30 July 2022 at 15 days interval. Twenty-five-day-old seedlings were transplanted in the main field.

Just after heading, data were recorded on visible internode length (1st to 5th internode), culm length, internode diameter and thickness, wrapping score, flag leaf angle, stem density, bending moment. Visual lodging rate was monitored time to time. Data on panicle exertion, panicle length, panicle weight were recorded at maturity. According to sowing date 15 June, among the tested varieties BRRI dhan75, BRRI dhan79, BRRI dhan80 was lodging tolerant. BRRI dhan76 and BRRI dhan77 were lodged partially compared with tolerant check BR11 and susceptible check BRRI dhan32. On the other hand, at other sowing after 15 July all the tested varieties were completely lodged due to cyclone (Fig. 4). From this study it is clear that weather has significant impact on lodging.

Among the tested varieties BRRI dhan76 and BRRI dhan77 has highest panicle dry weight than tolerant check variety. The highest wrapping score 37.67 was observed in BRRI dhan79 and the lowest wrapping score 31.58 was observed BRRI dhan77. The lowest bending moment in BRRI dhan75, 1225.92 gm cm and BRRI dhan79, 1609.95 gm cm was compared with the other tested varieties. Minimum stem length of BRRI dhan75, BRRI dhan79 and BRRI dhan80, the lowest bending moment of BRRI dhan75, BRRI dhan79, BRRI dhan80, well wrapped stem of BRRI dhan79 and BRRI dhan80 might be the reason of its lodging tolerance (Table 8). The highest culm wall thickness and diameters were observed in case BRRI dhan76 and BRRI dhan77 but due to other dominant characters they showed lodging susceptible.

Table 8. Culm stiffness of T. Aman rice varieties (average of three replications)

Genotype	Culm wall thickness (mm)	C u l m diameter (mm)	B e n d i n g moment (gm cm)	Total wrapping score	Stem dry weight (gm)	S t e m length (cm)	S t e m density (mg/cm)
BRRI dhan75	0.72 d	4.67 ^e	1225.92 d	31.69 b	2.48 d	89.31d	27.71 e
BRRI dhan76	1.09 a	7.44 ^a	2572.54 a	35.58 a	7.63 a	130.66 ab	58.43 ab
BRRI dhan77	1.08 a	6.91 ^b	2550.22 a	31.58 b	7.40 a	137.67 a	54.04 bc
BRRI dhan79	0.95 b	6.53 ^c	1609.95 c	37.67 a	6.38 ab	99.71 cd	63.98 ab
BRRI dhan80	0.82 cd	6.69 ^{bc}	2298.70 b	37.18 a	7.58 a	107.71 c	70.36 a
BR11 (Tol. ck)	0.94 b	6.00 ^b	1508.24 c	32.54 b	4.42 c	103.19 c	42.73 c
BR32 (Sus. ck)	0.83 c	6.16 ^d	2094.87 b	32.64b	5.43 bc	127.71 ^b	42.68 c
Maximum	1.09	7.44	2572.54	37.67	7.63	137.67	70.36
Minimum	0.72	4.67	1225.92	31.58	2.48	89.31	27.71
CV %	5.83	2.9	6.95	3.78	12.86	4.79	13.29
LSD _{0.05}	0.09	0.33	244.71	2.29	1.35	9.69	12.16

CV= Coefficient of variation, LSD= Least significant difference

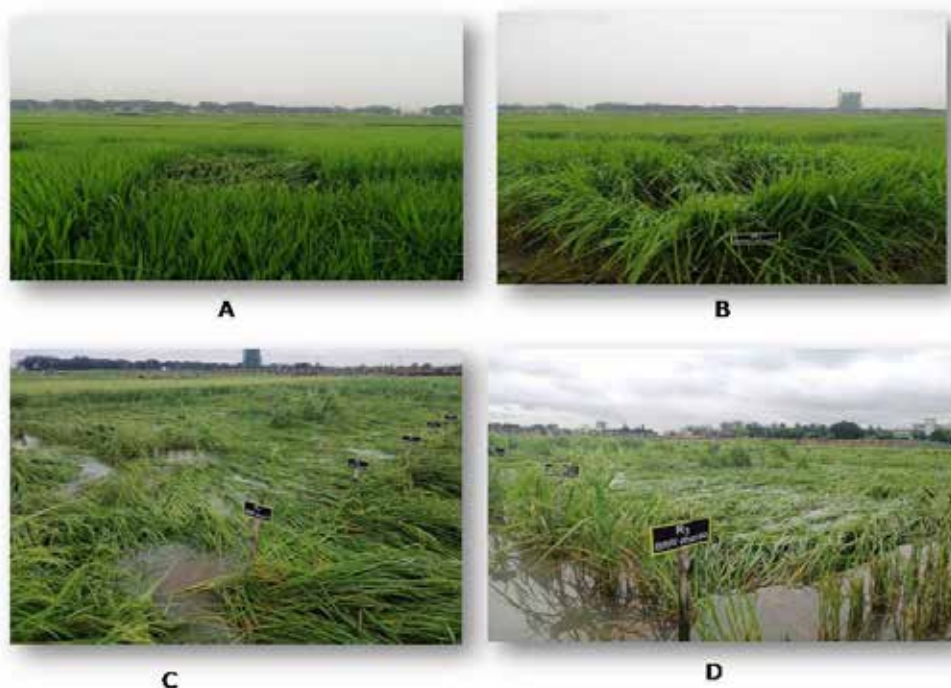


Fig. 4. Plant lodged before Chitrang cyclone (A and B) and full field lodged after Chitrang cyclone (C and D) at T. Aman season 2022.

Characterization for lodging tolerance of BRRI released Boro varieties and advanced breeding lines

An experiment was conducted in Boro season 2023 in BRRI HQ farm, Gazipur to determine the lodging characters of nine BRRI varieties viz BRRI dhan47, BRRI dhan58, BRRI dhan61, BRRI dhan67 and BRRI dhan81, BRRI dhan88, BRRI dhan89, BRRI dhan96, Bangabandhu dhan100 and nine advanced breeding lines along with lodging tolerant check variety BRRI dhan29 and lodging sensitive variety BRRI dhan28. Forty-day-old seedlings were transplanted in the main field. Just after heading, data were recorded on visible internode length (1st to 4th internode), culm length, internode diameter and thickness, wrapping score, flag leaf angle, stem density, bending moment. Visual lodging rate was monitored time to time. Data on panicle exertion, panicle length, panicle weight were recorded at maturity. At the maximum tillering stage anatomical study like outer layer

thickness, large and small vascular number, number of air space was measured by electronic microscope. Compared with check variety, results revealed that BRRI dhan96, BRRI dhan81, BRRI dhan89, BRRI dhan61, BRRI dhan58, BRRI dhan47, IR12A173, BR11318-5R-63, IR17A1694 has lodging resistance capacity in various aspect of morphological and anatomical lodging parameters. Visual lodging rate was not observed in this season due to favourable field weather. According to anatomical study BRRI dhan96, BRRI dhan61 like check BRRI dhan29 has no air space or lacunae which have positive relation with lodging resistance (Fig. 5). On the other hand, BRRI dhan67, BRRI dhan88 and breeding line IR12A173 also has air space or lacunae as like as susceptible variety BRRI dhan28 (Fig. 6). Outer layer thickness of the tested genotypes was statistically insignificant. In case of small or outer vascular bundle BRRI dhan89, BRRI dhan81 has the highest number of outer vascular bundle but SV109, BRRI dhan58 has the highest

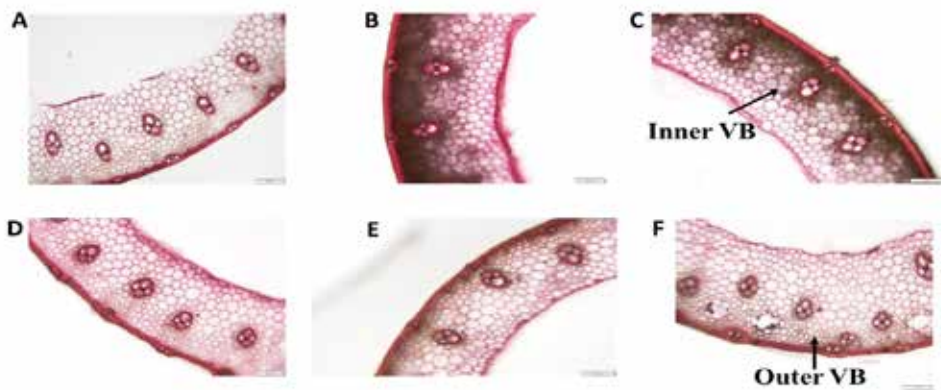


Fig. 5. Anatomical structure of rice stem. A: BRRI dhan29, B: BRRI dhan61, C: BRRI dhan96, D: SVIN19, E: BR11318-5R-63 and F: BRRI dhan58.

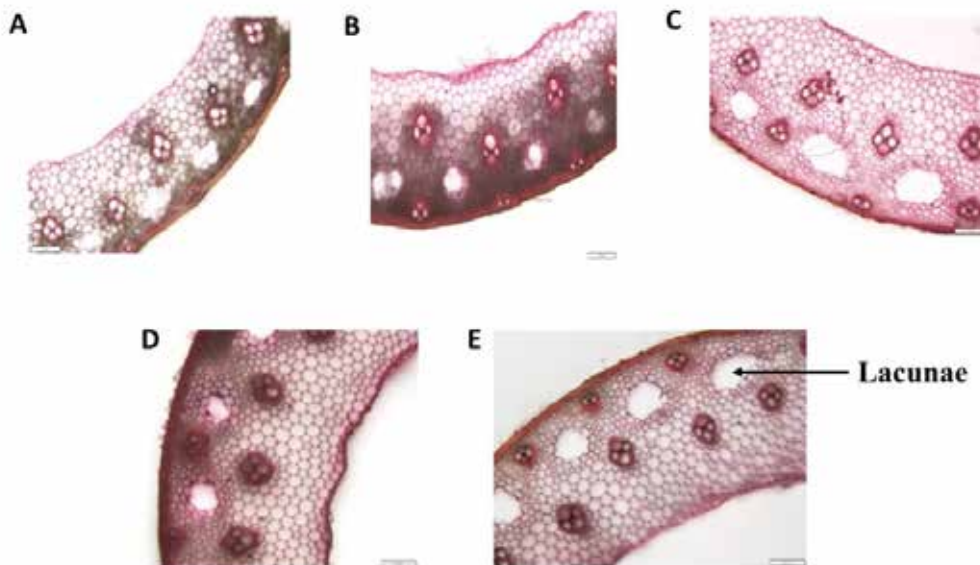


Fig. 6. Anatomical structure of rice stem. A: BRRI dhan28, B: BRRI dhan67, C: BRRI dhan98, D: Bangabandhu dhan100 and E: BR12454-BC2-56-81-27-3-30.

Table 9. Anatomical data of tested genotypes. Each datum is average of three samples and three replications.

Genotype	Outer layer thickness (mm)	No. of inner vascular bundle	No. of outer vascular bundle	No. of lacuna
BRRI dhan47	0.017 b	29.67cdefg	28.33cdef	8.0 bcde
BRRI dhan58	0.017 b	33.00b	28.67bcdef	21.78 a
BRRI dhan61	0.02 b	28.67defg	28.33cdef	0.0 e
BRRI dhan67	0.02 b	28.67defg	28.67bcdef	8.33 bcde
BRRI dhan81	0.02 b	32.00bc	31.67a	23.78 a
BRRI dhan88	0.02 b	29.00defg	27.67ef	16.11 abc
BRRI dhan89	0.02 b	32.0a	32.0a	19.00 ab
BRRI dhan96	0.027a	30.00cdefg	28.33cdef	0.0 e
Bangabandhu dhan100	0.02b	31.00bcd	26.67ef	7.34 bcde
IR12A173	0.02b	30.67bcde	27.00ef	25.67 a
SVIN109	0.02 b	36.00 a	30.33 abcd	4.22 cde
BR12454-BC2-56-81-27-3-30	0.017 b	32.00 bc	31.00 ab	16.00 abc
BR 11318-5R-63	0.020 b	28.33 efg	28.67 bcdef	7.11 bcde
BR12454-BC2-75-32-31-39-7	0.02 b	29.0 defg	30.67 abc	4.89 cde
BR12454-BC2-69-97-39-5-44	0.02 b	29.67 cdefg	29.00 bcde	3.61 de
BR 11337-5R-72	0.020 b	28.00f g	28.00 def	23.00 a
BR12454-BC2-71-91-6-23-26	0.02 b	29.00 defg	30.33 abcd	14.33 abcd
IR17A1694	0.017 b	30.67 bcde	28.67bcdef	9.33 bcde
BRRI dhan28 (Sus. Check)	0.02 b	27.67 g	26.33 f	17.78 ab
BRRI dhan29 (Tol. Check)	0.02 b	30.33 cdef	27.33 ef	8.67 bcde
Maximum	0.02	36.00	32.00	25.67
Minimum	0.017	27.67	26.33	0.00
CV %	14.52	5.25	5.17	61.06
LSD (5%)	0.004	2.63	2.47	12.05

CV= Coefficient of variation, LSD= Least significant difference

Effect of harvesting time on yield of rice at wet and dry season

Harvesting time of rice is an important variable which determines the field level yield of rice. In favourable condition, farmers are forced to harvest their crop very early or late and face them to yield loss and reduce the grain quality. So, an experiment was conducted to estimate the yield loss due to early or late harvesting of rice. BRRI dhan87 and BRRI dhan88 was used at wet and dry season respectively. Harvesting was done at 21, 25, 29, 33, 37 and 42 days after 50% flowering.

It was observed that crop matured earlier in dry season than wet season. The highest yield was found

between 29 to 33 DAF and 33 to 37 DAF for dry and wet season respectively. A significant yield (about 20-50%) can be reduced due to early harvesting (about 21 to 25 DAF) in wet season. On the other hand, as the crop matured earlier in dry season, the percentage of reduction in yield was quiet less. About 18-28% yield could be reduced if harvesting was done after three the weeks after flowering. Interestingly, similar yield loss was found at late harvesting than the optimum harvesting time in dry season. It was observed that, about 12% reduction in field yield was occurred when harvesting was done one week later than optimum time (Fig. 7).

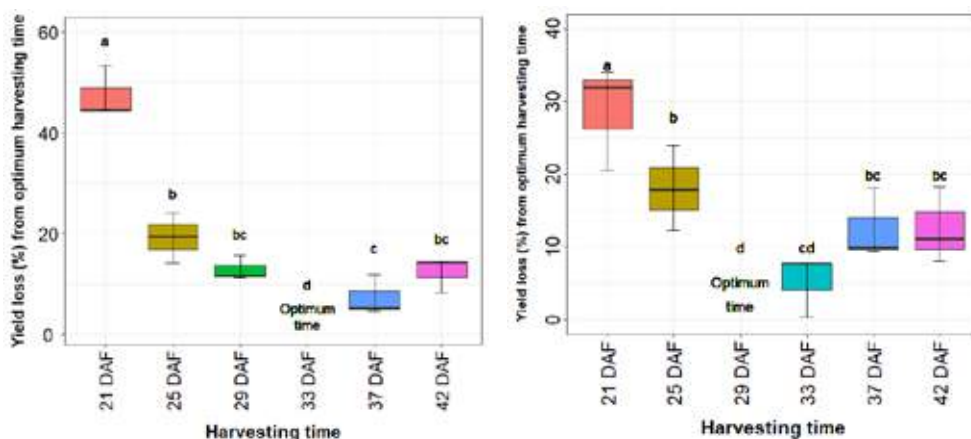


Fig. 7. Percent reduction in yield due to early and late harvesting than optimum harvesting time. (Fig. a and b represents wet and dry season, respectively)

Phenological development of newly released two BRRI varieties in T. Aman season

The study attempted to analyze developmental stages of modern varieties of rice in different planting times to determine the genetic coefficient of rice. In order to achieve the objective a field experiment was conducted at the BRRI farm, Gazipur. In Aman season 2021, three rice cultivars BRRI dhan88, BRRI dhn92 and IR64 were transplanted with 20×20 cm² configuration. Plant height of rice cultivars recorded varied significantly at different seeding dates (Table 10). The highest plant height was recorded with 1st date of seeding on 7 July and became shorter with the advancement

of seeding time irrespective of varieties. Among the varieties the maximum plant height was recorded with BRRI dhan92 (129.3 cm). Number of panicle per m² varied from 236 to 261. Due to high sterility grain yield reduced irrespective of variety and seeding time. The percent sterility was maximum in BRRI dhan92 in and minimum in IR64 for 1st seeding. Grain size (1000 grain weight) was similar for BRRI dhan92 (22.5 g) and IR64 (22.3) and smaller (20.2g) for BRRI dhan88 (Table 10). Seeding date did not exhibit any significant influence on grain size. Grain size is a varietal character and is genetically controlled. It appears that the number of filled spikelets per unit area and

grain size in combination created the difference in grain yield across varieties. Grain yield drastically reduced irrespective of variety and seeding time due to high sterility. Number of panicles and number of filled spikelets per unit area and 1000-grain weight (grain size) are the major determinants of grain yield. Irrespective of variety there was an increase in the duration of the sprouting to panicle initiation with the advancement of sowing time. It took 89 days when seed was sown at the 1st week of July and 92 days for 22 July sowing and then increased to 93 days for the variety BRRI dhan92. Similar trend was observed for the variety BRRI dhan88 and IR64. The days required from PI to 50% flowering was taken in consideration for flowering stage. The time required for 50% flowering (from PI to 50% flowering) and maturity (from 50% flowering to maturity) was more or less similar irrespective

of variety and sowing time (Table 11). Table 12 presents growing degree days (GDD) of rice cultivars taken in different phenophases at different growing environment. It is evident from the table that the highest value of growing degree days was taken by 1st date of seeding on 7 July followed by 22 July and the lowest was recorded on 8 August. Among the varieties it is evident that GDD was the highest in cultivar BRRI dhan92 2727.30 (± 57.40) followed by IR64 2634.89 (± 64.54) and BRRI dhan88 2376.08 (± 38.51). The tested varieties varied in growing degree days ($^{\circ}\text{Cd}$) requirements both for panicle initiation and flowering (Table 12). The degree days ($^{\circ}\text{Cd}$) requirements for panicle initiation were 1393.40 ± 25.04 , 1901.89 ± 18.39 , 1754.15 ± 16.43 , while for flowering 517.76 ± 27.25 , 451.63 ± 35.71 , 471.04 ± 34.69 , for BRRI dhan88, BRRI dhan92 and IR64, respectively (Table 12).

Table 10. Interaction effects between variety and date of seeding on yield and yield components.

Variety $\times$ date of seeding	Plant height (cm)	No. of panicle m^{-2}	No. of filled grains panicle ⁻¹	Sterility (%)	1000-grain weight (g)	Yield (tha^{-1})	Duration (from seeding to maturity) (day)
BRRI dhan88 $\times$ Set 1	100.44	258.33	52.11	43.59	20.36	2.47	117
BRRI dhan88 $\times$ Set 2	93.78	255.56	48.84	49.12	20.17	2.39	118
BRRI dhan88 $\times$ Set 3	86.33	233.33	46.12	46.80	20.10	2.12	120
BRRI dhan92 $\times$ Set 1	129.33	236.11	58.82	54.91	22.70	2.87	140
BRRI dhan92 $\times$ Set 2	125.56	225.00	56.54	44.71	22.63	2.85	144
BRRI dhan92 $\times$ Set 3	111.44	236.11	46.33	45.31	22.18	2.31	145
IR64 $\times$ Set 1	111.00	261.11	55.97	31.70	22.56	3.01	133
IR64 $\times$ Set 2	97.56	236.11	51.72	44.09	22.41	2.49	135
IR64 $\times$ Set 3	81.22	225.00	47.95	44.81	22.01	2.11	137
LSD at 5% level	4.72	54.02	12.29	15.24	1.30	0.29	0.00
CV	2.62	12.97	13.76	19.56	3.48	11.49	0.00

Seed sowing: Set 1: 7Jul 2021, Set 2:22 Jul 2021, Set 3:8 Aug 2021

Table 11. Growth stage of rice varieties as affected by sowing time in Aman season 2021, Plant Physiology, BRRI.

Sprouting date	Variety	Day to PI (from sprouting)	Day to 50% flowering (from PI)	Day to maturity (from 50% flowering)	Day to maturity (from sprouting)
07 Jul 2021	BRRI dhan88	65	26	26	117
	BRRI dhan92	89	25	26	140
	IR64	82	25	26	133
22 Jul 2021	BRRI dhan88	66	25	27	118
	BRRI dhan92	92	26	26	144
	IR64	84	25	26	135
08 Aug 2021	BRRI dhan88	68	25	27	120
	BRRI dhan92	93	26	26	145
	IR64	85	26	26	137

Table 12. Degree days of rice varieties as affected by sowing time in Aman season 2021, Plant Physiology, BRRI.

Variety	Required DD (°Cd)			
	from Sprouting to PI	from PI to 50% flowering)	from 50% flowering to maturity)	from sprouting to maturity)
BRRI dhan88	1393.40 (±25.04)	517.76 (±27.25)	467.15 (±36.35)	2376.08 (±38.51)
BRRI dhan92	1901.89 (±18.39)	451.63 (±35.71)	374.48 (±30.25)	2727.30 (±57.40)
IR64	1754.15 (±16.43)	471.04 (±34.69)	394.69 (±30.66)	2634.89 (±64.54)

GENOME EDITING

CRISPR-Cas9 mutagenesis of the *OsRR22* gene for improving salinity tolerance of rice

Salinity is one of the most important abiotic stress affecting rice production. Numerous salt tolerance quantitative trait loci were identified and few of them had been transferred into popular rice varieties via marker-assisted selection (MAS) but none of them showed greater promise. The *OsRR22* gene encodes a 696–amino acid B-type response regulator transcription factor that is involved in

both cytokinin signal transduction and metabolism; its loss of function has been reported to significantly increase salt tolerance. To design a CRISPR/Cas9 targeting the *OsRR22* gene in rice, a 19bp guide sequence (5'-AGAGGGATCAATCCCCGT-3') was a protospacer adjacent motif lying within the *OsRR22* coding sequence (*LOC_Os06g08440*). The guide sequence was properly cloned into the binary vector pC1300-Cas9 (Fig. 8). The binary vector pC1300-Cas9 harboring Cas9/*OsRR22*

sgRNA was mobilized into *Agrobacterium tumefaciens* LBA4404 by freeze-thaw method and confirmed through PCR-gel electrophoresis. Plants were regenerated through *Agrobacterium*-mediated transformation. Genomic DNA was extracted from the leaves of transformed plants using the sodium dodecyl sulfate (SDS) method. Hygromycin phosphotransferase positive plants were identified

using HPT primer pair designed from Hygromycin phosphotransferase resistant zone of the Cas9 vector. PCRs amplifications have been performed using primer pairs, which generated an amplicon harboring the target site. The resulting amplicons have been sequenced using the Sanger method and mutant plant have been identified where deletion of two nucleotides occurred at the target site (Fig. 9).



Fig. 8. Confirmation of vector constructs by sequence alignment of recombinant pC1300-Cas9 harboring Cas9/OsRR22 sgRNA with guide sequence.

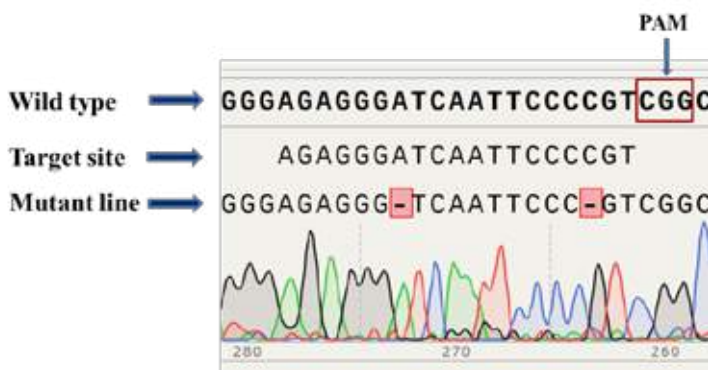


Fig. 9. Nucleotide sequences at the target site of the T1 mutant rice plants.

Generation of male sterile rice line for two-line hybrid system by editing *TMS5* gene using CRISPR/Cas9 system

The two-line hybrid rice system is an important innovation for the better exploitation of hybrid vigour (heterosis). Thermo-sensitive genic male sterile (TGMS) line has been shown to be an ideal replacement for cytoplasmic male sterility (CMS) and explored in two-line hybrid systems; particularly in rice. TGMS lines are sensitive to the temperature for the expression of male sterility or fertility. To design a CRISPR/Cas9 targeting the *TMS5* gene in rice, a 19bp guide sequences (5'-ACCGTCGAGGGCTACCCCG-3') was a

protospacer adjacent motif lying within the *TMS5* coding sequence (LOC_Os02g12290.1). The guide sequences were properly cloned into the binary vector pC1300-Cas9 (Fig. 10). The binary vector pC1300-Cas9 harboring Cas9/*TMS5* sgRNA was mobilized into *Agrobacterium tumefaciens* LBA4404 by freeze-thaw method and confirmed through PCR-gel electrophoresis. Plants were regenerated through *Agrobacterium*-mediated transformation. Genomic DNA was extracted from the leaves of transformed plants using the sodium dodecyl sulfate (SDS) method. Hygromycin phosphotransferase positive plants were identified using HPT primer pair designed from Hygromycin phosphotransferase resistant zone of the Cas9 vector.

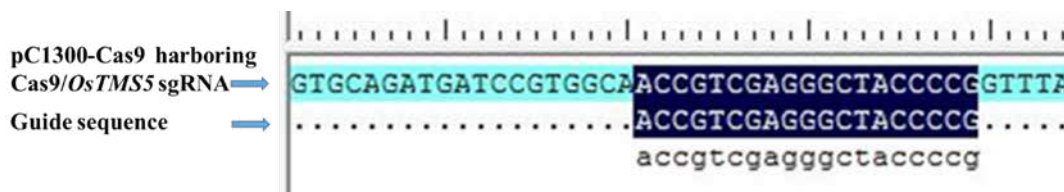


Fig. 10. Confirmation of vector constructs by alignment of sequence of recombinant pC1300-Cas9 harboring Cas9/*OsTMS5* sgRNA with guide sequence.

C4 RICE DEVELOPMENT

Investigation of anatomical differences in the spikelets of rice and Uri dhan

The chloroplast-containing leaf and other green tissues significantly regulate photosynthesis and are essential to each phase, from the absorption of light through the biochemical fixation of carbon dioxide. The characterization of anatomical variations between C3 (rice) and C3-C4 lineage plants, such as Uri dhan, has gained increasing attention. Thus, improving yields through enhanced photosynthetic efficiency could directly benefit current research projects that aim to engineer the

leaves and other green photosynthetic structures of cultivated rice. On the basis of morphological, cellular ultrastructure, and molecular data, Chowrasia and Mondal (2020) have asserted that Uri dhan (*Oryza coarctata*) should be capable of C4 photosynthesis. Based on this knowledge, the morphological distinctions between rice and Uri dhan spikelets' green tissues were examined. Uri dhan contains more vascular bundles in the lemma and palea than rice, in comparison. Rice only has 5 and 3 vascular bundles in the lemma and palea, compared to 12-15 and 8-12 in the Uri dhan lemma and palea (Photographs 1 and 2).



Photograph 1. Vascular bundles in the rice spikelets lemma (left) (4×) and palea (right) (10×).

Photograph 2. Vascular bundles in the Uri dhan spikelets lemma (left) (10×) and palea (right) (10×).

Optimizing chlorophyll fluorescence imaging system for photosynthetic efficiencies of rice in the submergence stress

Advances in image-based phenotyping techniques enabled non-destructive imaging to be used to screen for submergence tolerance traits in a diverse variety of germplasm in a reliable, quantifiable, and efficient manner. However, the use of image-based phenotyping in the development of submergence-tolerant rice is still restricted. As a result, the current study sought to investigate the application of chlorophyll fluorescence-based imaging to

quantify rice submergence tolerance at the seedling stage. FR13A (SUB1 donor), IR42 (standard sensitive check), and BRRI dhan52 (SUB1-HYV) were tested under complete submergence stress for 24, 48, 72, 96, and 120 hours. The chlorophyll fluorescence image was collected following submergence treatments and at 7 days of recovery. At two days of complete submergence treatment and six days of recovery, significant variations in maximal quantum yield (Fv/Fm) were identified between the submergence donor and BRRI dhan52 to submergence sensitive (Figs. 11 and 12).

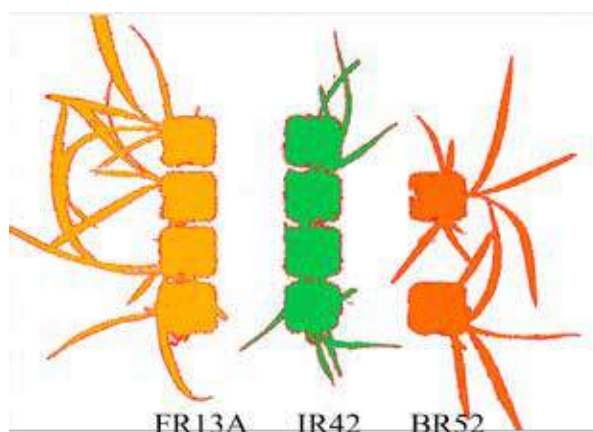


Fig. 11. Maximum quantum yield (Fv/Fm) after two days of complete submergence stress and six days of recovery period.

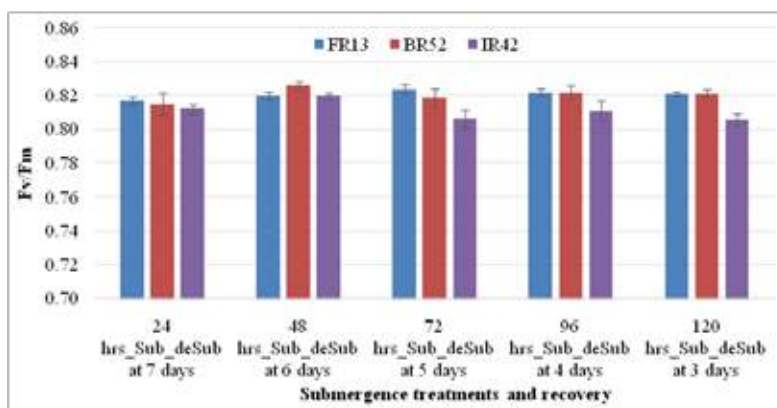


Fig. 12. Fv/Fm values at different submergence treatments and recovery period. Values are the mean $\pm$ SE (n=4).

Entomology Division

194	Summary
195	Survey And Monitoring Of Rice Arthropods
201	And Natural Enemy
201	Biological Control Of Rice Insect Pests
202	Evaluation Of Chemicals And Botanicals Against Rice Insect Pest
203	Insecticide Toxicology
205	Host Plant Resistance
206	Integrated Pest Management
208	Vertebrate Pest Management

SUMMARY

Short horned grasshoppers (SHG), green leafhopper (GLH) and white leafhopper (WLH) were the most abundant pests and found in all habitats (seedbed, ratoon, grass fallow, grass bund, irrigated rice, rice bund and upland rice) during the reporting year. Total numbers of insect pests were observed the highest in light trap at Habiganj followed by Gazipur, Barishal, Cumilla, Rangpur, Rajshahi and Sonagazi respectively. The highest catch of natural enemies in light trap was recorded at Barishal followed by Habiganj, Cumilla, Sonagazi, Gazipur and Rajshahi.

Survey of insect pests of rice in Rangpur region during T. Aman 2022 season revealed that insect pests infestation was below the ETL. Among the insect pests, rice leafroller (RLR) population was found the highest followed by GLH and SHG. Among the natural enemies SPD population were found the highest followed by Dam.fly, LBB, CBD and GMB. Survey of insect pests of rice in coastal areas showed no significant correlation between salinity and insect pests. Although some location had severe damage of YSB infestation but it was not affected by salinity. Moreover, natural enemy of rice insect pests were also varied location to location. The numbers of insects/20 sweep were found lower when the natural enemy population was higher in number. Fall Armyworm (FAW) moth catches in pheromone trap were 0.02 to 0.08/trap/day in four different locations of Bangladesh. The highest FAW moth catches were observed 0.08 moths/trap /day at the farmers' field of Vagjoare, Pirganj, Rangpur.

The growth duration of different developmental stages of rice leafroller (RLR) from egg to adult has shown differences in changing temperature in the growth chamber. Overall, egg incubation period to adult longevity duration of RLR, *Cnaphalocrosis medinalis* was higher in the lowest temperature (20°C) compared to higher temperature at 25°C and 30°C. Striped stem borer (SSB) was the dominant species followed by YSB and DHB at BRRI HQ farm Gazipur. Total 263 stem borer larvae

were found from 374 tillers on seven different dates and the highest 92 SSB larvae was found from a single stem. It was a small size data and need more study with large data to draw a conclusion.

Insect pests status remained below the economic threshold level (ETL) both in Eco-engineering plots (T_1) and insecticide treated plots (T_2). The highest beneficial insects, predator and parasitoid were observed in rice field with nectar-rich flowering plants on bunds (Eco-engineering). However, least natural enemies and parasitism were found in farmers' practice rice field where 3-4 times insecticides were applied. Moreover, there was no yield reduction observed in eco-engineering field compared to farmers' practice field (insecticide application). Though grain yield were observed similar both in T_1 and T_2 during T. Aman season but additional sesame produced in T_1 which increase the rice equivalent yield (REY). So, growing nectar-rich flowering plants on the bunds of rice crop are being used in IPM.

A total of 155, 09, 04 and 12 commercial formulations of insecticides were evaluated and 145, 09, 04 and 12 were found effective against BPH, YSB, RH and rice weevil respectively. Tested Silver (Ag) nano-particle showed 56.67% and 73.33% mortality against BPH nymph at 24 and 72 hours after spray (HAS) respectively in 500 mg/ml concentration. Insect mortality decreases with decreasing the concentration of Ag nano-particle. Among the tested six generic insecticides (acetamiprid, spinosad, abamectin, chlorantraniliprole, fipronil and chlorpyrifos) in rice field chlorantraniliprole showed comparatively safe for natural enemies.

Insecticide residue analysis through LCMS 2022 showed that application of insecticide chlorantraniliprole three times in rice field with recommended dose and double of the recommended dose have no effect on rice grain. But application of thiamethoxam with the same doses 0.014 and 0.034 mg kg⁻¹ insecticide residues were detected in rice grain. The detection level of thiamethoxam were below the EU MRL level 0.6 mg kg⁻¹.

Chlorantraniliprole insecticide was applied 5, 10 and 15 days after flowering (DAF) of rice plants and no residues were found in grain of 5 and 10 DAF samples but chlorantraniliprole spray at 15 DAF samples contained 0.039 mg kg⁻¹ residues which is less than EU MRL 0.4 mg kg⁻¹. Method development for multiple residue analysis of five insecticide namely carbofuran, chlorantraniliprole, chlorpyrifos, isoprocarb and thiamethoxam were standardized by Shimadzu LCMS/MS 8050. Detection of the above-mentioned insecticides was carried out with the positive ion mode of the ESI probe. Detection was carried out in multiple reaction monitoring (MRM). The pesticide residue database of the LCMS/MS system was used for the data analysis. QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) Method for Pesticide Residue Analysis (Method AOAC 2007.01) was applied for sample preparation.

In total three breeding lines, namely SV0724 (ING229) of IRBPHN Set 17 and another two lines BR9674-1-4-1-3-P1 and BR9674-7-3-2-1-P2 of zinc enriched (ZER) in regional yield trial (RYT), were found moderately susceptible (score 5) against BPH during the evaluation at green house. A total of 26 advanced breeding lines out of 780 were showed moderately susceptible reaction (score 5) and only single breeding line (BR 12193-5 R-96) showed resistant reaction (score 3) against BPH. In Line Stage Testing (LST) of Insect Resistant Rice (IRR), seven breeding lines out of 204 showed moderately susceptible (score 5) reaction against BPH. Out of 250 observational yield trial materials six were found moderately susceptible (score 5) and only one line (BR 12193-5 R-96) showed resistant (score 3) reaction against BPH. Among the 65 advanced yield trial (AYT) breeding lines only 11 breeding lines showed moderately susceptible reaction (score 5) against BPH. Among the 261 observational yield trial Boro 2022-23 breeding lines only two breeding lines (BR13219-4R-382 and BR13218-4R-110) showed moderately susceptible reaction (score 5) against BPH and the rests all were susceptible. All of the 26 local germplasm entries showed susceptible reaction (score 7 and 9) against BPH.

As employed to develop insect resistant rice variety, we knockout serotonin biosynthesis gene CYP71A1 from rice genome using CRISPR Cas9 genome editing tool to create insect resistance an elite rice variety. We screened some population of T₁ against 3rd instar BPH nymph in green house condition and got some tolerant plants. But the sequence analysis of T₁ and T₂ lines with Cas9 specific primers did not confirm the homozygous mutation. This result suggests that mutated part of the gene of T₀ was not successively transferred into the next generation.

Irrespective of location and rice variety the insect pests remained below the economic threshold level (ETL) both in IPM practice (T₁) and farmers' practice i.e., insecticide application (T₂) fields during Boro 2022-23. Benefit cost ratio (BCR) analysis was done on the basis of full cost and were found always higher in T₁ (IPM) compared to T₂ (insecticide application).

Aluminium phosphide was very effective rodenticide followed by zinc phosphide 2, bromadiolone and zinc phosphide 1 to control rice field rat.

SURVEY AND MONITORING OF RICE ARTHROPODS

Pest and natural enemy incidence at BRRI HQ farm, Gazipur

Populations of rice insect pests, their natural enemies and crop damage intensities in seven habitats (seedbed, ratoon, grass fallow, grass bund, irrigated rice, rice bund and upland rice) were monitored weekly at BRRI HQ farm, Gazipur. Overall insect pest incidence was low in the reporting year. Green leafhopper (GLH), WLH and SHG were the most abundant pests and found in all habitats. Highest number of SHG was found in grass fallow followed by grass bund, ratoon and transplanted rice (Fig. 1). Higher numbers of natural enemies were found in the grass bund, grass fallow and seedbed. Green mirid bug (GMB), damsel fly (Dam.fly), spider and ladybird beetle (LBB) were the dominant predators in all the habitats of the reporting year (Fig. 2).

P.I: Sadia Afrin **C.I:** Tapon Kumar Roy **PL:** Sheikh Shamiul Haque

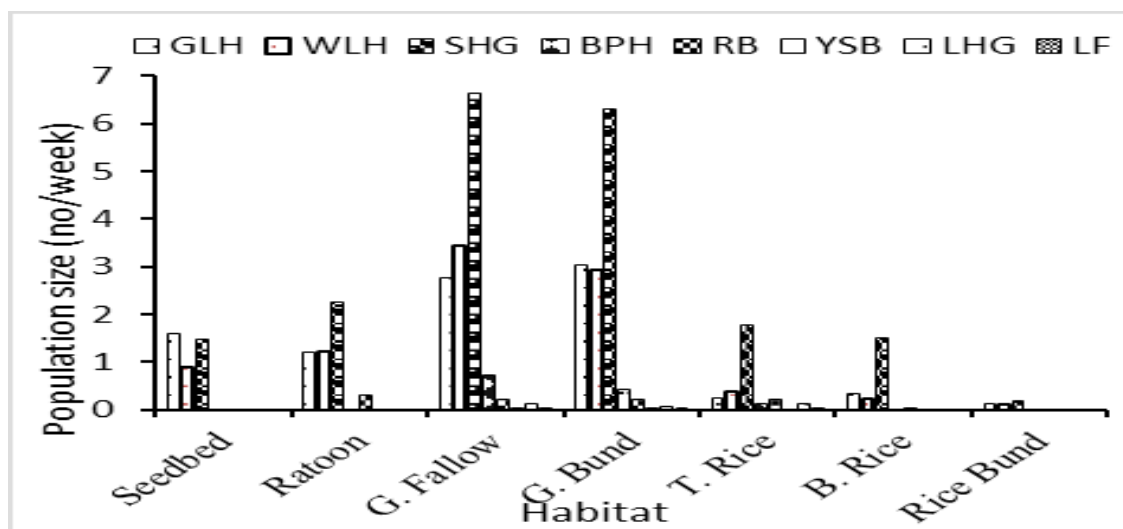


Fig. 1. Incidence of insect pest in different habitats at BRRI farm, Gazipur.

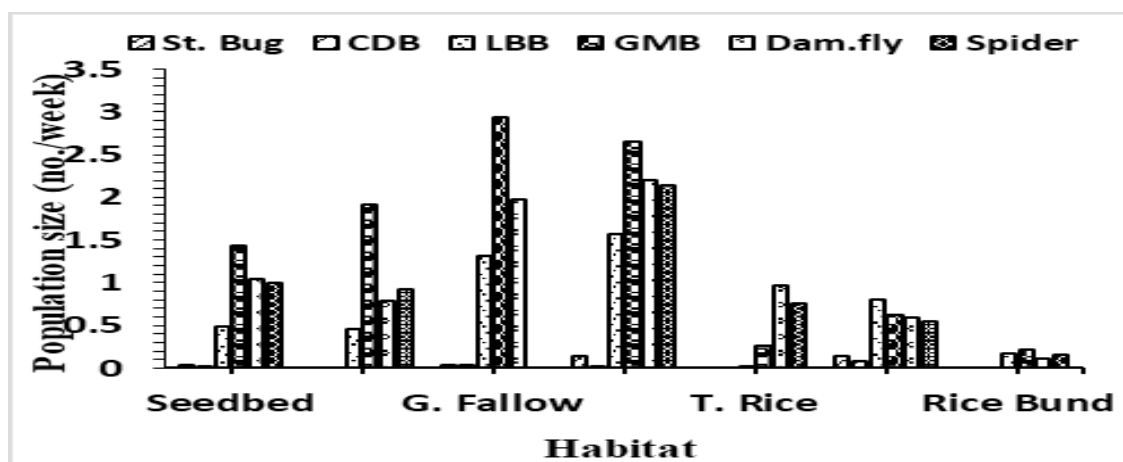


Fig. 2. Incidence of natural enemies in different habitats at BRRI HQ farm, Gazipur.

Incidence of insect pests and natural enemies in light trap

Rice insect pests and their natural enemies were monitored throughout the year by Pennsylvanian light trap from dusk to dawn at BRRI HQ, Gazipur and six BRRI regional stations. The abundance of BPH, WBPH, GLH and YSB was observed almost all the seven locations. Total numbers of insect pests were the highest at Habiganj followed by Gazipur, Barishal, Cumilla, Rangpur and Rajshahi (Fig. 3). Total number of natural enemies was found the highest in Barishal followed by Habiganj, Cumilla, Sonagazi, Rangpur and Gazipur (Fig. 3).

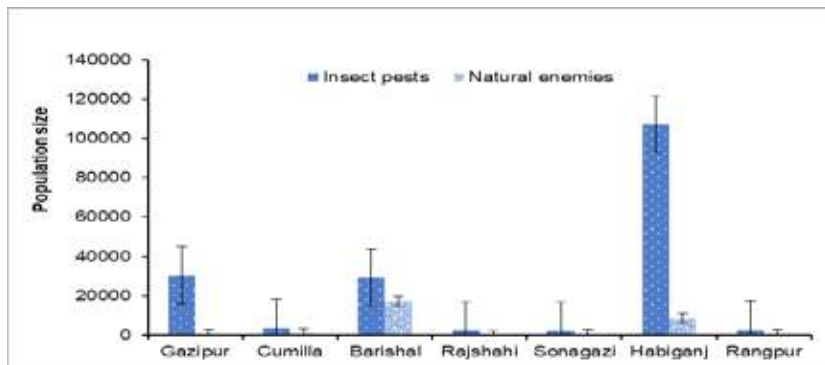


Fig. 3. Insect pests and natural enemies at BRR HQ, Gazipur and regional stations (RS).

Among the major insect pests the highest number of BPH was observed in November at Habiganj and in October at Gazipur (Fig. 4). Two peaks of WBPH were observed in October and May at BRR HQ, Gazipur and another peak in January was observed at BRR RS, Barishal. The highest peak of YSB was observed at BRR RS, Barishal in January and another peak in April (Fig. 4). Two peaks of YSB

were observed at BRR RS, Habiganj in October and April. Usually stem borer shows two peaks in a year- one in April-May and the other in October-November. Peak of GLH was found in November at BRR RS, Habiganj (Fig 4). The highest rice leafroller (RLR) was found in May at Barishal and October in Cumilla. In conclusion, higher peak of insect pests was found in October-November and May to June across the locations (Fig. 4).

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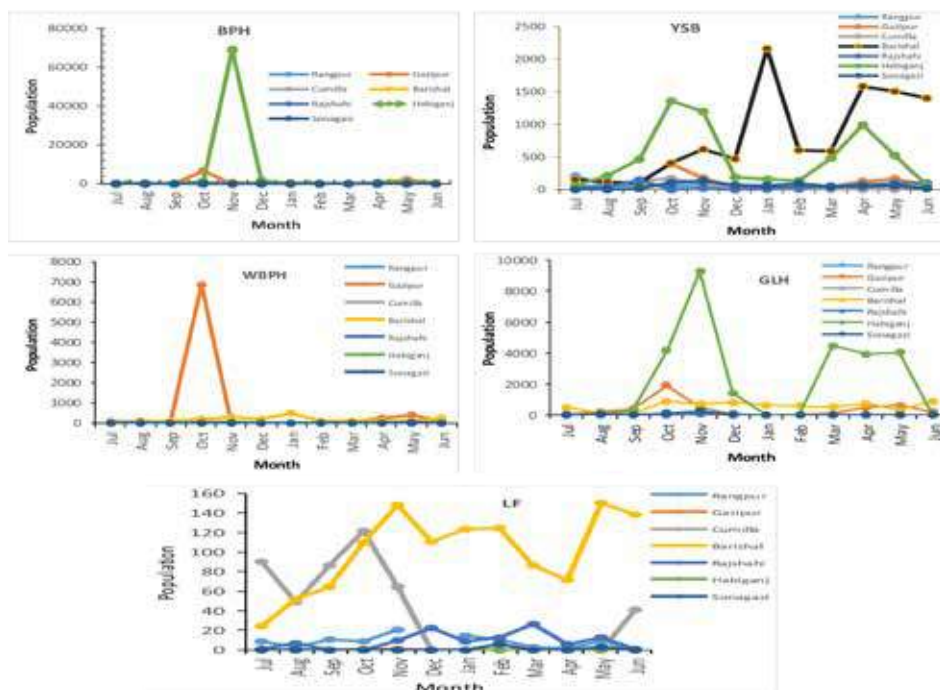


Fig. 4. Incidence pattern of major insect pests in light trap, BRR HQ, Gazipur and regional stations during July 2022-June 2023.

The highest peak of GMB was observed in November at Habiganj followed by Gazipur in December and Barishal in January. The highest number of LBB was found in May at Habiganj and February at Barishal. CDB showed the highest population at Barishal in April, October in Gazipur and November (Fig. 5). Similarly, In contrast,

several peaks of STPD were observed at Barishal but the highest was found in January (Fig. 5). A small peak of STPD was observed in the month of August and May at BRRI, Gazipur. Among natural enemies, the highest peak was found in April to May and October to November for CDB, November to January for GMB, February and May for LBB and January for STPD (Fig. 5).

P.I: Sadia Afrin **C.I:** Tapon Kumar Roy **PL:** Sheikh Shamiul Haque

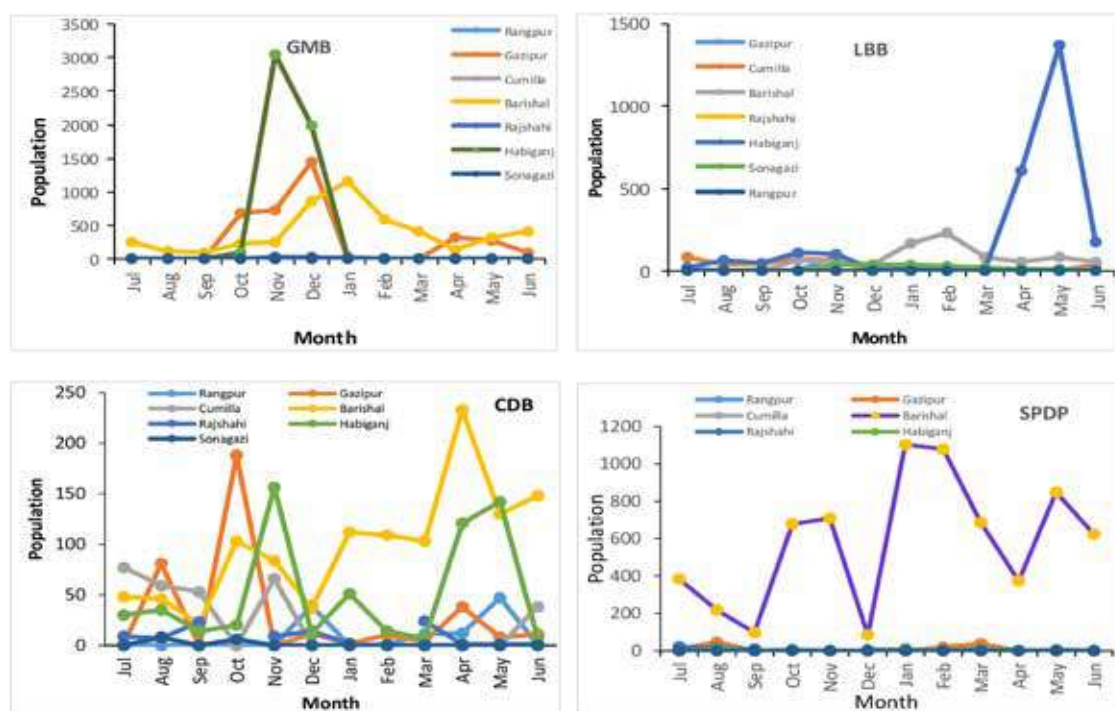


Fig. 5. Incidence pattern of natural enemies of rice insect pest in light trap, BRRI HQ and regional stations, July 2022-June 2023.

Survey and monitoring of rice arthropods in Rangpur region

The insect pest population, their damage intensities and abundance of the natural enemies were surveyed during T. Aman 2022 in Rangpur region to know the incidence patterns of major insect pests and their natural enemies and to find out the present status of insecticide application in rice field. The insect pests infestation was below the ETL during T. Aman 2022 season in Rangpur region. Among the insect pests leafroller (LR)

population was found the highest (6.35/20 sweep) followed by GLH and SHG, 4.25 and 3.35/20 sweep respectively (Fig. 6). Other insect pest populations were very low- 0.10 to 1.8/ 20 sweep. Among the natural enemies SPD population were found the highest (10.05/20 sweep) followed by Dam. fly (6.25/20 sweep), LBB (2.5/20 sweep) CBB (1.35/20 sweep) and GMB, 0.15/ 20 sweep (Fig. 7). During interview it was found that most of the farmers (>87%) used granular insecticide with 1st urea top dressing at 15-20 days after

transplanting (DAT) and consecutively they used additional 2-3 times spray insecticide to control the insect pests of rice though insect infestation did not reach the ETL. Again, more than 90% farmers used unrecommended insecticide (chlorpyrifos + cypermethrin) to control the rice insect pests.

Not only that they were using tank mix pesticides (mix two or more insecticide+ one fungicide in the same spray tank). They also used low doses and low volume of pesticide. As a result there have chance to resist the pest against pesticide which may induce pest resurgence.

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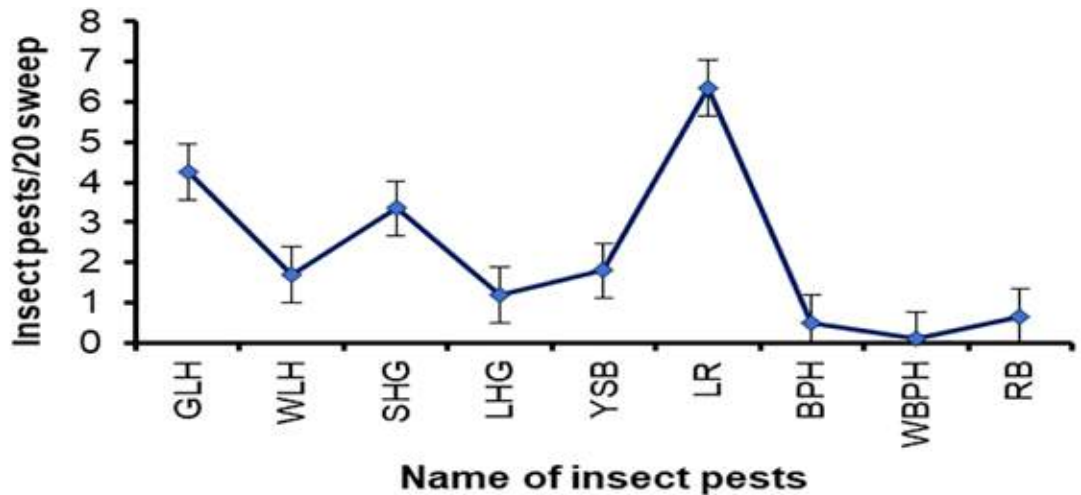


Fig. 6. Insect pests number/20 sweep in Rangpur region during T. Aman 2022.

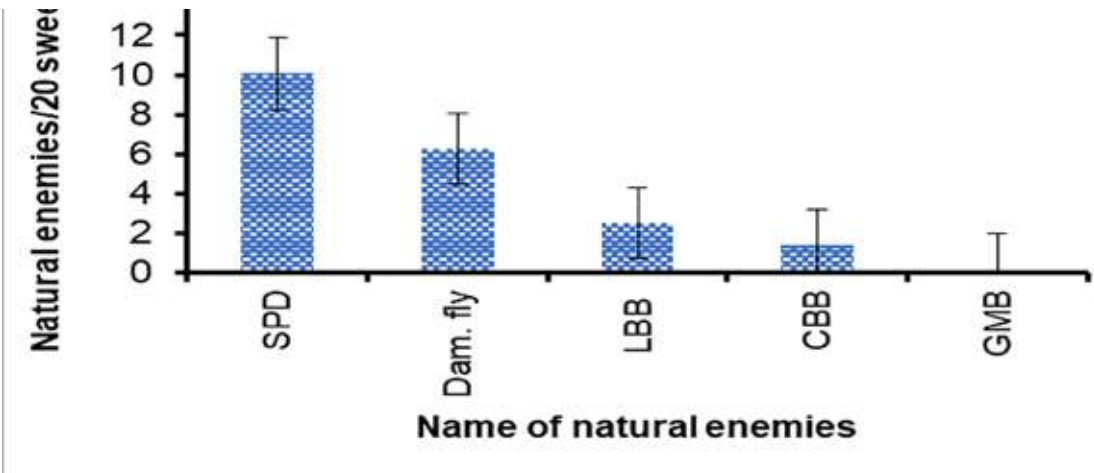


Fig. 7. Natural enemies number/20 sweep in Rangpur region during T. Aman 2022.

Survey and monitoring of rice arthropods in coastal areas

The survey was conducted at 12 locations in Botiaghata, Khulna during Boro 2022-23 season to find out the arthropod composition and community structure in coastal areas and to identify the peak abundance of insect pests in rice. During Boro season, among the recorded insects, whorl maggot (WM) population was found the highest in location 3 and 5 (Fig. 8). In location 1, 5 and 6, short horned grasshopper (SHG) population was higher. Number of adult moths of YSB was found in most of the location (Fig. 8) and the damage symptoms of YSB was also very evident in almost all the locations.

Some other insects were also found such as white leafhopper (WLH), green leafhopper (GLH), long horned cricket (LHC), leaf roller (LR) and rice bug (RB). But the population were below the economic threshold level (ETL). Among the natural enemies (NE) spider population was the highest followed by damsel fly (Dam. fly), green mirid bug (GMB), staphylinid beetle (STPD), lady bird beetle (LBB), carabid beetle (CBB) and tiger beetle (Fig.9). There were no definite correlation between salinity level and insect pests (Fig. 10).

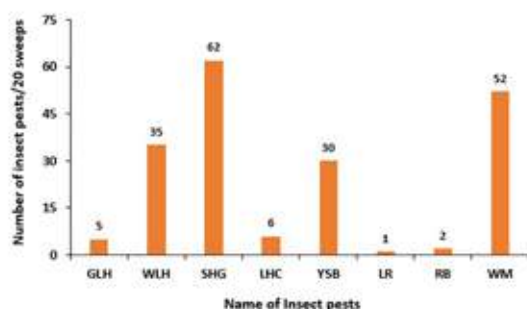


Fig. 8. Insect pests status in the rice field of Botiaghata, Khulna during Boro season 2022-23.

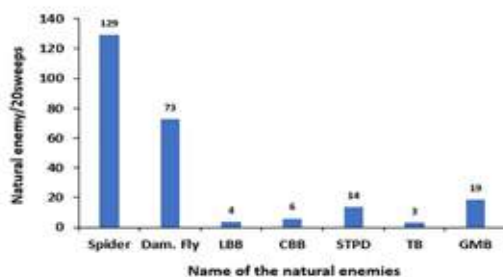


Fig. 9. Natural enemy status in the rice field of Botiaghata, Khulna during Boro season 2022-23.

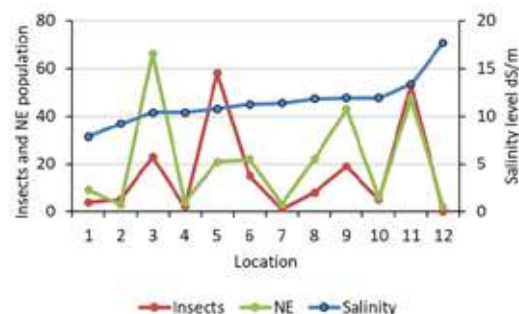


Fig. 10. Incidence pattern of insect pests and natural enemies of rice in Botiaghata, Khulna during Boro season 2022-23.

Fall Armyworm (FAW) monitoring through pheromone trap in rice crops

Three pheromone traps were set 100 m between traps in each of four locations BRRI HQ, Gazipur, farmers field at Jogitola, Gazipur, BRRI regional station, Cumilla and farmers field of Vagjoare, Pirganj, Rangpur from vegetative to ripening stage of rice crops during Boro 2022-23 to know the abundance and damage intensity of Fall Armyworm (FAW) in rice crop. The range of FAW moth catches was 0.02 to 0.08/trap/day (Fig. 11). The highest FAW moth catches was observed 0.08 moths/trap/day at the farmers' field of Vagjoare, Pirganj, Rangpur (Fig. 11). That might be happened as maize field was remained 200 m adjacent to the trial field. No fresh window panes (FW) and infested plants (IW) were found during scouting.

PI: Md Nazmul Bari, PL: Sheikh Shamiul Haque,

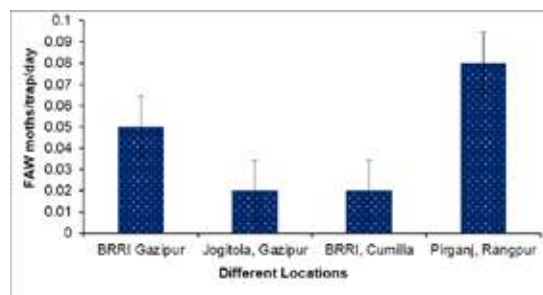


Fig. 11. Catches of FAW moths in pheromone trap Boro 2022-23.

BIO-ECOLOGY OF RICE INSECT PEST

AND NATURAL ENEMY

Effect of temperature on the biology and life cycle of rice leafroller, *Cnaphalocrosis medinalis*

Rice leafroller colony was maintained on BR3 plants under greenhouse conditions at BRRI, Gazipur to know the impact of elevated temperature on the development of rice leafroller. The growth duration of different developmental stages of RLR has shown differences in changing temperature in the growth chamber. Egg incubation period and larval period were significantly higher in 20°C compared to 25°C and 30°C. But pupal duration was not significantly different but that completed quickly at 30°C (Fig. 12). Adult longevity was more in 25°C temperature compared to 20 and 30°C temperature (Fig. 13). The growth duration from egg to adult was decreased by increasing temperature. The highest growth duration 34 days was found at 20°C and that was 26 and 20 days in 25°C and 30°C respectively (Fig. 14).

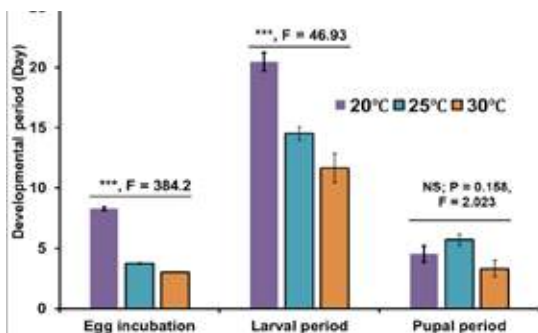


Fig. 12. Effect of temperature on rice leaf folder growth duration.

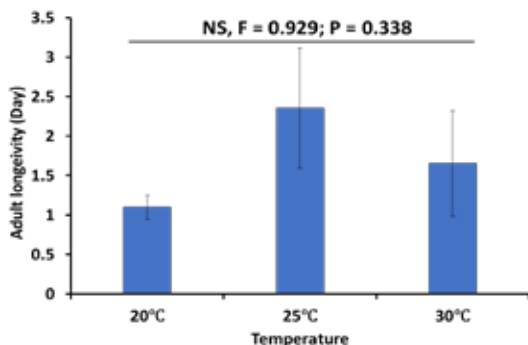


Fig. 13. Adult longevity of rice leaf folder in different temperatures.

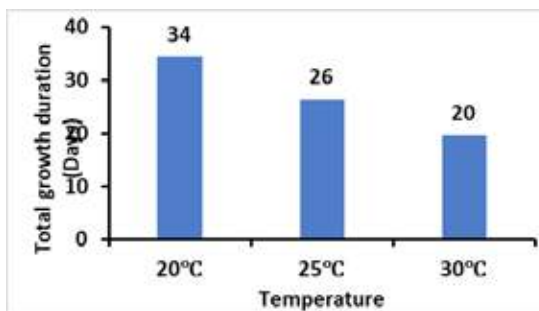


Fig. 14. Total growth duration of rice leaf folder in different temperatures.

Species composition of stem borer at BRRI research field, Gazipur

Striped stem borer (SSB) was the dominant species followed by YSB and DHB at BRRI farm Gazipur. Total 263 stem borer larvae were found from 374 tillers on seven different dates and the highest 92 SSB larvae was found from a single stem. It was a small size data and need more study is needed with large data to draw a conclusion.

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BIOLOGICAL CONTROL OF RICE INSECT PESTS

Conservation of natural enemies through eco-engineering

The experiment was conducted with BRRI dhan87 at BRRI HQ farm Gazipur during T. Aman 2022 season with two treatments i.e., T_1 =Rice field with flowering plants (sesame and cosmos) on bunds and T_2 =Farmers practice i.e., prophylactic insecticide use with a view to conserve natural enemies through ecological engineering approaches to reduce insecticide use and its environmental pollution in rice production. Insect pests status remained below the economic threshold level (ETL) in both the treatments. The highest number of grasshopper (GH) was found in T_2 followed by BPH, WLH and GLH (Fig. 15). Other insect pests like YSB, RB and RLF were found very low at BRRI, Gazipur.

Among the natural enemies the highest numbers of natural enemies were found in T_1 where insecticide was not used. Number of SPD, Dam. fly and LBB were found the highest in T_1 compared to T_2 (Fig. 16).

Rice leaffolder larval parasitism and YSB egg parasitism observed the highest in T_1 (37.8 and 36.84 % respectively) compared to T_2 (2.75 and 1.25 % respectively). Though grain yield was observed similar both in T_1 and T_2 (6.10 and 6.07 t/ha respectively) but additional sesame produced in T_1 which increased the rice equivalent yield (REY) (Fig. 17).

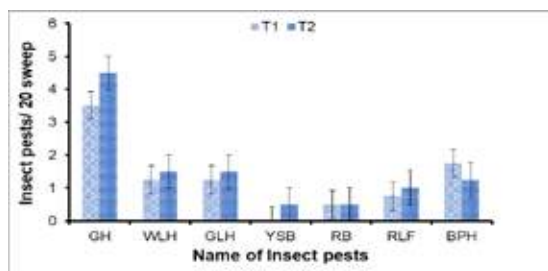


Fig. 15. Insect pests number per 20 complete sweep in different treatments during T. Aman 2022, BRRI, Gazipur (T_1 =Rice field with flowering plant on bunds, T_2 = Farmers' Practice i.e., insecticide application).

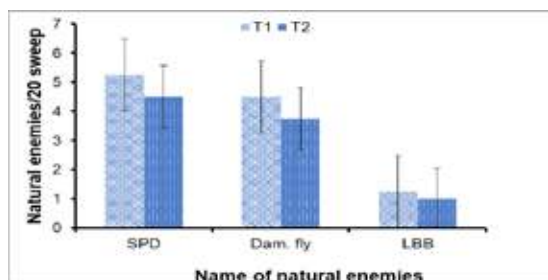


Fig. 16. Natural enemies number / 20 sweep during T. Aman 2022, BRRI, Gazipur (T_1 =Rice field with flowering plants on bunds, T_2 = Farmers' practice i.e., insecticide application).

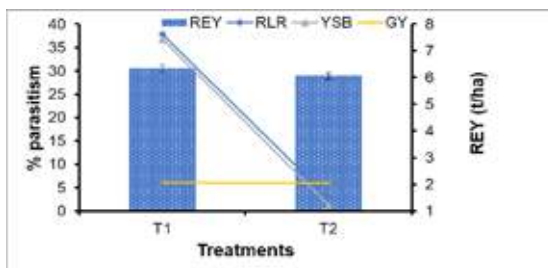


Fig. 17. Rice equivalent yield (REY) and % parasitism of YSB and RLR larvae during T. Aman 2022, BRRI, Gazipur.

Aman 2022, BRRI, Gazipur. (T_1 = Rice field with flowering plant on bunds, T_2 = Farmers' Practice i.e., insecticide application).

EVALUATION OF CHEMICALS AND BOTANICALS AGAINST RICE INSECT PESTS

Test of different insecticides against major insect pests

The effectiveness of commercial formulations of different insecticides against major insect pests of rice was evaluated in field and storage condition. A total of 155 commercial formulations of insecticides were evaluated against brown planthopper (BPH). Among them 145 insecticides were found effective against BPH. All the nine tested commercial formulations against YSB, four against rice hispa and 12 against rice weevil (RW) were found effective.

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Use of nanoparticle to control rice insect pests

The efficacy of Ag (Silver) nanoparticles against BPH was tested at four different concentrations (500, 350, 250 and 125 mg/ml), which were prepared by dilutions with distilled water along with adhesive solution (Promoter plus, ACI Ltd.). Nanoparticle solutions of different concentration were sprayed on 15-day-old rice seedlings. Ten 3rd - 4th instar nymphs of BPH were released into each treatment and kept them at $27 \pm 1^\circ\text{C}$, 60 ± 5 % relative humidity with 16:8 hour light and dark photoperiod in the growth chamber. Silver nanoparticles showed 56.67% mortality of BPH nymph both in 500 and 350 mg/ml concentration at 24 hours after application. On the other hand, the lowest mortality (46.67%) was observed both in 125 and 250 mg/ml concentration at 24 hours after application. Furthermore, 72 hours after Ag application the highest 73.33% mortality of BPH nymph was found at 500 mg/ml concentration and the lowest (60%) was observed both in 125 and 250 mg/ml concentration. Percent mortality increases with time and the rate of mortality was found the highest in higher concentration (Fig. 18).

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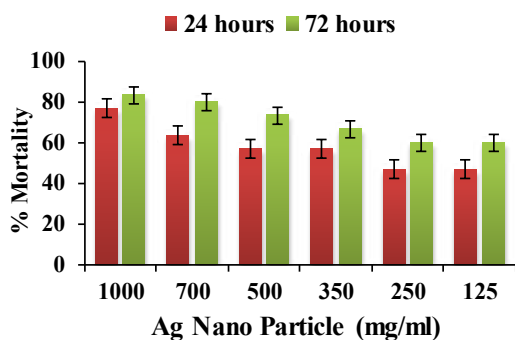


Fig. 18. Effect of Ag nanoparticle on the mortality of BPH.

Effect of insecticides on natural enemies of rice insect pests

Six commercially registered insecticides for rice of different chemical group were evaluated at BIRRI HQ, Gazipur to know the effect of insecticides on natural enemies of rice insect pests. The name of six insecticides were acetamiprid, spinosad, abamectin, chlorantraniliprole, fipronil and chlorpyrifos. Among them chlorantraniliprole showed comparatively less toxic to natural enemies of rice.

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INSECTICIDE TOXICOLOGY

Residues analysis of insecticide in rice by using Liquid Chromatography and Mass Spectrometry (LCMS)

A popular insecticide (chlorantraniliprole 20% + thiamethoxam 20%) was used both in T. Aman and Boro season. Two treatments were used i.e., T_1 =Prophylactic use (3 times) with standard dose, T_2 = Three times use with double of standard dose. During Boro season insecticide applications were performed at 5, 10 and 15 days after flowering (DAF) and three plots were remained untreated (not sprayed) as a control. After harvest, a homogenous sample 1.0 kg was separated for each treatment. The collected samples were then stored in a freezer at -20°C during 30-day period until extraction for pesticide residues analysis.

The samples were extracted using acetonitrile (ACN) following QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) Method for Pesticide Residue Analysis (Method AOAC 2007.01). Pesticide residues were detected using a LC-MS2020 fitted with electrospray ionization (ESI) probe operated in the positive ion mode. The following parameters were optimized for chlorantraniliprole and thiamethoxam: capillary voltage, 3500 V; ion source temperature, 150°C ; desolvation gas temperature, 500°C ; desolvation gas flow rate, 1000 L h^{-1} of nitrogen. Detection was carried out in multiple reactions monitoring (MRM) mode. The retention time of chlorantraniliprole was 2.4 minute and thiamethoxam 2.05 minute.

The concentrations of chlorantraniliprole in rice grain were less than limit of detection ($<\text{LOD}$) when applied three times with recommended and double of the recommended doses but the concentration of thiamethoxam were 0.140 to 0.034 mg kg^{-1} in the polished rice grain with same treatments (Table 1). But the detected concentration of thiamethoxam was below the maximum residue limit (EU MRL: 0.6 mg kg^{-1}). The correlation coefficients (r^2) were 0.999 (standard solutions).

The concentrations chlorantraniliprole were less than limit of detection ($<\text{LOD}$) in treatment T_1 (insecticide application at 5 DAF and T_2 (insecticide application at 10 DAF) but the concentration of chlorantraniliprole was determined 0.039 mg kg^{-1} in the polished rice grain of T_3 treatments, where insecticide applied at 15 DAF (Table 2). This concentration was also lower than the maximum residue limit (MRL). The European Union MRL of thiamethoxam is 0.6 mg kg^{-1} . The correlation coefficients (r^2) were 0.999259 (standard solutions).

PI: Md. Nazmul Bari, **CI:** Farzana Nowrin, Sadia Afrin, Tapon Kumar Roy, **PL:** Sheikh Shamiul Haque

Table 1. Residue analysis of chlorantraniliprole (CTP) and thiamethoxam (THM) in rice grain.

Treatments	Insecticide residue (PPM)		EU MRL*	EU MRL*
	(CTP)	(THM)	CTP	THM
T ₁ = Recommended dose (3 times)	<LOD	0.014		
T ₂ = Double of recommended dose (3 times)	<LOD	0.034	0.4	0.6
T ₃ = Control	n.d.	n.d.*		

r²=9998407

LOD= Limit of detection n.d= not detected EU MRL*= European union Maximum Residual Limit

Table 2. Residue analysis of chlorantraniliprole (CTP) in rice grain at different days after flowering.

Treatments	Residue (mg kg ⁻¹)	EU MRL (mg kg ⁻¹)	
T ₁ = Insecticide application at 5 DAF	<LOD		
T ₂ = Insecticide application at 10 DAF	<LOD	0.4	r ² = 0.9992591
T ₃ = Insecticide application at 15 DAF	0.039		
Control	n.d.*		

DAF=Days after flowering LOD= Limit of detection EU MRL*= European union Maximum Residual Limit

Development and validation of analytical methods for multiple pesticide residue determination in**rice grain using LCMS/MS**

Method development for multiple pesticide residue determination in rice grain was carried out by using Liquid Chromatography with Tandem Mass Spectrometry (LCMS/MS8050, SHIMADZU) fitted with electrospray ionization (ESI) probe operated in the positive ion mode. The methods were developed for the determination of carbofuran, isoprocarb, thiamethoxam, chlorpyrifos and chlorantraniliprole. The pesticide residue database of the LCMS/MS system was used for the data analysis. QuEChERS Method for Pesticide Residue Analysis (Method AOAC 2007.01) was applied for sample preparation.

A total of five insecticides namely carbofuran (m/z 222.2500>123.1000 and RT 1.81 mins),

chlorantraniliprole (m/z 482.0000>450.9000 and RT 1.91 mins), chlorpyrifos (m/z 350.0000>198.0000 and RT 2.50 mins), isoprocarb (m/z 194.1000>77.0000 and RT 1.91 mins) and thiamethoxam (m/z 292.0000>211.1000 and RT 1.67 mins) were standardized by Shimadzu LCMSMS 8050. In the method file, ESI interface, desolvation temperature, DL temperature, nebulizing gas flow, heating gas flow, and drying gas flow were set at 300°C, 526°C, 250°C, 2.00 L/min, 10.00 L/min and 10.00 L/min respectively. Detection was carried out in multiple reactions monitoring (MRM). The ranged of limit of detection (LOD) was m 0.02 to 0.23 PPM and limit of quantification (LOQ) was 0.06 to 0.69 ppm.

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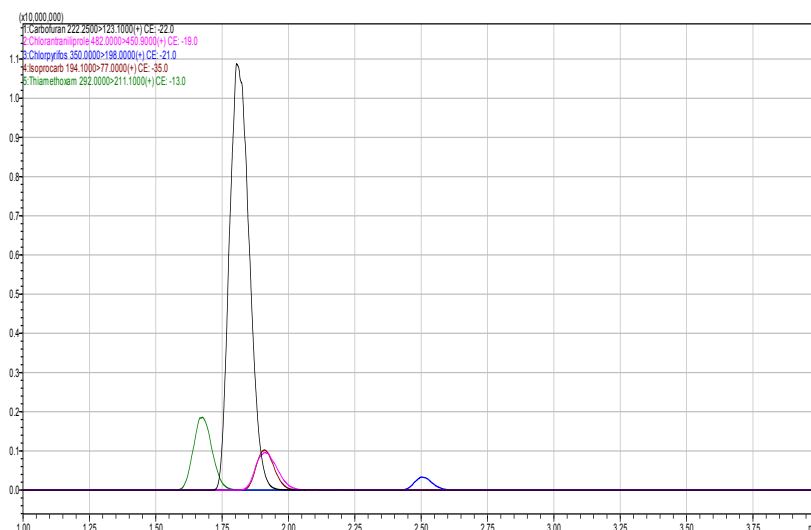


Fig. 19. Chromatogram of multiple pesticide residue determination in rice.

HOST PLANT RESISTANCE

Screening of rice germplasm, advanced lines against major insect pests

Among the rainfed lowland rice, premium quality rice and zinc enriched rice, no resistant lines were found in T. Aman 2022 season. Only one IRBPHN set 17 material, SV0724 (ING229) showed moderately resistant reaction (score 5) against BPH. Among eleven premium quality RYT-1 lines, five premium quality RYT-2 lines, six blast disease resistant ALART lines and ten salinity tolerant RYT lines, no line was found resistant. Two entries, BR9674-1-4-1-3-P1 and BR9674-7-3-2-1-P2 of zinc enriched RYT lines, showed moderately susceptible reaction (score 5) against BPH in Boro 2022-23 season.

PI: Sadia Afrin, **CI:** Sanjida Akter, **PL:** Sheikh Shamiul Haque

Development of BPH resistance rice introgression lines through marker assisted selection

IR101791-10-1-4-3-2-4 is an indica introgression line with stable resistance to BPH, which was used for developing elite donor and introgression resistance gene into modern cultivar. BRRI dhan87 and BRRI dhan89, susceptible to BPH, was applied

to develop mapping population by crossing with IR101791-10-1-4-3-2-4. For BRRI dhan87: A total of 320 F₄ lines were advanced from the population of BRRI dhan87 × IR101791-10-1-4-3-2-4 cross. For BRRI dhan89, a total of 285 F₄ lines were advanced from the population of BRRI dhan89 × IR101791-10-1-4-3-2-4 cross. These breeding lines were handed over to the Plant Breeding Division for further advancement as a BPH resistance variety.

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Screening of rice germplasm, advanced lines against BPH

Among them 26 advanced breeding lines were showed moderately susceptible reaction (score 5) and only single breeding line (BR 12193-5 R-96) showed resistant reaction (score 3) against BPH. Most of the entries showed susceptible reaction against BPH. In LST (IRR) seven breeding lines showed moderately susceptible (score 5) reaction against BPH. Six breeding lines showed moderately susceptible (score 5) reaction against BPH and only one line (BR 12193-5 R-96) showed resistant (score 3) reaction against BPH. Eleven breeding lines showed moderately susceptible reaction (score

5) against BPH. Two breeding lines (BR13219-4R-382 & BR13218-4R-110) showed moderately susceptible reaction (score 5) against BPH and the rests were all susceptible. All of the entries showed susceptible reaction (score 7 and 9) against BPH.

Identification of BPH resistance sources from local germplasm

A local germplasm Acc 489 (Digha-3) is stable resistance to BPH, which was used for developing elite donor and cross with BRRI dhan89. A total of 235 F₄ lines were advanced from the population of BRRI dhan89 × Acc489 cross and handed over to Plant Breeding Division for BPH resistance variety development.

PI: S Afrin, **CI:** MRA Sarkar (PBD), **PL:** Sheikh Shamiul Haque

Suppression of serotonin synthesis in rice using CRISPR Cas9 for insect pest control

As employed to develop insect resistant rice

variety, we knockout serotonin biosynthesis gene CYP71A1 from rice genome using CRISPR Cas9 genome editing tool to create novel alleles of CYP71A1 leading to introduction of insect resistance an elite rice variety BRRI dhan92. PCR analysis of putative transformants using primers targeting the flanking regions of sgRNA of CYP71A1 identified mutation in T₀ generation. Sequence

analysis of T₀ lines with Cas9 specific primers which identified that the mutation located within sgRNA region in T₀ population of BRRI dhan92. We screened some population of T₁ and T₂ against

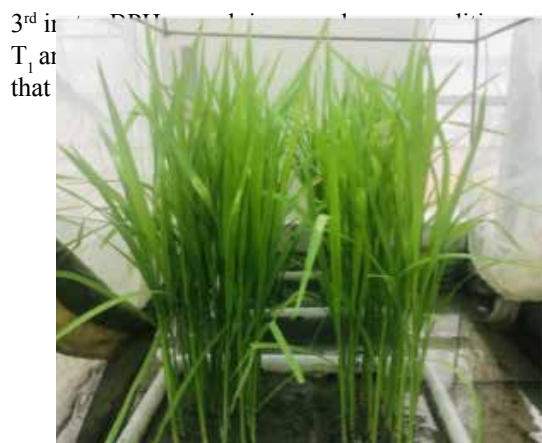


Photo 1. Plants just after infestation with BPH (Left Side); 21 days after BPH infestation (Right side).

PI: Md Panna Ali, **CI:** Sanjida Akter, **PL:** Sheikh Shamiul Haque

INTEGRATED PEST MANAGEMENT

Use of sex pheromone in corporation with other IPM tools to control stem borer

Three pheromone traps were set 100 m between traps in each of four locations BRRI HQ, Gazipur, farmers field at Jogitola, Gazipur, BRRI regional station, Cumilla and farmers field of Vagojore,

Pirganj, Rangpur during Boro 2022-23. Every Monday the trap catch and field scouting data were collected and recorded. The ranged of YSB catches was 0.01 to 0.05/trap/day. The highest YSB moth catches was observed 0.05 moths/trap /day at the farmers' field of Vagojore, Pirganj, Rangpur (Fig. 20).

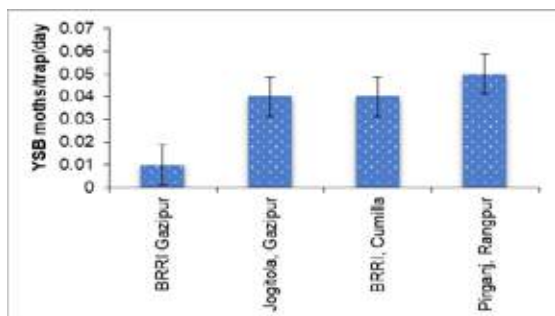


Fig. 20. Catches of YSB moths in pheromone trap.

YSB populations and damages were noticeably lower not only the experimental plots but population of YSB and its damage remain very low all over the country during Boro 2022-23. This might be happened due to high temperature and low humidity. YSB is a terrestrial species but highly adopted to an aquatic environment and requires high levels of moisture in all developmental stages. Conversely, dryness or moisture stress is a major limiting factor for growth and development. High temperatures combined with low humidity ($>34^{\circ}\text{C}$ with RH $<70\%$ causing so-called lethal day) kills many eggs and first instars larvae of YSB during the summer months. As a result no dead hearts and white heads were observed during field scouting for YSB.

Validation Trials on the Develop IPM Package for Rice

Four experiments were conducted in four different locations i.e., i) BRRI HQ farm Gazipur ii) Farmers field at the village Jogitola, Gazipur iii). Farmers' field at the village Vagoiare, Pirganj, Rangpur and iv) BRRI RS, Cumilla during Boro 2022-23 season to validate IPM packages for pest management in farmer's field with conserving natural enemies in rice eco system. Each of the fields was divided into two blocks for two treatments i.e., T_1 = Integrated pest management (IPM) practice and T_2 = Farmers practice i.e. prophylactic insecticide use. In T_1 , flowering plants (Marigold, cosmos and sunflower) were grown on bunds surroundings of the rice crop (to serve as nectar and pollen sources and shelter for different parasitoids and predators). Seedlings remained free from weed seedlings at the time of transplanting. Balanced doses of basal fertilizer



Photo 2. Field view of IPM plot at BRRI Gazipur, Boro 2022-2.

Irrespective of location and rice variety the insect pests remained below the economic threshold level (ETL) both in IPM practice (T_1) and farmers' practice (T_2) field during Boro 2022-23. Grasshopper (GH), WLH and GLH were found in all the locations. But small number of YSB and BPH were found in the farmers' field of Vagoiare, Pirganj, Rangpur and RLF at BRRI RS, Cumilla. No significant differences were found in insect pests number between IPM practiced field and insecticide applied field. But irrespective of locations, all natural enemies were found highest in T_1 compared to T_2 except CBB at Vagoiare, Pirganj, Rangpur. The range of natural enemies at BRRI farm, Gazipur were 0.83 to 3.83/20 sweep in T_1 and 0.5 to 2.5/20 sweep in T_2 , which was 0.67 to 2.67/20 sweep and 0.5 to 1.25/20 sweep in T_1 and T_2 respectively at Vagoiare, Pirganj, Rangpur.

No significant differences on yield were observed in IPM practiced field (T_1) and farmers practiced field (T_2). The range of yield were 6.83 to 7.73 t/ha in T_1 and 6.73 to 7.60 t/ha in T_2 (Table 3). Neither insecticide nor herbicide or fungicide was used in T_1 in all the locations. But one time herbicide, insecticide thrice and fungicides twice were used in T_2 (Farmers' practice). Moreover, 1.68 to 4.53% yield reduction was found in T_2 .

Irrespective of locations and variety BCR is always higher in T_1 compared to T_2 (Table 3). For T_1 the highest BCR (1.68) was found at Vagoiare, Pirganj, Rangpur followed by BRRI Gazipur (1.46), farmer's field of Jogitola, Gazipur (1.29)

and the lowest (1.26) at BRRI RS, Cumilla (Table 3). Similar trend was also found in T₂ (Table 3). Due to higher yield and lower variable cost BCR was found highest at the farmers field of Pirganj, Rangpur. BCR 1.68 and 1.56 were observed in T₁ and T₂ that indicated if farmers invest 1.0 taka in

IPM practice he/she will get return 1.68 taka. On the contrary if farmers invest 1.0 taka in their own practice (pesticide application) he/she will get return 1.56 taka.

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Table 3. Grain yield and benefit cost ratio (BCR) in IPM practiced field (T₁) and farmers practiced field (T₂) at four different locations of Bangladesh.

Location	Grain yield (t/ha)		Benefit cost ratio (BCR)		% Benefit in T ₁ over T ₂
	T ₁	T ₂	T ₁	T ₂	
BRRI, Gazipur	6.83	6.81	1.46	1.39	07
Jogitola, Gazipur	6.85	6.54	1.29	1.11	18
Pirganj, Rangpur	7.73	7.60	1.68	1.56	12
BRRI, Cumilla	6.85	6.73	1.26	1.06	02

VERTEBRATE PEST MANAGEMENT

Study on the efficacy of different commercial rodenticides against rice field rats

Efficacy of four different rodenticides available in market namely Lanirat, Zinc phosphide, Rat killer and Phostoxin were evaluated to control rat in rice field of BRRI, Gazipur in T. Aman 2022 and Boro 2022-23. Phostoxin treated rat pit had the maximum numbers of dead pits than other rodenticide treated rat pit. Zinc phosphide showed less effective than

other three rodenticides. So, to control rice field rat Phostoxin was very effective followed by Rat killer, Lanirat and zinc phosphide.

PI: Md Mosaddque Hossain, Md Mofazzel Hossain, **PL:** Sheikh Shamiul Haque

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Plant Pathology Division

210	Summary
212	Transferable Technology
212	Survey And Monitoring Of Rice Disease
223	Epidemiology, Yield Loss And Grain Quality Studies
224	Disease Management
226	Technology Transfer

SUMMARY

Disease incidence and severity was higher in Aman season 2022 compared to Boro 2022-23. Irrespective of season number of diseases was found higher in Cumilla and Rangpur compared to the other regions. The prevalence of bacterial leaf blight (BLB), brown spot (BS), neck blast (NB) and sheath blight (ShB) diseases was noticeable whereas the severity of NB, ShB and BLB were higher compared to the other diseases.

The digitization of disease surveillance and visualization in BRRI website is on-going. The initiative of developing an early warning system (EWS) for rice blast disease adapts the existing wheat blast EWS model and involves collecting data to validate the disease coupling model.

Out of five designed primers from the RTBV whole genome sequence, one primer effectively detected the RTBV strain of Bangladesh. ITS-primer based sequencing data analysis successfully differentiated the three pathogens of the sheath disease complex (sheath blight, aggregate sheath spot and sheath spot). Four different varieties of rice plants showed positive reaction against rice blast isolates but did not show any reaction to other blast isolates. All wheat, kaun and torpedo grass blast isolates were pathogenic to only corresponding plants. There was no cross infection among the tested blast isolates. New 182 blast-infected samples were collected and meticulously processed for molecular characterization, and evaluated pathogenicity against differential varieties. While initially promising, the candidate gene *Pik-h* for durable blast resistance during the Boro season in Bangladesh has shown ineffectiveness against Aman isolates, prompting further DNA extraction efforts. There were no visual differentiations among BLB, BLS and BPB in DNA profiling, although showed different colours on King's B media. Unfortunately, none of the isolates confirmed *Burkholderia glumae* among the tested isolates based on the sequence data. Irrespective of variety and seed source 16 pathogens have been detected. The higher incidence of seed borne pathogens was recorded in farmers' own seed followed by DAE,

BADC and BRRI seed. The higher incidence of seed borne pathogens was recorded in BRRI dhan87 followed by BRRI dhan95, BRRI dhan75 and BRRI dhan67.

Among the T. Aus BB resistance materials, two genotypes, BR(PATH)13784-BC3-61-1-6-HR3 and BR(PATH)13784-BC3-34-9-10-HR9 could be selected for further research. For BB and False smut resistance, four advanced breeding lines BR (Path)13817-BC3-14; BR(PATH)13817-BC3-9; BR (PATH)13817-BC3-4; BR (PATH)13817-BC3-13 produced significantly higher yield in both the location compared to the check variety (BRRI dhan49). Four blast resistant T. Aman lines from Satkhira and one line 87-5 Pi9 from Gazipur were selected for RYT, T. Aman 2023. Three Boro advanced lines could be selected for further research. In ALART, all of the tested lines produced more than 8t/ha grain yield which was more than 1t/ha higher than the standard checks. Hopefully two lines will be recommended for proposed variety trial. For BB RYT resistance, three advanced breeding lines, BR (Path)13800-BC3-8-1; BR(Path)13800-BC3-8-9; BR (Path)13800-BC3-109-10 produced better yield compared to the check variety. For blast and BB RYT resistance, seven advanced breeding lines produced significantly higher yield compared to the check variety. Moreover, all the materials showed a good degree of disease resistance as well. For blast resistance in BRRI dhan58, in BC_3F_6 generation, 27 plants were selected. To develop tungro resistant pre-breeding material five crosses were made between resistant donors and susceptible parents. Out of 50, a total of 32 advanced lines were found tungro resistant in the tungro hot spot trials. In T.Aman 2022, among 295 breeding lines 133, 26 and 15 were found as R, MR and 15 MS whereas in Boro 2022-23, among 295 breeding lines 41, 74, 16 and 19 were observed as HR, R, MR and MS, respectively against BB disease. Among the tested 56 INGER materials, nine entries showed moderate resistant (MR) reaction against leaf blast disease. A total of 100 germplasm were tested against sheath blight of which three showed moderately resistant and five showed moderately susceptible against the disease.

Out of 24 upland Aus, 19 entries showed resistance to blast disease. Malaysian genotypes were taller

than the others and flowered early. All Malaysian genotypes were recorded having higher antioxidant properties. In collaboration with JIRCAS, Japan, five blast-resistant genes, including *Pi9*, *Pish*, *Pbl*, and *pi21*, were introgressed into BRRI dhan28, BRRI dhan29, BRRI dhan34, BRRI dhan63, and BRRI dhan64 using marker-assisted selection (MAS) and pathogenicity tests. Among the tested materials, four lines—BR1379-5R-1, BR13796-5R-102, BR13785-5R-7, and BR13796-5R-203 showed superior blast resistance and desirable phenotypic characteristics, holding promise for recommendation in Regional yield trials (RYT) during the upcoming Boro season. Additionally, the development of 4,586 blast-resistant recombinant inbred lines (RILs) is underway, with ongoing screening against differential blast isolates in both the nursery and greenhouse conditions.

Through genome-wide association (GWAS) mapping, genotype data from 119 specific Bangladeshi germplasms were analyzed, revealing significant quantitative trait loci (QTL) associated with blast disease resistance, with the exceptional isolation of KOIYA DIGHA (IRIS_313-9445) in a distinct cluster among the genotypes assessed.

Experiments were conducted to find out the source of infection of major rice diseases. The indication is there that the diseased seeds could be a source of natural infection in both blast and false smut disease.

The multi-year data was summarized in a model providing an easy-to-estimate of yield loss in relation to percentage of grains in blast-affecting panicles. The model has the scope of its application in quantifying the yield loss for wide range of varieties beyond BRRI dhan28 due to the disease.

In 1st planting time, neck blast disease incidence was about 16 to 14% in V3 and V4 varieties where as V1 and V2 showed 5 to 6% disease incidence. In 2nd planting time, more or less similar pattern of neck blast disease incidence was observed in the varieties compared to first planting time.

The highest dead heart was observed in control (T3) treatment compared to the others. The highest yield was recorded in plots where insecticide was

sprayed followed by T1 where *Bacillus thuringiensis* was sprayed. Yield was increased (0.5-0.75t/ha) in treated plots with *A. xylosoxidans* compared to control. Bakanae symptom (0%) was observed when neem leaf mediated AgNPs used and the result was similar to the healthy control. From the results it was observed that Silver Nano is effective to manage bakanae disease as GA₃ (12.01ppm), IAA (3.93ppm) and ABA (0.57ppm) decreased compared to control. Cu-chitosan showed best result at 6,250 ppm and could perform upto 1,250 ppm whereas Zn-chitosan showed best the result at 10,758 ppm and could perform up to 6,455 ppm than their precursor salt. Nanoparticles ZnO and CuO at 4000ppm concentration singly performed almost similar than that of applying in combination. NP-mediated fungicide at 3g ZnO+1.5g Bismethiazol and 3g CuO+1.5g Bismethiazol formulation showed best the performance in rice BB disease management. After the standard check (Nativo 75 WG), the lower blast DS (3) and DI (25%) with higher disease reduction (52%) were observed in AgNPs and ZnONPs at 40% and 50% concentration, respectively. Bio-synthesized AgNPs (40%) could be effective, sound and eco-friendly disease combating agents.

Biosynthesis of Ag and ZnONPs using bacterial isolate was done successfully with the plasmon band at the wavelength of 435 and 335nm, respectively. AgNPs inhibited the mycelial growth of *R. solani* by 100%, whereas ZnONPs reduced the growth by 55.93%. Among the 40 new chemicals, only 11 fungicides controlled more than 80% sheath blight whereas it was 5 (from another 20 chemicals) for blast disease. Those chemicals could be suggested for registration. Maximum number of bacterial colonies was found three days before fungicide spray in all the treatments. And the number of colonies significantly reduced after spraying of Amister top. Maximum toxic effect of fungicide was observed just after fungicide application but population tended to increase afterwards. To assess the residual effects of fungicides in rice grains, particularly in aromatic rice varieties, 12 samples were collected. These are now undergoing preparation for analysis in BRRI's Central Laboratory after validating methods for detecting tricyclazole group fungicidal

residues. Seven batches of a ‘day-long’ training program on integrated rice disease management were conducted. Each training programme consisted of 30 farmers having both male and female participants.

TRANSFERABLE TECHNOLOGY

Development of prebreeding materials. Two short duration blast resistant rice lines BR(path)12452-BC3-42-22-11-4 and BR(path)12452-BC6-53-21-11 and two long duration blast resistant lines BR12454-BC2-69-97-39-5-44 and BR12454-BC2-71-91-6-23-26 could be used as prebreeding materials.

SURVEY AND MONITORING OF RICE DISEASE

To monitoring rice disease incidence, identification of the source of infection and furcating the disease appearance studies of rice disease epidemiology survey was conducted in different rice ecosystems covering nine districts viz Rangpur, Rajshahi, Sirajganj, Barishal, Gazipur, Habiganj, Cumilla, Chattagram and Khagrachari during T. Aman 2022 and Boro 2022-23. Incidence pattern and severity of rice diseases over the locations and varieties were assessed. Three upzilas in each district were selected for disease survey. Disease incidence (%) and disease severity data of major rice diseases were recorded following SES IRRI, 2013. Disease incidence and severity was higher in T. Aman season 2022 compared to Boro 2022-23. Irrespective of season number of diseases was found higher in Cumilla and Rangpur compared to the other regions. Across the regions, the prevalence of BLB, BS, ShB and NB diseases was noticeable whereas the severity of NB, ShB and BLB were higher compared to the other diseases. Other diseases namely tungro, narrow brown leaf spot (NBLS), false smut, karnel smut, leaf scald and sheath rot were also observed. Incidence of false smut was less in Habiganj and Sirajganj districts in T. Aman season and to some extent more in Rangpur district. This disease is also observed in the Boro season but incidence was very low. Infection of BLB, BLS and sheath blight was recorded in almost all the surveyed varieties. Severe tungro incidence was found in high disease prone region Cumilla only during

T. Aman. Moderate incidence of Tungro disease was also recorded in Rangpur. A considerable percentage of sheath blight incidence was recorded in Boro season which indicates the threat for rice production in this season. Incidence of NBLS was higher in Chittagong and Khagrachari. Low incidence of neck blast disease was found during T. Aman season in all of the aromatic varieties. Moderate infection of this disease was observed in Boro season specially in BRRI dhan28 and BRRI dhan81.

■ T H Ansari, Q S A Jahan, M Hossain, M S Mian, M A I Khan, S Akter, M Ahmad, M R Bhuiwan, B Nesa, M M Rashid, A Ara, S A I Nihad, H R Hira, R Akter, H A Dilzahan, and M A Latif

Digitization of disease surveillance system and visualization at BRRI website. Digitization of the disease surveillance system and visualization represents a pioneering effort aimed at revolutionizing the monitoring of disease outbreaks. This endeavour harnesses the power of digital technology and data visualization to create a dynamic and accessible platform. This platform will serve as a central hub for tracking and visualizing disease-related data, providing real-time insights into disease patterns and trends within the agricultural sector. Such digitization not only enhances the efficiency of disease surveillance but also empowers stakeholders with timely information to make informed decisions, ultimately contributing to improved crop health and food security in Bangladesh. A total of 3,641 data points were collected from farmers’ fields during the Aman and Boro seasons in eight rice-growing regions, including Cumilla, Rangpur, Rajshahi, Gazipur, Barishal, Satkhira, and Sirajganj. Data were collected using an Android-based software called Open Data Kit (ODK) and stored on the ‘kobotoolbox’ website. The data visualization activities for rice disease information on the BRRI website are currently in the developmental stages.

■ M A I Khan, M A Qayum, M R Bhuiyan, M M Rashid, H R Hera, T H Ansari and M A Latif

Development of Early Warning System (EWS) of rice blast disease. To provide rice growers with advanced notice of blast disease infection at least

seven days in advance and to collect data regarding the impact of temperature and humidity on rice disease development, a collaborative initiative was launched with CIMMYT to develop an Early Warning System (EWS) for rice blast disease in Bangladesh. This EWS for rice blast is being adapted from the existing Wheat Blast EWS model. The BRRI team is currently collecting data to

establish the relationships between weather factors and blast disease, with the aim of validating the disease coupling model. Notably, among the five trials conducted in Boro 2022-23, severe leaf and neck blast disease infestations were observed in Cumilla, Rangpur, and Hankata, Gazipur.

■ M A I Khan, M R Bhuiwan, M M Rashid, B Nesa, H R Hera, T H Ansari and M A Latif

PATHOGEN POPULATION STRUCTURE and BIOLOGY OF MAJOR PATHOGEN

Development of new markers for the detection of Rice Tungro Bacilliform Virus. To develop novel primer to detect RTBV strain of Bangladesh five primers were designed from the genome sequence and primers were purchased accordingly. Out of five primers, one primer effectively detected the RTBV strain of Bangladesh. Band size was approximated 800 bp (Fig. 1).

■ S A I Nihad, M M Rashid, M S Mian, M A Latif, T H Ansari

Studies on host range of the blast pathogen: To determine the host specificity of blast isolates among the rice, grasses, foxtail millet and wheat blast infected samples were collected and inoculated. Four different variety of rice plants showed positive reaction against rice blast isolates but did not show any reaction to other blast isolates. All wheat, kaun and torpedo grass blast isolates were pathogenic to only corresponding plants. Three different weed grass plants did not show any reaction against all blast isolates. It was also observed that there was no cross infection among the tested blast isolates.

■ M S Mian, M A Munsor, M Hossain, T H Ansari, M A Latif

Improvement of differential system and selection of candidate gene for rice blast disease resistance in Bangladesh (JIRCAS). To enhance the existing differential system for rice blast, we collected 182 new blast-infected samples from highly affected fields during the Aus, Aman, and Boro seasons of 2022-23 in various rice-growing regions across the country. These pathogens were isolated as single-spore cultures, and the purified isolates were carefully preserved on blotter paper under dry conditions at -20°C

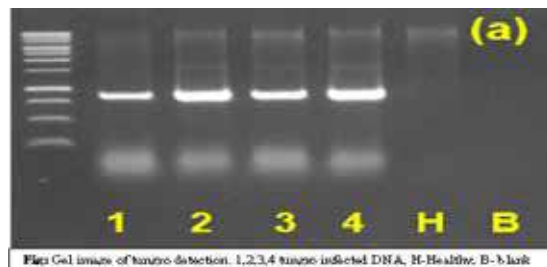


Fig. Gel image of tungro detection. 1,2,3,4 tungro infected DNA, H-Healthy, B-blank

for subsequent molecular characterization using avirulence (avir) gene markers and pathogenicity assessments on differential varieties (DVs). We also standardized alternative protocols for artificial disease inoculation under controlled conditions, utilizing the detached leaf technique. Furthermore, we evaluated the pathogenicity of these purified isolates against differential varieties harbouring 23 different blast resistance genes. Interestingly, a candidate gene known as *Pik-h* was initially selected for developing durable blast resistance specifically for the Boro season in Bangladesh (Table 1). However, it has since been observed that this gene is no longer effective against Aman isolates in Bangladesh. DNA extraction of selected isolates are in progress.

■ M A I Khan, N Ausraf, MR Bhuiyan, M M Rashid, H R Hira, T H Ansari and M A Latif

Boro 2023	Total 2016	T. Aman 2016	Boro 2016	Ecosystem	Virulence to differential varieties (%)																												
					LTH (Non)	IRBLa-A (<i>Pta</i>)	IRBLsh-B (<i>Pish</i>)	IRBLb-B (<i>Pib</i>)	IRBLt-K59 (<i>Pti</i>)	IRBLj-F5 (<i>Pti</i>)	IRBL3-CP4 (<i>Pi3</i>)	IRBL5-M (<i>Pi5(n)</i>)	IRBLks-F5 (<i>Piks</i>)	IRBLkm-Ts (<i>Pik-m</i>)	IRBLj-CL (<i>Pi1</i>)	IRBLsh-K3[LT] (<i>Pik-h</i>)	IRBLk-K[LT] (<i>Pik</i>)	IRBLkp-K60 (<i>Pik-p</i>)	IRBL7-M (<i>Pi7(n)</i>)	IRBL9-W (<i>Pi9</i>)	IRBLz-Fu (<i>Piz</i>)	IRBLz5-CA-1 (<i>Piz-5</i>)	IRBLzr-T (<i>Piz-r</i>)	IRBLt02-Pi (<i>Pti02</i>)	IRBLt02-Re (<i>Pti02</i>)	IRBL12-M (<i>Pi12(n)</i>)	IRBLte-K1 (<i>Pti01</i>)	IRBLte-CP1 (<i>Pti01</i>)	IRBL19-A (<i>Pi19(n)</i>)	IRBL20-IR24 (<i>Pi20</i>)			
	100.0	100.0	100.0			100.0	93.8	25.4	65.0	67.2	72.3	76.8	70.1	95.5	84.2	78.0	81.4	48.0	52.6	58.6	54.4	12.7	43.2	53.5	76.4	11.5	6.2	6.2	70.1	16.4	49.2	71.8	81.6
	81.3	92.4	90.9			93.8	90.9	32.5	62.5	83.8	14.9	19.5	14.9	90.3	14.3	13.0	9.7	17.5	29.9	22.7	14.9	42.9	48.7	53.9	17.5	13.6	89.6	25.5	36.4	92.9	87.0		
	23.8	28.7	32.5			25.4	32.5																										
	83.8	78.2	93.5			65.0	93.5																										
	95.0	74.9	83.8			67.2	83.8																										
	35.0	45.6	14.9			72.3	14.9																										
	36.3	50.2	19.5			76.8	19.5																										
	43.8	44.4	14.9			70.1	14.9																										
	90.0	93.1	90.3			95.5	90.3																										
	17.5	51.7	14.3			84.2	14.3																										
	23.8	47.7	13.0			78.0	13.0																										
	11.3	48.0	9.7			81.4	9.7																										
	32.5	52.6	17.5			83.1	17.5																										
	47.5	58.6	29.9			83.6	29.9																										
	37.5	54.4	22.7			81.9	22.7																										
	27.5	12.7	14.9			10.7	14.9																										
	47.5	43.2	42.9			43.5	42.9																										
	72.5	53.5	48.7			57.6	48.7																										
	47.5	76.4	53.9			96.0	53.9																										
	18.8	11.5	17.5			6.2	17.5																										
	26.3	9.7	13.6			6.2	13.6																										

■ M A I Khan, N Ausraf, MR Bhuiyan, M M Rashid, A Ara, T H Ansari and M A Latif

while the lower pathogens was observed in BRRI varieties (2.7%). Among the tested varieties, the higher % incidence of seed borne pathogens (3.4%) was recorded in BRRI dhan87 followed by BRRI dhan95 (3.2%) and BRRI dhan75 (3.1%) while the lower incidence was found in BRRI dhan67 (2.8%). Incidence of seed borne pathogens was higher in Satkhira followed by Cumilla, Rajshahi and Habiganj while the lower incidence was recorded in Rangpur.

■ M Hossain, T H Ansari, M S Mian, S Akter and
M A Latif

Response of upland Aus rice germplasm to blast disease. Among the tested materials, 19 entries such as IR 5533-14-1-1, IR 5533-56-1-12 a, IR 5533-56-1-12 a, IR 5533-PP854-1, IR 5533-PP856-1, IR 9559-PP871-1, IR 9669-23-12-7, IR 9669-PP823-1, IR 9669-PP830-1, Ja La Shau, Ja Loy, Ja No Naq, Padi Beleong (Jenis Padi Beleong), Padi Kalopak, BR16 * Karingam, Lansam, BRR1 dhan27, BRR1 dhan83 and unknown showed resistance. Malaysian genotypes (Padi Beleong (Jenis Padi Beleong), Padi Kalopak, BR16 * Karingam and Lansam) were taller than the other genotypes. It also flowered early, which was a useful trait because early flowering resulted

in early heading and matured earlier. In terms of antioxidant properties all Malaysian genotypes had higher antioxidant properties.

■ H A Dilzahan, M Hossain, M R Bhuiwan, M A Latif and T H Ansari

DISEASE RESISTANCE AND MOLECULAR STUDIES

Re-ALART of short duration blast resistant rice (BRR) in Boro 2022-23. The trial with blast resistant (*Pi9*) short duration (SD) lines containing *Pi9* gene were conducted at ten different locations

during Boro 2022-23 with two checks (BRRI dhan28 and BRRI dhan88). Out of four tested SD lines two lines (V1 and V2) were found effective (< 1 % neck blast) against blast among all locations. The check varieties received max 40-70% neck blast. These lines produced 6.8-7.2 t/ha yield while the check varieties produced 5.4-6.9 t/ha. Grain quality of both the lines is similar to BRRI dhan28. These lines would be selected for PVT in the next season (Table 2).

■ AR Div., P. Path. Div, P. Breeding Div. and RS scientists

Table 2. Average yield of blast resistant lines (short duration) at ten locations in Boro 2022-23.

Line	PH (cm)	GD (day)	Sterility (%)	TGW (g)	Panicle/m ²	Yield (t/ha)	Max Neck blast (%)
BR (path)12452-BC3-42-22-11-4	109	141	22	22.9	288	6.8	1
BR (path)12452-BC6-53-21-11	111	143	21	22.7	289	7.0	1
BR (path)13784-BC3-61-1-6-HR3	99	141	23	22.4	287	6.5	70
BR (path)13784-BC3-63-6-4-HR6	96	141	21	24.5	290	7.0	50
BRRI dhan28 (Sus. Ck)	104	140	24	22.8	272	5.4	70
BRRI dhan88 (Sus. Ck)	90	142	20	21.9	287	6.9	40
LSD (5%)	1.59	0.20	2.68	0.59	11.81	0.29	
CV (all locations)	3.08	0.27	23.18	5.02	8.17	8.1	

ALART of long duration blast resistant rice in Boro 2022-23. The ALART for blast resistant long duration (LD) lines containing *Pi9* gene were conducted at ten different locations during Boro, 2022-23 with 2 checks (BRRI dhan29 and BRRI dhan89). Out of four LD lines two would

be selected for PVT in the next season. All of the tested lines produced 7.3-7.5 t/ha grain yield which was similar to the standard checks (Table 3). All the lines showed field resistance among all spots.

■ AR Div., P. Path. Div, P. Breeding Div. and RS scientists

Table 3. Average yield of blast resistant lines (long duration) at ten locations in Boro 2022-23.

Line	PH (cm)	GD (day)	FG/ panicle (no.)	Sterility (%)	TGW (g)	Panicle/m ²	Yield (t/ha)
BR12454-BC2-56-81-27-3-30	108	157	131	21	22.43	288	7.25
BR12454-BC2-69-97-39-5-44	101	157	135	21	20.13	296	7.38
BR12454-BC2-71-91-6-23-26	106	157	128	25	21.98	278	7.52

BR12454-BC2-75-32-31-39-7	110	156	147	20	22.29	281	7.48
BRRI dhan29 (Std. & Sus. ck)	99	157	131	20	21.54	287	7.25
BRRI dhan89 (Std. & Sus. ck)	103	156	134	19	23.45	254	7.02
LSD _{0.05}	4.25	0.65	24.34	6.29	1.24	35.35	0.89
CV% (all location)	2.51	0.26	11.18	18.33	3.49	7.78	7.52

Advanced yield trial of blast resistant (*Pita2*) lines in Boro. Advanced yield trial was conducted with seven lines introgressed with *Pita2* gene (IRBLta2-Pi) in addition with BRRI dhan29 at BRRI, Gazipur. The growth duration and yield

were similar to that the blast susceptible check BRRI dhan29 (Table 4). These lines will be tested at regional station and multi-locations in the next Boro season.

■ T H Ansari, M. Ahmed and M S Mian.

Table 4. Yield and growth durations of blast resistant (*Pita2*) lines at Gazipur in Boro 2022-23.

Entry no.	Plant ht. (cm)	Panicle/hill (no.)	GD (day)	Yield (t/ha)
PL4911	-	-	157	7.8
PL5435	113.3	12.8	156	7.3
PL5440	113.5	12.0	156	7.0
PL5578	110.2	11.2	157	7.2
PL5662	-	-	158	7.8
PL5665	-	-	158	7.5
PL5795	113.3	11.8	156	7.4
BRRI dhan29			157	7.5
LSD (0.5%)				NS

Advanced yield trial of blast resistant lines (SD) in Boro. Seven blast resistant lines developed from different crosses and back-crosses were evaluated along with BRRI dhan28 and BRRI dhan88. *Pi9* gene was introgressed in these lines. In Satkhira, out of seven SD-lines, V1 and V7 produced 7.2-

7.5 t/ha which were at least 1.0 t/ha higher than the checks (Table 5). Other lines performed equally. The lines are lodging tolerance as compared to the checks. These lines will be tested in RYT/MLT in the next Boro.

■ T H Ansari, M. Ahmed, M S Mian, and M Khatun

Table 5. Yield and growth duration of blast resistant (*Pi9*) lines at BRRI RS, Satkhira in Boro 2022-23 (short duration).

	Line	PH (cm)	GD (day)	Panicle/hill	Yield (t/ha)	Comment
	BR (Path)15641-10-7-1-1	112.7	146	12.8	7.2	BC1F6, BR89*BR29-Pi9
	BR (Path)... 10-2-5-3	104.4	138	13.4	6.0	F6, BR89*PL-22
	BR (Path)... 10-2-3-8	103.0	135?	13.0	6.3	F6, BR89*PL-22
	BR (Path)... 10-3-6-2	96.4	139	10.8	5.9	F6, BR89*PL-22
	BR (Path)... 4-8-4	101.4	140	15.6	6.7	BC3F7, BRRI dhan63 X PL-22
	BR (Path)... 10-2-3-3	97.2	142	12.4	6.5	F6, BR89*PL-22
	BR (Path)... HN3-3-7-5	112.6	144	14.4	7.5	BC1-F6, BR89*PL-22
	BRRI dhan28	105.6	140	12.8	6.0	

	BRRi dhan88	90.6	139	12.6	6.1	
	LSD (0.05)				1.01	
	CV (%)				12.17	
DS: 06/12/22 DT: 13/01/23: PL-22: BR(path)12452- BC3-42-22-11-4, BR89: BRRi dhan89, BR29: BRRi dhan29, Pi9: IRBL9W						

Advanced yield trial of blast resistant pyramided lines (*Pi9* and *Pita2*) in Boro: Blast resistance lines were developed pyramided with *Pi9* and *Pita2* genes through multi-crosses. *Pi9* and *Pita2* were introgressed in BRRi dhan29 differently and produced F1 seeds. Then the cross was done between *Pi9* and *Pita2* plants. Finally fixed lines were developed and evaluated in the UBN with artificial inoculation. The evaluated lines were

found resistant (Score-0). Eight advanced lines were evaluated at Satkhira which produced higher significant yield from 7.9-8.4 t/ha. The check varieties produced 7.1-7.5 t/ha. Therefore few selected lines will be further evaluated at RYT and MLT during the next Boro season (Table 6).

■ T H Ansari, M Ahmed, MA Monsur and M S Mian

Table 6. Yield, growth duration (GD) and disease reaction of blast resistant pyramided lines at BRRi Satkhira in Boro, 2022-23.

	Line	GD (day)	Yield (t/ha)	Leaf blast (F)	Neck blast (F)	Leaf blast (AI)
	BR (Path)... 547 (1-3)	149	8.42	0	0	0
	BR (Path)... 556	150	8.05	0	0	
	BR (Path)... 558	146	8.21	0	0	2
	BR (Path)... 573	151	8.13	0	0	0
	BR (Path)... 582	149	7.95	0	0	
	BR (Path)... 613(1)	146	8.02	0	0	0
	BR (Path)... 615	151	8.31	0	0	0
	BR (Path)... 645	148	7.94	0	0	0
	BRRi dhan58	151	7.11	0	0	5 (US2)
	BRRi dhan89	155	7.45	0	0	
	LSD (0.05)		0.86			
CV (%)	10.67					
DS: 6 Dec 2022, DT: 11 Jan 2023, F: Field, AI: Artificial inoculation						

Advanced yield trial of blast resistant lines in T. Aman 2022. To develop blast resistant variety 12 and four advanced lines with checks (BRRI dhan87 and BRRI dhan75) were cultivated at Satkhira during T. Aman 2022. Four blast resistant lines, BR (Path) 15640-3-4-4-6, BR (Path)15640-10-4-4-1, BR (Path)15640-39-8-3-2 and BR (Path) 15641-10-7-1-1 were selected for RYT (Table 7).

Table 7. Advanced yield trial of blast resistant lines in T. Aman 2022 and Boro 2022-23.

	Line	PH (cm)	GD (day)	Yield (t/ha)	Grain
	BR(Path) 15640-3-4-4-6	107.3	124	6.69	Bold
	BR (Path)15640-3-5-5-8	121.7	126	6.35	Bold
	BR (Path)15640-10-4-4-1	113.0	121	6.86	Bold
	BR (Path)15640-10-4-4-2	127.0	122	6.40	Bold
	BR (Path)15640-39-8-3-2	108.3	127	6.84	Bold
	BR (Path) 15640-39-8-3-7	122.0	128	6.43	Bold
	BR (Path)15640-39-8-3-8	112.0	127	5.97	Bold
	BR (Path)15640-39-5-8-2	115.7	127	5.89	Selender
	BR (Path)15640-46-1-4-6-1		120	5.91	Bold
	BR (Path)15640-46-1-4-6-2		121	5.98	Bold
	BR (Path) 15640-46-2-5-2	117.0	118	6.04	Bold
	BR (Path) 15641-10-7-1-1	117.7	123	6.30	long Selender
	BRRI dhan87	123.2	129	5.53	long Selender
	BRRI dhan75		113	5.40	
	LSD (0.05) and %CV	0.79 and 6.13%			
Sl. 1-11: Parent- BRRI dhan29 X BR33; Sl. No. 12: Parent- BRRI dhan89 X PL-22					

■ T Ansari

Advanced yield trial of blast resistant lines, T. Aman. Blast resistance gene Pi9 and Pbl were introgressed separately in the background of BRRI dhan87. Two lines from each group were evaluated

at BRRI, Gazipur. Only PL87-5Pi9 produced similar yield and growth duration (Table 8). PL87-Pb1 was found to produce 5.2 t/ha in 129 days.

■ T H Ansari, M. Ahmed, M. A, Monsur and M S Mian

Table 8. Yield and growth durations of blast resistant lines at Gazipur in T Aman 2022.

Entry no	GD (d)	Yield (t/ha)	Cross
PL87-5 Pi9	129	5.5	BRRI dhan87*PL-22
PL87-1 Pi9	129	5.2	BRRI dhan87*PL-22
PL87-Pb1	129	5.1	BRRI dhan87*Pb1
PL87Pb1	119	4.7	BRRI dhan87*Pb1
BRRI dhan87	129	5.5	
PL-22: BR (path) 12452-BC3-42-22-11-4			

Regional yield trial (RYT) for bacterial blight resistant advanced lines in Boro 2022-23. Six genotypes including four checks (BRRI dhan58, BRRI dhan89, BRRI dhan92, BRRI dhan101) were evaluated at Gazipur, Sirajganj, Rangpur, Sonagazi, Cumilla, Habiganj, Rajshahi and Barishal in RYT. Three advanced breeding lines, BR (Path)13800-BC3-8-1; BR (Path)13800-BC3-8-9; BR (Path)13800-BC3-109-10 produced better yield compared to the check variety. Moreover, all the materials showed a good degree of disease resistance as well (Table 9).

Table 9. Regional yield trial (RYT) results for bacterial blight resistant advanced lines.

Designation	Avg. Y	Avg. GD	Designation	Avg. Y	Avg. GD
BR11604-4R-24	6.53	149	BR11868-5R-9	6.02	143
BR11607-4R-2	5.95	153	BR(Path)13800-BC3-8-1	7.50	151
BR11607-4R-258	5.90	148	BR(Path)13800-BC3-8-6	7.05	152
BR11866-5R-73	7.41	153	BR(Path)13800-BC3-109-10	7.34	151
BR11866-5R-136	6.48	154	BR(Path)13800-BC3-8-7	7.08	152
BR11866-5R-223	7.17	157	BR(Path)13800-BC3-8-9	7.42	153
BR11866-5R-277	6.92	154	BR(Path)13800-BC3-224-28	7.16	151
BR11867-5R-117	5.77	149	BRRI dhan58 (Std. ck)	6.62	148
BR11867-5R-140	6.34	152	BRRI dhan89 (Std. ck)	7.61	152
BR11867-5R-154	6.34	150	BRRI dhan92 (Std. ck)	7.54	154
BR11867-5R-347	5.34	142	BRRI dhan101 (Res. ck)	6.71	148

■ M A Latif, M R Bhuiyan, H R Hera and M A I Khan

Regional yield trial (RYT) for blast and bacterial blight resistant advanced lines in Boro 2022-23. A total of 10 genotypes including two checks (BRRI dhan89, and BRRI dhan92) were evaluated at Gazipur, Sirajganj, Rangpur, Sonagazi, Cumilla, Habiganj, Rajshahi and Barishal in RYT. Seven

advanced breeding lines, BR(Path)13800-BC3-8-5; BR (Path)13800-BC3-134-8; BR (Path)13800-BC3-8-11; BR (Path)13800-BC3-12-13; BR (Path)13800-BC3-224-17; BR (Path)13800-BC3-134-25; BR (Path)13800-BC3-224-44 produced significantly higher yield compared to the check variety. Moreover, all the materials showed a good degree of disease resistance as well (Table 10).

Table 10: Regional yield trial (RYT) results for blast and BB resistant advanced lines in Boro 2022-23.

Designation	Yield	GD	SL	Designation	Yield	GD
BR(Path)13800-BC3-8-5	8.26	155	7	BR(Path)13800-BC3-134-25	8.18	154
BR(Path)13800-BC3-134-8	8.35	154	8	BR(Path)13800-BC3-8-37	7.31	156

BR(Path)13800-BC3-8-11	8.19	156	9	BR(Path)13800-BC3-110-4	7.42	156
BR(Path)13800-BC3-110-19	7.48	157	10	BR(Path)13800-BC3-224-44	7.77	155
BR(Path)13800-BC3-12-13	7.65	155	11	BRRI dhan89 (ck)	7.56	157
BR(Path)13800-BC3-224-17	7.53	154	12	BRRI dhan92 (ck)	7.90	159

■ M A Latif, M R Bhuiyan, H R Hera and M A I Khan

Development of pre-breeding materials of BB and False smut resistance in the background of BRRI dhan49. Eight advanced breeding lines for both BB and false smut resistant fixed lines along with a check variety (BRRI dhan49) were evaluated at two districts (Sherpur and Gazipur) of

Bangladesh during the T. Aman 2022 season. Four advanced breeding lines BR (Path)13817-BC3-14; BR (PATH)13817-BC3-9; BR (PATH)13817-BC3-4; BR(PATH)13817-BC3-13 produced significantly higher yield in both the location compared to the check variety (BRRI dhan49). However, these materials also showed good degree of disease resistance as well (Table 11).

Table 11. Yield and yield attributing characters of BB and false smut resistant advanced lines on BRRI dhan49 background, Sherpur, T. Aman 2022.

Line	Pl. ht (cm)	#Tiller /hill	#Pan. /hill	Yield (t/ha)	GD (day)	Disease score	
						FSm	BB
BR (PATH)13817-BC3-4	116	17	15	7.29	127	0	0
BR (PATH)13817-BC3-9	118	19	17	7.72	122	0	0
BR (PATH)13817-BC3-13	112	18	16	7.00	123	0	0
BR (PATH)13817-BC3-14	111	21	19	8.07	120	0	0
BR (PATH)13817-BC3-16	115	21	18	6.20	120	1	0
BR (PATH)13817-BC3-18	117	20	16	6.18	122	0	0
BR (PATH)13817-BC3-20	116	18	16	6.22	125	0	0
BR (PATH)13817-BC3-21	110	17	15	6.15	123	0	0
BRRI dhan49	111	16	14	6.25	133	5	0

■ M A Latif, M R Bhuiyan, B Nesa, H R Hera and M A I Khan

Development of bacterial blight resistant pre-breeding materials for T. Aus. Seven BB resistant (*xa13* and *Xa21*) fixed lines along with the checks BRRI dhan28, BRRI dhan48, BRRI dhan82 and BRRI dhan98 were evaluated during the T. Aus

2022 season. Among the materials, the highest yield (7 ton/ha) was recorded from the genotype BR (PATH)13784-BC3-61-1-6-HR3, followed by BR (PATH)13784-BC3-34-9-10-HR9 (6.79 t/ha), and check variety BRRI dhan48 and BRRI dhan98 produced 6.57 and 6.61 t/ha, respectively. On the other hand, growth duration ranged from 102 days to 118 days (Table 12).

Table 12. Yield and yield attributing characters of BB resistant advance lines.

Line	Pl. ht (cm)	#Tiller /Hill	#Pan. /hill	Yield (t/ha)	GD (day)	BB Score
BR(PATH)13784-BC3-6-8-9-HR16	113	14	12	5.74	102	1
BR(PATH)13784-BC3-5-3-8-HR4	111	15	13	5.87	105	0
BR(PATH)13784-BC3-61-1-6-HR3	117	16	14	7.00	106	0
BR(PATH)13784-BC3-62-3-5-HR2	113	14	13	5.33	102	1
BR(PATH)13784-BC3-63-6-4-HR6	113	15	13	5.79	102	0

BR(PATH)13784-BC3-34-9-10-HR9	112	14	13	6.79	102	2
BR(PATH)13784-BC3-240-6-9-HR10	111	14	13	5.71	104	0
BRRi dhan28(ck.)	114	12	11	6.28	110	4
BRRi dhan48(ck.)	113	14	13	6.57	115	5
BRRi dhan82(ck.)	112	14	13	6.12	106	3
BRRi dhan98(ck.)	113	14	13	6.61	118	4

■ M A Latif, M R Bhuiyan, H R Hera and M A I Khan

Development of pre-breeding materials of tungro resistant and evaluation of tungro resistant advanced lines. Five crosses were done in both T.Aman, 2022 and Boro 2022-23 for the development of tungro resistant pre-breeding materials. Heterozygosity of the populations was confirmed by using the respective marker. During T. Aman 2022 a total of 309 and in Boro 2022-23 a total of 366 seeds/lines were obtained. After confirmation crossing was done to make the next generation.

On the other hand 50 advanced lines of the following three crosses were evaluated in Gazipur, Feni and Cumilla (two locations). No disease occurrence was found in Gazipur and Feni. In Cumilla, tungro disease was found in both the locations i.e. in Debidwar and Chandina. Out of 50 lines tested only 23 were found as disease free line (in hotspot area).

■ S A I Nihad, M M Rashid, M S Mian, M A Latif, T H Ansari

Introgression of blast resistance gene(s) into BRRi dhan58 using marker assisted backcross breeding. BRRi dhan58 was used as recurrent parent while IRBL9-W was used as the donor parents. Primer/marker NMSM-Pi9 was used to detect *Pi9*, while RM206 was used for *Pb1* confirmation. In BC₃F₆ generation, 27 plants were selected which would be further advanced based on morphological homogeneity, and yield potentiality.

■ MR Bhuiyan, MAI Khan, and MA Latif

Screening of breeding materials against bacterial blight (BB), blast and sheath blight diseases. To identify suitable BB resistant lines several materials/entries including resistant, susceptible and standard checks were screened against bacterial blight, blast and sheath blight pathogens. Plants were artificially inoculated with corresponding pathogens. Breeding materials were scored as highly resistance (HR), resistant (R), moderately resistant (MR) (Table 13), moderately susceptible (MS) and susceptible (S). Results of susceptible reaction were not presented in the table.

Table 13. Screening results for bacterial blight, blast and sheath blight resistance.

Source	T. Aus 2022						T. Aman 2022						Boro 2022-23					
	Dis.	# line	HR	R	MR	MS	Dis.	# line	HR	R	MR	MS	Dis.	# line	HR	R	MR	MS
Advance Breed. Line	-	-	-	-	-	-	BB	295	-	133	26	15	BB	295	41	74	16	19
TRB	BB	448	-	34	1	3	BB	1605	-	276	164	284	BB	1751	276	110	77	-
TRB	-	-	-	-	-	-	-	-	-	-	-	-	Blast	1577	-	776	-	-
INGER	-	-	-	-	-	-	-	-	-	-	-	-	Blast	56	-	-	9	-
Germplasm	-	-	-	-	-	-	ShB	100	-	-	3	5	-	-	-	-	-	-
		448	0	34	1	3		2000	0	409	193	304		3679	317	960	102	19

Dis.= name of the disease, BB=bacterial blight, HR=highly resistance, R= resistance, MR=moderately resistance, MS= moderately susceptible, SHB=sheath blight

■ PI for INGER materials: M S Mian; PI for TRB materials: M A I Khan; PI for germplasm materials: S Akter, PI for adv. breeding materials: M H R Hera; CI: T H Ansari and M A Latif

Development of blast resistant varieties using differential system and molecular markers (JIRCAS). To introgress five blast-resistant genes, including *Pi9*, *Pish*, *Pb1*, and *pi21*, into the genetic background of BRRI dhan28, BRRI dhan29, BRRI dhan34, BRRI dhan63, and BRRI dhan64 through marker-assisted selection (MAS) and pathogenicity tests in collaboration with JIRCAS, Japan. From the pool of tested materials, we selected 10 lines for evaluation through multi-location trials (MLT) in six disease hotspots. Among these lines, BR1379-5R-1, BR13796-5R-102, BR13785-5R-7, and BR13796-5R-203 demonstrated the best combination of blast resistance and desirable phenotypic characteristics. These four lines hold promise and could be recommended for RYT in the upcoming Boro season. Additionally, we've also developed 4,586 blast-resistant recombinant inbred lines (RILs) and are currently in the process of screening them against differential blast isolates in both blast nursery and greenhouse conditions.

■ M A I Khan, M R Bhuiyan, M M Rashid, N Ausraf, H R Hera, T H Ansari and M A Latif

BRRI dhan74. A broad spectrum blast resistant cultivar revealed resistance against global blast isolates including Bangladesh. BRRI dhan74 distinguishes itself as an exceptional rice cultivar, primarily owing to its broad-spectrum blast

resistance, which has demonstrated effectiveness not only against local blast isolates within Bangladesh but also on a global scale. This cultivar has emerged as a beacon of hope for rice farmers, providing robust defence against the devastating blast disease, which can wreak havoc on rice crops. Its capacity to withstand a wide array of blast races from various regions underscores its paramount importance in ensuring food security and stabilizing rice production, not confined to Bangladesh alone but potentially extending to rice-growing regions worldwide. BRRI dhan74's resistance to global blast isolates serves as a testament to its exceptional genetic makeup and its potential contribution to sustainable rice cultivation and crop protection. In extensive trials involving three seeding dates, BRRI dhan74 was pitted against three blast-susceptible varieties—BRRI dhan28, BRRI dhan63, and BRRI dhan81—in multiple blast hotspots. Remarkably, while all other tested materials were severely affected to neck blast, BRRI dhan74 remained impervious, exhibiting no signs of infection (Table 14). Furthermore, data from Plant Pathology Division surveys, assessments by BRRI regional station scientists, and field experiences of DAE personnel, as well as artificial inoculation screenings, unequivocally affirm BRRI dhan74's broad-spectrum blast resistance, extending its potential recommendation for cultivation in blast-prone regions during the Boro season in Bangladesh.

■ M A I Khan, M R Bhuiyan, M M Rashid, N Ausraf, H R Hera, T H Ansari and M A Latif

Table 14. Scenario of neck blast incidence of BRRI dhan74 at blast hot spots of Bangladesh.

Variety	Neck blast disease incidence (%) of BRRI varieties at blast hot spots								
	Hankata, Gazipur			Debidwar, Cumilla			Mithapukur, Rangpur		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
BRRI dhan28	60	90	95	95	90	70	70	70	50
BRRI dhan63	80	60	80	100	85	90	50	60	30
BRRI dhan74	0	0	0	0	0	0	0	0	0
BRRI dhan81	95	99	99	100	90	90	70	30	30

Note: Neck blast severity score of all cases were 9.

Detection of novel QTLs for blast and bacterial blight resistance revealed by genome-wide association studies in 112 rice landraces from Bangladesh. IRRI has already completed the sequencing of the rice genome, known as the 3K rice genome database, which includes genetic information from 186 Bangladeshi germplasms. In the pursuit of identifying sources of resistance to blast and bacterial blight (BB) diseases, Genome-Wide Association (GWAS) mapping was carried out using Tassel 5 software. This involved extracting genotype data from 119 specific Bangladeshi germplasms, resulting in a final genotype file comprising 119 germplasms and 808,776 SNP data points spanning the entire genome. For the assessment of blast disease resistance, two differential isolates were employed, leading to the identification of three major quantitative trait loci (QTL) for isolate-1 and 11 QTL for isolate-2. Notably, this analysis unveiled three distinct clusters, encompassing 110, 8, and 1 genotype (s), with the remarkable isolation of KOIYA DIGHA (IRIS_313-9445) in a separate cluster.

■ M A I Khan, M R Quddus, N Ausraf, M R Bhuiyan, M M Rashid, H R Hira, S A I Nihad, M A Monsur, T H Ansari and M A Latif

EPIDEMIOLOGY, YIELD LOSS AND GRAIN QUALITY STUDIES

Identification of the source of infection of major

rice diseases – The effect of infected seeds on blast and false smut diseases. Two years results revealed that blast disease was significantly higher in 2022 ($P \leq 0.05$). In the previous year (2021), there was a tendency of higher blast incidence in diseased seed source; however, the difference was not significant with healthy seed source. In 2021, the difference of false smut disease incidence was not significant between diseased and healthy seed sources. In the following year (2022), rice false smut disease did not appear in the experimental field. The indication is there that the diseased seeds could be a source of natural infection in both blast and false smut disease.

■ Bodrun Nessa

Blast yield loss model development. Panicles were randomly collected from severely blast-infected BRRI dhan28 rice in farmers' fields during Boro 2019-21. Data were summarized as % filled grains and corresponding weight of filled grains, separately in healthy and diseased panicles. To deduce yield loss (%) the reduction in weight of filled grains between the healthy and diseased panicles under each category (10–100%, at 10 intervals) was expressed in percentage. Both the data set fitted in the same POWER function in MS Excel. Having closeness of the characteristics of the data, a power function-based model was developed (Fig. 2) using both the data sets (from 2019 and 2021).

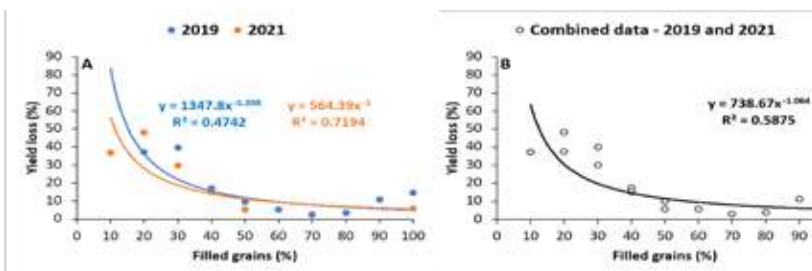


Fig. 2. (A) The response of yield loss due to blast disease and (B) Two years combined data

■ Bodrun Nessa

Effect of blast and false smut infected seeds on grain quality. Healthy and diseased seed samples of rough rice (unhusked paddy) from BRRI dhan34 (for blast disease) and BRRI dhan49 (for false smut disease) had been collected from T. Aman season

2021 for grain quality (% head rice, % chalkiness and % protein content) evaluation. There was a tendency of high protein (%) in healthy seed compared to disease seed in both the diseases. The head rice (%) and the percent chalkiness showed reverse results.

■ Bodrun Nessa

Genotype and environmental interaction on neck blast incidence in blast prone area, Boro 2022-23. The experiment was conducted with variety and planting time against neck blast disease under natural condition. Four varieties were transplanted (V1= BRRI dhan29, V2= BRRI dhan89, V3= BRRI dhan28 and V4= BRRI dhan28, at 1st (Set A, D1= 14 December, 2022) and at 2nd planting time (Set B, D2= 4 January 2023). Variety V4 was transplanted at 20 days later after both planting time in order to synchronize the flowering time of BRRI dhan29 and BRRI dhan89. In set A, the flowering time of V3 and V1, V2, V4 were second week and last week of March respectively. During this period average minimum temperature ranged from 20° to 23°C with 80 to 78% RH. With this environmental condition, neck blast disease incidence was about 16 to 14% in V3 and V4 varieties where as V1 and V2 showed 5 to 6% DI. In set B, the flowering time of V3 and V1, V2, V4 were last week of March and first week of April respectively. During this time, average minimum temperature ranged from 22° to 24°C with 82 to 69% RH. In this situation, more or less similar pattern of neck blast disease incidence was observed in the varieties compared to first planting time (Set A). In this study, it was observed that BRRI dhan28 was more susceptible to neck blast disease compared to other varieties.

■ M S Mian, T H Ansari, M Hossain, M Ahmad, and M A Latif

DISEASE MANAGEMENT

Evaluation of biopesticides for management of leaf folder and stem borer in field condition. This experiment was set up at BRRI, Barishal with four treatments (T1= *Bacillus thuringiensis* @25ml/L, T2= *Serattia* sp.@25 ml/L, T3=Insecticide, Belt Expert @0.5ml/L, and T4=control) for controlling stem borer. Twenty moth per plot was inoculated keeping the plot covered by mosquito net. Both entomopathogenic bacterial biopesticides was sprayed (@25ml/L H₂O) on plants two days after inoculation with stem borer. After 14 days of treatment application data were recorded on dead heart/hill, white head/hill and yield/hill. The highest dead heart was observed in control (T4) treatment

compared to the other treatments. The highest yield was recorded in plots where insecticide (T3) was sprayed followed by T1 where *Bacillus thuringiensis* was sprayed. This experiment would be further evaluated to get more conclusive result.

■ Q S A Jahan and M M Kabir

Bioaccumulation and detoxification of As (III) and disease management by *Achromobacter xylosoxidans* and increase rice yield in As-contaminated soil. To decrease Arsenic (As) uptake and increase rice yield by spraying *A. xylosoxidans* bacteria inoculation two experiments were carried out of which one at BRRI RS, Bhanga in Boro 2022-23 whereas another one at farmers' field of Nagarkanda, Bhanga. *Achromobacter xylosoxidans* was applied @ 20ml/L H₂O at seedling stage two weeks after transplant. BRRI dhan58 was used at BRRI RS whereas BRRI dhan92 was used at farmers' field. Plant height, total tiller, panicle length/hill and effective tiller/hill were increased in treated plot compared to the control plot. Yield was increased by 0.5 t/ha and 0.75 t/ha in treated plots compared to the control plots in BRRI dhan58 and BRRI dhan92, respectively.

■ Q S A Jahan and HB Sajib

In vivo efficacy of nano mediated fungicides to control sheath blight and BB of rice. Two different pot experiments were conducted for controlling sheath blight and BB diseases by nano mediated fungicides following completely randomized design with three replications. In case of sheath blight disease, 70-day-old rice plants were inoculated with *Rhizoctonia solani*. Six different concentrations of AgNPs and ZnONPs mediated fungicide were sprayed four days and 11 days after inoculation. Compared to the standard fungicide (Folicur), AgNPs mediated fungicide (1:1) performed better. On the other hand ZnO and CuO mediated fungicides were used for rice BB disease management. Nanoparticles were sprayed at different concentrations at three days before and after pathogen inoculation. Among all the treatments 3g ZnO+1.5g Bismethiazol and 3g CuO+1.5g Bismethiazol showed better performance compared to the control.

■ PI for Sheath blight: S Akter and PI for BB: R Akter

Study on efficacy level of AgNPs and ZnONPs biosynthesized from bacterial isolates for controlling rice sheath blight disease. Two nanoparticles, Ag and ZnO, were biosynthesized using bacterial isolate GB29(i) with the plasmon

band at the wavelength of 435 and 335 nm, respectively (Fig. 3). To see their efficacy against the sheath blight disease an experiment was conducted under artificial inoculation technique. In *in vitro* test mycelial growth of *Rhizoctonia solani* was 100% inhibited in AgNPs and Amister top treated plate whereas 55.9% inhibition was obtained by ZnONPs.

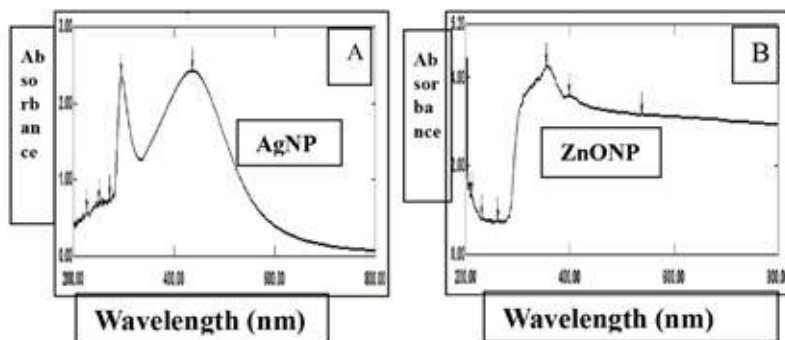


Fig.3: UV-Visible absorption spectrum of Ag and ZnO NP biosynthesized using Bacterial isolate GB29(i).

■ S Akter, M A Monsur and M A Latif

Effect of plant extract mediated silver nanoparticle on bakanae disease management. Pre-germinated seeds of susceptible variety BRRI dhan92 were inoculated with *F. proliferatum* (10^6 conidia/ml) for overnight. AgNO_3 (1 mM) was used along with neem leaf mediated silver nanoparticle to observe bakanae disease development. Data were recorded on % infected and % healthy seedlings after 14 days of nano treatment. No bakanae symptom (0%) in AgNPs (neem) was recorded which was similar to the healthy control. Plant height was somewhat decreased (-2.4%) but root length was increased (6.4%) in AgNPs (neem) compared to the diseased control. Silver Nano (neem leaf) was effective to manage bakanae disease as GA_3 (12.01 ppm), IAA (3.93 ppm) and ABA (0.57 ppm) were decreased after the treatment in inoculated plant.

■ Q S A Jahan and H B Sajib

Efficacy of nanoparticles against rice bacterial blight disease management. In green house Zinc oxide (ZnO) and copper oxide (CuO) NPs were used in a pot experiment. Nanoparticles were sprayed at different concentrations at 3 days before

and after inoculation of BB pathogen. Among all the biosynthesized treatments CuO+ZnO (3000+3000ppm), CuO+ZnO (4000+4000 ppm) and ZnO and CuO (4000 ppm) showed better performance. In CuSO_4 salt (6000 ppm) treatment, lesion length was not found because leaf was burnt due to high concentration. In another *in vitro* experiment, Cu Chitosan and Zn Chitosan nanoparticles was used against BB. Cu-Chitosan showed better performance upto (2:8) dilution i.e. 1250 ppm and Zn-Chitosan showed better performance upto (6:4) i.e. 6455 ppm compared to other treatments.

■ R Akter, MA Latif

Study on efficacy level of different nano agents comparing with fungicide for controlling rice blast disease. Blast pathogen at 1×10^5 spore/ml concentration was inoculated on 21-day- old seedlings of BRRI dhan28 at controlled condition (temp $24^\circ\text{C} \pm 2$ and RH $> 80\%$). Eleven treatments along with disease control were used. Minimum DS (2) and DI (13%) with maximum disease control (75%) were recorded in Nativio 75WG treated plot. Moderate DS (3), DI (25%) with 52% disease control were recorded in AgNPs at 40% and 50%

concentration the over untreated plot. AgNPs (40%) could be effective, sound and eco-friendly disease combating agents against blast disease of rice.

■ M A Monsur and S Akter

Evaluation of new chemicals against blast, sheath blight and brown spot diseases. Twenty new fungicides with standard check (Nativo) were tested for blast disease control at Gazipur (artificial inoculation and Cumilla (natural condition). For sheath blight disease control two sets of experiments were conducted under artificial inoculation: 1st set at BRRI Gazipur and Cumilla and 2nd set at BRRI Rajshahi and Cumilla. Twenty new fungicides for each set with standard check (Amister Top) were tested. For BS (natural) four new chemicals were sprayed. Among 20 new chemicals, only five fungicides controlled blast disease by more than 80%. From the 1st set of experiments only six and from the 2nd set of experiments only five new chemicals controlled more than 80% sheath blight disease. None of the tested chemicals were effective against BS disease.

■ PI for blast: M Hossain; PI for sheath blight: A Ara and H A Dilzahan; P I for B S: A Ara; CI: M M Rashid, M S Mian, T H Ansari and M A Latif

Residual effect of fungicide on microbial community in phylloplane and phyllosphere. For the enumeration of bacterial population in the soil samples serial soil dilution was done. The slimy, colourless and coloured bacterial colonies appeared in the NA medium after 72 h incubation. Maximum number of colonies were found three days before fungicide spray in all treatments. And the number of colonies significantly reduced after spraying Amister top. The toxic effects of the fungicides were more pronounced immediately after the application of fungicides. On the other hand, with an increasing incubation period, the bacterial population tended to increase.

■ H A Dilzahan, H B Shozib, M R Bhuiwan, S Akter, M A I Khan, M A Latif and T H Ansari

Determination of residual effect of fungicides in rice grain. The study aimed to determine the residual effects of fungicides in rice grains. Twelve aromatic rice samples were collected from rice-growing

regions in northern Bangladesh including Rangpur, Dinajpur, and Nawgan, where farmers frequently use fungicides for controlling rice blast disease. Additionally, a trial was conducted to manage neck blast disease using trooper (Tricyclazole) and nativo (Tebuconazole+Trifloxystrobin) fungicides. Validation of methods for detecting tricyclazole group fungicidal residues in rice grains using the QuEChERS method has been completed, and the collected samples are currently being prepared for analysis in the Central Laboratory at BRRI.

■ M A I Khan, R Akter, M R Bhuiyan, M M Rashid, H R Hira, H A Dilzahan, S A I Nihad, T H Ansari and M A Latif

TECHNOLOGY TRANSFER

Farmers training on integrated rice disease management. Seven batches of a ‘day-long’ training programme on integrated rice disease management were conducted at Gazipur, Sirajganj, Cumilla and Rangpur districts of Bangladesh. Each training programme consisted of 30 farmers having both male and female participants. Therefore, altogether 210 farmers were trained on different rice diseases and its management technique under changing climatic condition of Bangladesh.

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Rice Farming Systems Division

228	Summary
230	Cropping Pattern Development For Favourable Ecosystem
234	Development Of Cropping Pattern For Stress Prone Environment
235	Development Of Cropping Pattern For Hilly Areas
237	Validation And Delivery Of Cropping System Technology
238	Integrated Farming Systems Research And Development

SUMMARY

Four cropped cropping patterns were evaluated using Boro, T. Aus, and T. Aman rice with Rabi and Kharif crops at BRRI research farm, Gazipur. The results showed that Tomato-Mungbean-T. Aus-T. Aman had the highest rice equivalent yield (REY) of 44.06 t/ha and gross margin (GM) of 6,49,680 Tk/ha. Potato+Maize-T. Aus-T. Aman had the second highest REY of 25.0 t/ha and GM of 2,06,570 Tk/ha.

An experiment was conducted to evaluate the yield and profitability of three-cropped cropping patterns using Boro, T. Aus and T. Aman rice varieties with Rabi and Kharif crop at BRRI HQ research farm, Gazipur. Higher REY (23.74 t/ha), GM (2,94,000 Tk/ha) and MBCR (2.40) was found from Onion-Jute-T. Aman cropping pattern.

The experiment was conducted at BRRI research farm, Gazipur to determine the optimal sowing/planting window for individual crop in Mustard-Boro-T. Aman cropping pattern. Results on different sowing/transplanting dates showed that BARI Sarisha-14 performed well when sown within 01-15 November. BRRI dhan89 turned out to higher grain yield among the tested varieties when transplanted from 10 January to 09 February. BRRI dhan71 produced higher grain yield while transplanted from 15 July to 14 August.

Newly released Boro and T. Aman rice were evaluated in different combinations in Boro-Fallow-T.Aman cropping pattern at BRRI, Gazipur. Result showed that combination of BRRI dhan89 and BRRI dhan92 with BRRI dhan75 and BRRI dhan 87 showed higher

gross margin of 2,25,000 to 2,41,000 Tk/ha at significant level with BCR of 2.30 to 2.40.

A study was undertaken at Trishal, Mymensingh to intensify the existing Boro-Fallow-T. Aman cropping pattern through the inclusion of T. Aus and varietal replacement. Among the five tested cropping patterns, the higher production was obtained from BRRI dhan92-BRRI dhan98-BRRI dhan71 (20.72 t/ha) whereas the lowest productivity was found from CP5: BRRI dhan28-Fallow-BRRI dhan49 (11.25 t/ha).

An experiment was undertaken to convert fallow marshy land into a productive system in East Byde of BRRI farm where six high raised beds and deep sinks were constructed. Different vegetables were intercropped with different perennial fruit trees in bed and different fish breeds were released in the sink. Among the summer vegetables, higher GM (360 Tk/dec.) was obtained from Ash gourd and Indian spinach combination. In winter season, higher GM (396 Tk/dec.) was obtained from watermelon and spinach combination.

A study was conducted in the farmers' field at Batiaghata, Khulna to improve the existing Fallow-Fallow-T. Aman cropping pattern. Results showed that higher rice production and GM obtained using salt tolerant Boro rice variety of BRRI dhan67 and BRRI dhan99 with BRRI dhan87.

A study was conducted involving 21 trials in Rangamati and Khagrachari districts. The average yield of BRRI dhan48, BRRI dhan82 and BRRI dhan98 were 4.80 t/ha, 4.56 t/ha and 4.85 t/ha, respectively in Aus season where BRRI dhan75 and BRRI dhan87 produced 4.72 t/ha, and 5.75 t/ha, respectively in T. Aman season.

Incorporation of Aus rice in the existing Fallow-Fallow-T. Aman cropping pattern can increase the productivity.

This study was evaluated in hill tract region using modern Aus rice varieties for replacing local rice varieties in Jhum system. The average grain yield of BR26, BRRI dhan48 and BRRI dhan83 was 3.42 t/ha, 3.46 t/ha and 3.57 t/ha, respectively whereas local varieties of Mongthongno, Ranqui, and Kokro showed better performance. And ring placement showed effective fertilizer management option for higher grain yield.

Another study was aimed to increase Boro-Fallow-T. Aman cropping pattern by incorporating of T. Aus. Results showed higher grain yield (20.72 t/ha) was observed in BRRI dhan92-BRRI dhan98-BRRI dhan87 cropping pattern with GM of 2,0,3670 Tk/ha.

This activity was conducted to increase the system productivity through incorporation of BARI Sarisha-14 in Boro-Fallow-T. Aman cropping pattern at different upazilas of Gazipur, Mymensingh, Habiganj, and Tangail districts. The REY was increased about 54%-84% due to inclusion of mustard in between the transition period of two rice where higher REY was observed at Dhanbari, Tangail (22.32 t/ha) followed by Madhabpur, Habiganj (18.60 t/ha).

Two trials were conducted at Kaliganj, Gazipur to improve the productivity of Boro-Fallow-T. Aman and single Boro cropping pattern. By the replacement of newly released rice varieties of BRRI dhan87 and Bangabandhu dhan100 increased GM of 91% over existing cropping pattern (1,03,000 Tk/ha) with MBCR of 8.12 in the

double rice ecosystem, while BRRI dhan92 showed better performance (9.55 t/ha) in a single rice ecosystem.

The study revealed that farmers in Kaliganj, Gazipur, were satisfied with the performance of BRRI dhan71 (6.05 t/ha) and BRRI dhan90 (3.56 t/ha) rice varieties during Aman season. BRRI dhan92 (7.63 t/ha) and Bangabandhu dhan100 (7.19 t/ha) performed better in Boro season, while, despite lower yields, BRRI dhan63 (6.06 t/ha) was appreciated for its fine grain quality.

An experiment was conducted at Muktarpur, Kaliganj, Gazipur to assess the performance of different inter-crops under mixed orchard system. There were six vegetable combinations for all the orchard system while the average size of orchard was 8.1 decimal. Among all the vegetable combinations, the highest yield (40.5 kg/dec) and return (1215 Tk/dec) of vegetables was found from Mango+Jujube orchard whereas the lowest yield (12.0 kg/dec) and return (360 Tk/dec) was obtained from Banana orchard. Overall, the average gross return for each farmer was 702.82 Tk /decimal per year.

The study conducted at the FSRD site in Muktarpur, Kaliganj, Gazipur aimed to improve vegetable production and generate income by selling surplus products. Ten cooperative farmers from marginal and small groups were selected for vegetable cultivation in homestead area of Muktarpur, Kaliganj, Gazipur. The intervention significantly increased vegetables production, consumption, distribution, and selling. The average gross return of Tk 2,304 was attained per farmer per year.

Eight farmers in Muktarpur, Kaliganj,

Gazipur were selected to explore growing spices in unused shady areas under their homestead orchard. The cultivated ginger and turmeric yielded an average of 18.62 kg/decimal and 6.39 kg/decimal with a GM of 900 Tk/decimal and 854 Tk/decimal, respectively.

An activity at FSRD site in Muktarpur, Kaliganj, Gazipur was conducted to enrich nutrition and income through rearing of Sonali chicken in small-scale farming. Individual farm household consumed 35%, and sold the 65% of produced egg and live chicken with an average gross profit of Tk 3,328 per farmer.

Two pairs of adult pigeon were distributed to ten marginal and small farmers at the FSRD site Muktarpur, Kaliganj, Gazipur. Farmers sold 75% and consumed and 25% squab, enhancing income and nutrition for farm family. Pigeon rearing is profitable, generating an additional Tk 4,350 per farmer annually.

Goat rearing activity aimed to increase income and awareness among small and marginal farmers in Kaliganj, Gazipur. Ten farmers are each given one Black Bengal she baby goat. The nine she goats laid nine kids, generating an average income of Tk 5,400 per farmer per year where one baby goat was died by PPR.

The management of integrated homestead production system increased the productivity and income of small and marginal farmers. The programme analyzed the income share of homestead vegetables, spices and livestock components. The results showed that livestock had the highest income share (63%) followed by vegetables (27%) and

spices (10%) of the total farm income.

The activity conducted at the FSRD site in Muktarpur, Kaliganj, and Gazipur to increase pond productivity and farm output. Bighead carp, Rohu, Mrigel, Tilapia, and Sorputi fingerlings were released, and the initiative included semi-aquatic aroid and stolon production. The stolon production reached 3.56 kg/decimal and the aroid production reached 57 pieces/decimal. The farmers sold most of the stolon and aroid, received gross margin of 2429 Tk/decimal.

CROPPING PATTERN DEVELOPMENT FOR FAVOURABLE ECOSYSTEM

Performance of four-cropped cropping patterns for irrigated medium high land ecosystem

The aim of this study was to compare the yield and profitability of different four cropped cropping under Boro, T. Aus and T. Aman rice varieties with different Rabi and Kharif crops at BRRI research farm, Gazipur. The tested cropping patterns (CP) were: CP₁: Tomato (BARI Tomato-1)-Mungbean (BARI Mung-6)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan75), CP₂: Mustard (BARI Sarisha-14)-Boro (BRRI dhan88)-T. Jute (BJRI Tossa Pat-8)-T. Aman (BRRI dhan75), CP₃: Mustard (BARI Sarisha-14)-Mungbean (BARI Mung-6)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan95), CP₄: Potato (Asterix)+Pumpkin (BARI Hybrid Mistikumra-2)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan87), CP₅: Potato (Asterix)+Maize (BARI Hybrid Maize-16)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan87), CP₆: Mustard (BARI Sarisha-18)-Vegetable (BARI Puishak-2)-T. Aus (BRRI

dhan48)-T. Aman (BRRI dhan87). The highest rice equivalent yield (REY) of 44.06 t/ha, gross margin (GM) of 6,50,000 Tk/ha and marginal benefit cost ratio (MBCR) of

3.30 were found from Tomato-Mungbean-T. Aus-T. Aman cropping pattern (CP1) followed by CP5, CP2, CP4 (Table 1).

Table 1. Yield and profitability of different crop combinations under four cropped cropping patterns, BRRI, Gazipur, 2022-23.

CP	Yield (t/ha)											REY (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)	MBCR
	Tomato	Mustard	Potato	Maize	Mungbean	Pumpkin	Vegetable	Jute	Boro	T. Aus	T. Aman				
CP ₁	52.97	-	-	-	1.01	-	-	-	-	4.07	4.58	44.06 a	452	650	3.30
CP ₂	-	0.75	-	-	-	-	-	3.40	6.98	-	4.46	20.64 c	313	203	1.95
CP ₃	-	0.67	-	-	1.61	-	-	-	-	3.80	4.40	16.09 e	260	142	1.70
CP ₄	-	-	13.36	-	-	8.00	-	-	-	3.63	3.45	19.24 cd	362	119	1.04
CP ₅	-	-	12.56	7.07	-	-	-	-	-	4.12	4.47	25.00 b	418	207	1.47
CP ₆	-	1.21	-	-	-	-	7.44	-	-	4.20	4.74	16.92 de	292	131	1.23
CP ₇ (Ck.)	-	0.69	-	-	-	-	-	-	5.44	-	5.66	13.29 f	219	113	-
CV (%)	6.7														

Means with the same letter(s) are not significantly different. Price (Tk/kg): Tomato=15, Mustard=80, Potato=15, Maize=30, Pumpkin=20, Mungbean=90, Jute=50, Vegetable (Indian spinach)=15, Rice=25

Performance of three-cropped cropping patterns for irrigated medium high land ecosystem

The experiment was conducted at BRRI research farm, Gazipur to evaluate the agronomic and economic performance of three-cropped cropping patterns. Eight cropping patterns of CP₁: Boro (BRRI dhan88)-T. Aus (BRRI dhan98)-T. Aman (BRRI dhan75), CP₂: Mustard (BARI Sarisha-14)-Boro (BRRI dhan88)-T. Aman (BRRI dhan95), CP₃: Potato (Asterix)-Boro (BRRI dhan88)-T. Aman (BRRI dhan75), CP₄: Wheat (BARI Gom-

30)-Mungbean (BARI Mung-6)-T. Aman (BRRI dhan87), CP₅: Sunflower (BARI Surjamukhi-3)-T. Aus (BRRI dhan98)-T. Aman (BRRI dhan87), CP₆: Onion (BARI Piaj-1)-Jute (BJRI Tossa Pat-8)-T. Aman (BRRI hybrid dhan6), CP₇: Lentil (BARI Mashur-8)-T. Aus (BRRI dhan98)-T. Aman (BRRI dhan49) and CP₈: Boro (BRRI dhan28)-Fallow-T. Aman (BRRI dhan49) (Ck.) were tested. The highest REY (23.74 t/ha), GM (2,94,000 Tk/ha) and MBCR (2.40) was found from Onion-Jute-T. Aman (CP₆) followed by CP₃ (Table 2).

Table 2. Yield and profitability of different crops combination under three-cropped cropping pattern, BRRI, Gazipur, 2022-23.

CP	Yield (t/ha)											REY (t/ha)	TVC (‘000 Tk/ ha)	GM (‘000 Tk/ha)	MBCR
	Mustard	Potato	Wheat	Sunflower	Onion	Lentil	Boro	Mungbean	Jute	T. Aus	T. Aman				
CP ₁	-	-	-	-	-	-	4.95	-	-	4.53	4.70	14.18 _c	239	115	1.09
CP ₂	0.69	-	-	-	-	-	5.44	-	-	-	5.66	13.29 _c	220	113	1.08
CP ₃	-	13.11	-	-	-	-	4.11	-	-	-	4.49	16.46 _b	300	111	1.02
CP ₄	-	-	3.07	-	-	-	-	0.82	-	-	5.44	13.29 _c	220	112	1.06
CP ₅	-	-	-	1.97	-	-	-	-	-	4.29	5.35	13.58 _c	227	112	1.06
CP ₆	-	-	-	-	9.49	-	-	-	3.40	-	5.55	23.74 _a	299	294	2.40
CP ₇	-	-	-	-	-	1.23	-	-	-	4.13	5.17	13.49 _c	223	114	1.09
CP ₈ (Ck.)	-	-	-	-	-	-	6.61	-	-	-	5.02	11.07 _d	167	109	-
CV (%)												6.39			

Means with the same letter(s) are not significantly different. Price (Tk/kg): Mustard=80, Potato=15, Wheat=40, Sunflower=50, Onion=30, Lentil=85, Mungbean=90, Jute=50, Rice=25

Determination of optimum planting window of newly released rice varieties in Mustard-Boro-T. Aman cropping system

An experiment was conducted at BRRI research farm in Gazipur to determine the optimal sowing/ planting window for the crops in Mustard-Boro-T. Aman cropping pattern. Mustard varieties of BARI Sarisha-14 and Binasarisha-9 were sown on 01, 08, 15, 22 and 29 November. In Boro season, BRRI dhan88, BRRI dhan89, BRRI dhan48 and BRRI dhan98 were transplanted across six planting dates viz 10, 20, 30 January, 09, 19 February and 01 March.

While BRRI dhan71, BRRI dhan75, BRRI dhan87 and BRRI dhan49 were transplanted at 15, 25 July, 04, 14 and 24 August during T. Aman season. BARI Sarisha-14 and Binasarisha-9 performed better when sown within 01-15 November. In Boro season, BRRI dhan89 turned out higher grain yield among the tested varieties when transplanted from 10 January to 09 February. BRRI dhan98 produced higher grain yield when transplanted from 19 February to 01 March. In T. Aman season, BRRI dhan71 produced higher grain yield than other the varieties when transplanted from 15 July to 14 August (Fig. 1).

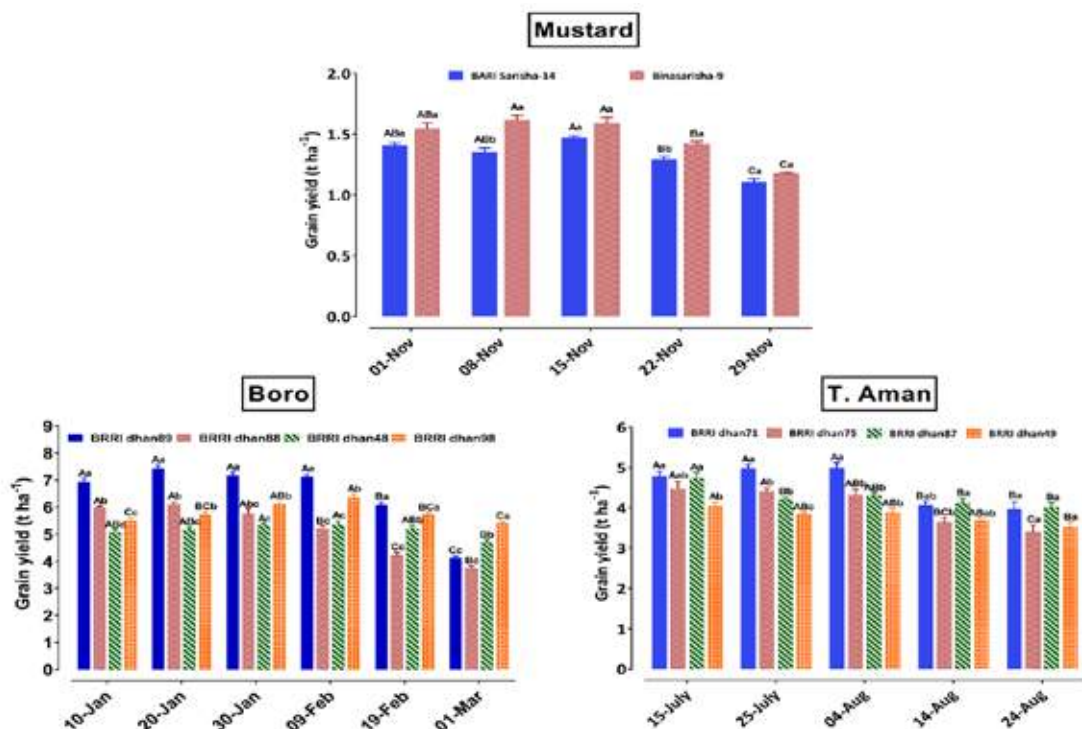


Fig. 1. Effects of planting/sowing date and variety on grain yield of mustard, Boro and T. Aman. Capital letters indicate the comparison among different planting dates of a given variety. Lower case letters indicate the comparison among different varieties within a given planting date. Different letters indicate significant difference at $P < 0.05$

Evaluation of newly released BRRI varieties under Boro-Fallow-T. Aman cropping pattern

A study was conducted to determine the suitable crop sequence with newly released BRRI rice varieties in Boro-Fallow-T. Aman cropping pattern at BRRI, Gazipur. Ten cropping patterns (CP) of CP₁: BRRI dhan67-Fallow-BRRI dhan75, CP₂: BRRI dhan67-Fallow-BRRI dhan87, CP₃: BRRI dhan88-Fallow-BRRI dhan75, CP₄: BRRI dhan88-Fallow-BRRI dhan87, CP₅: BRRI dhan89-Fallow-BRRI dhan75, CP₆: BRRI dhan89-Fallow-BRRI dhan87, CP₇: BRRI dhan92-Fallow-BRRI dhan75, CP₈: BRRI dhan92-Fallow-BRRI dhan87, CP₉:

Bangabandhu dhan100-Fallow-BRRI dhan75 and CP₁₀: Bangabandhu dhan100-Fallow-BRRI dhan87 were tested in this experiment. Among the ten combinations of Boro and T. Aman varieties, the highest total grain yield (13.40 t ha⁻¹) was attained from CP₇, which was statistically similar to CP₁ (13.36 t ha⁻¹), CP₈ (13.22 t ha⁻¹) and CP₅ (12.86 t ha⁻¹). The yield of BRRI dhan87 was notably poor due to lodging at flowering stage by Sitrang cyclone effect. Cost and return analysis showed that CP₇ had the highest GM (2,41,000 Tk ha⁻¹), followed by CP₆ (2,40,000 Tk ha⁻¹), CP₈ (2,36,000 Tk ha⁻¹), and CP₅ (2,25,000 Tk ha⁻¹) with similar trend of BCR (Table 3).

Table 3. Yield and profitability of Boro-Fallow-T. Aman cropping patterns with newly released BRRI varieties, BRRI, Gazipur, 2022-23.

Cropping pattern		Yield (t ha ⁻¹)		TVC (‘000 Tk ha)	GM (‘000 Tk ha)	BCR
	Boro	T. Aman	Total grain yield			
CP ₁	6.66 de	4.59 a	11.25cd	172	177 cd	2.03 cd
CP ₂	6.76 de	4.14 b	10.90 d	172	165 d	1.96 d
CP ₃	7.12 cd	4.58 a	11.70 bc	172	191 bc	2.11 bc
CP ₄	7.42 c	4.56 a	11.98 b	172	199 b	2.16 b
CP ₅	8.33 b	4.53 a	12.86 a	172	225 a	2.30 a
CP ₆	8.68 ab	4.68 a	13.36 a	173	240 a	2.38 a
CP ₇	8.87 a	4.53 a	13.40 a	172	241 a	2.40 a
CP ₈	8.47 ab	4.75 a	13.22 a	173	236 a	2.36 a
CP ₉	6.64 e	4.73 a	11.37 bcd	172	181 bcd	2.06 bcd
CP ₁₀	6.58 e	4.79 a	11.37 bcd	172	181 bcd	2.05 bcd
CV (%)	2.14	2.79	1.80		3.33	1.84

Means with the same letter(s) are not significantly different. Price (Tk kg): Boro=30 and T. Aman=33

Exploration of water-logged wetland ecosystem through modification of land type for fish, vegetables and fruit production

Waterlogged uncultivable marshy fallow land in East Byde of BRRI HQ farm creates environmental pollution, even making threats for lives and inhabitants of the surroundings. Therefore, this experiment was undertaken to convert this land type into a productive system. Hence, six high raised beds (63m × 3.8m) and six deep sinks (63m × 3.8m × 1m) were constructed to develop a suitable diversified cultivation of vegetables, fruits, and fish system. The raised bed was planted with different perennial fruit trees where intercropping of different types of summer and winter vegetables were grown. In the deep sink, different fish breeds were released with different size and stocking density maintaining six combinations following the recommendation of Bangladesh Fisheries Research Institute.

Among the summer vegetables the highest GM (2160 Tk/decimal) was obtained from Ash gourd

and Indian spinach combination. In winter season, the highest GM (2375 Tk/decimal) was obtained from watermelon and spinach combination. Saplings of mango, jujube, guava, lemon, malta and custard apple were planted. All the ditches were flooded, and fishes were escaped due to the effect of Sitrang on 22-24 October 2022.

DEVELOPMENT OF CROPPING PATTERN FOR STRESS PRONE ENVIRONMENT

Improvement of single T. Aman cropping pattern through inclusion of salt tolerant Boro rice variety in saline coastal area

The study was conducted in the farmers' field of Batiaghata upazila in Khulna district to improve the productivity of existing Fallow -Fallow-T. Aman cropping pattern. The result showed that total rice production (TRP) and GM was correspondingly 229%-241 % and 230%-272 % higher by inclusion of salt tolerant Boro rice of BRRI dhan67, BRRI dhan99 with BRRI dhan87 in T. Aman season against the existing single T. Aman (Morichshail/ Chapshail) cropping pattern (Table 4).

Table 4. Yield and profitability of Boro-Fallow-T. Aman cropping pattern, Batiaghata, Khulna, 2022-2023.

Price (Tk/kg): Rice=26

Cropping pattern	Yield (t/ha)				TRP (t/ha)	TVC ('000 Tk/ha)	GM ('000 Tk/ha)
	B dhan99	R R I	B R R I dhan67	B R R I dhan87	T Aman		
Boro-Fallow-T. Aman	-		5.29	5.64	-	10.93	161
Boro-Fallow-T. Aman		5.22	-	5.33	-	10.55	165
Fallow-Fallow-T. Aman (Local)	-		-	-	3.20	3.20	51

DEVELOPMENT OF CROPPING PATTERN FOR HILLY AREAS

Intensification of Fallow-Fallow-T. Aman area through the inclusion of modern Aus rice in plain land in hilly areas

Twenty-one trials were conducted in farmers' field of four upazilas in Rangamati and Khagrachari districts in collaboration with DAE. This study was initiated to improve the productivity of existing Fallow-Fallow-T. Aman cropping pattern through

inclusion of Aus and replacement of Aman rice varieties. Farmers adopted BR11, BRRI dhan49, and Babilon in the T. Aman season. The average yield of BRRI dhan48, BRRI dhan82 and BRRI dhan98 was 4.56 t/ha to 4.85 t/ha in Aus season while BRRI dhan75 and BRRI dhan87 produced 4.72 t/ha and 5.75 t/ha, respectively in the T. Aman season (Table 5). Inclusion of Aus rice in the existing Fallow-Fallow-T. Aman cropping pattern increased the productivity.

Table 5. Grain yield (t/ha) of T. Aus and T. Aman rice in piedmont plain land, Chittagong Hill Tract, 2022.

Cropping pattern	T. Aus			T. Aman				
	BRRI dhan48	BRRI dhan82	BRRI dhan98	BRRI dhan75	BRRI dhan87	BR11	BRRI dhan49	Babilon
Aus-Fallow-T. Aman	4.80	4.56	4.85	4.72	5.75	-	-	-
Fallow-Fallow-T. Aman (check)	-	-	-	-	-	4.26	4.52	4.89

Productivity improvement of Jhum cultivation through the replacement of local Aus rice in hilly areas

A study was conducted in Bandarban, Rangamati, and Khagrachhari districts to evaluate the yield performance of high yielding Aus against farmers'

adopted local rice varieties for jhum system. The average grain yield of BR26, BRRI dhan48, BRRI dhan82, BRRI dhan83 and BRRI dhan98 was 3.42 t/ha, 3.46 t/ha, 3.42 t/ha, 3.57 t/ha and 3.40 t/ha, respectively. Mongthongno, Ranqui, and Kokro yielded better among the local varieties (Table 6).

Table 6. Yield of Aus rice under Jhum cultivation, Chittagong Hill Tract, 2022.

HYV Aus	Grain yield (t/ha)	Local variety	Grain yield (t/ha)	Local variety	Grain yield (t/ha)
BR26	3.42	Binni	2.33	Shonamukhi	2.14

BRRI dhan48	3.46	Badui	2.25	Lankapora	2.23
BRRI dhan82	3.42	Khamarang	2.03	Longur	1.93
BRRI dhan83	3.57	Surjomani	2.20	Kokro	3.25
BRRI dhan85	3.40	Bordhan	2.34	Mongthongno	3.38
		Beti	1.89	Gallon	2.27
		Khalabadia	2.28	Amedhan	2.31
		Churoi	2.13	Ranqui	3.34
		Pidi	2.29	Gunda	1.96
		Kanbui	3.22	Kapali	2.32
				Khoborok	2.22

Fertilizer management for HYV Aus rice in Jhum cultivation

Field experiments were conducted in Jhum system at Panchhari, Rajasthali and Thanchi upazilas of hill tract region during Aus season. Four Nitrogen (N) fertilizer treatments were: T₁=Farmer's practice i.e., neither manure nor fertilizer (control), T₂=Localized placement (Ring placement around the dibbling hole), T₃=Row placement in between the dibbling lines and T₄= ½ Basal + ¼ at tiller initiation and ¼

at maximum tillering stages as broad cast method. Urea, TSP, and MoP were applied at 60-10-40 kg/ha. The seeds of rice were sown by dibbling method with the help of Tagol (one kind of knife) in May 2022 and harvested at maturity in September 2022.

Irrespective of N-treatment, BRRI dhan83 yielded higher followed by BRRI dhan48 and BRRI dhan85 (Table 7). Ring placement (T₂) might be an effective option for efficient fertilizer management in Jhum cultivation system.

Table 7. Yield of Aus rice under different fertilizer application methods in Jhum cultivation system, Chittagong Hill Tract, Aus 2022.

Variety	Treatment	Grain yield (t/ha)			
		Panchhari	Rajosthali	Thanchi	Mean
BRRI dhan48	T ₁	2.22	2.35	2.27	2.28
	T ₂	3.53	3.64	3.49	3.55
	T ₃	3.41	3.45	3.56	3.47
	T ₄	3.48	3.32	3.45	3.42
BRRI dhan83	T ₁	2.31	2.47	2.32	2.37
	T ₂	3.78	3.64	3.63	3.68
	T ₃	3.59	3.51	3.54	3.55
	T ₄	3.55	3.43	3.41	3.46
BRRI dhan85	T ₁	2.27	2.13	2.44	2.28
	T ₂	3.59	3.48	3.52	3.53
	T ₃	3.33	3.33	3.44	3.41
	T ₄	3.25	3.25	3.36	3.33
LSD _{0.01} for treatment (T)		0.51			

LSD _{0.01} for variety (V)	0.54
LSD _{0.01} for location (L)	0.45
LSD _{0.01} for T×V	0.11
LSD _{0.01} for L×V	0.87
LSD _{0.01} for T×L×V	0.19
CV (%)	4.5

VALIDATION AND DELIVERY OF CROPPING SYSTEM TECHNOLOGY

Improvement of Boro-Fallow-T. Aman cropping system through inclusion of Aus and varietal replacement in irrigated ecosystem

To intensify the existing Boro-Fallow-T. Aman cropping pattern a study was undertaken through the inclusion of T. Aus rice and varietal replacement in the farmers' fields of Balipara, Trishal, Mymensingh in 30 farmers field. In Boro season, the highest grain yield was obtained from BRRI

dhan92 (8.91 t/ha) in the CP₄, while the lowest yield was found from farmers' adopted variety of BRRI dhan28 (6.20 t/ha). Statistically similar yield was found in all the CPs in Aus season. In Aman season, the highest yield was found from BRRI dhan71 (6.23 t/ha) under CP₃, followed by BRRI dhan87 under CP₂ (6.00 t/ha) and CP₄ (5.83 t/ha). The yield of BRRI dhan87 was notably poor due to lodging at flowering stage by Sitrang cyclone effect. The highest gross margin (GM) was obtained from CP₃ (2,0,3670 Tk/ha), followed by CP₂ (1,92,600 Tk/ha) and CP₁ (Table 8).

Table 8. Yield (t/ha) of different rice varieties under different cropping patterns, Trishal, Mymensingh, 2022-23.

Cropping pattern	Boro	Aus	T. Aman	TRP
CP ₁ : BRRI dhan89-BRRI dhan98-BRRI dhan71	7.33 b	5.21 a	5.50 bc	18.06 b
CP ₂ : BRRI dhan89-BRRI dhan98-BRRI dhan87	8.58 a	5.54 a	6.00 ab	20.11 a
CP ₃ : BRRI dhan92-BRRI dhan98-BRRI dhan71	8.66 a	5.84 a	6.23 a	20.72 a
CP ₄ : BRRI dhan92-BRRI dhan98-BRRI dhan87	8.91 a	5.70 a	5.83 ab	20.45 a
CP ₅ : BRRI dhan28-Fallow-BRRI dhan49 (Control)	6.20 c	-	5.07 c	11.25 c
CV (%)	7.94	7.81	5.27	3.64

Means with the same letter(s) are not significantly different. TRP=Total rice production

Intensification of Boro-Fallow-T. Aman cropping pattern through integration of mustard

Short duration high yielding BARI Sarisha-14 was introduced in Boro-Fallow-T. Aman cropping pattern to increase productivity, profitability and cropping intensity. This study was conducted at four different locations during 2022-23. BRRI dhan87 and BRRI dhan90 were cultivated in Aman season where BRRI dhan89, BRRI dhan98 and BRRI dhan102 were produced in Boro season under improved cropping patterns. The highest rice equivalent yield was obtained from the improved cropping pattern at Dhanbari, Tangail

(22.32 t/ha) followed by Madhabpur, Habiganj (18.60 t/ha). The highest GM was obtained from Madhabpur, Habiganj (3,33,000 Tk/ha), followed by Dhanbari, Tangail (2,82,000 Tk/ha) and Kaliganj,

Gazipur (2,47,000 Tk/ha) (Table 9). The findings revealed that crop productivity and profitability increased due to inclusion of mustard in lands those remain fallow after harvesting of T. Aman rice.

Table 9. Grain yield and profitability of different cropping patterns, 2022-23.

Location	Grain yield (t/ha)			REY (t/ha)	TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	MBCR
	Mustard	Boro	T. Aman				
Dhanbari, Tangail	1.77	9.87	6.79	22.32	276	282	2.15
	-	6.58	5.52	12.10	157	145	-
Kaliganj, Gazipur	1.44	7.81	5.35	16.84	330	247	1.89
	-	6.18	3.43	9.60	204	135	-
Trishal, Mymensingh	1.40	7.1	5.97	18.11	269	184	2.41
	-	6.2	4.70	10.90	194	78	-
Madhabpur, Habiganj	1.51	7.65	4.30	18.60	225	333	3.16
	-	7.02	4.67	12.08	163	199	-

Price (Tk/Kg): Rice=25 to 30, Mustard=75 to 85

INTEGRATED FARMING SYSTEMS RESEARCH AND DEVELOPMENT

Crops and Cropping Pattern

Introducing newly released BRRI rice varieties for the improvement of major cropping patterns in FSRD site, Kaliganj, Gazipur

Two trials were conducted in 24 farmers' fields in Kaliganj, Gazipur to increase productivity of Boro-Fallow-T. Aman and Boro-Fallow-Fallow cropping

pattern. In the double rice ecosystem, the replacement of newly released rice variety of Bangabandhu dhan100 and BRRI dhan87 in Boro and T. Aman season, respectively in improved cropping pattern (ICP) produced higher GM (1,97,000 Tk/ha) and MBCR (8.12) compared to the existing cropping pattern (ECP). When BRRI dhan92 was substituted for BRRI dhan29 in the ECP, resulted higher gross margin (1,64,000 Tk/ha) and MBCR (4.36) in the improved cropping pattern (ICP) (Table 10).

Table 10. Grain yield and profitability of double and single rice-based cropping patterns, Kaliganj, Gazipur, 2022-23.

Cropping pattern Boro		Yield (t/ha)			TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	MBCR
		T. Aman	Total productivity				
Double rice	ICP	6.93	193.39	12.76a	241	197	8.12
	ECP	5.44	95.64	9.53b	227	103	-
Single rice	ICP	9.55a	-	9.55a	142	164	4.36
	ECP	7.33b	-	7.33b	128	115	-

Double-rice based cropping pattern: ICP=Bangabandhu dhan100-Fallow- BRRI dhan87, ECP=BRRI dhan28-Fallow-BRRI dhan49 (ck.); Single rice-based cropping pattern: ICP= BRRI dhan92-Fallow-Fallow, ECP=BRRI dhan29-Fallow-Fallow (ck.), MBCR=Marginal Benefit Cost Ratio

Farmers' participatory evaluation of recently released BRRI varieties for Boro and T. Aman season

A study was conducted in Kaliganj, Gazipur,

involving ten farmers assessing suitable T. Aman and Boro rice varieties for their respective locations. In the Aman season, farmers were satisfied with the higher yield of BRRI dhan71 (Table 12). However, farmers were interested to cultivate BRRI dhan90 because of its excellent grain quality. In Boro season, BRRI dhan92 and Bangabandhu dhan100 performed better (Table 11). Despite lower yields, BRRI dhan63 was appreciated by the farmers for its fine grain quality.

Table 11. Grain yield of Aman and Boro varieties, Kaliganj, Gazipur, 2022-23.

T. Aman		Boro			
Variety	Yield (t/ha)	Variety	Yield (t/ha)	Variety	Yield (t/ha)
BRRI dhan71	6.05 ± 0.04a	BRRI dhan88	6.77 ± 0.16bc	Bangabandhu dhan100	7.19 ± 0.15ab
BRRI dhan75	4.04 ± 0.12bc	BRRI dhan63	6.06 ± 0.03cd	BRRI dhan28	5.94 ± 0.12d
BRRI dhan87	4.61 ± 0.26b	BRRI dhan67	7.07 ± 0.24ab	BRRI dhan74	7.45 ± 0.20ab
BRRI dhan90	3.56 ± 0.07cd	BRRI Hybrid dhan5	7.25 ± 0.11ab		
BRRI hybrid dhan6	3.38 ± 0.16c	BRRI Hybrid dhan3	5.98 ± 0.09d		
Ranjit (check)	3.10 ± 0.11d	BRRI dhan92	7.63 ± 0.22a		

Agroforestry System

Evaluation of intercropping under mixed orchard in Madhupur tract

To evaluate the performance of different inter-crops under different orchard systems, an experiment was conducted at Muktarpur, Kaliganj, Gazipur with the treatments consisted of six combinations (T1: Turmeric, T2: Ginger, T3: Kangkong-Indian spianch-Datashak-Red amaranth, T4: Patshak-Okra-Snake gourd-Brinjal, T5: Sweet gourd-Chili-Bitter Gourd-Cauliflower, T6: Cabbage-Spinach-Radish-Tomato and T7: Banana/Guava/Mango+Jujube/Jujube (Control). Average size of the orchard was 8.1 decimal for each farmer. Among all the vegetable combinations, the highest yield was obtained from Cauliflower (4.51 kg/decimal) followed by tomato (4.08 kg/decimal) for per farmer/year. Furthermore, the highest yield (40.5

kg/dec) and return (1,215 Tk/dec) of vegetables was found from Mango+Jujube orchard whereas the lowest yield (12.0 kg/dec) and return (360 Tk/dec) was obtained from Banana orchard. Overall, the average gross return for each farmer was 702.82 Tk /decimal per year.

Homestead Production System

Year-round vegetables production in homestead area

The study was conducted at the FSRD site Muktarpur, Kaliganj, Gazipur to improve the vegetables production round the year at homestead area and to generate additional income for farmers by selling surplus products. Ten cooperative farmers from marginal (5-50 dec.) and small (51-247 dec.) group were selected for homestead vegetables cultivation. The intervention had a significant impact on vegetables production and income. The

vegetable production by small and marginal farmers increased from 61 kg and 56 kg (before intervention) to 191 kg and 174 kg after intervention, showing an increase of about 213% and 211%, respectively. Overall, consumption increased by 184% and 300%, distribution increased by 247% and 258%, and the selling increased by 238% and 64%, respectively for small and marginal farmers. The average gross return from homestead vegetables production was Tk 2,304 per farmer for small and marginal farmer.

Performance of turmeric and ginger in shady places of homestead area

This activity was carried out at the FSR&D site Muktarpur, Kaliganj, Gazipur to explore the possibility of growing spices in the unused shady areas under the homestead orchard. Eight farmers participated in this programme. The plots for turmeric and ginger were 50 m² and 38 m², respectively. The average yield of turmeric and ginger was 23 kg and 6 kg per farmer which resulted in a gross margin of Tk 1,112 and Tk 802 respectively.

Livestock System

Production performance of Sonali chicken at FSRD site, Muktarpur, Kaliganj, Gazipur

The activity aimed to improve the nutrition and income of farm household (marginal and small) in FSRD site, Muktarpur, Kaliganj, Gazipur by providing them for rearing of Sonali chicken. Each farmer received 20 chicks of about one month old, with a male to female ratio of 1:4. Overall, farmers consumed about 35% chickens whereas they sold 65% of their reared chicken. The average gross profit per farmer was Tk 3,328 per year.

Small scale pigeon rearing in farmer's household

The activity was carried out at the FSR&D site Muktarpur, Kaliganj, Gazipur. Ten farmers (marginal and small) received two pairs of adult pigeon each. The vaccination was done regularly, and natural feed were given. On average, farmers sold about 75% and consumed 25% squab which enhanced their income and nutritional food intake. Pigeon rearing is profitable, and it generates an additional Tk 4,350 per farmer per year by producing squab.

Goat rearing in homestead area at FSR&D site, Muktarpur, Kaliganj, Gazipur

Goat rearing activity was launched in Kaliganj,

Gazipur to raise awareness and income among small and marginal farmers. Ten farmers were selected, and each received one Black Bengal she goat baby from the local market. The goats had an average initial body weight of 10 kg and were 4-5 months old. The goats produced nine kids and generated an average income of Tk 5,400 per farmer per year.

The programme showed that the household components of homestead vegetables, spices and livestock system had different contributions to the income of small and marginal farmers. The livestock component had the highest contribution (63%), followed by vegetables (27%). The programme demonstrated the potentiality of increasing productivity and farm income through integrated homestead production system (Fig. 2).



Fig. 2. Annual contribution of household components, FSRD site, Muktarpur, Kaliganj, Gazipur, 2022-23

Fisheries

Semi-aquatic production system of vegetables and fish in derelict mini pond

The programme was launched at the FSRD site in Muktarpur, Kaliganj, and Gazipur to boost the productivity of existing ponds as well as farm output and income. Bighead carp, Rohu, Mrigel, Tilapia, and Sorputi fingerlings with an average initial size and weight of 10.23 cm and 13.50 g were supplied in the ponds. The initiative also includes semi-aquatic stolon and aroid production. With no mortality, the stolon production was 3.57 kg/decimal, and the aroid production was 57 pieces per decimal. The farmers sold most of the stolon and aroid and consumed only 6 kg stolon and 30 pieces of aroid for home consumption. The total GM from stolon and aroid was Tk 2,429 decimal.

AED

- 242 Summary**
- 243 Estimation Of Costs And Return Of Mv Rice Cultivation At The Farm Level**
- 246 Adoption Determinants And Profitability Of Stress-Tolerant (Drought) Rice In
Selected Areas Of Bangladesh**
- 250 Effect Of Subsidy On Mechanization In Rice Cultivation: An Evidence From
Combined Harvester In *Haor* Areas**
- 253 Assessment Of Food Security Of Garo Tribe In Selected Areas Of Mymensingh Division**
- 256 Impact Of Poverty Reduction On Nutrition Security In Bangladesh**
- 258 Livelihood Vulnerability To Flood Hazard In Bangladesh**

SUMMARY

The yield of paddy was 4,354, 4,775, and 6,603 kg/ha at the Aus, Aman, and Boro seasons, respectively. Per hectare, gross margin of rice cultivation in Boro season (Tk 71648) was higher followed Aman (Tk 71,335) and Aus season (Tk 48,987). Overall rice cultivation was profitable in the reporting year due to higher yield and market price. Gross profit ratios were 39, 46, and 36 for Aus, Aman, and Boro seasons, respectively. A high-profit ratio is an indication that the farmers sold their produce at a higher market price.

The overall adoption rate of drought-tolerant rice cultivars is relatively low (1.03%), but it varies across different regions. BRRI dhan71 is the most popular drought-tolerant rice variety in Bangladesh. The adoption of drought-tolerant rice varieties is more pronounced in Rajshahi than in Chapainawabganj. The profitability analysis shows that planting drought-tolerant rice cultivars is more profitable than planting other cultivars. The econometric model results indicate that education, land size, training, extension service, participation in field demonstration, membership in any agricultural organization, severity of drought, and total varieties cultivated had a statistically significant effect on the adoption of drought-tolerant rice cultivars. The study suggests that the government should provide subsidies to farmers, conduct awareness campaigns, make drought-tolerant rice varieties more available, and support

research and development of new drought-tolerant rice varieties.

Haor regions are given special attention by the government for its extreme vulnerability and ample scope. Farmers in haor areas have reduced total cost of paddy cultivation by Tk 15,807.04/ha through combined harvesters rather than conventional manual harvesting. Net return and BCR of paddy cultivation reached to Tk 23,610.53/ha and 1.20, respectively for using combined harvester whereas it was only Tk 11,686.36/ha and 1.09, respectively in case of conventional harvesting process. On the other hand, investing in combined harvesters has been appeared as very successful ventures in the study area because of highly positive net present worth (Tk 82,2663.50) and high internal rate of return (58.39%). Owners of combined harvesters are enjoying higher net return as the BCR for them was estimated at 1.51 in the study areas. There is a dearth of detailed investigation about fixation of a justified rental price for combined harvesters to spread out the economic benefit to a large number of user farmers fostering better welfare for the community.

The daily average consumption of rice, vegetables, and milk among the respondents exceeded the national average. The assessment of calorie intake within households revealed that approximately 42% were classified as non-poor, while the remaining 52% were categorized as ultra-poor, hardcore poor, or absolute poor. When evaluating food consumption scores, 53% of the respondents demonstrated acceptable high consumption, while others fell into

categories such as poor consumption, borderline consumption, and acceptable low consumption. Regarding financial aspects, out of a yearly total expenditure of 161,986 taka, a significant portion, equivalent to 56% (or 90,810 taka), was allocated to food expenditures.

For this study, two-period panel data were used and collected from the International Food Policy Research Institute (IFPRI). IFPRI conducted two nationwide surveys covering 6,500 nationally representative sample rural households in Bangladesh between 2011 and 2015. Out of 6,500 rural households, we selected 3,180 rural households in both the 2011 (base) and 2015 (follow-up) periods for achieving the goal of the study. Poisson two-way fixed effect model with the Mundlak approach was used to achieve the set objective. Nutrition security was significantly increased due to the reduction of the poverty gap among households over the periods in different divisions. Agricultural diversity score was also significantly influenced to increase nutrition security. In Bangladesh, at present one of the top policy priorities is to improve food and nutrition security. The poverty gap (increased consumption among poor people up to the poverty line) reduction highly contributed to increasing nutrition security through increasing income.

Assessing the livelihood vulnerability to flood hazards among the households of Kurigram and Jamalpur districts of Bangladesh shows that Kurigram is more vulnerable than Jamalpur. However,

considering the adaptive capacity, LVI-IPCC values show that Jamalpur is more vulnerable than Kurigram. The findings of this study would help to identify the causes of household vulnerability in the study areas and plan for drawing policy options for suitable adaptation to reduce vulnerability.

ESTIMATION OF COSTS AND RETURN OF MV RICE CULTIVATION AT THE FARM LEVEL

Economic decisions are primarily concerned with the most profitable level of input use in the production process. The viability of technology mostly depends on its cost and return. Therefore, it is indispensable to know the cost and return of rice cultivation, where farmers used different types of technologies. Moreover, through the cost and return analysis, researchers and planners can get an indication in developing a technology, which will help the farmers in increasing return and reducing cost. Thus, the present study has been undertaken to assess the profitability of rice cultivation in the country with the following specific objectives.

- Determine the level of inputs used in MV Aus, MV T. Aman and MV Boro rice cultivation.
- Estimate the cost of MV rice cultivation in different seasons; and
- Evaluate the profitability of MV Aus, MV T. Aman and MV Boro rice cultivation at the farm level.

Multistage random sampling technique was adopted to select farmers from all the 14 agricultural regions of Bangladesh. Farm-

level data on input use pattern, prices of inputs and outputs and yields were collected from 210, 280 and 280 farmers for the Aus, T. Aman and Boro season, respectively. Thus, the total respondents were 770 rice-growing farmers. Data were collected through face-to-face interview using a structured questionnaire. Mainly, the descriptive statistical technique was applied to analyze the data, and tabular technique was used to present the results.

Input use pattern. Farmers mainly hired contractual labours for the three major labour-intensive intercultural operations such as transplanting, harvesting and carrying. They also hired labour on a daily

wage basis for other intercultural operations such as land preparation, weeding and post-harvest processing. Besides, most farmers rely on power thresher for threshing rice on a custom hired basis. The highest number of human labour (130 man-days/ha) was used for MV Boro cultivation, followed by MV Aman (115 man-days/ha) and MV T. Aus (110 man-days/ha). (Table 1)

The seed rates for Aus, Aman and Boro were 34, 32 and 34 kg/ha, respectively, indicating that the farmers substantially used a higher amount of seed than BRRI recommended rate (25 to 30 kg/ha). In most of the cases farmers used higher amount of fertilizer than BRRI recommended dose.

Table 1. Per hectare Input used for MV rice cultivation in different season of Bangladesh, 2022-23.

Input item	Season		
	Aus	Aman	Boro
Human Labour (man-day/ha)	110	115	130
Hired	37	39	43
Family	17	18	20
Hired contract (transplanting, weeding and harvesting)	56	58	67
Seed (kg/ha)	34	32	34
Fertilizer (kg/ha)			
Urea	150 (125)	167 (150)	216 (250)
TSP	63 (44)	62 (56)	75 (94)
MoP	66 (67)	93 (75)	91 (123)
DAP	56 (44)	71 (56)	91 (94)
Gypsum	15 (33)	39 (50)	58 (62)

ZnSO ₄	3 (7)	4 (7)	8 (10)
Mg	2	4	5
Theovit	2	5	5

Note: Parentheses indicate average BRRI recommended fertilizer doses (Adhunik Dhaner Chas book, 2022). Source: Field Survey 2022-23

Cultivation costs

Per hectare, human labour costs were Tk 52,503, Tk 56,564 and Tk 70,560 for MV Aus, MV T. Aman and MV Boro rice cultivation, respectively. Fertilizer cost of Boro (Tk 17,559/ha) and T. Aman rice (Tk 9,750/ha) was higher than that of Aus (Tk 7,845/

ha) rice cultivation. Fertilizer cost was a little bit higher due to increase in fertilizer price. Irrigation cost was higher (Tk 25,778/ha) for MV Boro rice cultivation than that of MV Aman (Tk 2,982/ha) and T. Aus (Tk 2,721/ha) (Table 2). Due to lack of rainfall this year farmers had to provide irrigation during Aus season. Irrigation cost has increased due to increase in fuel price. Per hectare total variable cost of Boro rice and T. Aman rice cultivation were higher than in T. Aus season (Table 2).

Table 2. Per hectare cost of MV rice cultivation in different seasons of Bangladesh, 2022-23.

Input-wise cost	Season		
	Aus	Aman	Boro
Seed	2056	2391	3044
Seedling development	2858	3175	3043
Land preparation (ploughing and laddering)	7262	6992	8443
Human labour	52503	56564	70560
Hired	16830	18216	21478
Family	7425	7084	9526
Hired contract	28248	31264	39556
Fertilizer cost	7845	9750	17559
Irrigation	2721	2982	25778
Pesticide	5089	5758	5902
Herbicide	563	1125	1138
Insecticide and Fungicide	4526	4633	4764
Power thresher	4351	4364	4464
Total variable cost	77260	84892	129267
Interest on operating capital	1449	1592	2424
Land rent	25930	27903	28737
Total fixed cost	34804	36579	40687
Total cost	112064	121471	169954

Source: Field Survey 2022-23

Profitability

Per hectare yield of Boro paddy (6,603 kg) was higher, followed by T. Aman rice (4,775 kg) and T. Aus rice (4,364 kg). Due to the favourable climate, low pest and disease infestation and a considerable amount of irrigation facilities in Boro season rice yield was higher compared to the last year. Similarly, per hectare, gross margin of rice

cultivation in Boro season (Tk 71,648) was higher followed by Aman (Tk 71,335) and Aus season (Tk 48,987) (Table 3). BCR based on cash cost was the highest (1.29) in Aman season, followed by 1.18 and 1.13 in Boro and Aus, respectively (Table 3). Gross profit ratios are 39, 46 and 36 for Aus, Aman and Boro, respectively. A high-profit ratio is an indication that the farmers are selling their produce at a high profit level.

Table 3. Per hectare profitability of MV rice cultivation in different seasons in Bangladesh, 2022-23.

Item	Aus	Aman	Boro
Total costs (Tk/ha) (2+3)	112064	121471	169954
Total variable cost (Tk/ha)	77260	84892	129267
Total fixed cost (Tk/ha)	34804	36579	40687
Yield (Kg/ha)	4364	4775	6603
Market value of paddy (Tk/ha) (4*12)	109100	133700	184884
Market value of straw (Tk/ha)	17147	22527	16031
Gross benefit (GB) (Tk/ha) (5+6)	126247	156227	200915
Gross margin (GM) (Tk/ha) (7-2)	48987	71335	71648
Gross profit ratio ((GM*100)/GB)	39	46	36
Net return (Tk/ha) (7-1)	14183	34756	30961
Cost of production (Tk/kg)	26	25	26
Selling price of grain (Tk/kg)	25	28	28
BCR (full cost basis) (7/1)	1.13	1.29	1.18

Source: Field Survey 2022-23

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ADOPTION DETERMINANTS AND PROFITABILITY OF STRESS-TOLERANT (DROUGHT) RICE IN SELECTED AREAS OF BANGLADESH

M S Rahaman, M C Rahman, S A Jui, M A Islam, M A R Sarkar and M S Islam

This study has been undertaken to assess the current level of adoption of climate-resilient rice varieties and the profitability and adoption determinants of rice production in drought-prone regions during the Aman season. This study hopes to facilitate a successful rice revolution and is expected to provide valuable data helpful in formulating an

appropriate policy for the widespread cultivation of rice in drought-prone areas of Bangladesh. Specific objectives are to:

- Determine the adoption status of drought-tolerant rice varieties in the Aman season.
- Compare profitability between drought-tolerant rice varieties and other rice cultivars.
- Identify the factors affecting the adoption decision of drought-tolerant rice varieties.

Study area and data. The sample for this research was chosen using purposive sampling. The study was conducted in two northwestern districts of Bangladesh, namely Rajshahi and Chapainawabganj. Two upazila and four villages were selected from each upazila to conduct the face-to-face interviews. From each upazila, 110 sample farmers were randomly selected, resulting

in a total of 220 farmers interviewed. Profitability was calculated in terms of gross return, gross margin, net return, and the benefit-cost ratio (BCR). This study aimed to identify socioeconomic and demographic factors that affect farmers' decision to adopt drought-tolerant rice varieties during the T. Aman season. Therefore, the probit analysis can provide statistically significant results to identify the factors that influence the farmers to cultivate/adopt drought-tolerant rice cultivars in the Aman season.

Adoption situation of drought-tolerant rice cultivars in Bangladesh

Table 4 shows the adoption (%) of rice cultivars resistant to drought in Bangladesh's various agricultural regions during the Aman season of 2021–2022. In Bangladesh, the overall adoption rate of drought-tolerant rice cultivars was 1.03 percent in the Aman season. Among the different

agricultural regions, the adoption of drought-tolerant rice varieties was the highest in Rangamati (4.97%) followed by Jashore (2.38%), Mymensingh (1.66%), Rangpur (1.59%), Bogura (1.56%), Faridpur (1.44%) and Rajshahi (1.07%). During the Aman season, BRRI and BINA developed (BINADHAN-19, BRRI dhan56, BRRI dhan57, BRRI dhan66, and BRRI dhan71) drought-tolerant rice varieties were cultivated across the country. In 2021-22, among the different drought-tolerant rice cultivars, BRRI dhan71 (0.73%) was the most popular followed by BRRI dhan56 (0.17%) and BRRI dhan57 (0.09%). The table also shows some variation in the adoption of drought-tolerant rice varieties in different regions of Bangladesh. Among the regions, BINA Dhan-19 is the most popular variety in Bogura, whereas BRRI dhan56, BRRI dhan57, BRRI dhan66, and BRRI dhan71 were most popular in Rangamati, Faridpur, Bogura, and Rangamati regions respectively.

Table 4. Adoption (%) of drought-tolerant rice cultivars in different agricultural regions of Bangladesh in the Aman season in, 2021-22.

Varieties	Barishal	Bogura	Chatogram	Cumilla	Dhaka	Dinajpur	Faridpur	Jashore	Khulna	Mymensingh	Rajshahi	Rangamati	Rangpur	Sylhet	Grand Total
Drought tolerant rice	0.35	1.56	0.64	0.13	0.69	0.26	1.44	2.38	0.5	1.66	1.07	4.97	1.59	0.52	1.03
BINADHAN-19	0.03	0.14	-	-	-	-	0.01	-	0.01	-	-	0.08	-	-	0.02
BRRI dhan56	0.04	0.38	-	-	0.08	0.1	0.52	0.09	0.01	0.04	0.16	1.11	0.65	0.1	0.17
BRRI dhan57	0.09	0.38	0.04	-	-	0.12	0.47	0.23	-	0.03	0.01	0.12	0.06	-	0.09
BRRI dhan66	-	0.22	0.1	-	-	0.01	0.03	0.02	0.02	-	-	-	0.01	-	0.03
BRRI dhan71	0.18	0.43	0.51	0.13	0.6	0.04	0.41	2.04	0.46	1.59	0.9	3.65	0.87	0.42	0.73
Grand Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Adoption status of BRRI-developed drought-tolerant rice cultivars in the study area

Table 2 represents the current adoption status of BRRI-developed drought-tolerant rice varieties in the study area in 2022/23. In Rajshahi district, BRRI dhan56, BRRI dhan57, and BRRI dhan71 were cultivated, while in Chapainawabganj, it was

only BRRI dhan71 among BRRI varieties. Also, BRRI dhan71 was the highest (0.95%) adopted variety in Rajshahi, whereas BRRI dhan56 was the lowest. On the other hand, in Chapainawabganj, the adoption of BRRI dhan71 was 0.17%. The yield of BRRI dhan71 was highest in Rajshahi and Chapainawabganj.

Table 2. Adoption (%) of BRRI-developed drought-tolerant rice varieties in the study area in 2022-23.

Varieties	Rajshahi		Chapainawabganj	
	Adoption %	Yield (t/ha)	Adoption %	Yield (t/ha)
BRRI dhan56	0.10	4.562	-	
BRRI dhan57	0.09	4.328	-	
BRRI dhan71	0.95	4.650	0.17	4.851
Drought-tolerant varieties	1.13	4.597	0.17	4.851

Comparative profitability of drought variety in the study area

Profitability

Table 3 shows the per hectare profitability of drought-tolerant and other rice varieties cultivation in Aman season in the study area, 2022-23. In the study area, other popular rice varieties have higher yields than Drought-tolerant varieties. In 2022-23, the average yield of drought-tolerant varieties was 5,313 kg/ha, while the average yield of other varieties was 5,008 kg/ha. Due to the favorable climate, low pest and disease infestation, and considerable irrigation facilities, Aman season rice yield was higher than last year. The table also shows that the profitability of drought-tolerant rice varieties cultivation is higher than the profitability

of other rice varieties cultivation. In 2022-23, the gross margin (GM) of drought-tolerant varieties was 84,416 TK/ha, while the GM of other varieties was 69,523 TK/ha. The net return (NR) of drought-tolerant varieties was 31,051 TK/ha, while the NR of other varieties was 16,236 TK/ha. It's because drought cultivars (including varieties like BRRI dhan51 and Swarna the farmer's opinion these two varieties can cope with drought like other drought varieties) yielded higher than other cultivars. The results also revealed that the BCR (benefit-cost ratio) of drought-tolerant rice varieties cultivation is higher than the BCR of other rice varieties cultivation. In 2022-23, the BCR of drought-tolerant varieties was 1.20 (full cost basis), while the BCR of other popular varieties was 1.16 (full cost basis) (Table 3).

Table 5. Per hectare profitability of drought-tolerant and other popular rice varieties cultivation in Aman season in the study area, 2022-23.

Item	Drought tolerant varieties	Other varieties	Average
Total costs (Tk/ha) (2+3)	152506	152437	152471.5
Total variable costs (Tk/ha)	99141	99150	99145.5
Total fixed cost (Tk/ha)	53365	53287	53326
Yield (kg/ha)	5313	5008	5389
Market value of paddy (Tk/ha) (4*11)	160825	144280	152552
Market value of straw (Tk/ha)	22732	24393	23563
Gross benefit (GB) (Tk/ha) (5+6)	183557	168673	176115
Gross margin (GM) (Tk/ha) (7-2)	84416	69523	76969
Gross profit ratio ((GM*100)/GB)	45.99	41.22	43.60
Net return (Tk/ha) (7-1)	31051	16236	23643

Cost of production (Tk/kg)	28.70	30.44	29.57
Selling price of grain (Tk//kg)	30.27	28.81	29.54
BCR (cash cost basis) (7/2)	1.85	1.70	1.78
BCR (full cost basis) (7/1)	1.20	1.11	1.16

Source: Prepared by authors from survey data 2022-23.

Determinants of Cultivating Drought-Tolerant Rice Varieties

The adoption decision of climate-resilient rice cultivars was influenced by socioeconomic, market, and institutional factors. The factors of education, land size, training, extension service, participation in field demonstration, membership in any agricultural organization, severity of drought, and total varieties cultivated had a positive and statistically significant effect on the adoption of drought-tolerant rice cultivars in the study region. The probability of adopting drought-tolerant rice cultivars will increase by 3.00%, 8.20%, 9.50%, 6.10%, 7.20%, 2.00%, 11.20%, and 1.1% if the farmer's education year, land size, training, extension service, participation in field

demonstration, membership in any agricultural organization, severity of drought, and total varieties cultivated is increased by 1 percent.

On the other hand, price difference and yield difference were found to be statistically significant and negative. This implies that if the price difference and yield difference increase by 1 percent (compared to the other cultivars), the adoption of drought-tolerant rice cultivars will decrease by 3.30% and 18.00% in the study area.

However, the factors age, occupation, family size, family members' involvement in agriculture, market demand, eating quality, credit, and diseases infestation had positive coefficients but were not significant, which implies these variables do not affect the adoption decision of drought-tolerant cultivars in the study area.

Table 6. Estimated probit results for the adoption decision of drought-tolerant rice varieties.

Variable	Coefficient	Standard error	Marginal effect
Age	0.003	0.035	0.001
Education	0.002**	0.001	0.030**
Occupation	0.097	0.085	0.005
Family size	0.022	0.064	0.003
Family members involve in farming	0.155	0.100	0.011
Land size	0.133***	0.040	0.082***
Market demand	0.304	0.359	0.005
Eating quality	0.023	0.031	0.009
Yield difference	-0.371***	-0.072	-0.180***
Distance to UAO	-0.135	-0.092	-0.029
Distance to local market	-0.011	-0.023	-0.003
Training	0.109***	0.038	0.095***
Extension service	0.131**	0.051	0.061**
Participate in field demonstration	0.013**	0.006	0.072**

Membership in any agricultural organization	0.136*	0.079	0.020*
Credit	0.012	0.018	0.011
Severity of Drought	0.132**	0.064	0.112**
Disease infestation	0.027	0.033	0.005
Total varieties cultivated	0.014**	0.008	0.011**
Constant	0.843**	0.376	
Log likelihood	-402.296		
Number of Observation	220.000		
Wald Chi ² (17)	76.480		
Prob> chi ² =	0.000		
Pseudo R ²	0.79		

Note: *, **, and *** mean significant at the 10%, 5%, and 1% probability level, respectively.

Source: Field survey 2022-23

EFFECT OF SUBSIDY ON MECHANIZATION IN RICE CULTIVATION: AN EVIDENCE FROM COMBINED HARVESTER IN HAOR AREAS

L Deb, SMMH Noman and MS Islam

Harvesting of paddy has always been considered as the most challenging operations in *haor* areas due to shortage of labour and acuteness of flash flood. By realizing the fact the government has taken up a project at a cost of Tk 3,020 crore titled ‘Mechanization of Agriculture Work through Integrated Management’ which has targeted to distribute 51,300 units of agro-machinery of 12 categories between 2020-2025. Twelve categories of machinery are being distributed with 70% subsidies in *haor* and coastal areas and 50% subsidy in plains through the project. So far, 25,165 agricultural machinery have been distributed through subsidies under the project, of which 7,256 are combined harvesters. But the ultimate success of this mission is dependent on the economic profitability of user farmers as well as owners of these combine harvesters. Therefore, this study was undertaken to evaluate the economic performance of combined harvester in *haor* areas both from user’s and owner’s perspective.

Sunamganj and Netrakona districts were selected purposively for the study as there are considerable combined harvester operated areas. Data were collected from 120 farmers equally distributed between the two districts, 60 of them harvested their paddy by combined harvester while the rest 60 did it by conventional method. Moreover, 10 combined harvester owners were interviewed through structured questionnaire. Survey method was employed to collect the data both from users and owners which was done during June 2023.

Results and Discussion

Table 7 present the economics of paddy cultivation of farmers using combine harvester and conventional method of harvesting. All the input costs were same in both conventional and combined harvester method of harvesting except harvesting, carrying and threshing, which were higher in case of conventional method. Farmers in *haor* areas had to carry less bulk (without straw) due to using combined harvester, so farmers incurred less carrying cost (Tk 5,426.52/ha) with lower harvesting (Tk 11,601.52/acre) and zero threshing cost. On the other hand, farmers who harvested their paddy by conventional method expensed Tk 21,908.16/ha for harvesting, Tk 6,706.42/ha for carrying and Tk 3,929.55/ha for threshing purpose in the study areas. Farmers incurred the highest proportion of their cost in human labour which were 28.83 % and 32.62% of total cost for conventional method and combined harvester users, respectively.

Table 7. Comparative Economics of rice cultivation of farmers using conventional and Combined harvester method of harvesting, (Tk per hectare).

Particular	Conventional method		Combined harvester	
	Tk/ha	%	Tk/ha	%
Seed	1946.06	1.43	1946.06	1.62
Seedling development	4416.06	3.25	4416.06	3.67
Land preparation (ploughing and laddering)	8652.48	6.36	8652.48	7.19
Human labour: (without harvesting)	39228.61	28.83	39228.61	32.62
Hired	18332.71	13.47	18332.71	15.24
Family	13455.97	9.89	13455.97	11.19
Hired contract	7439.94	5.47	7439.94	6.19
Fertilizer cost	8762.89	6.44	8762.89	7.29
Irrigation	8046.22	5.91	8046.22	6.69
Pesticide	4625.64	3.40	4625.64	3.85
Herbicide	973.03	0.72	973.03	0.81
Insecticide and fungicide	3652.61	2.68	3652.61	3.04
Harvesting	21908.16	16.10	11601.52	9.65
Carrying	6706.42	4.93	5426.52	4.51
Power thresher	3929.55	2.89	0.00	0.00
Total variable cost	108222.09	79.53	92705.99	77.08
Interest on operating capital	2029.15	1.49	1738.24	1.45
Land rent	25822.74	18.98	25822.74	21.47
Total fixed cost	27851.89	20.47	27560.98	22.92
Total cost	136073.98	100	120266.94	100

Total cost varied mainly due to total variable cost which were Tk 1,08,222.09/ha and Tk 92,705.99/ha with manual and combined harvester methods of harvesting respectively. Total fixed cost were Tk 27,851.89/ha and Tk 27,560.98/ha with conventional and combined harvester method respectively, which varied a bit by interest on operating capital only. Total cost for paddy cultivation in the study areas were Tk 1,36,073.98/ha and Tk 1,20,266.94/ha for farmers using conventional method and combined harvester, respectively.

Table 8 presents the results from profitability analysis of paddy cultivation using conventional and combined harvester method. In case of conventional

method, the gross return was Tk 1,47,760.34/ha but it was even lower in case of combined harvester users which was Tk 1,43,877.50/ha exactly. This was because those who harvested their paddy with combined harvester didn't receive any return from straw. However, because of lower variable cost, farmers with combined harvester earned higher gross margin (Tk 51,171.51/ha) as compared to those with conventional method (Tk 39,538.25/ha). Therefore, the cost of production went down to Tk 20.90/kg with combined harvester while it became 23.64/kg in case of manual harvesting. The returns per taka invested were higher in combined harvester (1.20) compared to conventional method (1.09).

Table 8. Profitability of paddy cultivation using conventional vs. combined harvester method.

Particular	Conventional method	Combined harvester
Total costs (Tk/ha)	136073.98	120266.97
Total variable costs (Tk/ha)	108222.09	92705.99
Total fixed cost (Tk/ha)	27851.89	27560.98
Yield (Kg/ha)	5755.10	5755.10
Market value of paddy (Tk/ha)	143877.50	143877.50
Market value of straw (Tk/ha)	3882.84	0.00
Gross return (GB) (Tk/ha)	147760.34	143877.50
Gross margin (GM) (Tk/ha)	39538.25	51171.51
Gross profit ratio ((GM*100)/GB)	26.76	35.57
Net return (Tk/ha)	11686.36	23610.53
Cost of production (Tk/kg)	23.64	20.90
Selling price of grain (Tk/kg)	25.00	25.00
BCR (full cost basis)	1.09	1.20

Before making a choice on any enterprise, it becomes necessary to examine the economic feasibility of that enterprise. Several techniques are available for evaluating the economic viability of paddy combine harvester. For this study project evaluation techniques like discounted measures namely net present worth, benefit cost ratio and internal rate of returns were employed to examine the economic feasibility of investment on Paddy combine harvester. Table 9 portrays the economic feasibility of investment on combined harvester at 12 percent discount rate. The basic data presented were collected from the combined harvester owners. Economic life span of new combined harvester was assumed to be five years based on several expert opinions. The price of combined harvesters varies from Tk 25,00,000 to 38,00,000 but for our study the average price of combined harvester was observed as Tk 36,00,000. Thus, the average initial investment for a combined harvester

was Tk 5,00,000. It is to be noted that the 70% of the machine's worth was paid by the government but there is a ceiling amount for this subsidy which is about Tk 23,00,000. Apart from the initial down payment, owner farmers had to pay back the rest of the money mostly in three installments i.e. by the second year of their initial investment. Therefore, cash outflow started to diminish after second year as there were no installment payment involved but as long as the machine get older the maintenance costs assumed to be higher. It is evident from the table 9 that the net present value was positive and high enough (Tk 8,22,663.50) at 12% discount rate. This high positive net present worth even at higher discount rate indicated the soundness of the investment made in maintaining the combine harvester as entrepreneur. Again, the internal rate of return was found to be 58.39% which was much higher than the existing bank rate of interest on long term loans and hence the combine harvester as an enterprise is economically well feasible.

Table 9. Economic feasibility of investment on combined harvester at 12 percent discount rate.

Year	Cost	Gross return	Net return	Discount factor	NPW
0	-500000	0	-500000	1.000	-500000.000
1	1225000	1500000	275000	0.893	245535.714
2	1350000	1500000	150000	0.797	119579.082
3	980000	1600000	620000	0.712	441303.754
4	1025000	1440000	415000	0.636	263740.003
5	995000	1440000	445000	0.567	252504.951
NPW					822663.50
IRR					58.39%

Table 10. Estimation of BCR at 12 percent discount rate.

Year	Cost	Gross return	Discount factor	Present worth of costs	Present worth of gross return
0	-500000	0	1.000	-500000	0
1	1225000	1500000	0.893	1093750	1339285.714
2	1350000	1500000	0.797	1076211.735	1195790.816
3	980000	1600000	0.712	697544.6429	1138848.397
4	1025000	1440000	0.636	651406.0304	915146.0329
5	995000	1440000	0.567	564589.7214	817094.6722
Total				3583502.129	5406165.632
BCR					1.51

From the Table 10 it is also observed that the benefit cost ratio was 1.51 for the owners of combined harvester which is quite higher. It is apparent that the returns per taka invested were much higher in case of combined harvester owners than that of user farmers. All of these project evaluation metrics show that the investment in the combine harvester business is highly profitable. Attention is needed to make the combined harvesters more profitable for user farmers by setting up a justified fixed rental price for them. More intensive studies are inevitable to get better insights into the facts. Paddy cultivation still involves huge number of human labour especially in operations like transplanting and harvesting while mechanization is considered to be the best solution in this regard. The cost of cultivation is less if farmers use combined harvester so as the return go higher. Again, despite certain

limitations and abundant of risk factors, investment in combined harvester is still very much profitable endeavour as an entrepreneur, which results higher return than many other current ventures. It is worth mentioning that there is a lack of thorough research into setting a fair rental rate for combine harvesters in order to distribute the economic gain among many user farmers and improve community welfare.

ASSESSMENT OF FOOD SECURITY OF GARO TRIBE IN SELECTED AREAS OF MYMENSINGH DIVISION

S M M H Noman, L Deb, S A Jui, M A Islam, and M S Islam

It is increasingly recognized that Indigenous populations may experience food insecurity differently than non-Indigenous peoples do. Food

insecurity is defined as ‘limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways’. Some analyses of food insecurity among Indigenous populations appear to minimize or overlook the contexts of state–Indigenous relations, colonization, settlement or land alienation, marginalization, cultural trauma, and discrimination that are typically seen as essential for understanding contemporary challenges facing Indigenous peoples. Some researchers examined food insecurity in Asia with no mention of cultural dislocation, forced assimilation, or other aspects of political violence experienced by Indigenous populations. This study aims to reveal (i) the calorie intake level of the sample households and (ii) the food consumption score of the Garo tribe.

This study involved interviews with 105 households, comprising 45 Garo households from Haluaghat upazila in Mymensingh and 60 Garo households from Jhinaigati upazila in Sherpur. To assess the calorie intake of the sampled households, we

analyzed their food consumption data over a period of seven days. We determined the calorie intake on a per person per day basis. To achieve this, we standardized the consumption of each food item by converting it to the equivalent of 100 grams of that item. Food consumption score was measured using the frequency of consumption of different food groups consumed by a household during the seven days before the survey. Using standard vulnerability analysis and mapping (VAM) 7-day food frequency data group observed all the food items into specific food groups.

Results and discussion. The figure showing bar chart presents a comparison between the national average food consumption and the average food consumption observed in the study among Garo households. In the studied areas, consumption of rice, pulse, vegetables, and milk was higher than the national average consumption. Figure 1 presents intake of different food items per person day in Mymensingh and Sherpur areas.

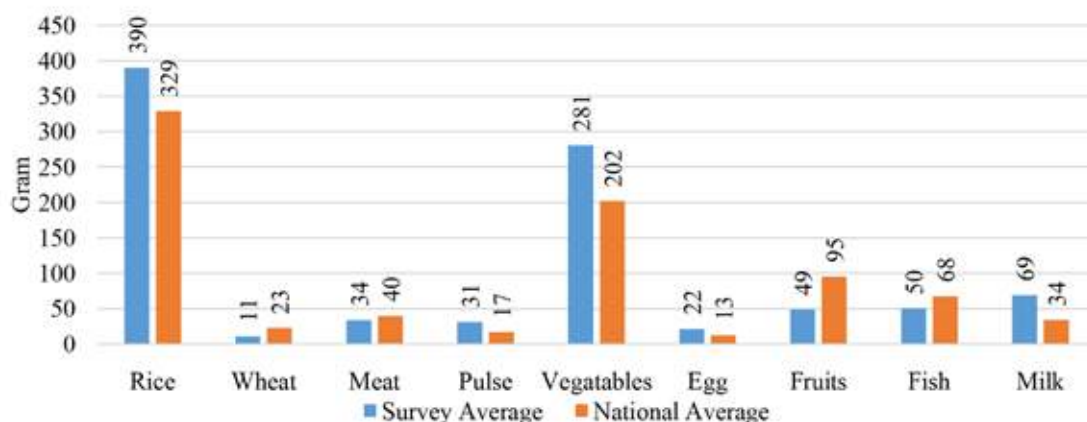


Fig. 1: Food Intake in Mymensingh and Sherpur (Gram per capita per day)

Source: Field survey, 2023 and HIES 2022

Around 42% Garo households fell in non-poor category while the rest of the 58% households fell

in other three categories (Table 11). Sherpur district (46.67%) had higher number of non-poor than Mymensingh district (35.56%).

Table 11: Calorie intake.

Category	Caloriy (K/Cal)	Number of respondent	Mymensingh	Sherpur
Ultra poor	<1600	5 (4.76%%)	2 (4.44%)	3 (5%)
Hardcore poor	1600-1804	16 (15.24%)	8 (17.78%)	8 (13.33%)

Absolute poor	1805-2121	40 (38.10%)	19 (42.22%)	21 (35.00%)
Non-Poor	>2122	44 (41.90%)	16 (35.56%)	28 (46.67%)

Source of the categories: World Food Programme, 2009

Table 12 illustrates that 1.90% of respondents had poor food consumption. Around 78% Garo

household of Mymensingh had acceptable high consumption while it was only 35% in Sherpur district.

Table 12. Food Consumption Score (FCS).

Profile	No. of respondent	Mymensingh	Sherpur
Poor consumption (≤ 28)	2 (1.90%)	0 (0%)	2 (3.33%)
Borderline consumption (>28 and ≤ 42)	20 (19.05%)	4 (8.89%)	16 (26.67%)
Acceptable consumption low (>42 and ≤ 52)	27 (25.71%)	6 (13.33%)	21 (35.00%)
Acceptable consumption high (>52)	56 (53.33%)	35 (77.78%)	21 (35.00%)
Total	105	45	60

Source of consumption classification: World Food Programme, 2009

Table 13 provides a comprehensive overview of the annual expenditures among Garo tribal households across various categories. Notably, the largest share, comprising 56.06% of their total yearly expenditure

amounting to Tk 161,986, is directed toward food consumption, highlighting its paramount importance. Following closely, the second-highest expenditure is directed towards the education of Garo children, signifying a strong commitment to their development, with an annual spending of Tk 22,402, equivalent to 13.83% of the budget.

Table 13. Average annual household expenditure.

Items	Mymensingh	Sherpur	Avg. expenditure
Food	102161	82297	90810 (56.06%)
Clothing	6460	7950	7311 (4.51%)
Housing	1467	1483	1476 (0.91%)
Education of children	21567	23028	22402 (13.83%)
Health care	6164	12602	9843 (6.08%)
Crop cultivation	19333	16550	17743 (10.95%)
Domestic animals, poultry	3433	1208	2162 (1.33%)
Parents	1633	3242	2552 (1.58%)
Relatives	1067	1448	1285 (0.79%)
Allowance for children	1689	3625	2795 (1.73%)
Social Activities	476	1172	873 (0.54%)
Transport and Travelling	1822	3417	2733 (1.69%)
Total	167272	158022	161986

Household income among the Garo people is multifaceted. According to the data presented in table

14, the primary contributor to the annual income, at 30.63%, is the employment of the household head,

amounting to Tk 57,771. Another substantial portion of their annual income, approximately Tk 19.65% or Tk 37,062, is derived from cultivating crops.

Table 14: Average annual household income

Item	Mymensingh	Sherpur	Avg. annual income
Crop cultivation	38478	36000	37062 (19.65%)
Selling domestic animals	24733	23300	23914 (12.68%)
Selling poultry	3756	5850	4952 (2.63%)
Income from occupation	59044	56817	57771 (30.63%)
Investment on petty business	33	4833	2776 (1.47%)
Local remittance from husband/wife	43867	22633	31733 (16.82%)
Money received from earning son/daughter	24156	27550	26095 (13.83%)
Help from parents	1222	0	524 (0.28%)
Help from relatives	4111	1000	3810 (2.02%)
Total	199400	177983	188638

The Garo community encounters a multitude of challenges concerning their food security and dietary practices. The recurrent incursions of elephant herds from the Indian border region have led to the consumption and destruction of a wide range of crops, both in the fields and within their homestead areas. Tragically, these encounters sometimes result in the loss of lives among the ethnic Garo population due to wild elephant attacks. Additionally, the insufficient access to irrigation water poses a significant crisis, causing disruptions in their agricultural production. To ensure greater food security for the Garo people, it is imperative to address these issues. This entails making the border areas safe for the ethnic Garo community and enhancing irrigation facilities to promote agricultural productivity.

IMPACT OF POVERTY REDUCTION ON NUTRITION SECURITY IN BANGLADESH

M A Islam, M C Rahman, M S Rahaman, and M S Islam

Bangladesh made significant progress in reducing poverty and malnutrition over the past two decades, yet many indicators of food insecurity and malnutrition remain high (HIES, 2016). The nature of malnutrition has significant long-term implications for the country's economic

development. It is presumed that Bangladesh would face enormous challenges in achieving nutrition security and ensuring food security for all individuals and groups in the country if the country cannot implement a sustainable development goal (SDG) by 2030. Although Bangladesh has achieved remarkable progress in food security in terms of access, nutrition security is still a central problem for heterogeneous farm households. However, this study aims to investigate whether the reduction of poverty increased the nutrition security status of rural farmers in Bangladesh using panel data and to draw some policy recommendations from the findings.

For this study, two-period panel data were obtained from the International Food Policy Research Institute (IFPRI). IFPRI conducted two nationwide surveys covering 6,500 nationally representative sample rural households in Bangladesh between 2011 and 2015. Out of 6,500 rural households, we selected 3,180 rural households in both the 2011 (base) and 2015 (follow-up) periods for achieving the goal of the study.

In the context of measuring poverty in a population, the indices in Foster *et al.* (1984) are commonly used which is expressed as:

.....(1)

where Z is the agreed-upon poverty line (US\$ 1.90/capita/day) converted to Bangladeshi taka, N is the total household population, y_i is household expenditure per capita for the i^{th} person and is a poverty aversion (sensitivity) parameter. When $\alpha = 1$, it is a measure of the poverty gap (Islam 2018). The study used the international poverty line of US\$ 1.90/capita/day for 2011-12 and 2015 (2011-12: base period). Real per capita household expenditure was used for measuring poverty up to March 2023 using the consumer price index.

The majority of the previous studies have employed household dietary diversity score (HDDS) as an indicator of nutrition security. In this study, we also used it for addressing nutrition security in developing countries like rural Bangladesh.

In this study, Poisson two-way fixed effect regression was used:

$$HDDS_{it} = \alpha + \beta_1 X_{it} + \beta_2 Z_{it} + \beta_3 C_{it} + \beta_4 \epsilon_{it} \quad (2)$$

Where HDDS is the respective outcome variable (household dietary diversity score). X_{it} is a vector of explanatory variables that influences the outcome variable, and it includes the poverty gap index (PGI), household socioeconomic, farm and contextual characteristics, and crop diversity score. β as the respective vectors of parameters to be estimated. C_{it} and ϵ_{it} represent unobserved individual and time-specific effects respectively, and is the error term. For addressing unobserved heterogeneity problems, we used the Mundlak approach. Our dependent variable is a count variable, so the Poisson two-way fixed effect model is a natural starting point. The log-linear model form of the Poisson regression model can be depicted as:

$$HDDS_{it} = \exp(\alpha + \beta_1 X_{it} + \beta_2 Z_{it} + \beta_3 C_{it} + \beta_4 \epsilon_{it}) \quad (3)$$

Results and discussion. Data in Table 15 shows that the agricultural diversity score (ADS) significantly increased the household dietary diversity score (HDDS). The magnitude of this variable was between 5.0 % to 12.1% higher in 2015 compared to the base period (2011) in different divisions in Bangladesh. It might be due to crop diversification projects implemented by the government. Similarly, if the poverty gap decreases, then nutrition security (HDDS) increases substantially from the base period (2011) to the follow-up period (2015). However, the magnitude of the increase was between 15.8% to 33.20% higher than the base period in different divisions in Bangladesh. Private Public Partnership (PPP) has been tried for the last two decades to reduce poverty among Bangladeshi people due to exploring different income-generating/earning works in different divisions as well as different districts of Bangladesh.

The analysis further showed that the level of household old age-dependent family members' food consumption significantly decreased, and the magnitude was about 9.8%% lower in the follow-up period than in the base period in the Barishal division. The family size of the households significantly increased nutrition security in Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet divisions over the years. The magnitude was between 0.09% to 2.80% higher in the follow-up period compared to the base period. HDDS increased significantly when minimizing the gender parity gap among rural farmers (both husband and wife), and the magnitude was 15.30% higher in the follow-up period than in the base period in the Sylhet division. The time lag also increased nutrition security over the years from 2011 to 2015.

Table 15. Estimated two-way fixed effect Poisson regression results of poverty impact on nutrition security in different divisions of Bangladesh (2011 to 2015).

Variable name	Barishal	Chattogram	Dhaka	Mymensingh	Khulna	Rajshahi	Rangpur	Sylhet
Dependent variable:	HDDS	HDDS	HDDS	HDDS	HDDS	HDDS	HDDS	HDDS
Agricultural diversity score	0.121***	0.050***	0.091***	0.106***	0.093***	0.096***	0.093***	0.091***
Market access (Access=1)	0.000*	0.000ns	0.000ns	0.000ns	0.000ns	0.000ns	-0.000ns	-0.000ns

Variable name	Barishal	Chattogram	Dhaka	Mymensingh	Khulna	Rajshahi	Rangpur	Sylhet
Dependent variable:	HDDS	HDDS	HDDS	HDDS	HDDS	HDDS	HDDS	HDDS
Poverty gap index	-0.159***	-0.332***	0.224***	-0.157***	-0.158***	-0.216***	-0.268***	-0.313***
Head age (year)	-0.000ns	-0.000ns	-0.000ns	0.001ns	0.002ns	-0.000ns	0.000ns	0.000ns
Young dependency	0.006ns	-0.022ns	-0.003ns	-0.004ns	0.001ns	0.018ns	0.027ns	-0.009ns
Old age dependency	-0.098***	-0.026ns	-0.025ns	-0.005ns	-0.003ns	0.011ns	0.013ns	0.035ns
Farm size (ha)	0.000ns	0.000ns	0.000ns	0.000ns	0.000ns	-0.000*	-0.000ns	-0.000ns
Number of houses owned	-0.083ns	0.027ns	0.013ns	0.074ns	0.019ns	-0.005ns	-0.002ns	-0.005ns
Family size	0.018ns	0.014ns	0.015**	0.006ns	0.016*	0.009*	0.028*	0.024***
Gender parity gap	-0.014ns	0.029ns	0.0123ns	0.029ns	-0.019ns	-0.027ns	0.011ns	-0.153***
Time dummy (base:2011)	-0.014ns	0.028*	0.036***	0.036**	0.023**	0.018ns	0.011ns	0.016ns
Diagnostic statistics								
Log pseudolikelihood	-550.910	-541.427	-1793.010	-573.839	-1156.764	-618.570	-496.251	-526.724
Wald Chi2(11)	78.06	168.17	413.18	96.74	193.58	115.33	117.83	184.94
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sample size	620	600	2004	640	1294	694	556	592

Note: Bootstrapped standard error with 1000 replication was considered. Data was updated to March 2023 using the consumer price index.

In summary, nutrition security was significantly increased due to the reduction of the poverty gap among households over the periods in different divisions. Agricultural diversity score was also significantly influenced to increase nutrition security. In Bangladesh, at present one of the top policy priorities is to improve food and nutrition security. The poverty gap (increased consumption among poor people up to the poverty line) reduction highly contributed to increasing nutrition security. Apart from poverty gap reduction, higher agricultural diversity is frequently theorized to contribute to better food and nutrition results, including increased dietary diversity (Islam et al. 2018). Other factors like family size, time lag, and closing the gender parity gap among farm households can improve dietary diversity in Bangladesh. Policy actions are required to increase income-generating activities that can help to purchase nutritious foods at any time. Reduce transaction costs and encourage increased

agricultural commercialization. The policy is needed to lower the cost of accessing credit, quality inputs, and research and development (R and D) to support intensification and diversification in low-productivity agricultural systems. To modernize agricultural systems, it is also necessary to correct rice, wheat, and maize subsidies to create a crop-neutral agricultural policy that encourages farm-level diversification. Women's empowerment might continue to play an essential role in resolving gender-specific access issues, especially in deciding agricultural production, use of resources, income, take leadership, and effective time allocation.

LIVELIHOOD VULNERABILITY TO FLOOD HAZARD IN BANGLADESH

M C Rahman, M S Rahaman, M A Islam, M S Islam, J C Biswas, M Maniruzzaman

Bangladesh is one of the world's most susceptible nations to climate change. Extreme events

connected to climate change are becoming more frequent and intense every day. Bangladesh clearly counts as a low-lying country given its location at the base of the Himalayas. Numerous factors, such as heavy rainfall, the melting of Himalayan snow, hydrographic changes within the Brahmaputra basin, and declining river carrying capacity, make it susceptible to flooding. The most common natural disaster that the country experiences is flooding. Therefore, this study estimated the livelihood vulnerability index (LVI) based on the impact of flood vulnerability on rural livelihoods in the northern areas of Bangladesh, where floods affect almost every year.

A multistage sampling technique was employed for selecting the sample households from the flood-prone Kurigram and Jamalpur districts of Bangladesh. A well-structured questionnaire was used to conduct face-to-face interviews among the 200 selected households. The well-known LVI-IPCC approach was used to analyze the collected data for vulnerability assessment.

The estimated results show that the study areas are highly vulnerable to floods (LVI: 0.402). Whereas, Kurigram is more vulnerable (LVI: 0.415) than Jamalpur (0.390). Considering the IPCC contributing factors, Kurigram has higher sensitivity

and exposure than Jamalpur. However, the adaptive capacity of Jamalpur is less than Kurigram. Therefore, the LVI-IPCC index shows that Jamalpur is more vulnerable than Kurigram (Table 16).

Table 16: IPCC contributing factors to the LVI.

I P C C contributing factor	IPCC contributing factor value		
	Jamalpur	Kurigram	Overall
A d a p t i v e capacity	0.333	0.369	0.351
Sensitivity	0.362	0.374	0.368
Exposure	0.587	0.606	0.596
LVI	0.390	0.415	0.402
LVI-IPCC	0.092	0.089	0.090

This study investigated the livelihood vulnerability to flood among the Kurigram and Jamalpur districts of Bangladesh. The LVI values show that Kurigram is more vulnerable than Jamalpur. However, considering the adaptive capacity, LVI-IPCC values show that Jamalpur is more vulnerable than Kurigram. The findings of this study would help to identify the causes of household vulnerability in the study areas and plan for drawing policy options for suitable adaptation to reduce vulnerability.

Agricultural Statistics Division

262	Summary
263	Stability Analysis Of Brri Varieties
266	Comparative Study For Rice Yield Estimation By Adjusting Moisture Content
268	Genotype × Environment Interaction Of Brri Varieties
277	Maintenance Of Rice And Related Database
278	Minimizing Agro Micro Climatological Risk Factors For Maximizing Sustainable Rice Production In Bangladesh
279	SUITABILITY MAPPING OF BRRI RELEASED VARIETIES
280	Climate Mapping Of Temperature And Rainfall Of Bangladesh
281	Season Wise Rice Area Mapping Of Bangladesh
281	Projected Climatic Factors (2050) Maps Of Bangladesh
283	Suitability Mapping Of Various Cropping Pattern
285	Capacity Building Through Training
286	Develop A Web Application To Calculate The Stability Index For Brri Stability Model
286	Establishing A Platform For Brri Developed Management Information System (Mis)
287	Digitalized Budget Management System Of Brri
287	Digitalized Quota Management System Of Brri
288	Digitalized Salary Management System Of Brri
288	Digitalized Labour Management System Of Brri
288	Digitalized Casual Leave Application System
288	Information And Communication Technology (Ict) Activities

Summary

T. Aman varieties BRRI dhan49 and BRRI dhan87 were found stable. None of the varieties were found to be unstable in T. Aman season. Among the aromatic rice BRRI dhan5, BRRI dhan34, BRRI dhan37 and BRRI dhan38 were found as below average stable in T. Aman season. Boro varieties, BRRI dhan89, BRRI dhan92, BRRI dhan29 and BRRI hybrid dhan3 were found stable. None of the varieties were found to be unstable in Boro season. On the other hand, only aromatic rice varieties BRRI dhan50 appeared to below average stable.

Results found that during yield estimation from crop cut samples, most of the cases had found significant overestimation. The change of initial moisture, moisture reduction and dust significantly increased overestimation with a rate of change 0.701, 0.859 and 0.818 percent, respectively. In most of the varieties a significant variation of the overestimation was found in crop cut sampled in sundry method. The highest and lowest overestimations observed were 7.08 and 23.08%, respectively for sundry methods. The average overestimation (%) for sundry sampled observed was 15.91%.

The highly significant genotype $\times$ environment interaction effects for grain yield confirmed that genotypes responded differently to the variation in environmental conditions for long, medium and short duration Aman varieties. Greater portion of total variation was explained by environmental main effect indicating that the environments were diverse and a major part of variation in grain yield reflected from environmental changes. In Aman season, BR11 and BRRI dhan30 recorded the highest average grain yielder and ideal genotypes among long duration varieties. BRRI dhan49, BRRI dhan93 and BRRI dhan94 were the most stable genotype with above-average yield in medium duration where BRRI dhan71, BRRI dhan72, BRRI dhan87 and BRRI dhan95 were the most stable genotypes and above average yielder for short duration.

Utilizing a multi-trait stability index, we assessed the performance of rice varieties across different factors. For instance, in the case of FA1, factors like

GY, TN, and PN identified BRRI dhan87, BRRI dhan79, and BRRI hybrid dhan4 as top performers, with FA1 contributing less than 0.25 to their performance. Out of the 47 varieties, BR10, BR22, BRRI dhan44, BR11, BRRI dhan51, BRRI dhan87, BRRI dhan30, BRRI dhan46, BRRI dhan41, BRRI dhan49, and BRRI dhan79 were selected using MTSI at a 30% selection intensity.

Rice area increased about one and half folds but the production increased about four folds during 1971-72 to 2021-22. Although the growth rate of rice area was 3.96 in year 1972-73 but in 2021-22 is -0.95. Similarly, growth rate of rice production was 1.30 in year 1972-73 but in 2021-22 is 8.91.

For reducing micro climatological risk factors weather-based rice advisory system considers and manages the full spectrum of risks from weather extremes or climate variability. This novel approach can help rice growers in a better and more coordinated way in response to weather extremes or climate variability that exceeds their inherent coping capacity. This can significantly reduce the disaster risk of the rice farming communities, which is a major development challenge in Bangladesh.

In Boro season, BRRI dhan96 is suited in all regions of Bangladesh. Whereas BRRI dhan97 and BRRI dhan99 are suitable for saline regions. In T. Aus seasons BRRI dhan98 is appropriate for western, region of Bangladesh.

More or less throughout the year eastern side of Bangladesh is high rainfall and low temperature area and western side is low rainfall and high temperature area. Spatial distribution of minimum temperature and total rainfall are more or less same but maximum temperature is vice-versa to minimum temperature and total rainfall.

During Aman 2022 about 5.82 Mha of rice was cultivated in Bangladesh and highest Aman production district was Dinajpur.

In all divisions of Bangladesh average total precipitation of July month in 2050 will be increased in comparison to average total precipitation during 2010-2018, only exception is Chattogram division, where precipitation will be decreased by about 69 mm. The precipitation of July month will rise the

highest in Sylhet and Mymensingh divisions with an amount of about 59 mm and 53 mm, respectively.

Boro-Fallow-T.Aman cropping pattern is suitable in west and middle part of Bangladesh and total suitable area is 3.85 Mha. Boro-Aus-T.Aman cropping pattern cover total suitable area 1.09 Mha and these suitable area in north-west and central northern sides of Bangladesh. Boro-Jute-T. Aman is suitable in north-west and central northern sides of Bangladesh. Total suitable area is 1.81 Mha

The evolution of rice cultivation areas in Babuganj upazila over three years has manifested several significant transformations, shedding light on the dynamic nature of agricultural practices and land usage in the region. There was a remarkable growth in newer rice cultivation zones, predominantly originating from fallow lands.

In the reporting year, two types of training were conducted under Capacity Building through Training programme. A total of 60 participants were trained through the training programmes. The participants of these training were scientists SA, FM and AFM of BRRI.

Seven activities have been done in the reporting year 2022-23 under the project computer programming, software development and Digitization. A new web application has been developed to calculate the stability index for BRRI stability model. A nique platform for BRRI developed all the Management Information System (MIS) has also been developed. Five web applications have been updated and continuously run in the whole reporting year named (1) Salary Management System for BRRI HQ (2) Labour Management System for BRRI HQ (3) Budget Management System (4) Quota Management System and (5) CL Application Management System for Agricultural Statistics Division of BRRI.

ICT cell of this division has developed Sensor-based rice pest management through artificial intelligence (AI) technology 'Rice Solution' mobile App and Rice profiling App. It has developed 'BRRI Rice doctor' mobile and web apps both English and Bengali versions with the help of BRRI different divisions. A developed dynamic view connectivity,

Bangla search and inner banner system for BRKB web apps has been developed. Besides, modified the RKB mobile apps and disseminate of modern rice technology and its management information at the farmers door step through RKB Mobile Apps. We developed vehicle requisition management system (VRMS) of BRRI. So that, the requester get informed through SMS on basis of demanding vehicle for official or personal purpose as well as driver get confirmation SMS for their upcoming duty. Also, we developed BRRI Alapon Telephone Directory Mobile App. We established video conferencing system (VCS) at BRRI to communicate with MoA and other government organizations. We organized five-day-long, two day-long, day-long 'Public Service Innovation' training workshops in the reporting year. A total of 400 participants were trained through the innovation, SPS trainings and e-Nothi in-house trainings. In addition, cyber security system has been strengthened for BRRI.

STABILITY ANALYSIS OF BRRI VARIETIES

The main objectives of the study were to determine the stability index of BRRI released varieties, maintain season, year and location-wise database and identify the bio-physical and socio-economic factors causing instability. Experiments are being conducted in T. Aman season with BRRI released rice varieties since 2001-2021 at Gazipur and different regional stations. The collaborative regional stations in the T. Aman season are Rajshahi, Rangpur, Cumilla, Sonagazi, Barishal, Satkhira and Kushtia and in the Boro season Rajshahi, Rangpur, Cumilla, Habiganj, Barishal, Bhanga, Satkhira, Sonagazi and Kushtia. The numbers of varieties we worked on are 47 and 49 in T. Aman and Boro season respectively. The design was RCB with three replications and the effective plot size (harvest area) was $3 \times 2 \text{ m}^2$, leaving the two-border row from each side. Recommended crop management practices were followed. Stability analyses of the experimental data were performed by using a newly developed model. The model deals with the performance of the genotypes across the geographical locations differing in land, soil and other biotic and abiotic factors over the years characterizing fluctuation of weather variable, floods, drought etc.

Variety	Stability parameter 2001-2022			Stability index	Stability rank	Nature of stability
	Si	Di	Pi	Gi	Ri	
Non-aromatic rice						
BR 3	18.117	-9.32	95	0.833	37	BAS
BR 4	13.228	0.464	84	1.26	23	AS
BR 10	13.902	8.493	76	1.406	17	AS
BR 11	14.13	8.126	89	1.461	13	AS
BR 22	14.082	6.382	88	1.411	16	AS
BR 23	15.812	1.576	87	1.18	28	AS
BR 25	15.741	-0.714	89	1.142	30	AS
BRRi dhan30	12.967	6.887	91	1.516	10	AS
BRRi dhan31	13.756	2.392	92	1.319	21	AS
BRRi dhan32	15.931	7.127	95	1.395	18	AS
BRRi dhan33	21.051	-11.297	85	0.645	40	BAS
BRRi dhan39	17.533	-1.656	78	0.975	35	BAS
BRRi dhan40	14.252	5.914	90	1.413	15	AS
BRRi dhan41	16.423	3.743	92	1.247	24	AS
BRRi dhan44	14.363	7.064	61	1.356	19	AS
BRRi dhan46	15.744	1.195	62	1.159	29	AS
BRRi dhan49	10.889	12.27	57	2.101	1	S
BRRi dhan51	16.364	4.939	48	1.234	25	AS
BRRi dhan52	11.269	9.57	53	1.713	5	AS
BRRi dhan53	14.355	2.467	44	1.271	22	AS
BRRi dhan54	18.226	5.502	46	1.233	26	AS
BRRi dhan56	17.048	-6.152	48	0.944	36	BAS
BRRi dhan57	20.737	-18.789	47	0.46	42	BAS
BRRi dhan62	27.497	-20.289	41	0.322	45	BAS
BRRi dhan66	13.156	4.925	35	1.428	14	AS
BRRi dhan70	18.464	-8.697	26	0.717	39	BAS
BRRi dhan71	13.553	8.798	32	1.52	9	AS
BRRi dhan72	11.515	14.328	27	1.736	4	AS
BRRi dhan73	16.139	4.452	35	1.32	20	AS
BRRi dhan75	17.027	1.393	29	1.102	32	AS
BRRi dhan76	16.363	-5.155	35	1.03	34	AS
BRRi dhan77	13.953	-5.529	31	1.063	33	AS
BRRi dhan78	13.044	7.117	23	1.504	12	AS
BRRi dhan79	10.229	10.645	21	1.778	3	AS
BRRi dhan80	12.369	5.711	23	1.505	11	AS
BRRi dhan87	12.94	19.709	24	2.015	2	AS
BRRi dhan90	18.044	-8.215	13	0.826	38	BAS
BRRi dhan91	17.852	-34.166	15	0.129	47	BAS
BRRi dhan93	11.207	12.708	11	1.692	6	AS
BRRi dhan94	14.319	11.929	13	1.545	8	AS
BRRi dhan95	19.645	5.373	11	1.104	31	AS
BRRi Hybrid dhan4	17.356	4.951	36	1.211	27	AS
BRRi Hybrid dhan6	15.269	16.185	28	1.662	7	AS
Aromatic rice						
BR 5	19.67	-23	87	0.354	44	BAS
BRRi dhan34	20.805	-25.718	90	0.259	46	BAS
BRRi dhan37	18.244	-23.275	92	0.399	43	BAS
BRRi dhan38	17.008	-20.359	88	0.508	41	BAS

Note: AS=Average stable, BAS=Below average stable, Stable=S and Unstable=US

Table 1. Stability parameters of grain yield for T. Aman.

PI: -MIH, **CI:** MSK, NMFR, MAQ, MAA, MAAM, MSR, KMI, MHK One scientist from each RS

Variety	Stability Parameter 2001-2023			Stability Index	Stability Rank	Nature of Stability
	Si	Di	Pi			
Non-Aromatic Rice						
BR 1	11.437	-5.749	93	0.939	36	BAS
BR 2	12.585	-9.609	99	0.724	46	BAS
BR 3	10.083	-0.894	102	1.315	19	AS
BR 6	12.993	-7.574	98	0.786	44	BAS
BR 7	12.422	-7.822	103	0.835	41	BAS
BR 8	13.007	-5.361	95	0.875	39	BAS
BR 9	10.707	1.463	102	1.376	15	AS
BR 12	11.297	-8.445	98	0.851	40	BAS
BR 14	9.645	-0.608	103	1.37	16	AS
BR 15	11.474	1.124	103	1.314	20	AS
BR 16	12.487	0.155	96	1.165	28	AS
BR 17	20.13	-11.924	93	0.315	48	BAS
BR 18	10.936	-8.197	100	0.89	38	BAS
BR 19	12.022	-4.458	92	0.96	35	BAS
BR 26	10.715	-6.759	105	0.998	32	BAS
BRRi dhan27	12.421	-7.501	93	0.798	43	BAS
BRRi dhan28	12.202	0.13	97	1.189	25	AS
BRRi dhan29	9.825	12.317	106	2.001	4	S
BRRi dhan35	11.741	-4.33	94	0.996	33	BAS
BRRi dhan36	11.611	-3.402	100	1.068	30	AS
BRRi dhan45	13.677	-6.682	79	0.806	42	BAS
BRRi dhan47	9.884	-1.374	65	1.292	21	AS
BRRi dhan55	10.33	1.454	59	1.464	14	AS
BRRi dhan58	10.475	7.051	57	1.696	6	AS
BRRi dhan59	11.999	-2.247	55	1.173	27	AS
BRRi dhan60	12.237	-0.964	50	1.174	26	AS
BRRi dhan61	10.126	-2.614	50	1.253	24	AS
BRRi dhan63	9.834	-4.537	37	1.124	29	AS
BRRi dhan64	12.876	-10.255	37	0.607	47	BAS
BRRi dhan67	10.501	-2.734	45	1.26	23	AS
BRRi dhan68	9.484	2.992	42	1.583	10	AS
BRRi dhan69	10.247	3.787	38	1.502	13	AS
BRRi dhan74	11.169	6.46	38	1.559	11	AS
BRRi dhan81	12.154	-10.644	28	0.769	45	BAS
BRRi dhan84	10.849	-7.592	23	0.9	37	BAS
BRRi dhan86	8.684	-9.527	22	0.987	34	BAS
BRRi dhan88	9.833	-1.524	25	1.316	18	AS
BRRi dhan89	10.094	17.335	24	2.223	1	S
BRRi dhan92	10.443	14.039	19	2.194	2	S
BRRi dhan96	9.293	-3.044	15	1.29	22	AS
BRRi dhan97	9.191	5.275	12	1.595	9	AS
BRRi dhan99	11.98	8.578	14	1.599	8	AS
Bangabandhu dhan100	9.779	3.526	10	1.556	12	AS
BRRi dhan101	-	6.916	10	1.329	17	AS
BRRi dhan102	-	14.427	10	1.685	7	AS
BRRi Hybrid dhan2	10.22	17.636	45	1.973	5	AS
BRRi Hybrid dhan3	10.477	18.179	48	2.174	2	S
BRRi Hybrid dhan5	9.63	21.051	33	2.38	1	S
Aromatic Rice						
BRRi dhan50	9.431	-7.524	63	1.039	31	AS

Note: S=Stable, AS=Average Stable, BAS=Below Average Stable

Note: S=Stable, AS=Average Stable, BAS=Below Average Stable

Table 2: Stability parameters of grain yield for Boro.

Among T. Aman varieties, BRRi dhan49 and BRRi dhan87 were found stable with stability index 2.101 and 2.015 respectively. while BR3, BRRi dhan33, BRRi dhan39, BRRi dhan56, BRRi dhan57, BRRi dhan62, BRRi dhan70, BRRi dhan90 and BRRi dhan91 appeared to be below average stable. BR4, BR10, BR11, BR22, BR23, BR 25, BRRi dhan30, BRRi dhan31, BRRi dhan32, BRRi dhan40, BRRi dhan41, BRRi dhan44, BRRi dhan46, BRRi dhan49, BRRi dhan51, BRRi dhan52, BRRi dhan53, BRRi dhan54, BRRi dhan66, BRRi dhan71, BRRi dhan72, BRRi dhan73, BRRi dhan75, BRRi dhan76, BRRi dhan77, BRRi dhan78, BRRi dhan79, BRRi dhan80, BRRi dhan93, BRRi dhan94, BRRi dhan95, BRRi hybrid dhan4 and BRRi hybrid dhan6 were found having

average stability among T. Aman varieties. Among the aromatic rice BRRI dhan5, BRRI dhan34, BRRI dhan37 and BRRI dhan38 were found as below average stable in T. Aman season (Table 1).

Among Boro varieties, BRRI dhan89, BRRI dhan92, BRRI dhan29 and BRRI hybrid dhan3 were found as stable with stability index 2.223, 2.194, 2.001 and 2.174 respectively. BR3, BR9, BR14, BR15, BR16, BRRI dhan28, BRRI dhan36, BRRI dhan47, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan60, BRRI dhan61, BRRI dhan63, BRRI dhan67, BRRI dhan68 BRRI dhan69, BRRI dhan74, BRRI dhan88, BRRI dhan96, BRRI dhan97, BRRI dhan99, Bangabandhu dhan100, BRRI dhan101, BRRI dhan102 and BRRI hybrid dhan2 were found as average stable and rest of the 17 varieties appeared to be below average stable. Among the non-aromatic rice. On the other hand, only aromatic rice BRRI dhan50 were found as average stable in Boro season (Table 2).

COMPARATIVE STUDY FOR RICE YIELD ESTIMATION BY ADJUSTING MOISTURE CONTENT

The moisture content of paddy grain decreases from different moisture (%) to 14% for safe storage of grains, and seeds should be dried to below 12 %. Ideal moisture content for milling is between 12–14%. (IRRI Rice Knowledge Bank, 2009). According to standard procedure for determining yield components at harvest, for the measuring final grain dry the samples to reduce moisture content to 10–16% (IRRI Rice Knowledge Bank, 2009). Differences in grain moisture content can result in a significant variation in the processing characteristics of the grain as well as estimation. During rice yield estimation, it is very much important to adjust the moisture content after crop cut. For reducing the estimation error a comparative study is needed for estimating the rice yield by adjusting moisture content. Hence, the objective of this study is to determine adjustment factors to estimate the paddy yield and develop a criterion for performing a reliable estimation. Which can help to reduce the estimation for rice production. BRRI released rice varieties were used for this study. The study has conducted in Aus, Aman and Boro seasons. The

samples were manually cleaned to remove all the foreign materials such as dust, dirt, small broken and immature kernels. The initial moisture content of the samples was determined by oven drying method at 70°C for 48 h (Sacilik et al., 2003). In order to obtain desired moisture levels below the initial moisture contents, the samples were kept for natural drying (sun dry) until the desired moisture contents of the samples were obtained (Yang et al., 2003). The data were analyzed statistically using programming R software and data preparation and compilation will be completed using Microsoft Excel software.

Results showed that, the sample initial moisture content was observed ranging from 17.09 to 26.61% for the sundry methods where, the used sample average initial moisture content had 21.37%. In the sundry method the reduced compared moisture (%) was 14 ± 0.07 . Also, in the sundry method the average moisture reduction from different sample was 7.31%. There are three important things observed for overestimation one is the initial moisture content, high range of moisture reduction and dust removal (dust, dirt, small broken and immature kernels, no. of unfilled grain, a small portion of panicle, broken straw, etc.) (Fig. 1). There is a strong relationship between ranges of initial moisture, moisture reduction and dust. A significant positive correlation has been found between initial moisture, moisture reduction and dust with overestimation (Fig. 1a-c). The graphical representation of Linear Regression Coefficients showed the relationship of initial moisture content and overestimation (Fig. 1a). The initial moisture content coefficient in the regression equation is 0.701. This coefficient represents the mean increase of initial moisture content in percentage for every additional one percent change in initial moisture. If the initial moisture content increases by 1 percent, the average overestimation increases by 0.701 percent. The regression coefficient of moisture reduction and dust percentage were 0.859 and 0.818, respectively (Fig. 1a-b). Data points are plotted on three axes in a 3D scatter plot to show the relationship between three variables i.e., moisture reduction, dust and overestimation. The position of the marker that symbolizes each row in the data

table is determined by the values of the columns set on the X, Y, and Z axes (Fig. 2). Results found that during yield estimation from crop cut samples, most of the cases had found significant overestimation (Fig. 3). The highest and lowest overestimations observed were 7.08 and 23.08%, respectively for sundry methods. The average overestimation (%) for sundry sampled observed was 15.52 ± 0.34 (red line) and most of the variety found a significant variation of the overestimation (Fig. 3).

PI: MAAM, **CI:** MIH, MAQ, MSK, NMFR, MAQ, MAA and AB

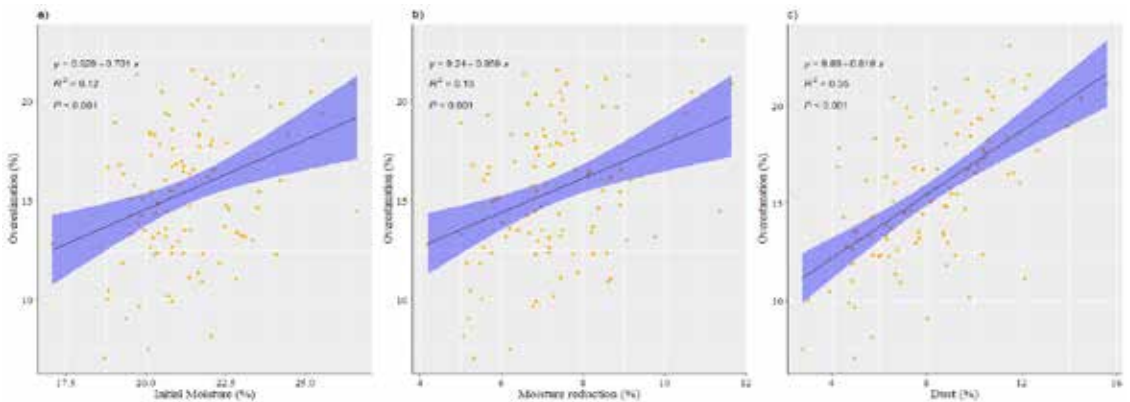


Fig. 1. Relationship of initial moisture content (a), moisture reduction (b), and dust percent (c) on overestimation of different crop cut sample in sundry methods.

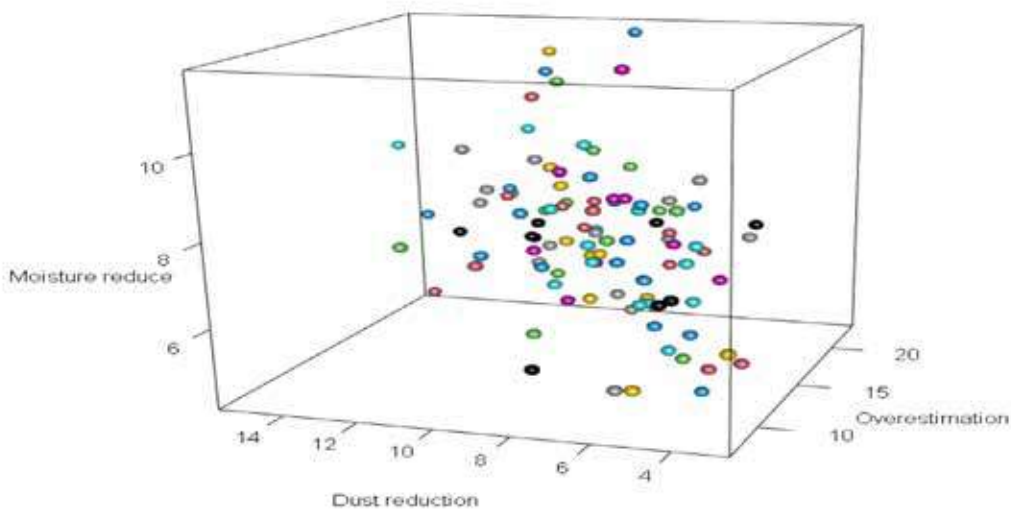


Fig. 2. 3D Relationship between moisture and dust reduction on overestimation in sundry methods.

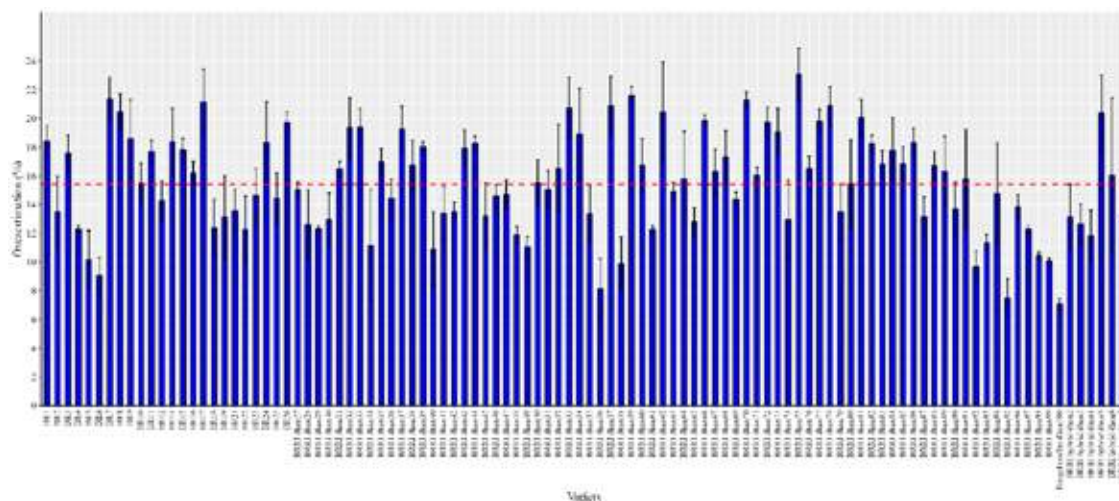


Fig. 3. Average overestimation of crop cut sample of different rice varieties in sundry dry method.

GENOTYPE $\times$ ENVIRONMENT INTERACTION OF BRRI VARIETIES

PI: MAAM, **CI:** MIH, MSK, NMFR, MAQ and MAA

The major objective of the study was to identify BRRI released rice genotypes that have both high mean yield and stable yield performance across different environments for different ecosystems of Bangladesh. The experiment was conducted in multi-environment trials for T. Aman 2022. Forty-seven BRRI developed T. Aman rice varieties were evaluated in nine environmental conditions of Bangladesh, such as Barishal, Bhanga, Cumilla, Gazipur, Kushtia, Rajshahi, Rangpur, Satkhira, and Sonagazi. The experimental sites covered all ecosystems of Bangladesh. The experiments were carried out in randomized complete block design (RCBD) with three replications and evaluated for rice grain yield. Each experimental plot comprised of 3 m $\times$ 2 m. Standard agronomic practices were followed and plant protection measures were taken according to Adhunik dhaner chash, BRRI (2021). AMMI model was used to quantify the effect of different factors (genotype, location) of the experiment. The model further provides graphical representation of the numerical results (GGE biplot analysis) with a straight-forward interpretation of the underlying causes of G $\times$ E.

ANOVA of combined analysis

The combined analysis revealed that the yield of rice genotypes was significantly influenced by environment and contributed 48.59, 39.20 and 36.14% of the total variation for short, medium, and long duration respectively in the Aman season. Additionally, the relative contribution of genotype sum of squares was found 23.48, 10.97 and 13.93% for long, short, and medium duration respectively. Genotype by environment (G $\times$ E) contributed the most 33.59% to the total variation for medium duration followed by 27.14% and 26.78% for long and short duration (Table 3).

Greater portion of total variation was explained by environmental main effect indicating that the environments were diverse and a major part of variation in grain yield reflected from environmental changes. The highly significant genotype $\times$ environment interaction effects for grain yield confirmed that genotypes responded differently to the variation in environmental conditions. The yield variations could be attributed to the different environmental (climatic) conditions and to different edaphic conditions at different locations. In this case application of stability analysis for identifying widely and/or specifically adaptation of rice genotypes is essential.

Table 3. ANOVA of individual category (long, medium and short duration) Aman 2022.

SV	Long duration			Medium duration			Short duration		
	DF	MS	SS (%)	DF	MS	SS (%)	DF	MS	SS (%)
ENV	8	25.94**	36.14	8	17.50**	39.20	8	36.75**	48.59
REP(ENV)	18	0.41**	1.29	18	0.39**	1.94	18	0.42**	1.26
GEN	17	7.93**	23.48	12	3.27**	10.97	15	5.62**	13.93
ENV:GEN	136	1.15**	27.14	96	1.25**	33.59	120	1.35**	26.78
Residuals	306	0.22	11.96	216	0.24	14.29	270	0.21	9.43
CV (%)		13.17			11.47			11.49	
LSD _{0.05}		0.76			0.78			0.74	

Note: ENV=environment, GEN= genotype, DF = degrees of freedom; MS = mean sum square; SS (%) = explain % sum of squares; ** = significant at the 1% level.

Evaluation of test environments

Aman season

The GGE biplot explained 73.43%, 68.47%, and 55.45% of the total variation of the environments for long, medium and short duration respectively (Figs. 1-3). In long duration (Fig.1), there were three clusters of environments, one contains Barishal, Satkhira, and Kushtia; another contains Gazipur, Bhanga, Cumilla, Sonagazi, Cumilla and Rajshahi; the other cluster contains only, Rangpur. Among them Cumilla and Sonagazi were closely

associated (Fig.1c). Kushtia, Rajshahi and Rangpur had the longest vector and hence was highly discriminating. Overall, the locations Sonagazi was highly representative and can be considered ideal environment for evaluating long duration genotypes (Fig.1c).

GGE biplot showed three distinct clusters in medium duration: one contains Cumilla, Sonagazi and Gazipur; another contains Barishal and Rajshahi; and Bhanga, Satkhira, Kushtia and Rangpur remain in the same cluster (Fig. 2c). The closest association were observed between the environments Gazipur, Sonagazi; Barishal, and Rajshahi. The location Rangpur positioned in the longest vector and showed weak correlation with Cumilla and Sonagazi. The ideal environment

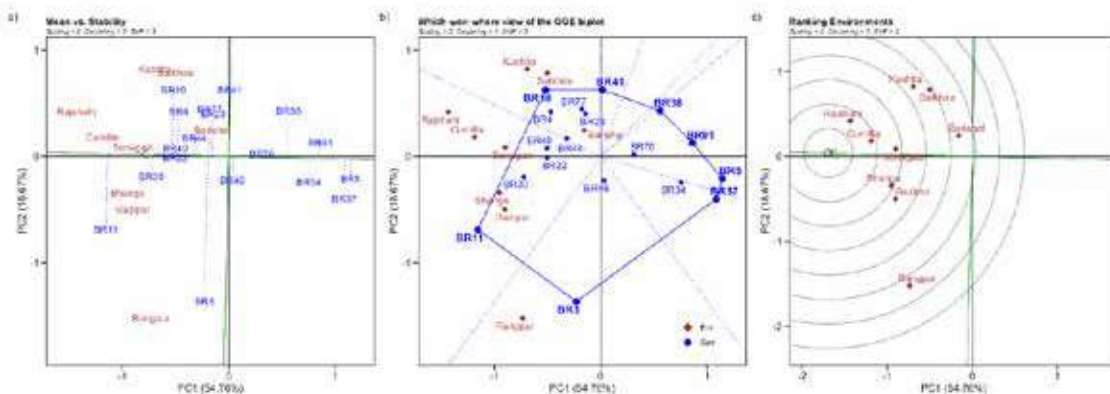


Fig. 1. GGE biplot of mean and stability (a), GGE biplot identification of winning genotypes and their related mega-

environments (b) and association among the test environments (c) of long duration rice genotypes for yield and specific genotype $\times$ environment interactions in T. Aman 2022.

Performance and stability of rice genotypes across tested environments

Within a single mega-environment, genotypes should be evaluated on both mean performance and stability across environments. Figures 1a, 2a and 3a show average-environment coordination (AEC) views of the GGE biplot for grain yield of long, medium, and short duration. Figure 4 shows the yield performances and summary of ideal genotypes and genotypes with stable and high mean yields in different categories (long, medium and short duration). BR11 recorded the highest average grain yield (4.49 t/ha) in long duration (Fig. 1a). BR10, BR22, BRRI dhan30, BRRI dhan40 and the

above-average yields (3.59 t/ha). Thus, the BR11 and BRRI dhan30 were the most ideal genotype with the highest mean yield and stability among the tested genotypes. The genotype BRRI dhan79 (4.63 t/ha), BRRI dhan78 (4.58 t/ha), BRRI dhan93 (4.56 t/ha), BRRI dhan49 (4.52 t/ha), were the most stable genotype with above-average yield (4.24 t/ha) with medium duration (Fig. 2a). BRRI dhan72 (4.88 t/ha), BRRI dhan87 (4.62 t/ha) BRRI dhan71 (4.58 t/ha), BRRI dhan95 (4.33 t/ha)), and BRRI hybrid dhan6 (4.31 t/ha) recorded the above-average yields among the short duration varieties. Among high yield varieties the BRRI dhan71, BRRI dhan72, BRRI dhan87 and BRRI dhan95 showed the closest position from the axis line, and designated as most stable and ideal genotypes in short duration (Fig. 3a). Also, BRRI hybrid dhan6, BRRI dhan66 were the moderately stable genotypes and above average yielder (Fig. 4).

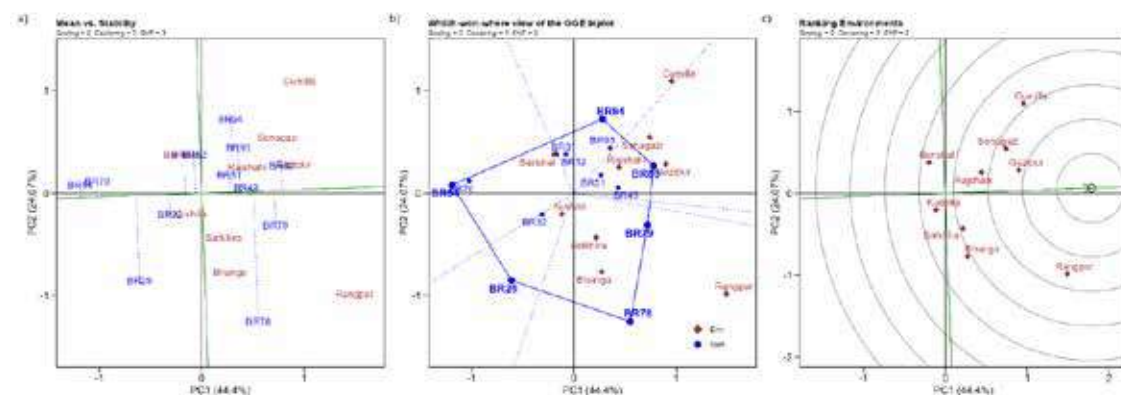


Fig. 2. GGE biplot of mean and stability (a), GGE biplot identification of winning genotypes and their related mega-environments (b) and association among the test environments (c) of medium duration rice genotypes for yield and specific genotype $\times$ environment interactions in T. Aman 2022.

Identification of which-won-where and mega-environment

One of the most attractive features of a GGE biplot is its ability to show the which-won-where pattern

of a genotype by environment dataset. This plot consists of a polygon with perpendicular lines, called equality lines, drawn onto its sides. These lines divide the polygon into various sectors. Genotypes located on the vertices of the polygon

are the best performers in one or more environments falling within a particular sector.

The biplot showed three sectors containing all the test environments in long duration and accordingly three mega-environments were identified (Fig. 1b): One mega-environment had five locations, Gazipur, Bhanga, Cumilla, Rajshahi and Sonagazi; the second consisting of three locations- Barishal, Satkhira, and Kushtia; and rest mega-environment contains only Rangpur location. Hence, the winning genotype in those environments was BR11 for the first; BR10 is the second location where BRRI

ghan41 only suitable for Kushtia and Satkhira. BR3 closed to third mega environment (Fig. 1b).

In medium duration, the biplot grouped the test locations into four mega-environments (Fig. 2b). The first mega-environment had three locations, Sonagazi, Rajshai, and Gazipur. The second had two locations those were Cumilla and Barishal. The third contained three locations Bhanga, Satkhira and Rangpur. The fourth mega environment had only one location i.e., Kushtia. BRRI dhan94 and BRRI dhan80 were the winning genotype in the first mega-environment while BRRI dhan94 was

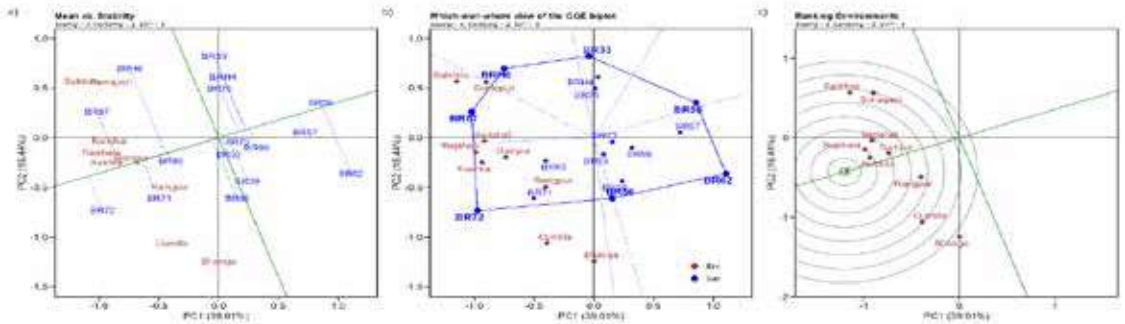


Fig. 3. GGE biplot of mean and stability (a), GGE biplot identification of winning genotypes and their related mega-environments (b) and association among the test environments (c) of short duration rice genotypes for yield and specific genotype × environment interactions in T. Aman 2022.

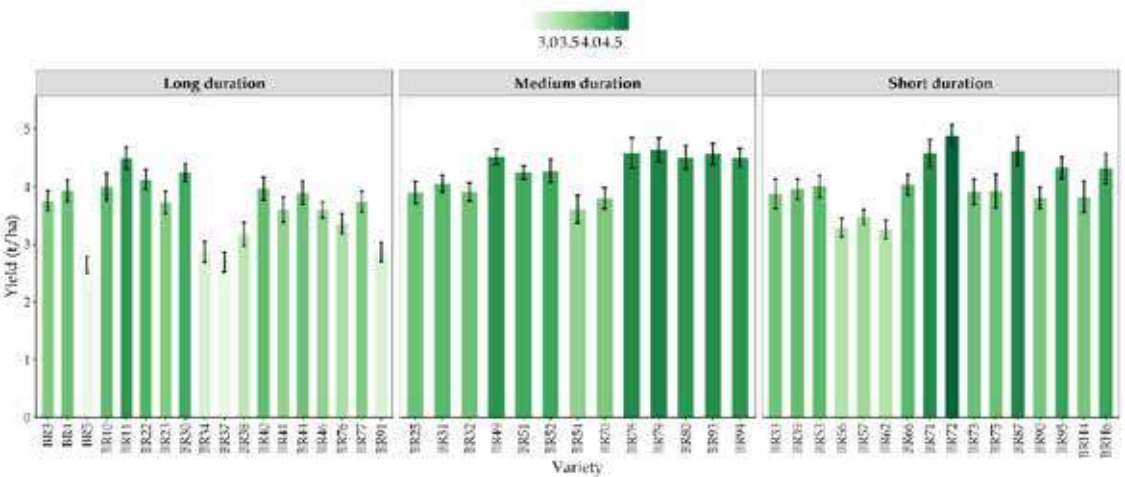


Fig. 4. Grain yield performance of BRRI developed T. Aman rice varieties during 2022.

Dynamics of Multi-trait stability index (MTSI) for identifying the most stable genotypes of three rice growing season in Bangladesh

PI: MAAM, **CI:** MIH, MSK, NMFR, MAQ and MAA

The main objective of the study is to evaluate the stability of rice genotypes by multi-trait stability index (MSTI) analysis under different environmental conditions. Also investigate the dynamics of MTSI for identifying stable genotypes. For this study an experiment was carried out for the evaluation of 47 T. Aman rice genotypes in a randomized complete block design (RCBD), with three replications in 2021. To assess the performance and stability simultaneously, these rice genotypes were evaluated in four different locations

of Bangladesh such as Barishal, Cumilla, Gazipur, and Rangpur. The data for GY: grain yield (ton/ha), GD: growth duration (day), TN: no. of tiller per hill, PN: no. of panicle per hill, PL: panicle length, GPP: no. of grain per panicle were used to perform all the analysis. The statistical analyses were performed by using R software with the metan package (Olivoto and Dal'Col Lúcio, 2020).

MTSI dynamics analysis

Rearranging attribute combinations resulted in different rankings of stability under various selection intensities, as represented by the MTSI index. The heatmap illustrated the dynamics of MTSI, aiding in the selection of target traits for varietal improvements through trait combinations. The following table represents the trait combination for developing the MTSI dynamics (Table 4).

Table 4 Trait combination of identifying the dynamics of multi-trait stability index (MTSI).

Dynamics	Trait combination	Dynamics	Trait combination
MTSI_1	GY,GD,TN,PN,PL,GPP	MTSI_14	GY,PN,PL
MTSI_2	GY,GD	MTSI_15	GY,PN,GPP
MTSI_3	GY,TN	MTSI_16	GY,PL,GPP
MTSI_4	GY,PN	MTSI_17	GY,GD,TN,PN
MTSI_5	GY,PL	MTSI_18	GY,GD,TN,PL
MTSI_6	GY,GPP	MTSI_19	GY,GD,TN,GPP
MTSI_7	GY,GD,TN	MTSI_20	GY,TN,PN,PL
MTSI_8	GY,GD,PN	MTSI_21	GY,TN,PN,GPP
MTSI_9	GY,GD,PL	MTSI_22	GY,PN,PL,GPP
MTSI_10	GY,GD,GPP	MTSI_23	GY,GD,TN,PN,PL
MTSI_11	GY,TN,PN	MTSI_24	GY,GD,TN,PN,GPP
MTSI_12	GY,TN,PL	MTSI_25	GY,TN,PN,PL,GPP
MTSI_13	GY,TN,GPP		

The statistical analyses were performed by using R software with the metan package (Olivoto and Dal'Col Lúcio, 2020).

The overall grain yield of T. Aman rice varieties ranged from 1.49 ton ha⁻¹ to 6.78 ton ha⁻¹ while the environments mean yield was 4.49 ton ha⁻¹.

Table 5 presents the thers statistical factors such as, mean, standard error of mean (SEM), standard deviation (St. dev.), coefficient of variation (CV %), confidence interval (CI) for characters in all the environments. The likelihood ratio test (LRT) demonstrated significant impacts of genotype and genotype-environment interactions (GEI) (Table 6).

Table 5. Basic descriptive statistic for various morphological and physiological traits of T. Aman rice varieties under studied evaluated in four environments.

Variable	CV (%)	Max	Mean	Median	Min	SD	Mean	SE	CI
GD	9.99	161.00	130.38	132.00	95.00	13.02	0.55	1.08	
GPP	26.12	250.00	113.20	113.00	32.00	29.57	1.25	2.45	
GY	22.24	6.78	4.49	4.60	1.49	1.00	0.04	0.08	
PL	8.41	31.00	26.40	26.92	18.90	2.22	0.09	0.18	
PN	16.28	12.20	8.72	8.80	5.00	1.42	0.06	0.12	
TN	12.71	14.60	10.02	10.00	6.00	1.27	0.05	0.11	

Where Yield: Grain yield (ton/ha), GD: Growth duration (day), TN: no. of tiller per hill, PN: No. of panicle per hill, PL: panicle length, GPP: no. of grain per panicle, CV: Coefficient of variation, SD: Standard deviation, SE: Standard error, CI: Confidence interval.

The genotypic variance was higher than residual for GY, GD and PL whereas the GEI variance was higher than for all the traits except TN and PN (Fig. 4). We have found for GY, GD and GPP is mostly dominated by genotype and environment effect. Growth duration is mostly regulated by both genotype-environment effects. The number of panicle, number of tiller mostly influence by residual factors then genotypes and environments interaction factor. High values of broad sense heritability were calculated for all traits under

study, the highest broad sense heritability of genotypic mean was growth duration (95%) and the lowest was no. panicle per hill (18%) (Table 7). The genotypic selection accuracy (Acc) values ranged from 0.43 (PN) to 0.97 (GD). The highest CVg was recorded for GY (11.33) and the lowest was TN (2.46). The CV ratio was the highest for growth duration (14.54) followed by panicle length (1.09), grain yield (1.05), grain per panicle (0.61), number of tiller per hill (0.22), and no. of panicle per hill (0.21) (Table 7).

Table 6 Likelihood ratio test (LRT) for different traits under studied of 47 T. Aman rice varieties evaluated in four environments.

VAR	model	logLik	AIC	LRT	Pr(>Chisq)
GY	GEN	-597.30	1222.60	36.28	0.000
GY	GEN:ENV	-649.78	1327.56	141.24	0.000
GD	GEN	-1304.34	2636.67	176.74	0.000
GD	GEN:ENV	-1805.04	3638.08	1178.14	0.000
TN	GEN	-928.32	1884.64	1.62	0.204
TN	GEN:ENV	-933.81	1895.61	12.59	0.000
PN	GEN	-964.87	1957.75	0.71	0.400
PN	GEN:ENV	-985.96	1999.92	42.88	0.000
PL	GEN	-1034.46	2096.91	39.84	0.000
PL	GEN:ENV	-1083.64	2195.28	138.21	0.000
GPP	GEN	-2398.28	4824.57	2.03	0.154
GPP	GEN:ENV	-2567.99	5163.97	341.44	0.000

Where Yield: Grain yield (ton/ha), GD: Growth duration (days), TN: No. of tiller per hill, PN: no.

of panicle per hill, PL: Panicle length, GPP: No. of grain per panicle, UGP: No. of unfilled grain per

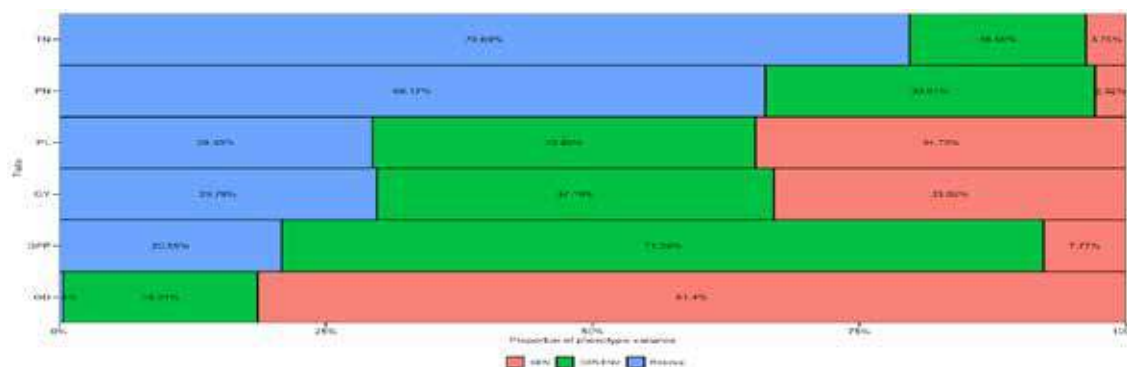


Fig. 4. Proportion of the phenotypic variance for 47 T. Aman rice traits assessed in four different environments. Where Yield: Grain yield (ton/ha), GD: Growth duration (day), TN: No. of tiller per hill, PN: No. of panicle per hill, PL: Panicle length, GPP: no. of grain per panicle.

Table 7. Deviance analysis, genetic parameters and variance components for nine morphological and physiological traits evaluated in 47 T. Aman rice varieties

Parameters	GY	GD	TN	PN	PL	GPP
Phenotypic variance	0.78	171.66	1.62	1.97	3.86	663.02
GEIr2	0.37	0.18	0.17	0.31	0.36	0.71
h2mg	0.74	0.95	0.26	0.18	0.75	0.28
Accuracy	0.86	0.97	0.51	0.43	0.87	0.53
rge	0.56	0.98	0.17	0.32	0.55	0.77
CVg	11.33	9.07	2.46	2.75	4.39	6.34
CVr	10.76	0.62	11.32	13.09	4.03	10.39
CV ratio	1.05	14.54	0.22	0.21	1.09	0.61

Where Yield: Grain yield (ton/ha), GD: Growth duration (days), TN: No. of tiller per hill, PN: No. of

panicle per hill, PL: Panicle length, GPP: No. of grain per panicle, PV: Phenotypic variance, GEI R²: GEI coefficient of determination, h²mg: heritability of genotypic mean, Acc: Accuracy of genotype selection, rge, association among genotypic values across environments, CVg: Genotypic coefficient of variation, CVr: Residual coefficient of variation.

Association analysis

A significant association was noticed between grain yield and grain per panicle (GPP), no. of tiller per hill (TN) no. of panicle per hill (PN), panicle length (PL) and grain per panicle (GPP). Grain yield have found insignificant low positive correlations on growth duration (GD) (Fig 5).



Fig. 5. Pearson's correlation matrix among 47 T. Aman rice traits evaluated in seven environments. Where

Yield: Grain yield (ton/ha), GD: Growth duration (day), TN: No. of tiller per hill, PN: No. of panicle per hill, PL: Panicle length, GPP: No. of grain per panicle.

Genotypes selection based on MTSI and contribution of factors to the MTSI

Six principal components were maintained, and the variance in these first two factors accumulated was 59.58% (Table 8). The six attributes were clustered into the two different factors as: FA1: (Yield, TN, and PN); FA2: (GD Yield, GPP and PL) (Table 9).

The strengths and weaknesses plot for varieties based on different factors using multi-trait stability

index reveal the factor presented the smallest contribution for variety indicating the most performer genotypes or vice versa. In the case of FA1, the factor elements GY, TN and PN; the BRRI dhan87, BRRI dhan79 and BRRI hybrid dhan4 are the most performer of those traits where FA1 contributes proportion less than 0.25 (Fig 6). The values of the MTSI presuming 30% selection intensity for selecting highly stable variety (Fig 7). Among 47 varieties BR10, BR22, BRRI dhan44, BR11, BRRI dhan 51, BRRI dhan87, BRRI dhan30, BRRI dhan46, BRRI dhan41, BRRI dhan49 and BRRI dhan79 are the selected varieties using MTSI at 30% selection intensity.

Table 8. Explained variance, eigenvalues, factorial loadings after varimax rotation and communalities estimated in the factor analysis.

VAR	FA1	FA2	PC	Eigenvalues	Variance (%)	Cum. variance (%)
GY	0.82	-0.05	PC1	2.18	36.34	36.34
GD	0.18	-0.80	PC2	1.39	23.24	59.58
TN	0.76	0.08	PC3	0.96	15.92	75.50
PN	0.84	-0.29	PC4	0.60	10.04	85.54
PL	0.23	-0.28	PC5	0.55	9.12	94.66
GPP	-0.18	-0.83	PC6	0.32	5.34	100.00

Where Yield: Grain yield (ton/ha), GD: Growth duration (days), TN: No. of tiller per hill, PN: No. of panicle per hill, PL: Panicle length, GPP: No. of grain per panicle, UGP: No. of unfilled grain per panicle, TGW: Thousand grain weight, FA, the factor retained, Bold values show the traits cluster within each factor, Cum. Var. (%) Cumulative variance.

Table 9. Selection differential of the WAASBY index and selection gain (%) for different traits of 47 T.Aman rice varieties

VAR	Factor	Xo	Xs	SD	SD perc	h2	SG	SG perc	sense	goal
GY	FA1	4.49	5.00	0.51	11.30	0.74	0.37	8.33	increase	100
TN	FA1	10.02	10.50	0.47	4.71	0.26	0.12	1.22	increase	100
PN	FA1	8.72	9.30	0.58	6.61	0.18	0.10	1.20	increase	100
GD	FA2	130.40	138.80	8.43	6.46	0.95	7.98	6.12	increase	100
PL	FA2	26.40	26.82	0.42	1.58	0.75	0.31	1.19	increase	100
GPP	FA2	113.20	122.00	8.79	7.76	0.28	2.50	2.20	increase	100

Where GY: Grain yield (ton/ha), GD: Growth duration (day), TN: No. of tiller per hill, PN: No. of panicle

per hill, GP: No. of grain per panicle, Xo: Mean for WAASBY index of the original population, Xs: Mean for WAASBY index of the selected genotypes, SD: Selection differential, SG: Selection gain.

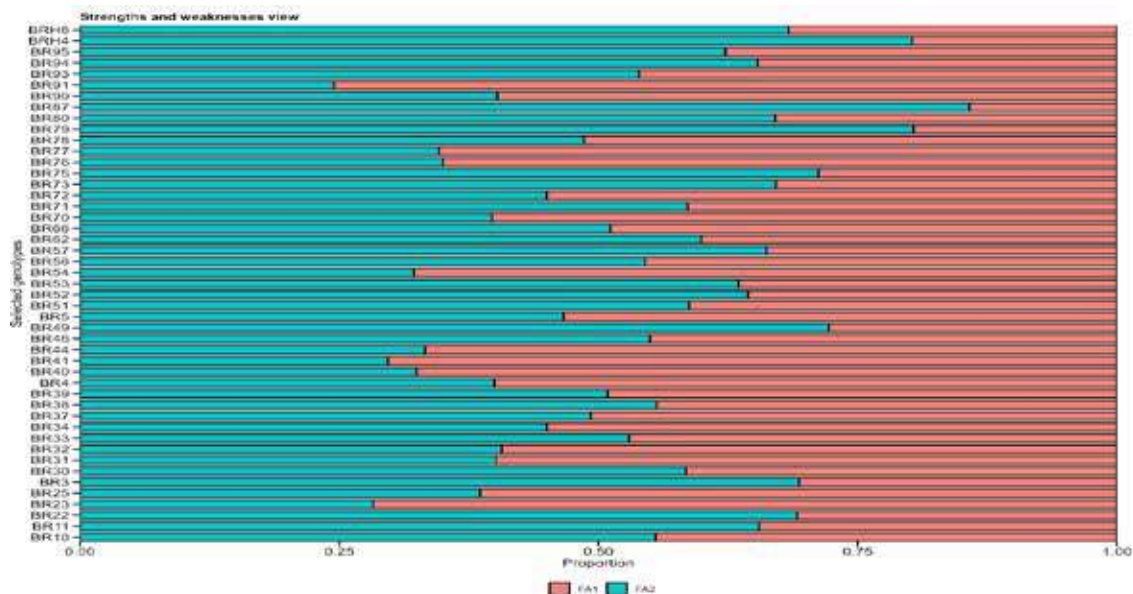


Fig. 6: The strengths and weaknesses view of genotypes selected. The y-axis presents the ratio of each factor on the calculated MTSI of the selected genotypes. The minimum the proportions explicated by a stands for genotypes and FA stands for factor.

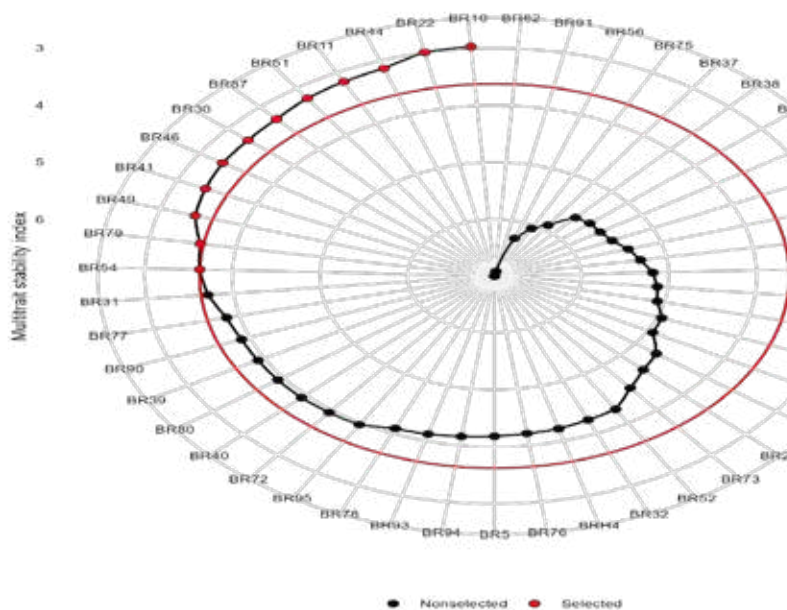


Fig. 7: Selection of highly stable variety on the basis of multi trait stability index considering

30 % selection intensity.

Dynamics of MTSI

The dynamics of the multitrait stability index (MTSI) provide valuable insights into the performance and adaptability of different traits within a set of varieties or genotypes. By analysing MTSI, researchers and breeders can assess how various combinations of traits contribute to overall stability and performance in different environments. This information is crucial for selecting and developing varieties that not only yield well but also exhibit resilience and consistency across diverse conditions. The MTSI allows for the identification of traits that have a substantial impact on variety performance and can

guide breeding efforts to prioritize and enhance these traits, ultimately leading to more robust and adaptable crop varieties. Furthermore, MTSI analysis aids in tailoring varietal improvements to meet specific agricultural goals and environmental challenges, making it a valuable tool in modern crop breeding and selection processes. The results rearrange the combination of different attributes the following MTSI index that represents the different ranking of stability under the respective selection intensity. Heatmap showed the dynamics of MTSI and will help to select the targeted traits in varietal impartments by applying traits combinations (Fig. 8).

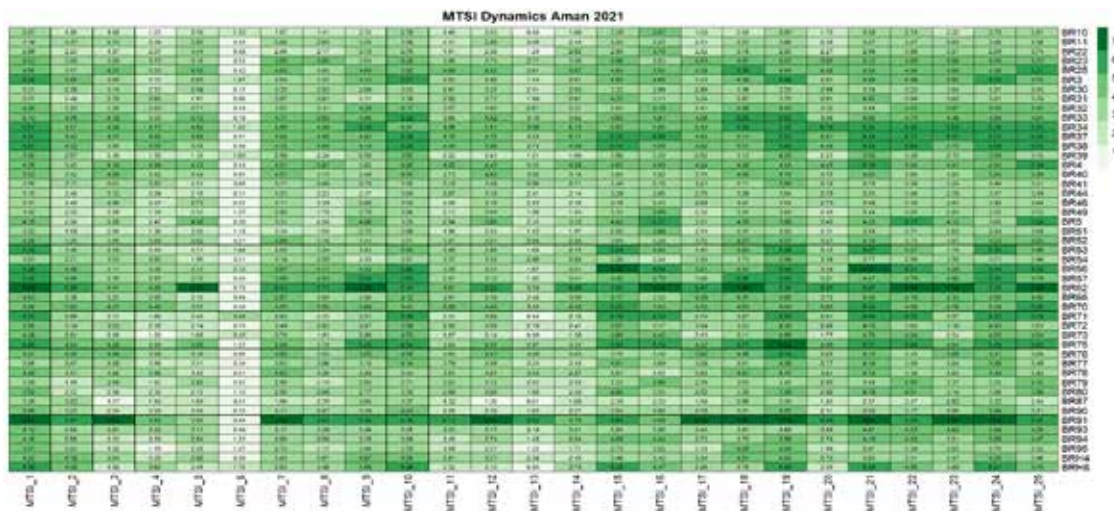
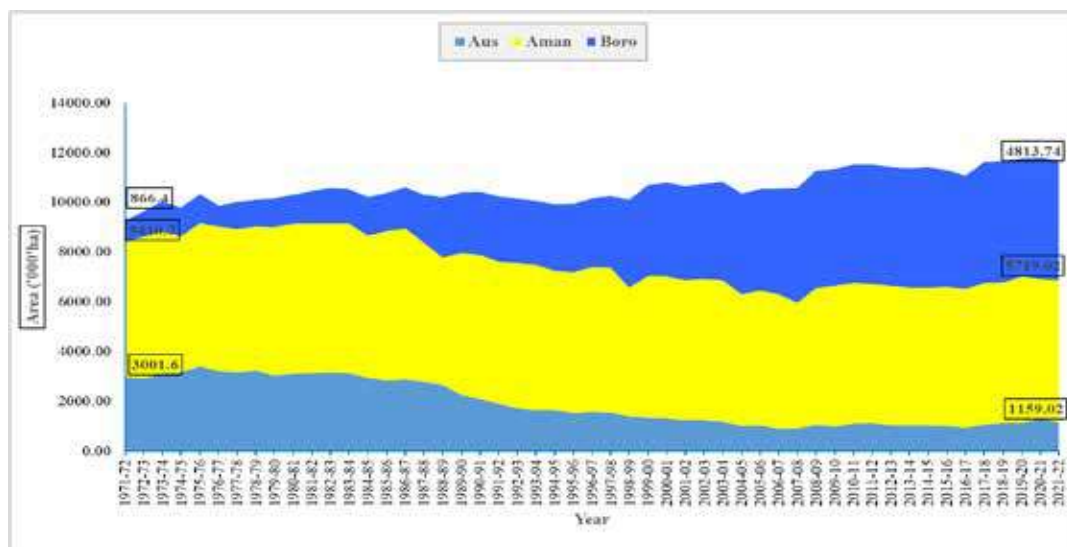


Fig. 8. Dynamics of multi trait stability index (MTSI) for Selection of highly desirable traits.

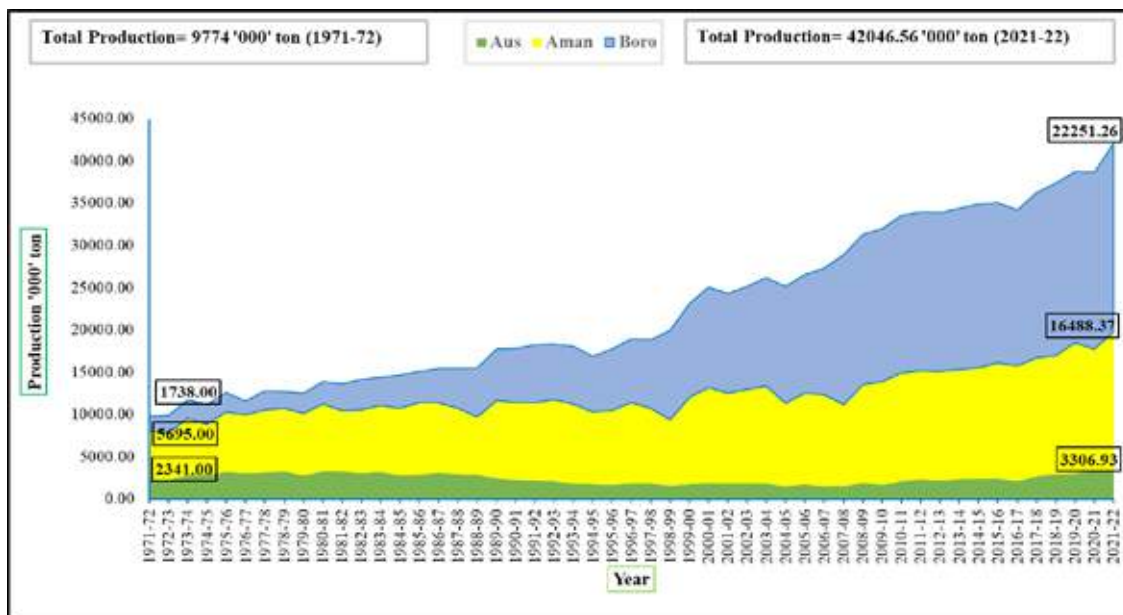
MAINTENANCE OF RICE AND RELATED DATABASE

Rice area increased about one and half folds (Graph 1) but the production increased about four folds (Graph 2) during 1971-72 to 2021-22. Although the growth rate of rice area was 3.96 in year 1972-73 but in 2021-22 is -0.95. Similarly, growth rate of rice production was 1.30 in year 1972-73 but in 2021-22 is 8.91.

Secondary data of rice and other important crops are collected periodically from Bangladesh Bureau of Statistics (BBS), Agricultural Marketing Directorate, Bangladesh Meteorological Department (BMD), Bangladesh Water Development Board (BWDB), Bangladesh Agricultural Development Corporation (BADC) and other sources periodically and recorded accordingly. Databases are being updated regularly and uploaded at BRRI website.



Graph 1. Cultivated area of Rice (Aus, Aman and Boro) in Bangladesh from 1971-72 to 2021-22



Graph 2. Rice Production (Aus, Aman and Boro) in Bangladesh from 1971-72 to 2021-22

PI: -MIH, CI: MSK, NMFR, MAQ, MAA, MAAM,

MINIMIZING AGRO MICRO CLIMATOLOGICAL RISK FACTORS FOR MAXIMIZING SUSTAINABLE RICE PRODUCTION IN BANGLADESH

The weather forecast and advisory service focused on food security and responsiveness to climate change in Bangladesh. Whereas, weather forecasts-based rice advisory system has the potential for reducing poverty by increasing the rice yield, avoiding insect

The seasonal weather forecast and rice advisory were generated in Aman season (July to September 2023) for BRRI HQ and different RSs. A team comprising of multidisciplinary researchers (agronomist, plant pathologist, entomologist, soil

PI: NMFR, **CI:** MAA, MAAM, RA, MCR, MMH, ABMZ, MAIK, MKAB, MMH, TH, MIH and MSK.

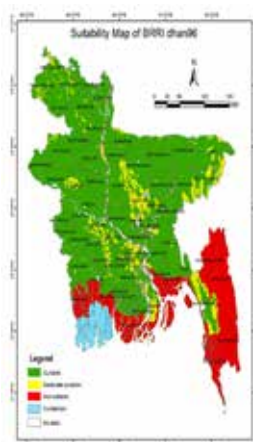


Our land is not homogenous all over Bangladesh. As we need to increase production with limited land, so it will be very helpful if we have variety wise suitability map based on soil properties. BRRI

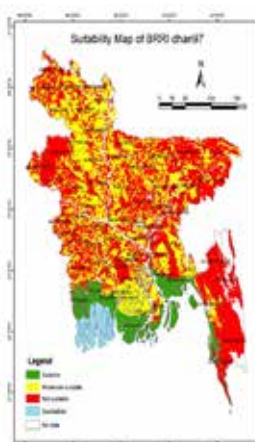
Agricultural Statistics 279

Soil physical properties namely, land type, top soil texture, relief, soil consistency, soil moisture, soil permeability, soil reaction, soil salinity, drainage and slope were considered to determine areas suitable for growing respective rice varieties. The suitability scale 1 to 3 were assigned to each soil characteristic in relation to respective rice varieties cultivation: 1- for the suitable, 2- for moderate and 3- for not suitable. So, proactivity will increase if we cultivate rice varieties according to their suitable

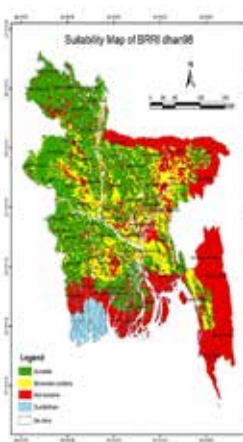
area. Boro season, BRRI dhan96 is suited all regions of Bangladesh except southern and hill tract regions (Map 3). Boro season, BRRI dhan97 is suitable for southern part especially saline area of Bangladesh (Map 4). T. Aus BRRI dhan98 is appropriate for all over Bangladesh, especially, western, regions of Bangladesh, but not for areas that are hilly or saline area. Map 5 shows the suitability diagram of BRRI dhan98. In Boro season BRRI dhan99 is suitable for saline area of Bangladesh (Map 6).



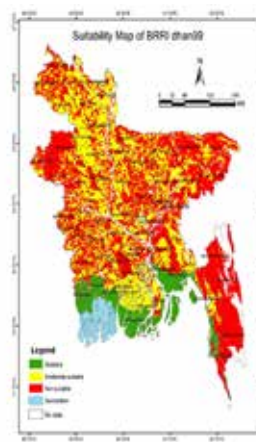
Map 3: Suitability map of BRRI dhan96



Map 4: Suitability map of BRRI dhan97



Map 5: Suitability map of BRRI dhan98



Map 6: Suitability map of BRRI dhan99

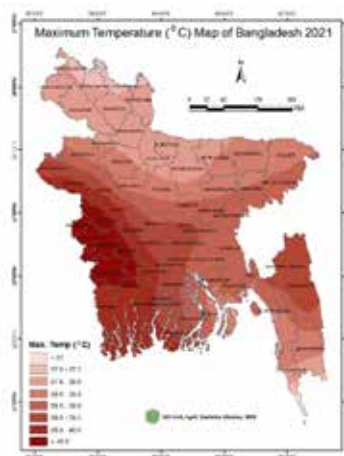
In Boro season, BRRI dhan96 is suited all regions of Bangladesh. Whereas BRRI dhan97 and BRRI dhan99 are suitable for saline regions. BRRI dhan98 is appropriate for western, region of Bangladesh.

PI: MAA, **CI:** RA, BK, MIH, NMF, MAQ and MAAM

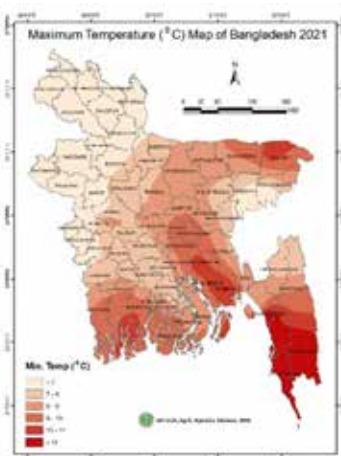
CLIMATE MAPPING OF TEMPERATURE AND RAINFALL OF BANGLADESH

Data on daily maximum and minimum temperature and rainfall of 42 weather stations of BMD for 2021 were used for the study. Year and station wise maximum value of maximum temperature and minimum value of minimum temperature and total rainfall were determined. Then by using geo-statistical tools of Arc GIS10.8 software maps were prepared. In the maps, scenarios of climatic factors were described. In 2021, maximum temperature

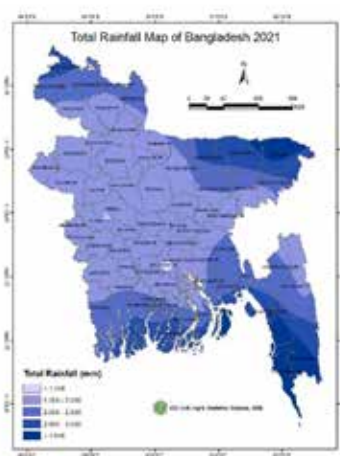
was high in central western part of Bangladesh and lower in south-eastern and north-western regions. Map 7 shows the maximum temperature map of Bangladesh for 2021. Minimum temperature were lower in north-western and high was in south eastern region. Map 8 shows the minimum temperature map of Bangladesh for 2021. Total rainfall was the highest in north-east corner and south-east areas and the lowest was in central part of Bangladesh. Map 9 shows the total rainfall map of Bangladesh for 2021. More or less throughout the year eastern side of Bangladesh is characterized by high rainfall and low temperature and the western side is known as low rainfall and high temperature area. Spatial distribution of minimum temperature and total rainfall are more or less same but maximum temperature is vice-versa to minimum temperature and total rainfall.



Map 7: Max.temp. of Bangladesh in 2021



Map 8: Min.temp. of Bangladesh in 2021



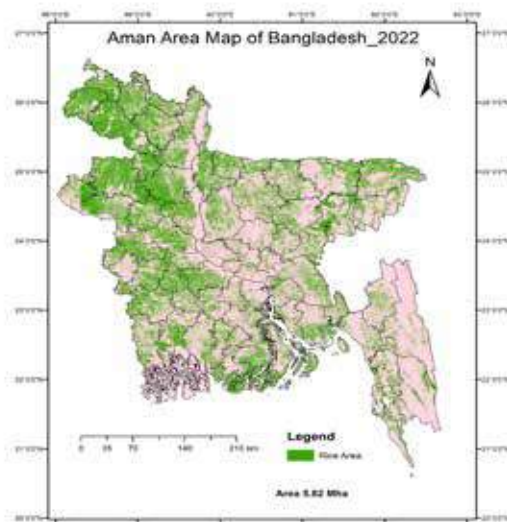
Map 9: Total rainfall of Bangladesh in 2021

PI: MAA, CI: RA, MIH, NMF, MAQ and MAAM SEASON WISE RICE AREA MAPPING OF BANGLADESH

Bangladesh is an agro-based country and rice is the main agricultural product. Rice contributes more than 80 percent to the total food supply. Nowadays, remote sensing and GIS are considering as powerful tools for crop mapping, monitoring and yield forecasting. These tools are very much reliable as well as time, labour and cost effective. Identification of crop types and mapping are the first steps of satellite remote sensing-based crop monitoring and yield forecasting system.

Remote sensing and GIS are being considered as powerful tools for crop mapping. Satellite Images were collected from MODIS data portal of NASA. Time series and level 3 product image of Normalized Difference of Vegetation Index (NDVI), Effective vegetation index (EVI) and Land Surface Water Index (LSWI) were collected according to the respective rice growing season. Whenever rice crop is initial stage in i.e. transplanting time its vegetation index are very low and peak vegetative stage i.e. PI or booting stage its vegetation index becomes very high and in ripening or harvest time its vegetation index becomes low. This algorithm was applied in agriculture area of Bangladesh and threshold value developed by ground truth data collected through GPS reading of various rice fields

all over Bangladesh. Then in Aman 2022 season rice map (Map 10) were prepared. Afterwards Then district wise rice cultivated area were calculated. The total area of rice grown in Aman 2022 was about 5.82 Mha.

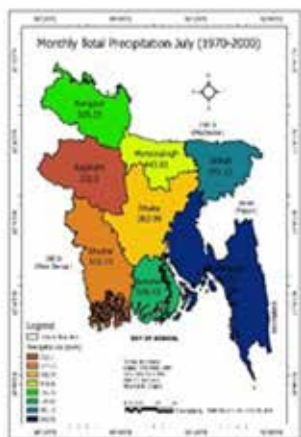


Map 10. Aman 2022 cultivated area map

PI: MAA, CI: RA, MIH, NMF, MAQ and MAAM PROJECTED CLIMATIC FACTORS (2050) MAPS OF BANGLADESH

In this study, we used the most recurrently used source of freely available, high resolution, downscaled, bias-corrected, and long-term climate raster dataset with global coverage, WORLDCLIM 1.4, for past (1970-2000) and future (2040-2060 or 2050), its updated version 2.1 (Fick and Hijmans

2017) presents precipitation (2010-2018). All the data are in raster with a high spatial resolution of 2.5 arc minutes. Whole country and division-wise precipitation maps (Map 11 to 16) for the past (1970-2000), present (2000-2018) and future (2040-2060 or 2050) were prepared by using Arc GIS software.



Map 11: July month average of total precipitation from 1970-2000



Map 12: July month average of total precipitation from 2010-2018



Map 13: July month average of total precipitation for the year 2050 according to RCP 2.6



Map 14: July month average of total precipitation for the year 2050 according to RCP 4.5



Map 15: July month average of total precipitation for the year 2050 according to RCP 6.0



Map 16: July month average of total precipitation for the year 2050 according to RCP 8.5

PI: MAA, **CI:** RA, BK, MIH, NMF, MAQ and MAAM

Table 10. Summary of July month average total precipitation of 1970 to 2000, 2010 to 2018 and forecasted 2050 (By RCP model 2.6, 4.5, 6.0 and 8.5).

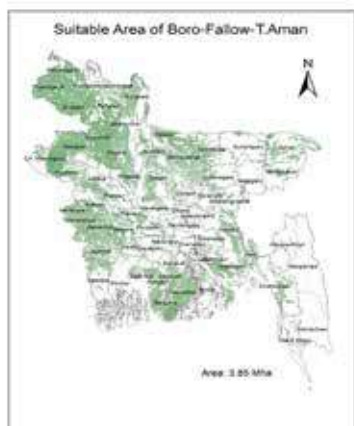
Division	Average precipitation (mm) 1970 to 2000	Average precipitation (mm) 2010 to 2018	Precipitation(mm) 2050 (RCP 2.6)	Precipitation(mm) 2050 (RCP 4.5)	Precipitation (mm) 2050 (RCP 6.0)	Precipitation (mm) 2050 (RCP 8.5)	Average of precipitation (mm) 2050(RCP 2.6, 4.5, 6.0 and 8.5)	Average of precipitation (mm) 2050 to 2010-2018
Rangpur	505.15	477.97	509.66	507	557.23	520.97	523.715	45.745
Rajshahi	332.3	323.51	361.7	385.26	380.32	342.66	367.485	43.975
Khulna	372.73	372.82	392.21	388.09	391.32	367.54	384.79	11.97
Mymensingh	443.91	426.93	464.84	477.08	499.56	478.61	480.0225	53.0925
Sylhet	551.11	545.11	585.36	594.3	630.69	606.4	604.1875	59.0775
Dhaka	383.99	396.37	396.48	399.39	406.53	397.14	399.885	3.515
Barishal	450.43	572.84	577.67	581.92	576.26	564.68	575.1325	2.2925
Chattogram	665.51	713.3	636.45	650.58	654.69	632.66	643.595	-69.705

Map 11 to 17 and Table 10, depict that in all divisions of Bangladesh average total precipitation (average by RCP 2.6, 4.5, 6.0, and 8.5 models) of July month in 2050 will be increased in comparison to average total precipitation during 2010-2018, only exception is Chattogram division, where precipitation will be decreased by about 69 mm. The precipitation of July month will rise the highest in Sylhet and Mymensingh divisions with an amount of about 59 mm and 53 mm, respectively.

SUITABILITY MAPPING OF VARIOUS CROPPING PATTERN

Cropping pattern is important in agricultural system. Various physical and chemical properties of soil varies spatially, on the other hand various

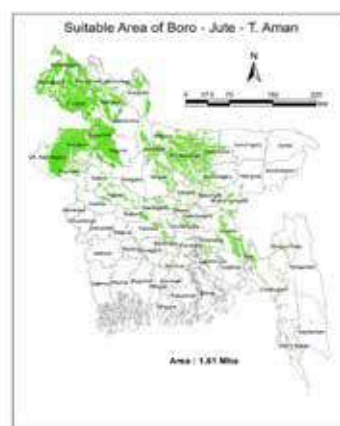
cropping pattern are suitable for some specific physical conditions. As we need high production with limited land, so it will be very helpful if we have cropping pattern wise suitability map based on soil properties. Soil physical properties and climatic parameter maps (shape file) were considered to determine suitable growing area for particular cropping pattern. Arc GIS software were used to prepare suitability maps. The suitability scale category 1 to 3 will be assigned to each soil and climate characteristic in relation to particular cropping pattern cultivation by the recommendation of relevant expert. Suitable areas from different soil and climatic properties will be intersected. Finally, the suitability map were generated.



Map 15: Suitability Map of Boro-Fallow-T. Aman



Map 16: Suitability Map of Boro-Aus-T. Aman



Map 17: Suitability Map of Boro-Jute-T. Aman

Boro-Fallow-T. Aman cropping pattern is suitable in west and middle part of Bangladesh and total suitable area is 3.85 Mha. Boro-AusT.Aman cropping pattern cover total suitable area 1.09 Mha and these suitable area in north-west and central northern sides of Bangladesh. Boro-Jute-T. Aman is suitable in north-west and central northern sides of Bangladesh and total suitable area is 1.81 Mha.

PI: MAA, **CI:** RA, BK, MIH, NMF, MAQ and MAAM

Delineation of Rice Area changes in Coastal Area of Bangladesh Using Remote Sensing

Data and Machine Learning Approach

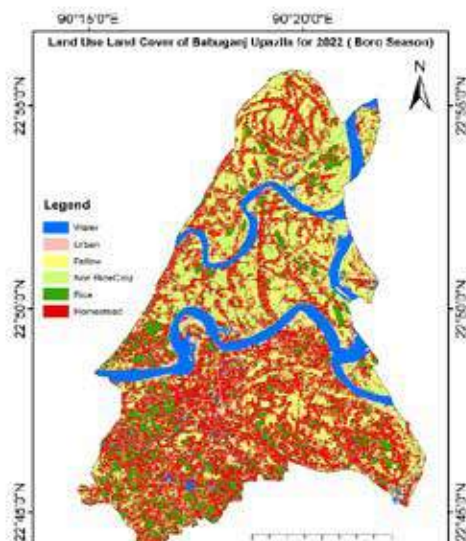
The rice area of Bangladesh is not the same over time. Various environmental and socio-economic causes of the rice area vary over time. Moreover, recently governments have many interventions to increase the rice area, especially in coastal regions like Barishal and Khulna divisions. Thus, it is important to know the effect of their programme through delineating the rice area changes over time. Babuganj upazila is an administrative unit located in southern Bangladesh, specifically within the

Barisal district. For this study, Sentinel 2A, 10m spatial resolution satellite imagery data was utilized to assess the land use land cover (LULC) changes during the Boro season in Babuganj upazila of the Barishal district.

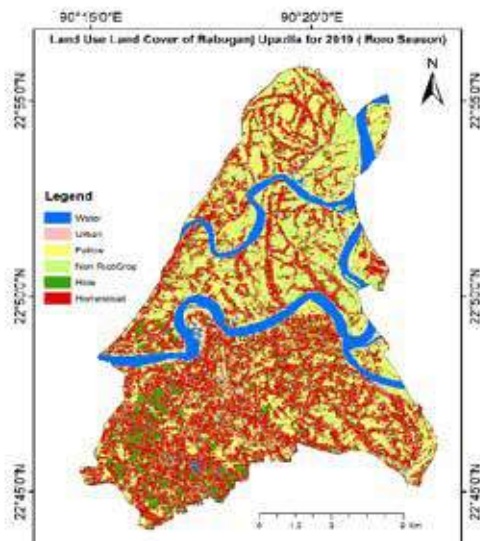
In Bangladesh Boro rice is cultivated from December to May. In March boro rice comes in peak vegetative stages i.e. maximum tillering/ booting stages. The collected images were stacked together to form an RGB image, which was then used to produce a preliminary land use land cover map (LULC) for each year (2019 and 2022). To achieve more accurate and detailed classification, the images were analyzed and training data were produced based on colour, texture, tone, and structure, which allowed for the identification of different land cover types. Then maximum likelihood supervised image classification was used to prepare final land use land cover maps.

From land use land cover map of 2019 and 2022 (Maps 18 and 19) the land cover changes can be detected precisely. The Rice area has increased sufficiently in 2022.

PI: MAA, **CI:** MIH, MMMK, RA, AD, MAQ and MAAM



Map 18. Land use land cover of Babuganj Upazila 2019.



Map 19. Land use land cover of Babuganj upazila 2022.

In Table 11 land cover changes have been depicted more precisely. From the table it is also evident that rice area increased dominantly in the four years (from 1013.41 ha to 1499.99) and the change percentage is more than 48% which is the highest among all other classes. After that the change percentage is 21% for water class. Almost every area class in Babuganj district experienced an increasing trend except for fallow lands. It experienced a declining trend exceptionally.

Perhaps, to understand the change percentage more

specifically a bar diagram has been created to point out which class has been changed more dominantly over the years. Furthermore, Figure 9 it shohes that rice area changed dominantly over the years having the highest percentage (48%), after that water area (21%) got the second highest position in the diagram and urban, non-rice crop area and homestead area come respectively. However, fallow land area showed negative percentage as it experienced declining trend over the years. Thus, we can say new rice area mainly comes from fallow land.

Table 11. Land use land cover change of Babuganj upazila over 2019 to 2022.

SL No	Class	Area (ha)_2019	Area (ha)_2022	Change	Change (%)
	Water	1628.84	1975.78	346.94	21.29982
	Urban	332.42	367.03	34.61	10.41153
	Fallow	3985.04	2609.21	-1375.83	-34.5249
	Non-Rice Crop	4156.34	4490.54	334.2	8.040728
	Rice	1013.41	1499.99	486.58	48.01413
	Homestead	6476.85	6650.35	173.5	2.678771
	Total	17592.9	17592.9		

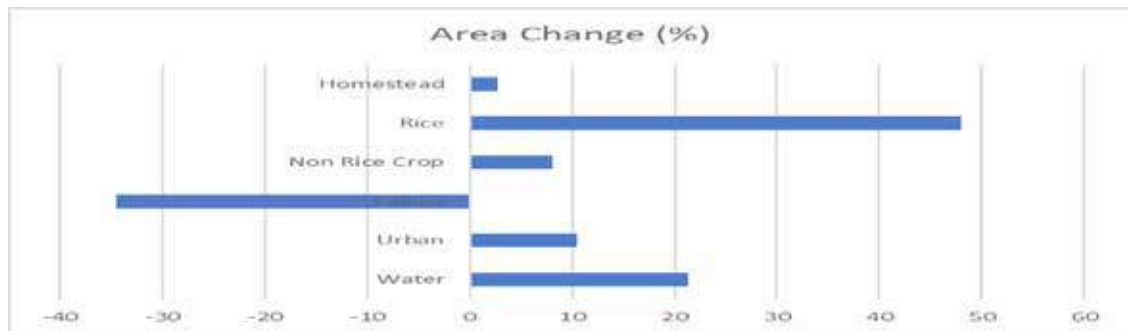


Fig. 9. Land use land cover change of Babuganj upazila over 2019 to 2022.

The evolution of rice cultivation areas in Babuganj upazila over three years has manifested several significant transformations, shedding light on the dynamic nature of agricultural practices and land usage in the region. There was a remarkable growth in newer rice cultivation zones, predominantly originating from fallow lands.

CAPACITY BUILDING THROUGH TRAINING

To set up the experiments, collecting, compiling, reporting, analyzing and presenting of the

experimental data and increase the accuracy of the findings and developing skills on research two types of training programmes were conducted in 2022-23. The topics were planning experiments, problem data, field experimentation, experimental design, factorial experiment, CRD, RCBD, LSD, SPD, Strip PD, SSPD, Strip SPD and augmented design in the training of 'Experimental Data Analysis'. Another topic was the 'Experimental field layout, data collection and data preparation' under this training programme.

A total of 68 participants were trained through the training programmes. Through the training on 'Experimental Data Analysis' eight participants were trained. The participants were CSO, PSO, SSO and SO of BRRRI. The second training programme was 'Experimental field layout, data collection and data preparation'. A total of 60 participants including FA, AFM and SA were trained through this training

PI: MIH, CI: MAAM, MAQ, NMFR and MAA

DEVELOP A WEB APPLICATION TO CALCULATE THE STABILITY INDEX FOR BRRRI STABILITY MODEL

In the genotype (Variety) development and release process stability analysis is one of the most important. Assuming this importance Agricultural Statistics Division of BRRRI developed a Stability model that was a great achievement of the division. But the analysis procedure to find out the stability index of genotypes is very laborious and time consuming act. We already developed a computer

programme using R software to calculate the stability index for BRRRI stability model. But for this R programming all users need an R environment setup in their machine (PC/Laptop). To overcome this complexity, we want to develop a web application software so that one can easily calculate the stability index of variety/genotype using BRRRI developed stability model under this study.

Methodology and Software Development Progress

Work is in progress to develop a web application integrating R and Batch Script (background software) with XAMPP, HTML, PHP, JQuery and JavaScript. For using this web application, user needs the arrangement of the data in the specific format to calculate the stability index for BRRRI stability model. Figure 10 the Home page, Menu bar with some view. Location map preparation, stability model view, model calculation and stability result view and print option has already been developed. However this software not hosted yet.

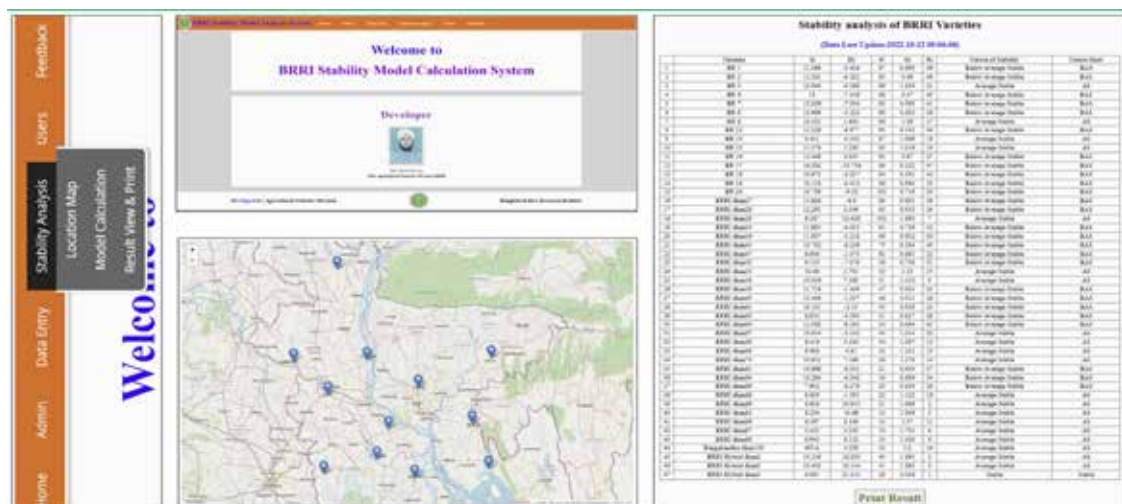


Fig. 10. Pictorial view of the stability analysis web application software

PI: MAQ CI: MIH, SMMR, NMFR, MAA, MAAM and RA

ESTABLISHING A PLATFORM FOR BBRI DEVELOPED MANAGEMENT INFORMATION SYSTEM (MIS)

BRRRI has already developed many web applications. (1) Salary Management System two Versions (2) Labour Management System two

Versions (3) Budget Management Software (4) Quota Management Software (5) CL Application Management Software (6) Stability Analysis for BRRI Model Calculation Software, develop (7) Rice Disease Monitoring System Software and (7) Tour Distance Calculation System Software. All the above mentioned softwares hosted in different servers with different addresses. So sometimes users face difficulty to find them. So, we more links to include in the BRRI website. It is the demand oh time to establish a unique platform for all the BRRI

developed MIS Software. Under this activity we established a unique platform for all the developed software so that one can easily find out and use their needed software.

Methodology and Progress

This unique platform has been developed by using XAMPP, HTML, PHP, Javascript (JS) and JQuery. The platform is ready and host in the BRRI LAN (172.16.101.17/MIS_BRRI). Figure 11 shows screenshot of the unique platform.



Fig. 11. Pictorial view of the unique platform for BRRI developed all MIS software.

PI: MAQ CI: MIH, SMMR, NMFR, MAA, MAAM and RA

DIGITALIZED BUDGET MANAGEMENT SYSTEM OF BRRI

Finance and Accounts (F and A) Division of BRRI HQ has to manage the yearly budget of BRRI. For this, they collect budget from the ministry and distribute to the employees of BRRI according to the demand and preserve in a register book. After that they prepare budget related report from the register book manually but the procedure is quite difficult and time as well as labour consuming. In this circumstance, Agricultural Statistics Division developed Digitalized Budget Management System for BRRI. The web application developed using XAMPP, HTML, PHP, Javascript (JS) and JQuery. The system already starts to use and the system is

in live in the BRRI LAN (172.16.100.168/budget). The respected user can input the budget related information and can see all the report with printable format after login with the system. We already have two reports prepared by using this application.

PI: MAQ CI: MIH, SMMR, RA and MFH

DIGITALIZED QUOTA MANAGEMENT SYSTEM OF BRRI

Employee recruitment is a continuous process of an organisation. To recruit the new employees for the vacant posts of the institute, Administration and Common Service Division continuously doing their hard work for this management service. Quota Management is one of the most important issue for new employee recruitment. Manually quota calculation is a very laborious

and time-consuming work. In this circumstance, Agricultural Statistics Division has developed Digitalized Quota Management System for BRRI. This is a web application and developed by using XAMPP, HTML, PHP, Javascript (JS) and JQuery. The system is already in use. Now the system is in live in the BRRI LAN (172.16.100.168/quota). The respected user can input the employee related information and can see all the report with printable format after login with the system.

PI: MAQ **CI:** MIH, SMMR, RA, NK and one from administration section

DIGITALIZED SALARY MANAGEMENT SYSTEM OF BRRI

One of the most important work of Finance and Accounts (F and A) of BRRI HQ is to prepare the monthly salary of the employees. For this, they collect the employee' salary related information and preserve in the salary register. After that they prepare salary related reports. Some of the reports have been prepared manually and the others by using software. In this circumstance, Agricultural Statistics Division developed Digitalized Salary Management System for BRRI HQ employees. The web application has been developed by using XAMPP, HTML, PHP, Javascript (JS) and JQuery. Now the system is in live in the BRRI LAN (172.16.100.168/salary). The system has included labour informations, attendance report, wages report and other reports with printable format. Many of the new features have been added to the network because of the demand of the users.

PI: MAQ **CI:** MIH, RA, SMMR, NMFR, MMBW, MAA, TSU, MAAM, MK, NK, AM, AH, MFH and SA

DIGITALIZED LABOUR MANAGEMENT SYSTEM OF BRRI

Farm Management Division (FMD) of BRRI works for labour management to collect attendance information from all divisions and sections. Previously was used FMD to do the entry, updates, monitoring and reporting the information manually. For that, many of these existing practices and procedures took long time to prepare wages sheet per month. In this circumstance, Agricultural Statistics

Division developed a update version (LMSV1) of the digitalized labour management system (LMS) for BRRI HQ. The system is a web application that has been developed by using XAMPP, HTML, PHP, Javascript (JS) and JQuery. Now the system is in live in the BRRI LAN (172.16.101.17/lmsV1). The system included labour informations, attendance report, wages report and other reports with printable format. Labour attendance correction option was included as the demand of the users.

PI: MAQ **CI:** MIH, RA, SMMR, NMFR, MMBW, MAA, MMR, MAAM, MK, NK, AM and AH

DIGITALIZED CASUAL LEAVE APPLICATION SYSTEM

Agricultural Statistics Division developed a web application of a casual leave (CL) using XAMPP, HTML, PHP, Javascript (JS) and JQuery. This is a very easy to access, accurate, consistent and most flexible casual leave (CL) application procedure added to the usual system (hard copy application). Now, this system is ready to use only for the Agricultural Statistics division and hosted in the BRRI LAN (172.16.100.168/cls). All kinds of reports related to casual leave can be generated by this web application whenever the authority needs.

PI: MAQ **CI:** MIH, RA, SMMR, NMFR, MMBW, MAA, MAAM, MK, NK, AM and AH

INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) ACTIVITIES

Sensor-based rice pest management through artificial intelligence (AI) technology of BRRI

BRRI Rice doctor mobile and web application has already them developed where BRRI released rice varieties, modern rice cultivation, insect and pest, disease and agricultural machinery related information are included. But it is an interactive tool for farmers, extension workers, scientists/researches, teachers, students and other users when the hi-tech will be initiated. It has introduced hi-tech solution through artificial intelligence (AI) for controlling disease and insect by image analysis. The dynamic mobile and web application is automatically providing the required problem-solving related information to the target audieuces. So, image data were collected from at least three

districts of different region (Gazipur Sadar, Rajshahi and Cumilla) for getting accurate results and it will be continued. Honorable Minister, Ministry of Agriculture (MoA) has launched the sensor-based rice pest management mobile application named Rice Solution with the aim of identifying diseases easily on 31 December 2022 at BRRI premises (Fig.12).



Fig. 12: Sensor-based rice pest management mobile app

SMMR, CI: MIH, Kabita and NK

A new website for BRRI

A website is a collection of web pages and related content that is identified by a common domain name and published on at least one web server. Hyperlinking between web pages guides the navigation of the site, which often starts with a home page. Some websites require user registration or subscription to access the content. Examples of subscription websites include many business sites, news websites, academic journal websites, gaming websites, file-sharing websites, message boards, web-based email, social networking websites, are providing real-time data, as well as other sites providing various other services. BRRI arranges national and international seminars and symposiums on a regular basis. Having a website makes it very easy for people to find information and also submit their papers, abstracts and posters for attending national and international seminars and symposiums. People can read about BRRI, discover what it does, and get the answer a bunch of questions they have. By visiting the website people will be able to get information about BRRI

when they search on a search engine like Google, Yahoo or Bing. The website has been used to collect information, submit their papers, abstracts, posters and to get other services (Fig. 13).



Fig. 13: New website for BRRI

Strengthening Cyber Security System for BRRI

The cyber security system is the technique of protecting server, computer network, software, application, files, source code and database from unauthorized access, hacked or attacks. Virtual Private Network (VPN) provides a safe and encrypted connection over private and public networks that transports data securely. A VPN protects data and identity over public networks by creating a private network from public internet connection. VPNs mask internet protocol (IP) addresses. So, it is impossible to link it to online activity via IP detection. A VPN tunnel is an encrypted connection between the VPN client (local computer) and the server (VPN server). Since the connection is encrypted, nobody is able to intercept, monitor, or alter the communications. For configuration of the VPN for BRRI, its outer and inner tunnels are completed successfully.

BRRI Alapon Telephone Directory Mobile App

The BRRI Telephone Directory Mobile app named as *BRRI Alapon* according to the monthly progress review meeting of innovation team in September 2020. This mobile app developed for BRRI officials to communicate with each other through this app like imo, Viber, Whatsup, WeChat etc. The app has features like chat, online calls, group messaging and location sharing. 'BRRI Alapon' available in Apple's App Store (*iStore*) and Google play store for *Android* phone users. Anybody can call and

exchange messages more securely using this app. App to app call, email and SMS is completely free for the users. Database already been developed for this app. All types of data have been collected from divisions, sections and regional stations of BRRI for developing the telephone directory mobile app.

Vehicle Requisition Management System of BRRI

Vehicle requisition management system (VRMS) is a transportation pool management activity of BRRI are complex and updating the allottee individually in time which is a tedious work. The designated official of Transport the Division is needed to work after office to manage the official vehicle requests and to convey the confirmation to the requester and driver over the phone. VRMS ease the allotment work using a simple requisition management system that doesn't require any advanced computing skills and the confirmation is sent by using SMS and email. So the requesters are informed through SMS on basis of demanding vehicle for official or personal purpose as well as driver get confirmation SMS for their upcoming duty. The database has already developed and architecture design has been finalized. The information of all vehicles of BRRI (driver's name, mobile number and vehicle reg. number etc.) has been collected from the transport section.

Training on Innovation, service process simplification (SPS) and e-Nothi management for enhancing capacity of BRRI employees

Innovation and service process simplification (SPS) tool is essential to introduce the culture of innovative practices that would accelerate and simplify the BRRI research activities and service delivery process. Agricultural Statistics Division has implemented all the innovation activities and conducted various trainings on Public service Innovation (PSI), Service Process Simplification (SPS), Simple Implementation Project (SIP) and e-Nothi management as well as several annual innovation work plan of BRRI. Two-day-long 'Service Process Smplication (SPS)' training has been completed on 27-28 May 2023 and 'Public Service Innovation' training has completed on 3-4 June 2023 (Fig. 14). Other than that, 'e-Nothi System' in-house training has been conducted from 31 May to 15 June 2021 for all divisions and sections of BRRI HQ.

BRRI Rice Doctor mobile and web app

BRRI Rice Doctor mobile and web application that provides information related to rice varieties, modern rice cultivation practices, insect-pest and diseases. It is a dynamic diagnosis tools. It is useful for scientists, researchers, teachers, students and private input dealers. English and Bengali version of Rice Doctor mobile apps and web apps have been developed to solve all the problems of rice cultivation. The apps also include a push notification and a Bangla text to speech option to facilitate users to view up-to-date information by sending text messages to specific problems. The 'Feedback' option has been added to provide the necessary information to the option is incposed to be euseful tor the farmers as well as the concerned officials improve the quality of the app (Fig. 13).



Fig. 13: BRRI Rice Doctor mobile apps

BRKB website management

Bangladesh Rice Knowledge Bank (BRKB) is a hub of rice knowledge. This is a dynamic source of knowledge and also updated regularly to keep consistency with the latest innovations and users' feedback. BRKB Website has been managed, maintained and modified in collaboration with Training, Breeding and other research divisions. BRKB is updated regularly with the latest varieties such as BRRI dhan106, BRRI dhan105, BRRI dhan104 and BRRI Hybride dhan8. In this reporting year, we have developed 24 web and mobile based fact sheets. And all fact sheets have been uploaded into BRKB website. A total of 4,50,985 users have visited the website.

Dynamic view connectivity system and Bangla searching system for BRKB website

We developed dynamic view connectivity and

Bangla searching system for BRKB website. Dynamic view connectivity works dynamically between BRKB website and Facebook page. Bangla searching system has the ability to search both in Bengali and English languages. It searches and automatically characterizes Bangla and English content of BRKB website about 1,020 research-related posts have been published in the dynamic view connectivity system and 35,589 users have got the service.

Web mail and group mail

We have created individual e-mail accounts in BRRI domain for all scientists and all class one officers as per requirement of MoA. We have updated the BRRI mail server from 8.8.15_GA_4372 FOSS version to 8.8.15_GA_4545 version. Now, our mail server is more secure than the previous one. We have provided 110 webmail related solutions in this reporting year. BRRI Web mail and Group mail have been hosted on BCC (Bangladesh Computer Council) server.

Developing secure system for BRRI Web Mail and Group Mail

We incorporated the Secure Sockets Layer (SSL) in the BRRI web mail. Spamming filtering system (SFS) scans all users of BRRI web mail every other hour and find out the user who occurs spamming. When a web mail user creates some or heavy spamming, the automatic active and close system (AACS) automatically detects the user and also blocks the user. As a result, the whole system (BRRI web mail) is safe from the block of Gmail, Yahoo, webmail or other e-mail servers. We have developed automatic active and close system (AACS) and also incorporated it in BRRI web mail, now our web mail is more secured. About 102 webmail users have created heavy spamming, AACS has detected those users and also blocked them so, the whole system has been saved from the block of Gmail, Yahoo, webmail or other e-mail servers. SFS has scanned about 84 webmail accounts and solved all the problems.

Online application system of BRRI

BRRI started online application system for the first time since 23 May to 12 June 2019. We have already completed another online application process from 4 March to 24 March 2020. Applicants complete

their application through this system and receive admit card, notification of written test date, result and all kinds of information through this online system and SMS based application. This system developed by Teletalk Bangladesh Limited.

e-Nothi management system of BRRI

At present, hundred percent e-Nothi system is being used in omunication with all divisions and sections of BRRI as well as regional stations. The in-house training on 'e-Nothi System' has been conducted for all divisions and sections' e-Nothi user of BRRI HQ for developing their skill. Using this system BRRI has issued 11,410 letters to Ministry of Agriculture (MoA) and different organizations as well as completed 28,605 note, from July 2022 to June 2023.

Management of BRRI local area network and internet connectivity

ICT network and internet connectivity of BRRI is managed and maintained by ICT Cell, Agricultural Statistics Division with the help of the Network developer company. We have increased our digital data network (DDN) bandwidth connectivity from 157 Mbps to 177 Mbps. Has been established a redundant internet line from Bangladesh Research and Education Network (BdREN). And also increased the bandwidth from 100 Mbps to 120 Mbps. We also established Local Area Network (LAN) connectivity at five regional stations i.e. Rangpur, Barishal, Sonagazi, Cumilla and Habiganj.

BRRI web portal management

BRRI web portal (www.portal.gov.bd) is developed, managed and updated by ICT Cell of Agricultural Statistics Division. BRRI web portal/ website is being uploaded regularly by latest information. BRRI web portal is in Bangla and English languages. In this reporting year, we have updated more than 1,365 pages and uploaded more than 6,643 pages and uploaded more than 6,720 documents like PDF, JPG, report, Word and other files on the BRRI website.

BRRI networks update, maintenance and extension

BRRI Networks Facebook group is a big forum for all the scientists, officers and staffs of BRRI. ICT Cell created this group to post research related

work for noble work of rice and related activities, various problems and their solutions, official interactions in this forum. The Facebook group of “*BRRRI Network*” link is <https://www.facebook.com/groups/1409267722690061/>. Thus, the *BRRRI Network* is continuing with regular updating posted by everybody of this group. Till now, *more than 4,100* individuals have joined this group. It is increasing gradually. It has stored at least 1200 and more photos of all national programme and research activities of head quarter and all the regional stations. It has also uploaded around 240 necessary pdf and word file document for all members.

Personal data sheet database

We have created personal data sheet (PDS) database for all the scientists, officers, clerks as per requirement of the Ministry of Agriculture (MoA). It has been increased up to 339 users in the BRRRI PDS database. In this reporting year, we have approved more than 2,437 specific information and general information also updated by personal user without help of admin approval. PDS database is updated regularly with the latest available information. It is routine work.

Video conference system

We have established video conferencing system (VCS) at BRRRI to communicate with MoA and other government organization. Also, established Distance Communication Center (DCC) at BRRRI with the help of Bangladesh Research and Education Network (BDREN) funded by University Grants Commission (UGC), which is similar to VCS. Besides, we have created Skype account for all divisional heads and regional stations heads. The communication between BRRRI headquarters and other regional stations has been conducted by Video Conference System in every monthly co-ordination meeting. Monthly co-ordination meeting, Thursday seminar, In-house training and workshop have been conducted by video conference system. Also, maximum meeting is being conducted by video conference system using Zoom Platform System.

Rice Pest Corner

We have developed Rice Pest Corner with information on insect and pest management as well as disease management. Rice Pest Corner has been developed for farmers, extension personnel,

scientists, researchers, teachers, students and other users who want to learn and control insects and diseases and other problems that can occur in case of rice.

Heritage of BRRRI

Heritage refers to something inherited from the past. So, ICT Cell of Agricultural Statistics Division creates a menu named Heritage (<http://www.brri.gov.bd/site/page/cdf8a394-1652-4607-a1d1-b87de15b20f8>). It has created individual pages like former DG and Directors, CSO, PSO, SSO, Officers and Staff's etc. It has included almost all former scientists' person photos, short description as well as a link where anybody can find about their detailed information. Thus, it has made the *Heritage*. Because the word Heritage in the broadest sense refers that which is inherited. ICT cell of Agricultural Statistics Division provides ICT related support services to other divisions such as, updating data and uploading information to BRRRI.

ICT and related fair

ICT Cell of Agricultural Statistics Division has been participated in several ICT and related fairs such as Digital World Fair, Development Fair, Tatha Mela and World Food Fair etc in the reporting period.

Support services

The scientists of this division are also engaged in helping scientists of other disciplines in their planning experiments, statistical data analysis and interpretation of results. Sixty different types of analyses were performed during the reporting period. A number of maps were prepared using GIS and supplied to the scientists of other divisions whenever required.

Overall, ICT Cell of Agricultural Statistics Division has taken initiatives in accordance with government perspectives but BRRRI Networks facebook group is first introduced among all National Agricultural Research System (NARS) and also first among all research institutes. The ICT cell of Agricultural Statistics Division provides e-Nothi management system, e-Tender and other internet related support services to other divisions and sections.

Farm Management Division

294 SUMMARY

296 RESEARCH ACTIVITIES

SUMMARY

An experiment was conducted at the West Byde of BRRI farm, Gazipur during T. Aman and Boro 2022-23 seasons to evaluate the efficacy of newly developed mechanical rice transplanter cum fertilizer applicator. In T. Aman season, tiller/m², panicle/m², filled grain/panicle and grain yield were statistically significant among the treatments. Mechanical transplanting along with 80% fertilizer deep placement produced the statistically highest grain yield (6.14 t ha⁻¹) of BRRI dhan87 in T. Aman season. On the other hand, in Boro season, filled grain/panicle and grain yield were statistically significant among the treatments. Mechanical transplanting along with 100% fertilizer hand broadcasting produced the highest grain yield (7.20 t ha⁻¹) of BRRI dhan92 which was statistically identical with hand transplanting along with 100% fertilizer hand broadcasting (7.17 t ha⁻¹) followed by Mechanical transplanting + 80% Urea, TSP and MoP deep placement by transplanter cum fertilizer applicator, Mechanical transplanting + 100% Urea, TSP and MoP deep placement by transplanter cum fertilizer applicator and Mechanical transplanting + 70% urea, TSP & MoP deep placement by transplanter cum fertilizer applicator (6.01, 5.64 and 5.46 t ha⁻¹, respectively). The efficacy of a mechanical seedling transplanter and deep placement of mixed fertilizer can have a significant impact on rice yield. Transplanting of seedlings by hand is labour-intensive and time-consuming whereas mechanical transplanter automates the process, saving time and reducing labour requirements.

An experiment was conducted at the west byde of BRRI HQ farm, Gazipur during T. Aman and Boro 2022 -23 seasons to investigate the effect of foliar application of silicon's aqueous solution on the yield of aromatic rice. No significant differences were found among the treatments in all the variables except grain yield in Boro seasons. But in T. Aman season, grain yield was not significantly different among the treatments. Silicon application has significant effect on the yield of aromatic rice (BRRI dhan50) in Bangladesh condition. It increases rice plant resistance to lodging and drought and

dry matter accumulation and can also positively affect the activity of some enzymes involved in the photosynthesis in rice as well as reduces the senescence of leaves and protects the plant against pests and diseases thus increases rice yield.

An experiment was conducted at the West Byde of BRRI farm, Gazipur during T. Aman 2022 season to find out the best planting time of fine rice varieties for higher yield and quality. In case of the tested fine rice varieties, 15 August transplanted plants produced the highest grain yield (5.36 t ha⁻¹) followed by 30 July and 30 August transplanting. The lowest the grain yield (2.77 t ha⁻¹) was found in 1 July transplanting. Milling outturn (%), head rice recovery (%) and protein content (%) were produced higher in 30 July to 15 August transplanting.

A laboratory experiment was conducted at BRRI HQ, Gazipur in Farm Management Division, Grain Quality and Nutrition Division as well as BRRI Central Laboratory from June 2022 to July 2023 to examine the effect of storage times in different container on quality of rice. During different storage times of BRRI dhan84 in Plastic Container showed pronounced effects on various quality traits. In case of seed quality, germination percentage and seedling vigour index were decreased with increased storage times at different storage container but in grain quality, milling outturn (%), head rice recovery (%), milled rice length (mm), breadth (mm), cooking time (min) and moisture content (%) were increased with increased storage times at different storage container. Content of amylose (%) and protein (%), and alkali spreading value were decreased with increased storage times at different storage container. Vitamins (B-complex) were significantly different with different storage container at different storage times. Vitamins were decreased with increased storage times at different storage container.

An experiment was taken aiming to find out possible way(s) to increase soil resistance capacity and to develop artificial plough pan in BRRI farm. After Boro harvest in the previous year, a trench of 12 inches was dug and a 3-inches fine sand layer were placed at 8 inches (20 cm) below from soil surface. After next T. Aman crop, compactions were

carried out when the moisture content was suitable. The compactions were done twice in 11 days' interval using wheel-to-wheel tractor passages using a pressure of (approximately) 80 k Pa (in treatment plots only). No significant differences were found among the treatment combinations in the experiment.

An experiment was taken to determine fertilizers' effect on algal growth in rice field and to identify suitable fertilizer management to control algae in rice field. Treatments were: (i) Full dose basal fertilizer of DAP, MoP, gypsum and Zinc (BRRI recommended); (ii) Full dose basal fertilizer of TSP, MoP, Gypsum and zinc; (iii) Half dose basal fertilizer of DAP and full dose MoP, gypsum and Zinc; (iv) Half dose basal fertilizer of TSP and full dose MoP, gypsum and zinc; and (v) Basal fertilizer of full dose TSP, MoP, gypsum and zinc, and 1/3rd urea. For treatment (iii) and (iv) the rest half dose DAP/TSP were applied during second urea top-dress. No significant differences were found among the treatments for yield and yield components. In the next year experiment, artificial inoculation of algae will be done to get a clear result.

The average wage rate per day (8.0 hrs) was Tk. 573-648 at different locations around BRRI HQ and regional stations by conducted a survey of labourers' wage rate throughout the year. The highest wage rate of labourers was in May (Tk. 700-800 per day) due to harvesting and post-harvest operations of Boro rice and transplanting of Aus rice.

The highest wage rate (650-750 Tk per day) with food was observed in Cumilla. The average labour wage rate without food varied between Tk 629-738 at different locations surrounding of BRRI Regional Stations and it was the highest (Tk 700-900) in Rajshahi. Working hour was also different based on location. The working time (8 hrs day⁻¹) of labourers was more or less similar except Barisal, Cumilla and Satkhira.

In total 04, 11 and 12 varieties were cultivated in BRRI research field for the purpose of TLS production during Aus, T. Aman and Boro seasons, respectively in 2022-23. Yield of the varieties ranged from 3.50 t ha⁻¹ to 5.23 t ha⁻¹, 2.54 t ha⁻¹ to 6.14 t ha⁻¹ and 4.87 t ha⁻¹ to 8.60 t ha⁻¹ in Aus, T.

Aman and Boro varieties, respectively. Among the Aus varieties, BRRI dhan98 produced the highest yield (5.23 t ha⁻¹) where as BRRI dhan87 gave the highest yield (6.14 t ha⁻¹) in T. Aman followed by BRRI dhan95 (6.04 t ha⁻¹) and BRRI dhan89 gave the highest yield (8.60 t ha⁻¹) followed by BRRI dhan104 (7.58) in Boro season.

Farm Management division produced 16,868 kg TLS of which 3090 kg, 5700 kg and 8078 kg was produced in Aus, T. Aman and Boro seasons, respectively. In addition, 80 kg non-seed and 1507 kg mixed rice were produced during this period.

In total 10,787 kg breeder seed was produced under the supervision of FMD. In T. Aman season, 4130 kg breeder seeds of BRRI dhan30 and BRRI dhan98 were produced whereas 6657 kg of BRRI dhan92 and Bangabandhu dhan100 were produced during Boro 2022-23 seasons.

In total 13,152 kg seed was distributed by FMD during the reporting period in which 3020, 4162 and 5900 kg seeds were distributed in Aus, T. Aman and Boro seasons, respectively. These seeds were distributed to DAE, researchers, different research division and regional stations of BRRI, seed producers, different agricultural organizations and agencies, BRRI employees and farmers.

Including regional stations, BRRI had 682 labors of which 464 regular and 218 irregulars at the start of the reporting time (1st July, 2022). In BRRI HQ, total number of laborers was 436 of which 281 regular and 155 irregular labors.

Total labour utilization by different divisions and sections of BRRI HQ was 1,91,869 man days of which 57.38%, 39.79% and 2.83% were utilized for research, support service and holidays, respectively.

In total Tk 10,98,78,631 was paid to the labourers as labour wage in which Tk 6,28,38,093, Tk 4,36,04,938 and Tk 3,189,000 were for research work, support service works, leaves and holidays, respectively.

Including regional stations of BRRI in total Tk 75,69,398 was given to 15 labourers as financial benefits for retirement and also Tk24,923 was given to 11 labourers as medical financial benefits for injury in working time during the fiscal year 2022-23.

BRRI has 284.40 ha of land of which 184.61 ha is cultivable. In total 81.85 ha of land were utilized by different research divisions in different season at BRRI HQ of which 6.18 ha in Aus, 37.65 ha in T. Aman and 38.02 ha in Boro season. Among the research divisions, Plant Breeding Division utilized the highest amount of land (25.41 ha) followed by GRS Division (13.25 ha) and Hybrid Rice Division (7.84 ha).

This division manages the BRRI flower garden to maintain the aesthetic view of the office campus, arrange beautification of BRRI premises and playground during different observation of national or international and organizational events, and execute tree plantation, management of different fruit and other trees in BRRI. This division effectively carried out activities of mosquito control, graveyard management, playground management and helped in other support services and management activities of BRRI.

Detailed Activities

The Farm Management Division (FMD) was established at the inception of BRRI in 1970. This division is one of the components of the Socio-economics and Policy Programme Area of BRRI and carries out research as well as management and support services for the institute, such as, HYV rice seed production (breeder seed and truthfully labelled seed), fixing of labour wages, weed management methods and economics, water management (irrigation and drainage), maintenance of the BRRI office premises and field management, garden management and beautification of BRRI office areas, graveyard management, land and labour management for smooth conduct of field research at BRRI etc.

RESEARCH ACTIVITIES

Rice Production Management

Efficacy of mechanical seedling transplanter and deep placement of mixed fertilizer on rice yield

This experiment was conducted at the West Byde of BRRI HQ farm, Gazipur during T. Aman and Boro 2022-23 seasons to evaluate the efficacy of newly developed BRRI mechanical rice transplanter cum fertilizer applicator. Urea fertilizer along

with TSP, MoP and Gypsum fertilizer can be placed and covered in 6-8 cm soil depth during mechanical transplanting using BRRI developed rice transplanter. Randomized Complete Block (RCB) design was followed with three replications. Individual plot size was 8 m × 5 m along with 30 cm buffer spacing. Treatments of the study were T_1 = Mechanical transplanting along with 100% fertilizer (Urea, TSP, MoP and gypsum) deep placement, T_2 = Mechanical transplanting along with 80% fertilizer (80% urea and 100% TSP, MoP and gypsum) deep placement, T_3 = Mechanical transplanting along with 70% fertilizer (70% urea and 100% TSP, MoP and gypsum) deep placement, T_4 = Mechanical transplanting along with 100% fertilizer hand broadcasting (TSP, MoP and gypsum fertilizer as basal dose and urea fertilizer in three splits) and T_5 = Hand transplanting along with 100% fertilizer hand broadcasting (TSP, MoP and gypsum in basal dose and urea fertilizer in three splits). In this experiment, BRRI dhan87 and BRRI dhan92 were used in T. Aman and Boro seasons, respectively. Twenty-day-old mat type seedlings were used in mechanical transplanting at 30 cm × 15 cm spacing whereas spacing of manual transplanting was 20 cm × 20 cm. Growth data (plant height and tiller) were collected. Collected data were statistically analyzed using standard statistical procedure (Statistix 10).

Results and Discussion

In T. Aman season, growth and yield contributing parameters such as tiller number m^{-2} , panicle number m^{-2} , filled grain/panicle and grain yield were significantly affected by mechanical transplanting with deep placement of NPK fertilizers. T_2 = Mechanical transplanting along with 80% fertilizer deep placement by transplanter cum fertilizer applicator plot produced the statistically highest tiller number (336) and panicle number per square meter (321) followed by other treatments.

But in Boro season, numbers of tiller/ m^2 and panicle/ m^2 were not significantly affected by mechanical transplanting with deep placement of NPK fertilizers and hand transplanting with hand broadcasting of fertilizer. T_4 (Mechanical transplanting along with 100% fertilizer hand broadcasting) produced the highest number of tiller

(401) per square meter and the lowest number (333) from the treatment T_5 = Hand transplanting along with 100% fertilizer hand broadcasting (Table 1).

The treatments T_5 = Hand transplanting along with 100% fertilizer hand broadcasting produced higher number of filled grain/panicle (179) in T. Aman and (160) in Boro season than other treatments and the lower number of filled grain/panicle from the treatment T_1 = Mechanical transplanting along with 100% fertilizer deep placement (112) in T. Aman and 113 from T_3 in Boro season (Table 1).

There were no significant differences among the treatments in case of number of unfilled grain/panicle in both the season.

In T. Aman season, grain yield were significantly varied among the treatments (Table 1). In T. Aman season, T_2 (Mechanical transplanting along with 80% fertilizer deep placement) produced the highest grain yield (6.14 t ha^{-1}) followed by T_5 , T_4 and T_3 (4.98 , 5.02 and 4.91 t ha^{-1} respectively). However, grain yield under treatment T_1 produced statistically lower yield compared to the others. On the otherhand, during Boro season, T_4 (Mechanical transplanting along with 100% fertilizer hand broadcasting) produced the highest grain yield (7.20 t ha^{-1}) which was statistically identical with T_5 (Hand transplanting along with 100% fertilizer hand broadcasting (7.17 t ha^{-1}) followed by T_2 , T_1 and T_3 (6.01 , 5.64 and 5.46 t ha^{-1} , respectively). However, grain yield of treatment T_3 produced statistically lower yield than the other treatments (Table 1).

No significant differences were found incase of straw yield and 1000-grain wt among the treatments in T. Aman season. But in Boro season, straw yield

and 1000-grain weight were highly significant among the treatments. T_4 produced the highest straw yield which was 6.47 t ha^{-1} and the lowest straw yield from T_2 (4.38 t ha^{-1}). T_2 produced higher 1000-grain wt (25.15gm) than other treatments and T_1 produced the lowest 1000-grain wt (23.16gm) (Table 1).

It may be concluded that significant variation was recorded in case of number of tiller m^{-2} , number of panicle m^{-2} , filled grain/ panicle and grain yield etc during T. Aman season and filled grain panicle $^{-1}$, grain yield, straw yield and 1000-grain weight during Boro season. From these results, mechanical transplanting with 80% fertilizer deep placement and mechanical transplanting with 100% fertilizer hand broadcasting practices are recommended for rice production. Mechanical rice transplanting is the most vital issue to overcome labour shortage and high wage of labour during transplanting. It has also been treated as time and labour saving, transplanting in proper time and maintaining proper plant density that helps to high productivity. Deep placement of fertilizer facilitates placing the fertilizer below the soil surface, closer to the rice root zone, reduced nutrient loss, enhancing nutrient uptake efficiency, promotes stronger and healthier root system. This can result in improved plant growth, increased tillering and ultimately higher the grain yield. But this integrated approach can not always increase yield due to less soil plough pan and improper calibration of machine. Uniform application of fertilizer always not be ensured due to proper operation of machine by skilled operator. So, it's important to note that the efficacy of theses practices can vary depending on factors such as soil type, climate conditions, rice variety and proper implementation of techniques.

Table 1. Yield and yield contributing parameters of rice as affected by mechanical seedling transplanting with deep placement of mixed fertilizer and hand transplanting with hand broadcasting in T. Aman and Boro 2022-23 seasons.

Treatment	Tiller m ⁻² (no.)	Panicle m ⁻² (no.)	Filled grain panicle ⁻¹ (no.)	Unfilled grain pani- cle ⁻¹ (no.)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	1000 grain wt (gm)
T. Aman season (BRRI dhan87)							
T ₁	234	226	112	19	4.66	7.33	24.42
T ₂	336	321	148	15	6.14	7.52	24.58
T ₃	328	318	123	20	4.91	7.87	24.63
T ₄	281	272	144	17	5.02	7.27	24.63
T ₅	294	283	179	18	4.98	6.83	24.63
Lsd (0.05)	***	***	***	ns	***	ns	ns
CV%	9	10	14	30	8.66	8.51	1.15
Boro season (BRRI dhan92)							
T ₁	387	374	117	21	5.64	4.38	23.16
T ₂	382	364	116	19	6.01	4.3	25.35
T ₃	379	361	113	27	5.46	4.77	24.58
T ₄	401	384	123	29	7.20	6.47	24.02
T ₅	333	328	160	17	7.17	6.38	25.15
Lsd (0.05)	ns	ns	***	ns	***	***	***
CV%	8	8	10	22	11.33	4.19	2.61

*** means statistically significant ns= non-significant

T₁ = Mechanical transplanting along with 100% fertilizer (Urea, TSP, MoP and gypsum) deep placement, T₂ = Mechanical transplanting along with 80% fertilizer (80% Urea and 100% TSP, MoP and gypsum) deep placement, T₃ = Mechanical transplanting along with 70% fertilizer (70% urea and 100% TSP, MoP and gypsum) deep placement, T₄ = Mechanical transplanting along with 100% fertilizer hand broadcasting (TSP, MoP and gypsum fertilizer as basal dose and urea fertilizer in three split) and T₅ = Hand transplanting along with 100% fertilizer hand broadcasting (TSP, MoP and gypsum in basal dose and urea fertilizer in three splits).

Effect of foliar application of silicon on yield of aromatic rice

This experiment was conducted at the West Bye of BRRI HQ farm, Gazipur during T. Aman and

Boro 2022-23 seasons to investigate the effect of foliar application of different concentrations of silicon solutions on yield of aromatic rice. BRRI dhan70 and BRRI dhan50 were used in T. Aman and Boro seasons, respectively. Transplanting was done maintaining spacing of 20 cm × 20 cm during T. Aman and Boro seasons respectively. All intercultural operations were done according to BRRI recommendation and were same for all treatments. Silicon was sprayed maintaining four concentrations (Si₁ = 0.0, Si₁ = 0.5, Si₁ = 1.0 and Si₁ = 1.5 %) in two different times (20 DAT and 35 DAT). The experiment was done following RCBD design. Yield and yield components data were taken at harvesting time. Growth data (plant height and tiller number) were collected. Collected data were statistically analyzed using standard statistical procedure (Statistix 10).

Results of T. Aman 2022

In T. Aman season, plant height was more or less similar among the treatments along with the growth duration. No significant differences were found among the treatments. Higher number of tiller m^{-2} , panicle m^{-2} and filled grain/panicle were produced in 1.5% silicon's solution sprayed plot followed by 0.5%, 1.0% and control plot and lower in 1.0% silicon's solution sprayed plot (Table 2).

More yield was found in 1.5% silicon's solutions sprayed plot ($4.31 t ha^{-1}$) than the other treated plot. No significant differences were found in case of all variables among the treatments (Table 2).

It may be concluded that no significant differences among the treatments were found in growth and yield parameters. Since the plots were lodged resulting low yield and no significant differences were found among the treatments.

Results of Boro 2022-23

Plant height was more or less similar among the treatments along with the growth duration. The longest plant height was found in 1.0% silicon solution sprayed plot (86.7cm) (Table 2) There

were no significant difference was found among the treatments in case of tiller/ m^2 , panicle/ m^2 filled grain/panicle, unfilled grain/panicle, straw yield and 1000-grain weight etc. Higher number of tiller/ m^2 , panicle/ m^2 were produced in 1.0% silicon's solution sprayed plot and lower in control plot (Table 2).

Significant variation was observed in the yield of BRRI dhan50 in different concentration of silicon's solution treated plots (Table 2). The 1.0% silicon solution sprayed plot produced the highest grain yield ($6.23 t ha^{-1}$) which was statistically significant among the treatments and the lowest grain yield ($5.41 t ha^{-1}$) was found from 1.5% silicon solution sprayed plot.

It may be concluded that effectiveness of silicon foliar application can vary depending on factors such as soil type, rice variety, application timing, dosage etc. These studies showed mixed results, with some studies reporting significant yield increases, while others showed no significant differences among the treatments in growth and yield parameters. Therefore, we can say that foliar application of silicon has significant effect on yield of aromatic rice (BRRI dhan50).

Table 2. Yield contributing parameters of BRRI dhan70 and BRRI dhan50 as affected by foliar spray of different concentrations of silicon solutions' during T. Aman and Boro 2022-23 seasons.

Treatment	Plant height (cm)	Tiller m^{-2} (no.)	Panicle m^{-2} (no.)	Filled grain panicle $^{-1}$ (no.)	Unfilled grain panicle $^{-1}$ (no.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	1000 grain wt (gm)
T. Aman season (BRRI dhan70)								
Si ₁	154.87	256	245	144	39	4.06	7.20	21.07
Si ₂	153.27	258	245	131	32	4.03	7.41	21.00
Si ₃	155.14	262	249	133	31	4.06	7.51	20.74
Si ₄	156.93	267	256	148	34	4.31	7.36	20.70
lsd (0.05)	ns	ns	ns	ns	ns	ns	ns	ns
CV %	3.35	4	4	14	29	2.65	3.21	2.15
Boro season (BRRI dhan50)								
Si ₁	84.73	345	330	141	31	5.68	6.55	15.50
Si ₂	86.73	368	356	118	39	6.01	6.32	15.62
Si ₃	85.87	382	368	140	27	6.23	6.30	15.78
Si ₄	83.33	349	339	137	34	5.41	5.92	15.77
lsd (0.05)	ns	ns	ns	ns	ns	***	ns	ns
CV %	3.35	9.27	9.77	19.22	22.21	1.76	4.11	2.96

[S₁, S₂, S₃ and S₄ represent 0.0, 0.5, 1.0 and 1.5 % silicon solution conc.]

** means statistically significant ns= non-significant

Influence of different dates of transplanting on growth, yield performance and quality of fine rice varieties

The experiment was conducted at the West Byde of BRRI farm, Gazipur during T. Aman 2022 season to find out the best planting time of fine rice varieties for higher yield and quality. The treatments were A. Transplanting dates: T₁ = 1 July, T₂ = 15 July, T₃ = 30 July, T₄ = 15 August, T₅ = 30 August, T₆ = 15 September; and B. Varieties: V₁ = BRRI dhan34, V₂ = BRRI dhan90 and V₃ = Binadhan-13. The treatments were distributed in strip-plot design with three replications (Transplanting dates in main plot and variety in sub plot) and spacing 20 cm × 20 cm. Twenty-day-old seedlings were transplanted on selected dates. All other intercultural operations were done as and when necessary. Yield and yield components data were taken at maturity stage. The collected data were analyzed using Crop Stat 7.2 Software programmer.

Results and Discussion

Results indicated that plant height and filled grain/panicles of tested varieties showed significant difference irrespective of transplanting date. The highest plant height was observed in 1 July transplanting of all tested varieties than the other transplanting dates (15 July, 30 July, 15 August, 30 August and 15 September) (Table 3). The highest number of panicles hill⁻¹ was found in BRRI dhan34 and BRRI dhan90 at 30 August transplanting except Binadhan-13 than 15 August and 30 July transplanting. The lowest was found in 1 July, 15

July and 15 September transplanting. The highest filled grain panicles⁻¹ was observed from BRRI dhan90 at 15 August transplanting and the lowest was in Binadhan-13 on 1 July transplanting (Table 3). Transplanting of 15 August produced the highest grain yield in BRRI dhan34, BRRI dhan90 and Binadhan-13 followed by 30 August and 30 July transplanting and the lowest in 1 July transplanting. After 30 August and before 30 July the yield of all tested fine rice varieties was decreasing. The highest harvest index (HI) was present in BRRI dhan34, BRRI dhan90 and Binadhan-13 at 30 August transplanting and the lowest in 1 July transplanting. The highest growth duration was present in 1 July transplanting in all the tested varieties and the lowest in 15 September. Binadhan-13 produced the highest growth durations in all transplanting dates followed by BRRI dhan34 and the lowest was in BRRI dhan90 (Table 4). Milling outturn and head rice recovery percentage had significant differences of transplanting dates and varieties. BRRI dhan34 produced the highest milling outturn (72.36%) and head rice recovery percentage (66.92%) followed by BRRI dhan90 with 15 August transplanting. The lowest head rice recovery percentage was present in 15 July transplanting with Binadhan-13. 15 July to 15 August transplanting, BRRI dhan34 produced the highest protein content than BRRI dhan90 and the lowest in Binadhan-13 at different transplanting dates (Table 5).

From the above results, it may be concluded that during T. Aman season, for tested fine rice varieties 30 July to 15 August transplanting produced statistically identical yield. Milling outturn (%), head rice (%) and protein content (%) produced higher yield in 30 July to 15 August transplanting.

Table 3. Effect of transplanting dates and varieties on plant height (cm), number of panicles hill⁻¹ and filled grain panicles⁻¹ in T. Aman 2022 at BRRI HQ farm, Gazipur.

Variety	Transplanting date																	
	1 st July			15 th July			30 th July			15 th August			30 th August			15 th September		
	PH	PN	GN	PH	PN	GN	PH	PN	GN	PH	PN	GN	PH	PN	GN	PH	PN	GN
V1	155.42	7.58	174.26	145.42	8.00	176.83	137.16	8.92	207.43	131.33	9.88	211.53	112.40	10.06	201.73	111.55	8.20	138.76
V2	115.58	7.66	261.60	117.10	7.35	273.03	115.33	9.09	288.07	102.08	9.52	297.63	86.58	11.22	288.66	86.66	7.98	243.93
V3	160.66	7.95	142.00	150.33	7.58	142.76	150.25	9.05	143.86	136.05	9.43	152.33	115.66	8.76	151.66	115.07	8.11	98.86
L S D (0.05)	5.49	1.11	25.11	5.49	1.11	25.11	5.49	1.11	25.11	5.49	1.11	25.11	5.49	1.11	25.11	5.49	1.11	25.11
CV	2.7	7.7	7.7	2.7	7.7	7.7	2.7	7.7	7.7	2.7	7.7	7.7	2.7	7.7	7.7	2.7	7.7	7.7

V_1 = BRRI dhan34, V_2 = BRRI dhan90, V_3 = Binadhan-13, PH = Plant height (cm), PN = Number of panicles hill⁻¹, GN = Filled grain panicles⁻¹

Table 4. Effect of transplanting dates and varieties on grain yield (t ha⁻¹), harvest index (%) and growth duration in T. Aman 2022 at BRRI HQ farm, Gazipur.

Variety	Transplanting date																	
	1 st July			15 th July			30 th July			15 th August			30 th August			15 th September		
	GY	HI	GD	GY	HI	GD	GY	HI	GD	GY	HI	GD	GY	HI	GD	GY	HI	GD
V1	3.26	0.34	161.00	3.36	0.35	151.33	3.90	0.37	134.66	3.96	0.39	123.66	3.93	0.39	120.33	3.35	0.38	116.66
V2	4.68	0.44	132.33	4.73	0.46	116.33	5.26	0.46	111.66	5.36	0.45	110.33	5.12	0.46	111.66	4.51	0.46	111.66
V3	2.77	0.33	178.33	3.06	0.36	165.00	3.44	0.39	148.33	3.64	0.39	135.33	3.55	0.40	128.66	3.26	0.40	121.00
LSD (0.05)	0.34	0.16	1.06	0.34	0.16	1.06	0.34	0.16	1.06	0.34	0.16	1.06	0.34	0.16	1.06	0.34	0.16	1.06
CV	5.2	2.5	0.5	5.2	2.5	0.5	5.2	2.5	0.5	5.2	2.5	0.5	5.2	2.5	0.5	5.2	2.5	0.5

V_1 = BRRI dhan34, V_2 = BRRI dhan90, V_3 = Binadhan-13, GY = Grain Yield (tha⁻¹), HI = Harvest Index (%), GD = Growth duration

Table 5. Effect of transplanting dates and varieties on grain qualities in T. Aman fine rice varieties 2022 at BRRI HQ farm, Gazipur.

Variety	Grain quality																	
	1 st July			15 th July			30 th July			15 th August			30 th August			15 th September		
	MO	HR	PC	MO	HR	PC	MO	HR	PC	MO	HR	PC	MO	HR	PC	MO	HR	PC
V1	72.36	66.92	9.97	72.36	66.42	10.06	72.51	67.82	10.04	72.54	67.80	10.06	72.35	67.66	9.96	71.20	66.03	9.93
V2	68.77	65.57	9.70	69.85	67.02	9.73	70.25	67.39	9.76	70.64	67.24	9.76	69.94	66.23	9.66	69.20	67.25	9.70
V3	69.87	54.65	8.22	68.44	54.08	8.22	69.05	55.56	8.39	69.70	55.90	8.64	68.23	55.56	8.43	67.92	55.12	8.28
LSD (0.05)	0.74	0.93	0.21	0.74	0.93	0.21	0.74	0.93	0.21	0.74	0.93	0.21	0.74	0.93	0.21	0.74	0.93	0.21
CV	0.6	0.9	1.4	0.6	0.9	1.4	0.6	0.9	1.4	0.6	0.9	1.4	0.6	0.9	1.4	0.6	0.9	1.4

V_1 = BRRI dhan34, V_2 = BRRI dhan90, V_3 = Binadhan-13, MO% = Milling outturn%, HR% = Head rice% & PC% = Protein content

Effect of storage times in different storage technologies on quality of rice

The laboratory experiment was conducted at BRRI HQ, Gazipur in Farm Management Division, Grain Quality and Nutrition Division and BRRI Central Laboratory from June 2022 to July 2023 to examine the effect of storage times in different container on quality of rice. For this purpose, we set up different storage times of fresh harvested paddy (0 month), 3, 6 and 9 months and different storage technologies of C_1 = Plastic Container, C_2 = Jute Sack, C_3 =

Plastic Bag, C_4 = Motka and C_5 = Grain pro bag. Samples were taken in 60 random treatments (3 replication × 4 storages time × 5 storage container) at 12% moisture content from BRRI dhan84 variety. The treatments were distributed in completely randomized design (CRD) with three replications. The un-parboiled paddy was used for this experiment. BRRI dhan84 would be stored in the five storage technologies and milling quality was assessed at every 3-month interval up to 9 months from the storage time. The collected data were analyzed using R Software programmer.

Results and Discussion

Seed quality parameters i.e. germination percentage (GM %) and seedling vigour index (SVI) were significantly affected due to different storage times and technologies. The highest GM% (98.00) and SVI (14.23) were observed in Grain Pro Bag at three months and the lowest (67% and 7.30) in Jute Sacks at nine months' storage times. GM% and SVI decreased with time of storage durations at different storage technologies (Table 6).

After yield, grain quality of rice is important parameters for researchers, consumers and traders. Consumer's acceptance of rice depends on its physicochemical quality of rice. During storage time of rice, a number of physicochemical properties changes that causes impact on rice cooking and eating quality. However, the main components of rice like starch, protein and lipids remains unchanged during storage time and only structural changes take place along with change in flavours and texture. Fresh harvest paddy was found that initially milling outturn was 69.17% and head rice recovery was 58.80% (based on milled rice). After storage times, the highest milling outturn (68.58%) and head rice recovery (60.48%) were found in nine months' storage time at plastic container followed by grain pro bag and plastic bag and the lowest in jute sacks at different storage times (Table 7). Milling outturn (%) and head rice recovery (%) increased with time of storage durations at different storage technologies. Initially, fresh harvested milled rice length and breadth were 6.16 mm and 2.04 mm. The highest milled rice length and breadth were present in nine months' storage times at different storage technologies and the lowest in three months storage times (Table 8). Initially, fresh harvested milled rice amylose and protein content were 26.56% and 8.56%. Amylose and protein content decreased with storage times at different storage technologies. The highest amylose (26.75%) and protein content (8.7%) were present in Grain Pro Bag with three months' storage times and the lowest in nine months' storage time at different storage technologies (Table 9). Initially, fresh harvested milled rice alkali spreading value and cooking time were 5.06 and 18.00 minute. Alkali spreading value decreased with storage times at different storage technologies. Highest alkali spreading value was present in three months'

storage times at different storage technologies and the lowest in nine months' storage times at different storage technologies. Cooking time increased with storage time durations at different storage technologies. The highest cooking time was found in nine months storage times at different storage technologies and the lowest in three months storage times at different storage technologies (Table 10).

Moisture plays an important role in determining the rice quality. Higher moisture content increases the microbial deterioration and storage temperature and intervals. Moisture content was significantly affected due to the different storage times and technologies. The highest moisture content was found in nine months storage times at different storage technologies and the lowest in three months storage durations at different storage technologies. The results showed that good moisture content was maintained in plastic container followed by Grain Pro Bag and it was the lowest in Jute Sacks (Table 11).

Vitamins were organic molecules that, in very small amounts, are required in the diet. They provide specialized and distinct tasks in the promotions of development and reproduction, as well as the maintenance of health and life. Vitamins were divided into two main types according to solubility: fat-soluble vitamins (A, D, E and K) and water-soluble vitamins (B-complex including B1, B2, B3, B5, B6, B7, B9, B12, C, D, E, and K). Vitamins in cereal food was not stable. Nutrients, particularly vitamins, found in cereal seed coats and germs were lost during milling. Thermal processing is the most detrimental to food vitamins, results in the degradation of water-soluble vitamins such as vitamin B complex and vitamin C, and the degree of thermal damage follows time and temperature relationship. Temperature, time, pH, moisture content, water activity, and oxygen concentration were all factors that influenced the quality of vitamins lost during food preservation. Storage times increased with decreased vitamins B-complex at different storage technologies. Initially, fresh harvested milled rice vitamin B1 and B2 contained 0.22 (mg/100 g) and 0.045 mg/100 g. The highest vitamins B1 and B2 were contained in 3 months storage time at different containers and the lowest in nine months storage times at different containers. The highest vitamins B1 (0.22 mg/100g) and B2 0.045 mg/100 g were contained in plastic container

and jute sacks and the lowest (0.16 mg/100g and 0.040mg/100g) in plastic bag and motka (Table 12). Initially, fresh harvested milled rice vitamin B3 and B6 were contained 5.72 mg/100g and 0.26 mg/100g. The highest vitamin B3 and B6 were contained in three months storage time at different containers and the lowest in nine months' storage times at different containers. The highest vitamin B3 (5.67 mg/100 g) and B6 (0.25 mg/100 g) were contained in plastic container and the lowest (5.16 mg/100 g and 0.21 mg/100 g) in plastic bag (Table13). Initially, fresh harvested milled rice vitamin B12 was contained in 21 (mg/100 g). The highest vitamin B12 was contained in three months' storage time at different containers and the lowest in nine months storage times at different containers. The highest vitamin B12 (21 mg/100 g) was contained in plastic container at three months storage times and the lowest (6 mg/100 g) in plastic bag at nine months storage times (Table 14).

It may be concluded that during different storage times of BRRI dhan84 in Plastic container showed pronounced effects on various quality traits. In seed quality, Germination percentage and seedling vigor index were decreased with increased storage times at different storage container. In grain quality, milling outturn (%), head rice recovery (%), milled rice length (mm), breadth (mm), cooking time and moisture content were increased with increased storage times at different storage container. On the other hand, content of amylose (%) and protein (%) and alkali spreading value were decreased with increased storage times at different storage container. Vitamins (B-complex) contents were significantly different with different storage container at different storage times. Vitamins were decreased with increased storage times at different storage container.

Table 6. Seed quality of rice at different storage times and storage container.

SC	Seed quality											
	Germination (%)						Seedling Vigor Index (10 DAS)					
	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅
FH	94.00	-	-	-	-	-	12.56	-	-	-	-	-
3M	-	91.66	84.33	86.33	86.33	98.00	-	12.44	10.86	12.23	12.40	14.23
6M	-	90.33	80.66	83.66	84.66	92.00	-	12.41	10.89	12.12	11.10	13.22
9M	-	86.66	67.00	76.00	83.00	85.00	-	9.83	7.30	9.53	9.23	10.08
LSD (0.05)				2.64						0.64		
CV				1.85						3.41		

ST = Storage time, SC = Storage container, FH = Fresh harvested, M = Month C₀ = No container, C₁ = Plastic container, C₂ = Jute sacks, C₃ = Plastic bag, C₄ = Motka and C₅ = Grain pro bag

Table 7. Physical properties of rice at different storage time and storage container.

SC	Grain quality											
	Milling outturn (%)						Head rice recovery (%)					
	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅
FH	69.19	-	-	-	-	-	58.80	-	-	-	-	-
3M	-	67.26	66.64	67.75	66.95	66.72	-	58.2	57.26	58.14	57.32	57.82
6M	-	67.80	66.74	68.13	67.08	67.61	-	58.73	58.06	58.35	58.28	58.58
9M	-	68.78	67.40	68.32	68.13	68.49	-	60.48	59.96	60.08	59.98	60.29
LSD (0.05)				0.43						0.20		
CV				0.38						0.20		

ST = Storage Time, SC = Storage Container, FH = Fresh Harvested, M = Month, C₀ = No Container, C₁ = Plastic Container, C₂ = Jute Sacks, C₃ = Plastic Bag, C₄ = Motka & C₅ = Grain Pro Bag

Table 8. Physical properties of rice at different storage times and storage container.

SC	Grain quality											
	Milled rice length (mm)						Milled rice breadth (mm)					
ST	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅
FH	6.16	-	-	-	-	-	2.04	-	-	-	-	-
3M	-	6.12	6.12	6.11	6.12	6.11	-	2.02	2.02	2.02	2.02	2.02
6M	-	6.29	6.19	6.29	6.29	6.29	-	2.09	2.09	2.10	2.10	2.09
9M	-	6.30	6.29	6.39	6.39	6.39	-	2.19	2.20	2.20	2.20	2.20
LSD (0.05)	0.012						0.008					
CV	2.03						0.24					

ST = Storage time, SC = Storage container, FH = Fresh harvested, M = Month, C₀ = No container, C₁ = Plastic container, C₂ = Jute sacks, C₃ = Plastic bag, C₄ = Motka and C₅ = Grain pro bag

Table 9. Chemical and cooking properties of rice at different storage times and storage containers.

SC	Grain quality											
	Amylose content (%)						Protein content (%)					
ST	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅
FH	26.56	-	-	-	-	-	8.56	-	-	-	-	-
3M	-	26.46	26.13	26.46	26.56	26.75	-	8.60	8.60	8.6	8.4	8.7
6M	-	26.36	26.05	26.34	26.17	26.70	-	8.50	8.60	8.6	8.38	8.63
9M	-	26.31	25.85	26.10	26.03	26.30	-	8.40	8.56	8.58	8.32	8.53
LSD (0.05)	0.11						0.053					
CV	0.27						0.58					

ST = Storage time, SC = Storage container, FH = Fresh harvested, M = Month, C₀ = No container, C₁ = Plastic container, C₂ = Jute sacks, C₃ = Plastic bag, C₄ = Motka and C₅ = Grain pro bag

Table 10. Chemical and cooking properties of rice at different storage times and storage containers.

SC	Grain quality											
	Alkali spreading value						Cooking time (min)					
ST	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅
FH	5.06	-	-	-	-	-	18.00	-	-	-	-	-
3M	-	5.10	5.19	4.92	5.07	4.90	-	18.09	18.00	17.32	17.31	18.10
6M	-	4.70	4.64	4.90	4.70	4.80	-	19.01	19.30	18.30	18.30	18.30
9M	-	4.66	4.60	4.90	4.62	4.70	-	19.48	19.76	18.50	18.50	19.00
L S D (0.05)	0.045						0.017					
CV	0.56						0.057					

ST = Storage time, SC = Storage container, FH = Fresh harvested, M = Month, C₀ = No container, C₁ = Plastic container, C₂ = Jute sacks, C₃ = Plastic bag, C₄ = Motka and C₅ = Grain pro bag

Table 11. Chemical and cooking properties of rice at different storage times and storage containers.

ST	SC	Grain quality					
		Moisture content (%)					
		C ₀	C ₁	C ₂	C ₃	C ₄	C ₅
FH		12.09	-	-	-	-	-
3M		-	12.33	12.60	12.45	12.40	12.35
6M		-	12.36	12.68	12.48	12.48	12.38
9M		-	12.50	13.00	12.70	12.65	12.50
LSD (0.05)		0.079					
CV		0.38					

ST = Storage time, SC = Storage container, FH = Fresh harvested, M = Month, C₀ = No container, C₁ = Plastic container, C₂ = Jute sacks, C₃ = Plastic bag, C₄ = Motka and C₅ = Grain pro bag

Table 12. Vitamins (B-complex) of rice at different storage times and storage containers.

ST	SC	Vitamins (B-complex)											
		VitaminB1 (mg/100g)						VitaminB2 (mg/100g)					
		C ₀	C ₁	C ₂	C ₃	C ₄	C ₅	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅
FH		0.22	-	-	-	-	-	0.045	-	-	-	-	-
3M		-	0.22	0.21	0.20	0.20	0.21	-	0.045	0.043	0.042	0.042	0.044
6M		-	0.21	0.20	0.18	0.18	0.19	-	0.044	0.043	0.041	0.041	0.043
9M		-	0.20	0.19	0.16	0.16	0.17	-	0.043	0.043	0.040	0.040	0.042
LSD (0.05)		5.50						3.87					
CV		1.70						5.47					

ST = Storage time, SC = Storage container, FH = Fresh harvested, M = Month, C₀ = No container, C₁ = Plastic container, C₂ = Jute sacks, C₃ = Plastic bag, C₄ = Motka and C₅ = Grain pro bag

Table 13. Vitamins (B-complex) of rice at different storage times and storage containers.

ST	SC	Vitamins (B-complex)											
		VitaminB3 (mg/100g)						VitaminB6 (mg/100g)					
		C ₀	C ₁	C ₂	C ₃	C ₄	C ₅	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅
FH		5.72	-	-	-	-	-	0.26	-	-	-	-	-
3M		-	5.67	5.46	5.42	5.29	5.51	-	0.25	0.24	0.23	0.22	0.24
6M		-	5.63	5.31	5.21	5.26	5.46	-	0.25	0.23	0.22	0.22	0.23
9M		-	5.59	5.16	5.16	5.23	5.46	-	0.24	0.22	0.21	0.22	0.22
L S D (0.05)		1.49						1.92					
CV		1.67						7.41					

ST = Storage time, SC = Storage container, FH = Fresh harvested, M = Month, C₀ = No container, C₁ = Plastic container, C₂ = Jute sacks, C₃ = Plastic bag, C₄ = Motka and C₅ = Grain pro bag

Table 14. Vitamins (B-complex) of rice at different storage times and storage containers.

SC	Vitamins (B-complex)					
	VitaminB9 (mg/100g)					
ST	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅
FH	21	-	-	-	-	-
3M	-	21	19	19	19	20
6M	-	18	16	12	14	15
9M	-	15	13	6	9	10
LSD (0.05)	4.07					
CV	1.58					

ST = Storage time, SC = Storage container, FH = Fresh harvested, M = Month, C₀ = No container, C₁ = Plastic container, C₂ = Jute sacks, C₃ = Plastic bag, C₄ = Motka and C₅ = Grain pro bag

Artificial plough pan development for facilitating modern farm machinery.

An experiment was taken aiming to find out possible way(s) to increase soil resistance capacity and to develop artificial plough pan in BRRI farm (Table 15). The experiment was conducted in plot number 18 of block C in West Byde of BRRI HQ farm during Boro 2023 using a strip plot design with three replications. BRRI dhan74 was used in the experiment. After Boro harvest in the previous

year, a trench of 12 inches was dug and a 3 inches fine sand layer was placed at 8 inches (20 cm) below from soil surface. After next T. Aman crop, compactions were carried out when the moisture content was suitable. The compactions were done twice in 11 days interval using wheel-to-wheel tractor passages using a pressure of (approximately) 80 kPa (in treatment plots only). Soil resistance couldn't be measured due to having no penetrometer availability. Yield and yield components were collected and analyzed using standard protocol.

Treatment combinations were as follows:

Treatment A (Method)	Treatment B (Water management)
M1: Control (normal practice).	W1: Continuous flooding
M2: Compaction of soil by tractor ¹ after harvesting.	W2: Alternate Wetting and
M3: Placing a three inches fine sand layer at 8 inch (20 cm) below soil surface and compaction.	Drying
M4: Compaction of soil by tractor ¹ after T. Aman harvesting and fallow in Boro season.	

Results and Discussion

No significant differences were found among the treatment combinations in the experiment. After compaction of soil, tillage operation using tiller was comparatively easier in the compacted plots (according to the tiller driver and scientific assistant). Tiller was stuck down into mud in one of the uncompacted (control) plot like previous years. Though we could not have opportunity to prove the soil resistance improvement, but tillage operation indicated that soil compactness might have created

some benefits in smooth tillage operation in the treated plots.

Since no significant differences among the treatment combinations were observed in yield and yield attributes, therefore, it could be assumed that soil compaction and placing of sand layer below 8 cm of soil surface do not affect rice yield. When soil penetrometer is available, then it could be measured whether artificial plough pan developed or not.

Table 15. Yield and yield components as affected by different treatments of artificial plough pan development methods.

Treatment	Plant height (cm)			Tiller per square meter			Thousand grain weight (g)			Grain per panicle (no.)			Sterility percentage(%)			Grain yield (t ha ⁻¹)		
	W1	W2	Av	W1	W2	Av	W1	W2	Av	W1	W2	Av	W1	W2	Av	W1	W2	Av
M1	90	91	91	276	317	296	30.4	29.6	30.0	83	74	78	9	9	9	5.86	6.56	6.21
M2	88	92	90	299	301	300	29.3	28.9	29.1	79	82	80	12	11	11	6.29	6.21	6.25
M3	90	89	90	275	292	283	30.2	30.2	30.2	85	75	80	9	12	10	6.23	6.20	6.22
M4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Av	89	91		283	303		29.9	29.6		82	77		10	11		6.13	6.32	
CV (%)		2.8			11.4			3.0			8.7			17.3			5.7	
lsd		NS			NS			NS			NS			NS			NS	

[M1=Control; M2=Compaction of soil by tractor after harvesting; M3=Compaction after placing a three inches fine sand at eight inches below soil surface; M4= Compaction of soil by tractor after harvesting and fallow in Boro season. W1= Continuous flooding W2=Alternate wetting and drying]

Determination of fertilizer management to control algae infestation in rice field

Algae infestation is one of the most common problems in BRRI farm, especially, during two years back in Boro season, the problem was found in almost all the plots. Some plots were severely affected where transplanted seedling establishment was hampered greatly. Therefore, an experiment was taken to determine fertilizers' effect on algal growth in rice field and to identify suitable fertilizer management to control algae in rice field.

The experiment was conducted at plot number 25 (N) of block A in the west byde of BRRI. BRRI dhan28 was used in Boro 2023 season following

RCB Design with 3 replications. Treatments were: (i) Full dose basal fertilizer of DAP, MoP, Gypsum & Zinc (BRRI recommended); (ii) Full dose basal fertilizer of TSP, MoP, Gypsum & Zinc; (iii) Half dose basal fertilizer of DAP and Full Dose MoP, Gypsum & Zinc; (iv) Half dose basal fertilizer of TSP and Full Dose MoP, Gypsum & Zinc; and (v) Basal fertilizer of full dose TSP, MoP, Gypsum & Zinc, and 1/3rd Urea. For treatment (iii) and (iv), rest half dose DAP/TSP were applied during second urea top-dress.

Results and Discussion

No significant differences were found among the treatments for yield and yield components (Table 16). Though algae occurrences and severity (Fig 1.) varied among different treatments, but their occurrence and severity were not so much to influence the yield and yield contributing characters. Therefore, significant influences were not found among the treatments. In the next year experiment, artificial inoculation of algae will be done to get a clear result and findings.

Table 16. Yield and yield components as affected by different fertilizer management practices to control algal infestation in rice field.

Treatment	PH	TMSM	FGPP	TGW	SP	GY
T1	104	310	104	21.77	19.22	5.79
T2	102	320	100	21.99	16.80	5.48
T3	100	332	104	22.50	22.08	5.85
T4	100	342	92	21.46	19.28	5.57
T5	102	331	91	21.32	19.74	5.76
CV (%)	3.6	8.0	8.3	4.4	21	5.7
Lsd	NS	NS	NS	NS	NS	NS

[T1=Full dose basal fertilizer of DAP, MoP, Gypsum & Zinc (BRRI recommended); T2=Full dose basal fertilizer of TSP, MoP, Gypsum & Zinc; T3=Half dose basal fertilizer of DAP and Full dose MoP, Gypsum & Zinc; T4=Half dose basal fertilizer of TSP and Full dose MoP, Gypsum & Zinc; and T5=Basal fertilizer of full dose TSP, MoP, Gypsum & Zinc, and 1/3rd Urea.]

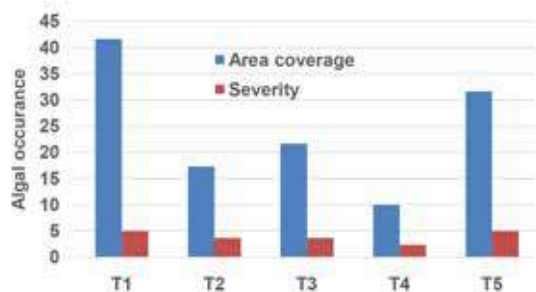


Fig. 1. Algal occurrence (area coverage) and severity in different fertilizer management plots during Boro 2023.

[T1=Full dose basal fertilizer of DAP, MoP, Gypsum & Zinc (BRRI recommended); T2=Full dose basal fertilizer of TSP, MoP, Gypsum & Zinc; T3=Half dose basal fertilizer of DAP and Full dose MoP, Gypsum & Zinc; T4=Half dose basal fertilizer of TSP and Full dose MoP, Gypsum & Zinc; and T5=Basal fertilizer of full dose TSP, MoP, Gypsum & Zinc, and 1/3rd Urea.]

Labour Management

Monitoring labor wage rate at different locations of Bangladesh

A survey was conducted throughout the year to find out the labourers' wage rate at different locations

around BRRI HQ such as Joydebpur Chowrasta, Salna, Board Bazar and Konabari, Tongi areas. It was observed that the average wage rate per day (8.0 hrs) was Tk 573-648 (Table 17). The highest wage rate of labourers was in May (Tk 700-800 per day) due to harvesting and post-harvest operations of Boro rice and transplanting of Aus rice. Another higher rate was during July-August (Tk 650-750) due to harvesting and post-harvest operations of Aus rice and transplanting of Aman rice. The third higher wage rate was observed during December-January (Tk 600-700 per day) due to the peak period for harvesting and post-harvest operation of T. Aman rice and transplanting of Boro rice.

Labourers' wage rate differs according to the location of the work. The average labour wage rate with food varied between Tk 496-563. The lowest wage rate with food was found in Habiganj, Satkhira and Sirajganj areas (400-500 Tk per day). The highest wage rate with food was observed in Cumilla (650-750 Tk per day) followed by Bhanga and Barishal (650-700 Tk per day). Working hour also different based on location (Table 18). The working time (8 hrs day⁻¹) of labourers was more or less similar except Barishal, Cumilla and Satkhira. The average labour wage rate without food varied between Tk 629-738 at different locations surrounding of BRRI Regional Stations. The highest wage rate without food was found in Rajshahi (Tk 700-900) and the lowest (Tk 500-600) was in Sirajganj, Rangpur and Sonagazi (Table 18).

Table 17. Labourers' wage rate at different places around BRRI, Gazipur during 2022-23.

Month	Wage rate (Tk)*	Remark
April	550-600	Normal period
May	700-800	Peak period. Harvesting and post-harvest operation of Boro rice and transplanting of Aus rice.
June	550-650	Normal period
July	650-750	Peak period. Harvesting and post-harvest operation of Aus rice and transplanting of Aman rice.
August	600-700	

September	520-580	Normal period
October	500-560	
November	550-600	
December	600-700	Peak period. Harvesting and post-harvest operation of Aman rice and transplanting of Boro rice.
January	600-650	
February	560-650	
March	500-540	Normal period
Average	573-648	

*Wage rate of each month is the average rate of different places such as Joydebpur, Chowrasta, Salna, Board Bazar, Konabari areas.

Table18. Labourers' wage rate with food and without food at different locations of Bangladesh during 2022-23.

Location	Average wage rate (Tk) with food	Average wage rate (Tk) without food	Working time
Gazipur	500-600	700-750	6.0am - 3.0pm
Habiganj	400-450	800-850	7.0am - 2.0pm
Rangpur	450-500	500-600	8.0am - 4.0pm
Rajshahi	500-600	700-900	6.0am - 2.0pm
Barishal	650-700	750-800	8.0am - 5.0pm
Sonagazi	450-500	500-600	6.0am - 2.0pm
Cumilla	650-750	800-850	6.0 am - 4.0pm
Satkhira	400-450	500-600	7.0am - 12.0pm
Kushtia	450-500	550-750	6.0am - 2.0pm
Bhanga	650-700	700-850	6.0am - 2.0pm
Gopalganj	450-500	550-700	6.0am - 2.0pm
Sirajganj	400-500	500-600	6.0am - 2.0pm
Average	496-563	629-738	-

Rice Seed Production

Performance of different rice varieties in seed production plots during 2022-23

In total 4, 11 and 12 varieties were cultivated in BRRI research field for the purpose of TLS production during Aus, T. Aman and Boro seasons, respectively in 2022-23. The varieties were harvested at 80-90% maturity and yields (t ha^{-1}) were adjusted to 14% moisture content. Yield of the varieties ranged from 3.50 t ha^{-1} to 5.23 t ha^{-1} , 2.54 t ha^{-1} to 6.14 t ha^{-1} and 4.87 t ha^{-1} to 8.60 t ha^{-1} in Aus, T. Aman and Boro varieties, respectively. Among the Aus varieties, BRRI dhan98 produced the highest yield (5.23 t ha^{-1}) (Table 19) where as BRRI dhan87 produced the highest yield (6.14 t ha^{-1}) in T. Aman followed by BRRI dhan95 (6.04 t ha^{-1}) (Table 20) and BRRI dhan89 produced the highest yield (8.60 t ha^{-1}) in Boro season followed by BRRI dhan104 (7.58 t ha^{-1}) (Table 21).

Truthfully Labeled Seed (TLS) Production

Rice seed production is one of the important mandates of FMD. This division produced two types of seeds, such as, breeder seed and truthfully labeled seed. In different rice seasons of the reporting period, FMD produced about 16,868 kg TLS of which 3,090 kg, 5,700 kg and 8,078 kg was in Aus, T. Aman and Boro seasons, respectively. In addition, 80 kg non-seed and 1507 kg mixed rice were produced during this period (Table 22). This division also purchased TLS 800 kg of BRRI dhan103 and 4400 kg of BRRI dhan102 seeds from the farmers during the reporting period.

Breeder Seed Production

In total 10,787 kg breeder seed was produced under the supervision of FMD during T. Aman and Boro season of 2022-23. In total 4,130 kg breeder seeds of BRRI dhan30 and BRRI dhan98 in T. Aman season 2022 were produced whereas 6,657 kg breeder seeds of BRRI dhan92 and Bangabandhu dhan100 were produced during Boro 2022-23 seasons (Table 23).

Seed Distribution

For popularizing and dissemination of BRRI rice varieties, 13,153 kg truthfully labeled seed was

distributed by FMD during the reporting period. In total 3020, 4162 and 5900 kg seeds were distributed during Aus, T. Aman and Boro seasons, respectively (Table 24). These seeds were distributed to DAE, researchers, different research divisions and regional stations of BRRI, seed producers, different agricultural organizations and agencies, BRRI employees and also farmers.

SUPPORT SERVICES

Land and Labour Management

Including regional stations, BRRI had 682 labourers of which 464 regular and 218 irregular at the start of the reporting time (1st July, 2022). In BRRI HQ, total number of labourers was 436 of which 281 regular and 155 irregular labourers (Table 25)

Soil health improvement

In order to improve soil health and productivity of BRRI farm, this division had taken a series of activities such as incorporation of Dhaincha as green manuring crops and rice straw, application of cowdung, compost and green grasses etc. according to the requirement of different research and seed production plots.

Irrigation and drainage anagement

Irrigation and drainage management is one of the important tasks carried out by FMD. Irrigation of the plots is done according to the land preparation and cultivation schedule and the needs of the plots in all the season (Aus, T. Aman and Boro). In addition, drainage system is to be managed in all the year round, especially when heavy rain and depression occurs.

Labour utilization

Total labour utilization in different divisions was 1,91,869 man days of which 57.38 %, 39.79 % and 2.83 % were utilized for research, support service and holidays, respectively in BRRI HQ (Table 26). Among the research divisions, Plant Breeding Division utilized the highest member of labourers (15,874 man days; 8.44%) followed by FMPHT Division (7,948 man days; 4.23%) and GRS Division (6,708 man days; 3.57%) for research purposes.

Labour wages

It was found that total labour wages were 10,98,78,631/- of which 6,28,38,093/-, 4,36,04,938/- and 3,189,000/- were paid to the labourers for research work, support service works, leaves and holidays, respectively (Table 27).

Retirement benefits

Including BRRI regional stations in total Tk 75,69,398 was paid to 15 labourers as financial benefits for retirement during the fiscal year 2022-23 (Table 28).

Medical financial benefits

In total Tk 24,923 was given to 11 labourers as medical financial benefits for injury during the reporting year 2022-23 (Table 29).

Land utilization

BRRI has 284.40 ha of land of which 184.61 ha is cultivable. In total 81.85 ha of land were utilized by different research divisions in different seasons at BRRI HQ of which 6.07 ha in Aus, 37.65 ha in T. Aman and 38.02 ha in Boro season. Among the research divisions, Plant Breeding Division utilized the highest amount of land (25.41 ha) followed by GRS Division (13.25 ha) and Hybrid Rice Division (7.84 ha). (Table 30)

Garden Management

This division manages the BRRI flower garden of the office campus. The office area and different gate areas and other beautification areas were managed and maintained the aesthetic view of the campus and created visible flower garden during summer and winter season.

Beautification of BRRI

FMD did the beautification works of BRRI premises

and playground for observing of different national, international and organizational events by different means such as embellishing, cleaning, arranging flower pots etc.

Tree plantation and management

Tree plantation and management of different fruits and other trees in the BRRI farm are another management work of FMD. Pruning, training and other management of the trees are done as regular basis.

Graveyard management

BRRI has one graveyard which is situated in the deep-water research area. Farm Management Division conduct all activities related to graveyard management. A graveyard management committee headed by Head of FMD is working in this regard.

Mosquito control activities

FMD tried to control mosquito infestation by spraying insecticides/mosquito oil in BRRI residential and office areas during the reporting period. For effective control of mosquitoes, total community approach is to be considered along with this activity.

Play ground management

BRRI has two playgrounds which are regularly maintained by FMD. Specially, maintaining of grass cover to the playground in suitable playing condition by cutting the grass regularly is a hard work.

Sale proceeds

This division earned in total of Tk. 69,555 by selling different farm products such as rice straw, dead tree and branches, green coconut, betel nut, jackfruit etc. and services (trolley use). The money was deposited to Accounts and Finance section for increasing government revenue (Table 31).

Table 19. Yield of different BRRI varieties in TLS production plot of FMD during Aus 2022 season.

Variety	Plant Height (cm)	Tiller m ⁻² (no.)	Grain panicle ⁻¹ (no.)	Sterility Percentage (%)	TGW (g)	Yield (t ha ⁻¹)
BRRI dhan48	121	297	74	32	23.93	4.16
BRRI dhan83	111	243	81	30	23.55	4.18
BRRI dhan98	104	298	89	25	23.26	5.23
BRRI dhan82	118	217	99	18	23.17	3.50

Table 20. Yield of different BRRI varieties in the TLS production plots under FMD during T. Aman 2022.

Variety	Tiller m ⁻² (no.)	Grain panicle ⁻¹ (no.)	Sterility Percentage (%)	TGW (g)	Yield (t ha ⁻¹)
BR22	208	135	11	20.09	4.85
BR23	221	140	17	26.24	5.88
BRRI dhan34	208	183	19	18.36	2.54
BRRI dhan46	245	97	20	19.12	5.16
BRRI dhan71	233	141	15	17.65	3.89
BRRI dhan75	196	83	26	20.92	4.24
BRRI dhan79	208	116	21	24.21	5.15
BRRI dhan87	336	148	22	24.58	6.14
BRRI dhan93	123	152	11	20.39	4.84
BRRI dhan95	172	139	13	21.25	6.04
BRRI dhan98	241	115	25	24.52	4.90
Naijarshail	196	118	18	19.35	3.73

Table 21. Yield of different BRRI varieties in the TLS production plots under FMD during Boro 2023.

Variety	Plant height (cm)	Growth duration (day)	Tiller m ⁻² (no.)	Grain panicle ⁻¹ (no.)	Sterility percentage (%)	TGW (g)	Yield (t ha ⁻¹)
BRRI dhan28	101	138	290	99	19	21.81	6.75
BRRI dhan29	96	164	277	121	14	22.51	6.73
BRRI dhan50	80	161	296	115	21	18.56	5.99
BRRI dhan67	105	148	310	89	17	20.63	6.47
BRRI dhan74	90	139	293	80	10	29.76	6.23
BRRI dhan81	98	141	267	124	12	22.80	7.01
BRRI dhan84	100	137	297	74	28	26.01	4.87
BRRI dhan88	88	147	283	124	11	21.52	6.93
BRRI dhan89	105	165	305	75	41	27.55	8.60
BRRI dhan92	103	165	316	131	19	24.98	6.90
BRRI dhan96	93	140	271	116	20	20.77	5.64
Bangabandhu dhan100	101	110	277	170	21	19.53	7.43
BRRI dhan101	105	156	251	170	15	26.29	7.02
BRRI dhan102	100	161	298	107	22	20.81	6.66
BRRI dhan104	105	139	375	210	20	19.08	7.58

Table 22. TLS production of different rice varieties during 2022-2023.

Variety	Season			Total (kg)
	Aus	Aman	Boro	
BR22	-	700	-	700
BR23	-	550	-	550
BRRI dhan28			320	320
BRRI dhan29			405	405
BRRI dhan30		500		500
BRRI dhan34	-	370	-	370
BRRI dhan46	-	330	-	330
BRRI dhan48	430			430
BRRI dhan50			400	400
BRRI dhan52		300		300
BRRI dhan67			385	385
BRRI dhan70		70		70
BRRI dhan71	-	350	-	350
BRRI dhan74			280	280
BRRI dhan75	-	320	-	320
BRRI dhan79		330		330
BRRI dhan81			545	545
BRRI dhan82	170			170
BRRI dhan83	240			240
BRRI dhan84			332	332
BRRI dhan87	-	460	-	460
BRRI dhan88			675	675
BRRI dhan89			1,600	1,600
BRRI dhan92			1,170	1,170
BRRI dhan93		300		300
BRRI dhan95	-	240		240
BRRI dhan96	-		310	310
BRRI dhan98	2,250			2,250
Bangabandhu dhan100			280	280
BRRI dhan101			576	576
BRRI dhan102			590	590
BRRI dhan103		720		720
BRRI dhan104			210	210
Nizershail		160		160

Variety	Season			Total (kg)
	Aus	Aman	Boro	
Seed (total)	3,090	5,700	8,078	16,868
Non seed		-	80	80
Mixed rice	-	-	1,507	1,507
Grand total	3,090	5,700	9,665	18,455

Table 23. Breeder seed production of different varieties during 2022-2023.

Variety	Season			Total (kg)
	Aus	T. Aman	Boro	
BRRI dhan30	-	314	-	314
BRRI dhan98	-	3,816	-	3,816
BRRI dhan92	-		3,540	3,540
Bangabandhu dhan100	-		3,117	3,117
Total	-	4,130	6,657	10,787

Table 24. TLS distribution of different varieties during 2022-2023.

Variety	Season			Total (kg)
	Aus	T. Aman	Boro	
BR22	-	525	-	447
BR23	-	538	-	275
BRRI dhan28			570	570
BRRI dhan29			620	620
BRRI dhan34	-	268	-	65
BRRI dhan46	-	325	-	257
BRRI dhan48	410			430
BRRI dhan50			205	205
BRRI dhan52		300		247
BRRI dhan58			150	150
BRRI dhan67			250	250
BRRI dhan70		78		76
BRRI dhan71	-	301	-	301
BRRI dhan75	-	287	-	300
BRRI dhan81			405	405
BRRI dhan82	150			170

Variety	Season			Total (kg)
	Aus	T. Aman	Boro	
BRRRI dhan83	230			240
BRRRI dhan84			150	150
BRRRI dhan87	-	2,773	-	2,773
BRRRI dhan88			255	255
BRRRI dhan89			1,040	1,040
BRRRI dhan92			1,015	1,015
BRRRI dhan95	-	221		221
BRRRI dhan96	-		305	306
BRRRI dhan98	2,230			2,250
Bangabandhu dhan100			935	935
Seed (Total)	3,020	4,162	5,900	13,152

Table 25. Land and labour strength of BRRI, in the date of 1st July 2022.

Station	Total land (ha)	Cultivable land		Labour (no.)						
		Area (ha)	% of total land	Regular			Irregular			Total
				Male	Female	Total	Male	Fe-male	Total	
BRRRI HQ, Gazipur	76.83	44.45	57.86	232	49	281	124	31	155	436
Cumilla	24.68	16.03	64.95	10	1	11	12	1	13	24
Habiganj	35.03	25.90	73.94	19	2	21	11	0	11	32
Sonagazi	45.77	34.00	74.28	31	2	33	4	0	4	37
Barishal	39.17	24.61	62.83	18	3	21	3	0	3	24
Rajshahi	13.24	8.92	67.37	21	3	24	6	0	6	30
Bhanga	11.46	9.55	83.33	12	2	14	5	0	5	19
Rangpur	6.07	4.05	66.72	28	1	29	4	1	5	34
Satkhira	20.00	8.10	40.50	18	1	19	2	0	2	21
Kushtia	4.05	3.0	74.07	9	0	9	1	0	1	10
Sirajganj	4.05	3.0	74.07	2	0	2	7	1	8	10
Gopalganj	4.05	3.0	74.07	-	-	-	5	0	5	5
Total	284.40	184.61	62.22	400	64	464	184	34	218	682

Table 26. Division/Section wise labour utilization during 2022-23.

Sl. no	Division	Number of labour days utilized	
		Total	Percentage (%)
(A) Research			
	Plant Breeding	15,874	8.44
	Hybrid Rice	6,570	3.49
	Biotechnology	5,277	2.81
	Genetic Resources and Seed	6,708	3.57
	Entomology	4,950	2.63
	Plant Pathology	4,156	2.21
	Agronomy	4,094	2.18
	Plant Physiology	5,377	2.86
	Soil Science	6,451	3.43
	Rice Farming System	3,794	2.02
	Grain Quality and Nutrition	2,485	1.32
	Adaptive Research	3,984	2.11
	Training	1,600	0.85
	Agricultural Economics	1,172	0.62
	Farm Machinery and Post-Harvest Technology	7,948	4.23
	Workshop Machinery and Maintenance	4,136	2.20
	Irrigation and Water Management	2,713	1.44
	Agricultural Statistics	2,624	1.40
	Farm Management a) Research	4,512	2.40
	b) Seed production	13,506	7.17
	Total	1,07,931	57.38
(B) Support services			
	Farm Management		
	a) Common Services	2,581	1.37
	b) Garden Management	11,983	6.37
	Building and Construction		
	a) Caretaking	10,679	5.68
	b) Electrical	8,414	4.47
	Publication and Public Relation	765	0.41
	Administration and Support Service		

Sl. no	Division	Number of labour days utilized	
		Total	Percentage (%)
	a)Administration	10,692	5.69
	b)Audit	411	0.21
	c)Transport	9,431	5.02
	d) Store	1,822	0.97
	e) Hostel/Dormitory	5,703	3.03
	f) Security	8,142	4.33
	g) Planning and Evaluation	445	0.24
	h) Medical	923	0.49
	Accounts and Finance	2833	1.51
	Total	74,824	39.79
(C) Leaves			
	a) Casual leave	2,576	1.37
	b) Govt. holidays	2,739	1.46
	Total	5,315	2.83
	Grand total (A+B+C)	1,91,869	100

Table 27. Division /Section wise labour wages during 2022- 23.

Sl.no	Division/Section	Wages Incurred (Tk.)
(A) Research		
	Plant Breeding	9202943
	Hybrid rice	3826156
	Biotechnology	3080660
	Genetic Resources and Seed	3913862
	Entomology	2883321
	Plant Pathology	2422867
	Agronomy	2389977
	Plant Physiology	3135475
	Soil Science	3760377
	Rice Farming System	2214566
	Grain Quality and Nutrition	1447142
	Adaptive Research	2313235
	Training	931472
	Agricultural Economics	703200

Sl.no	Division/Section	Wages Incurred (Tk.)
	Farm Machinery and Post Harvest Technology	4637433
	Workshop Machinery and Maintenance	2411904
	Irrigation and Water Management	1633800
	Agricultural Statistics	1534848
	Farm Management a) Research	2631268
	b) Seed production	7763587
Total		6,28,38,093
B) Support Services		
	Farm Management a) Common Services	1501958
	b) Garden Mgt.	6983558
	Building and Construction a) Caretaking	6177097
	b) Electrical	4900550
	Publication and Public Relation	459000
	Administration & Support Service	
	a) Administration	6238060
	b) Transport	5492562
	c) Audit	246600
	d) General Store	1077100
	e) Hostel	3321749
	f) Security	4747065
	g) Planning and Evaluation	267000
	h) Medical	537196
	Accounts and Finance	1655443
Total		4,36,04,938
(C) Leaves		
	a) Casual leave	1545600
	b) Govt. holidays	1643400
Total		31,89,000
Grand total (A+B+C)		10,98,78,631

* This expenditure excluded the temporary labourers engaged by the respective divisions/sections.

Table 28. Retirement benefits of labourers during 2022-23.

Working place	Male	Female	Amount(Tk)
BRRI HQ	5	-	29,88,000
BRRI RS	10	-	45,81,398
Total	15	-	75,69,398

Table 29. Medical financial benefits of labourers in working time injury during 2022-23.

Types of Labourers	Medical benefits	
	Labourer number	Amount(Tk)
Regular	6	16,864
Irregular	5	8,059
Total	11	24,923

Table 30. Land utilization by different division/sections during 2022-23.

Divisions /Section	Land area used (ha)			
	Aus	T. Aman	Boro	Total
Plant Breeding	2.83	11.29	11.29	25.41
Genetic Resources and Seed	0.11	6.57	6.57	13.25
Entomology	1.27	1.15	1.39	3.81
Soil Science	0.47	2.17	2.17	4.81
Biotechnology	0.40	1.28	1.28	2.96
Plant Physiology	-	0.61	0.61	1.22
Hybrid Rice	-	3.86	3.98	7.84
Agronomy	0.20	1.51	1.51	3.22
Plant Pathology	-	1.04	1.02	2.06
Rice Farming Systems	-	1.44	1.46	2.90
Adaptive Research	-	1.34	1.34	2.68
Grain Quality and Nutrition	0.12	0.66	0.66	1.44
Farm Machinery and Post-harvest Technology	-	0.53	0.53	1.06
Irrigation and Water Management	-	0.71	0.71	1.42
Agricultural Statistics	-	0.51	0.51	1.02
Farm Management: a) Research	-	0.53	0.57	1.10
b) Seed production	0.78	2.45	2.42	5.65
Grand total	6.18	37.65	38.02	81.85

Table 31. Sale proceeds of FMD during 2022-23.

Item	Amount (Tk)
Dead tree and branches	7100
Green coconut	435
Straw	56,500
Betel nut	3000
Jackfruit	1200
Trolley fare	1320
Total	69,555

FARM MACHINERY AND POSTHARVEST TECHNOLOGY (FMPHT) DIVISION + WORKSHOP MACHINERY AND MAINTENANCE (WMM) DIVISION

322	Summary
326	Agricultural Machinery Development And Testing
350	Milling And Processing Technology
356	Renewable Energy
362	Precision Agriculture
364	Industrial And Farm Level Extension

Summary

The FMPHT Division of BRRI has developed a prototype of whole feed mini combine harvester at divisional workshop, which was aimed to develop a machine that was simple and cost-effective to produce but boasted a high capacity inexpensively, had a high capacity and required minor repair and maintenance. The third whole-feed combine harvester prototype was developed in the FMPHT divisional workshop while considering the challenges encountered with the earlier models. The most difficult phase in operating the machine arises during grain harvesting, where improper handling could lead to significant crop losses, consequently impacting farmers' income. Preliminary tests were conducted in the BARI research field to assess its preference in capacity, travel speed, fuel consumption, grain and straw output. The whole-feed combine harvester demonstrated a harvesting capacity ranging from 0.252 to 0.262 ha/h, with a fuel consumption of 3.00 to 3.50 l/h. The field efficiency for the developed combine is about 71%. The average grain and straw output were recorded at 1013.88 and 922.06 kg/h, respectively. The machine exhibited a crop throughput of 1,935.94 kg/h. The estimated pre-harvest loss for the selected field was 27.19 kg/ha at 14% moisture content. The total grain loss for the developed combine harvester was 1.27%. Further comprehensive performance tests are imperative to obtain more detailed insights into the capabilities of the BRRI-developed whole-feed combine harvester.

The BRRI whole-feed combine harvester, model BRRI WCH 2021, was developed under the SFMRA project. It underwent assessments during Boro 2022 and Aman 2022 seasons in different locations in the

Rangpur region of Bangladesh. To operate this harvester with a cutting width of 1.5 meters at maximum capacity, the field size should be more than 1,500 square meters. The harvester was determined to have a theoretical total of 0.23 hectares per hour, but the actual field capacity is 0.11 hectares per hour. The harvester's field efficiency was 62.5% in Boro season and 57.9% in Aman season. Additionally, it was noted that in Boro season, the harvester consumed 2.77 liters of fuel per hectare, while in Aman season, this figure was 2.31 liters per hectare. The optimal total grain losses (1.64%) were observed at a moisture content of 23.2% and a forward speed of 3.5 kilometers per hour. The average losses, including various losses during harvesting, were 0.56% in the Boro season and 0.48% in the Aman season. Compared to manual harvesting, the BRRI whole-feed combine harvester reduced paddy losses by 5.81%. The evaluation showed that the harvester operated effectively, and using it during peak periods could reduce the need for manual labour. This technology is expected to provide sustainable mechanization for rice harvesting to advanced farmers, promoting the adoption of improved practices in Bangladesh. The performance of the BRRI combine harvester was rated as good and very satisfactory, indicating its suitability for use in both small and large fields.

The laser land leveler is an advanced agricultural technology that uses laser beams to grade and level the land precisely. This study was conducted during the Boro season 2022 at the BRRI regional station in Sonagazi, Feni. A total of 4,142.4 m² field with 24 sub-plots was used. The initial mean height of marked points was 204.24 cm, effectively lowered to 203.51 cm during the AUTO motion of the laser leveler,

demonstrating improved leveling efficiency. The accuracy of the leveler was assessed using the leveling index (LI) parameter, which returned a value of 0.011, indicating excellent performance. This technology also helps enhance water distribution in rice fields, contributing to sustainable land management practices. Farmers and land managers can benefit from responsibly implementing laser land levellers while ensuring ecological prevention.

The existing BRRI hydro-tiller was tested at the BRRI West Byde to determine the causes of frequent tearing of the hydro-tiller chain. Its capacity was found 0.023 ha/hr. The reason associated with the fault of hydro-tiller chain tearing was identified, i.e., the thickness of the chain is not sufficient to bear the load, and the strength of the bearing of the rotary box is not adequate to handle the load. To overcome the problem, the thickness of the sprocket was increased to 11 mm. ASME #60 chain was used instead of ASME #50 chain. The width of the ASME #60 chain is 23 mm. In addition, two bearings were set in combination with the rotary box shaft instead of a single bearing to increase the strength of the hydro-tiller in smooth operation at complete load conditions. The size of each bearing was 62 mm x 16 mm. The complete design of the modified hydro-tiller was done with the help of the solid works tool. After that, the modification of the tiller was tested, and the capacity of the hydro-tiller was increased to 0.039 ha/hr. The average fuel consumption of the modified hydro-tiller was 2.01 l/hr. After the modification, the hydro-tiller's chain and belt tearing has decreased drastically to below 8 per year. No event of engine stopping due to overloading arose during land cultivation.

The failure frequency of fast-moving spare

parts is considered a significant challenge for farmers or entrepreneurs in Bangladesh due to unavailability and high prices. Therefore, the study was conducted to identify the most frequently used fast-moving spare parts and make them readily available in the local markets. The results revealed that the failure frequency of fast-moving spare parts of combine harvester increased with the operational hour or season. The maximum spare parts failure was found when the Yanmar combine harvester had 1,450 hours of operational period. The most frequently failed spare parts were cutting blades, belts, bearings, fingers, chains, and threshing teeth.

The manual briquette machine offers a viable and accessible solution for producing biomass briquettes in areas with limited resources and electricity. While there are challenges associated with manual operation, the study's results demonstrate its potential for generating clean and efficient fuel sources. The manual briquette machine holds promise as a sustainable energy solution and a tool for community development.

The BRRI FMPHT Division has successfully developed a solar-assisted paddy seed dryer equipped with a central air distribution system (along the length of the drying chamber). The initial aim was to design, manufacture, and evaluate the prototype's performance, tailored to the specific conditions of Bangladesh. The divisional workshop has developed the machine, including incorporating a black-painted solar collector to enhance solar heat absorption. In an initial test conducted at BRRI's FMPHT Division, the dryer operated flawlessly,

The dryer performed a preliminary test at BRRI's FMPHT Division to find mechanical problems in the unit. The ambient temperature varied between 27~34.8°C. The

seed will need to dry for at least 10 hours if it has less than 15% moisture content. The machine was free of significant flaws. The drying chamber capacity was found 80-100 kg of paddy seed. A complete performance test will be held at the FMPHT divisional research workshop throughout the upcoming season. Additional prototype development will be required to increase the machine's functions. This innovative dryer, which uses solar energy as its primary heat source, intends to provide an efficient and environmentally friendly solution for paddy seed storage, thereby contributing to rice seed preservation and food security in the region.

Twelve trials were conducted during the reporting periods on BRRI-developed rice transplanter cum mixed fertilizer applicator, different models of combine harvesters, and BRRI multi-row power weeder in the project locations. Eight trials (4 in Aman 2022 and 4 in Boro 2022-23 season) were conducted on the rice transplanter cum mixed fertilizer applicator for validation. Treatments of the trials were: T1: Machine transplanting with 100% urea fertilizer; T2: Machine transplanting with 80% urea fertilizer; T3: Machine transplanting with 70% urea fertilizer; T4: Machine transplanting without fertilizer; and T5: Farmers' practice. Detailed information on the Aman 2022 trials was presented in the result section, while the field performance of the transplanter in the Boro 2022-23 season was presented in the result section. On the other hand, ten trials (four in Boro 2021-22, four in Aman 2022, and two in Boro 2022-23) were conducted to observe the field performance of whole feed and head feed combine harvesters under different crops, soil, and field length. Detailed reports of the Aman 2022 trials were presented in the result section. Grain loss of

the head feed combine harvester is less than 1%, while it was about 1.81% for the whole feed combine harvester. Eight trials (four in Boro 2021-22 and four in Boro 2022-23) were conducted in the project locations. Detailed results of the study were presented in the results sections. The height weeding efficiency was observed for treatment one (one weeding by a developed power-operated weeder (PoW) followed by (sb) one hand-weeding), followed by treatment three (one weeding by manual weeder, sb, and HaW (local practice). Four training programmes and six demonstrations were also conducted in the project locations on the proposed technologies. Skilled manpower in machine operation was developed, providing hands-on training.

A mini rice mill, suitable for household-level use, is developed in the Farm Machinery divisional workshop. Locally available materials were used to develop the mill. It was also evaluated using BRRI dhan96 and BRRI dhan87 in an unparboiled condition. There are options for different milling rpm and polishing pressures. The study hypothesizes that finding the optimal huller speed and flow rate adjustments is essential for achieving maximum milling recovery while minimizing kernel breakage. The study concludes that optimizing the huller speed and flow rate can improve the overall efficiency and quality of the rice milling process, benefiting both the rice industry and consumers.

BRRI employed a modified rubber roll husker and MNMP-15 polisher to assess the milling efficiency of BRRI dhan104. The de-husker exhibited an efficiency of approximately 90.97% for BRRI dhan104. The MNMP-15 polisher yielded a milling recovery rate of 61.8%. Notably, based on

input paddy, the head rice recovery averaged 52.67%, indicating promising results for high-quality rice processing. To enhance rice quality, it is recommended to substitute the steel Engelberg huller with a rubber roll de-husker and a polisher. The separated husk and bran from the de-husker and friction-type polisher are valuable resources for briquette and edible oil production.

This study focuses on developing a portable solar panel carrier to enhance the accessibility and efficiency of solar energy for small agricultural machinery as well as multipurpose use. BRRI FMPHT Division of has developed a self-propelled mobile carrier with 3 kW solar panels and a 3-phase pure wave solar inverter with MPPT and VFD. The carrier is powered by 12-volt 130 Ah-04 batteries charged using an MMPT battery charger. It successfully powered a 2-horsepower motor throughout the day, with further evaluation for small agricultural machinery. Modifications are still required to optimize solar energy usage in transportable carriers.

This research evaluates the impacts of climate change on Thermal Bioclimatic Indicators (TBIs) in Bangladesh, a region vulnerable to climate change and heavily reliant on rice cultivation. Using a multi-model ensemble of 18 bias-corrected CMIP6 GCMs, the study projects variations in TBIs under three socio-economic pathways (SSPs) for near, mid, and far future periods. The findings indicate an anticipated increase in average annual temperature in Bangladesh, with variations depending on the SSP scenario. The study also predicts a potential decrease in the diurnal temperature range and variations in temperature changes across different regions. The results suggest an increasing threat to rice cultivation

due to rising temperatures and varying regional impacts. The study calls for urgent climate change mitigation strategies and the integrating of climate-resilient approaches in rice cultivation to safeguard food security and farming communities. The findings highlight the pressing need for policymakers and stakeholders to address the challenges of climate change to ensure the sustainability of rice production in Bangladesh.

Eighteen batches of two-day long residential training programme was conducted under financial and technical support of SFMRA project of FMPHT Division during the period of 2022-23. Participants of the training programme were from all BRRI RSs and their adjacent areas and in total 360 participants were trained, among them 340 were male and 20 were female. The participant were trained on operation, repair and maintenance of different agricultural machinery and technologies like; transplanter, combine harvester, diesel engine, power weeder, prilled urea applicator, self propelled reaper, power tiller , tractor etc theoretically and practically in the threshing floor and in the main field. At the end of the training, a post-evaluation and trainees reactions regarding the training were collected. Certificates, leaflets and a set of tools were distributed among the participants. Trainees opined that they are now more confident about the use of the agricultural machinery.

One training programme on manufacturing, safety and work environment to the workshop personnel of local farm machinery manufacturing industries was conducted at Alim Industry Ltd., Sylhet. Three days long hands on training were conducted on machine tools used in the agriculture machinery fabrication workshop, welding, filing, grinding, drilling, power transmission

system, operation and maintenance of workshop machinery, safety and work environment of the workshop. The trainees were upgraded to fabricate good quality machine using appropriate tools and accurate measurement through these training.

AGRICULTURAL MACHINERY DEVELOPMENT AND TESTING

Performance evaluation of the BRRI developed mini whole feed combine harvester

A combine harvester is a complex farm machine that can harvest, thresh, clean, and bag crops in one operation. The combine harvester is used for various crop harvesting, especially rice and wheat. To enhance the

rice mechanization, the FMPHT Division of BRRI started to design and develop a combine harvester. To manufacture the combine harvester, locally available materials were used, and a medium-type whole-feed combine harvester prototype (plate 1) was manufactured at the FMPHT Divisional Workshop at BRRI, Gazipur. Several prototypes were developed to reach the final version. Various factors were considered during the development process, such as drawbacks (each phototype), operators' recommendations and expert opinions. Each version was tested in workshop and field conditions, and defects/ issues were documented and fixed for fine-tuning.

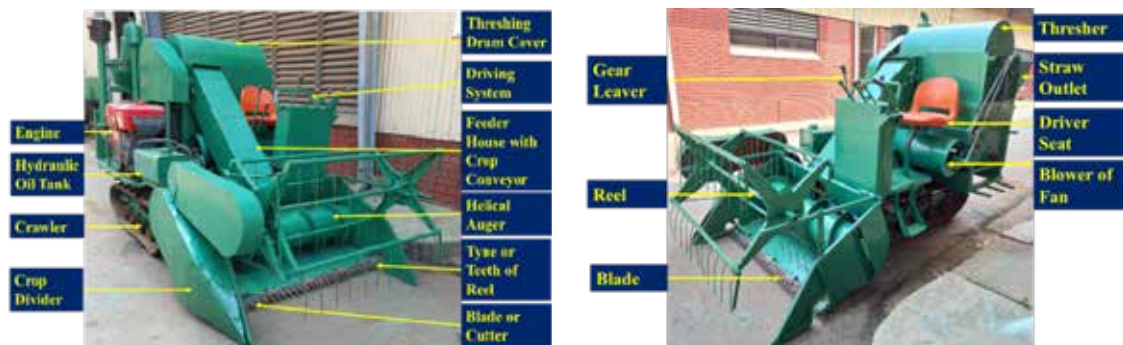


Plate 1. The complete view of the BRRI whole feed combine harvester.

Investigational activities

For the investigation activities various types of empirical equations and formulas were considered. To investigate the performance, of the considered major parameters have been listed below. The operation of a combine harvester begins with the header unit, where the harvesting and gathering of grain takes place (Plate 2). Once, the grain tank

reaches full, the harvested grain is subsequently bagged and moved elsewhere. Crop loss incurred during the harvesting process can be categorized into two distinct types: header losses which occurs at the front of the harvester and combine losses, which become apparent during threshing, separating, cleaning and collecting. For estimation of performance, considered different empirical equations and formulas.



Plate 2. Performance test of the developed whole feed combine harvester.

Machine performance evaluation

The combine harvester performance metrics such as field capacity, field efficiency, net grain output (kg/h and kg/ha), grain throughput (kg/h and kg/ha), straw output (kg/h and kg/ha), crop throughput (tons/h) were considered. A combine harvester's performance was affected by size, forward speed, and grain yield.

During the Boro 2023 season, the initial performance assessment was conducted at the BARI farm in Gazipur. While the cutting, transporting, threshing, and cleaning processes were executed satisfactorily (Fig. 1), an issue arose concerning the belt pulley of the machine's blower component, resulting in some slippage. This occurrence may be attributed to the moisture content in both the paddy plant and the gain.

Furthermore, it was noted that reduced engine performance correlated with lower emissions of exhaust gases. Therefore, to enhance overall capacity, it is imperative to augment engine power. Fuel consumption rates were recorded within the 3.00 to 3.50 liters per hour, while field capacity varied between 0.252 and 0.262 hectares per hour. Table 1 presents the detailed machine performance field test data.

Table 1 also presents the machine's output in terms of grain and straw for the location at BARI farm, Gazipur. During its operation at the BARI farm, the machine provided an average grain output of 1013.88 kg/h. At the same site, the machine's operational average straw output was found to be 922.06 kg/h.

Table 1. Field performance of BRRI fabricated whole feed combine harvester.

Place: BARI farm, Gazipur Sadar, Gazipur						
Plot no.	Forward speed, S (km/h)	Total operating time (h)	Effective field capacity (ha/h)	Effective cutting width, w (m)	Theoretical field capacity (ha/h)	Field Efficiency (%)
	$S=L/S*3.6$		$EFC=A/h$		$TFC=(S*W)/10$	$FE=(EFC/TFC)*100$
1	2.35	0.8	0.252	1.5	0.353	71.39
2	2.50	1.0	0.259	1.5	0.375	69.07
3	2.40	0.6	0.262	1.5	0.360	72.78
Average			0.258	-	0.363	71.08
Plot section no.	Duration of test (Working hours)	Travel speed (km/h)	Rate of work		Fuel consumption (l/h)	
		Grain output (kg/h)	Straw output (kg/h)	Crop throughput (kg/h)		

1	0.8	2.35	1005.50	910.40	1915.9	3.50
2	1.0	2.50	1015.65	940.20	1955.85	3.00
3	0.6	2.40	1020.50	915.60	1936.1	3.15
Average		2.41	1013.88	922.06	1935.94	3.22

Figure 1 illustrates the machine's capacity during operation. The machine travelled on the BARI farm at an average 2.41 km/h speed. At the BARI farm, the machine's average field capacity was measured at 0.258 ha/h, while its operational average fuel consumption was estimated at 3.22 l/h. Overall, the machine's field efficiency was about 71%.

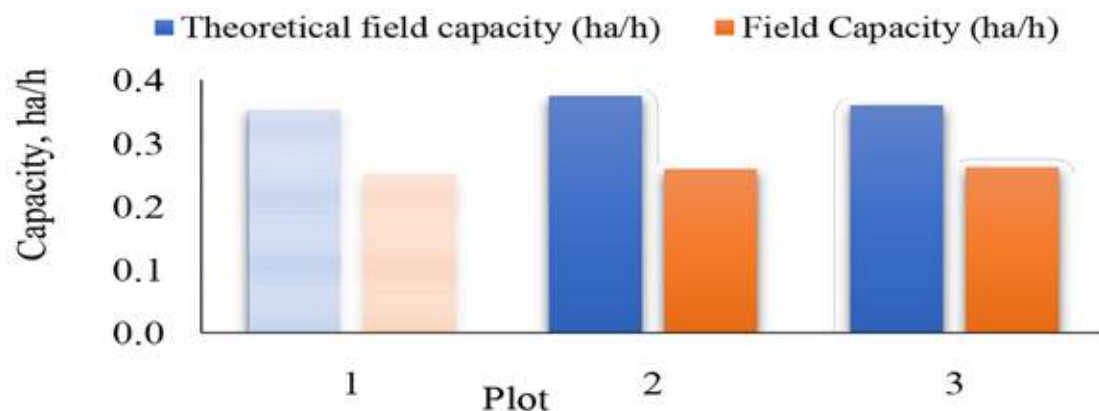


Fig. 1. Capacity of the machine.

Pre-harvest losses in a rice field refer to the loss of rice grains or panicles before harvesting begins. These losses can happen due to various factors, significantly impacting rice yield and

farm profitability. Pre-harvest losses are generally measured as a percentage of the potential yield (Table 2). The average pre-harvest loss of the selected field was estimated at 14% moisture content of 27.19 kg/ha.

Table 2. Pre-harvest losses of the selected field.

Plot no.	Trial no.	Area		No. of collected grain	Grain weight (g)	Grain weight (kg)	Moisture content (%)	Loss= Grain wt./Area (kg/ha)	Grain loss at 14% M.C (g)	Grain loss at 14% M.C = Grain wt./Area (kg/ha)
		m ²	ha							
1	1	0.36	0.000036	42	1.040	0.001040	24.25	28.89	0.916	25.44
	2	0.36	0.000036	45	1.111	0.001111	24.25	30.86	0.979	27.19
2	1	0.36	0.000036	40	0.980	0.000980	24.25	27.22	0.863	23.97
	2	0.36	0.000036	43	1.053	0.001053	24.25	29.25	0.927	25.75
3	1	0.36	0.000036	38	0.939	0.000939	25.18	26.08	0.817	22.69
	2	0.36	0.000036	48	1.186	0.001186	25.18	32.94	1.032	28.67
Average		0.36	0.000036	42.67	1.051	0.0010515	24.56	29.21	0.922	25.62

Table 3 shows information regarding grain shattering/cutter bar/header losses for the BRRI-developed whole feed combine harvester. It varies according to the cutter bar speed, shattering

tendency, and grain maturity percentages. At 14% moisture content, the average shattering loss of grain in the investigated field was estimated at 27.79 kg/ha.

Table 3. Shattering/cutter bar/ header losses of the BRRI developed whole feed combine harvester.

Plot no.	Trial no.	Area		No. of collected grain	Grain weight (g)	Grain weight (kg)	Moisture content (%)	Loss= Grain wt./Area (kg/ha)	Grain loss at 14% M.C (g)	Grain loss at 14% M.C = Grain wt./Area (kg/ha)
		m ²	ha							
1	1	0.36	0.000036	47	1.161	0.001161	24.25	32.25	1.023	28.42
	2	0.36	0.000036	50	1.235	0.001235	24.25	34.31	1.088	30.22
2	1	0.36	0.000036	43	1.062	0.001062	24.25	29.50	0.935	25.97
	2	0.36	0.000036	45	1.112	0.001112	24.25	30.89	0.979	27.19
3	1	0.36	0.000036	48	1.186	0.001186	25.18	32.94	1.032	28.67
	2	0.36	0.000036	44	1.087	0.001087	25.18	30.19	0.946	26.28
Average		0.36	0.000036	46.17	1.141	0.001141	24.56	31.68	1.001	27.79

Table 4 shows grain separating/ cylinder/rear-end losses for the BRRI-developed whole feed combine harvester. The grain losses are influenced by the combine harvester's threshing, cleaning

and separating mechanism. It was measured in 12 m length of the field with the entire cut width. At 14% moisture content, the average separating loss of grain in the investigated field was estimated to be 18.99 kg/ha.

Table 4. Separating/ cylinder/rear-end losses of the whole feed combine harvester.

Plot no.	Length (m)	Width (m)	Area		Grain weight		Moisture content (%)	loss= Grain wt./Area (kg/ ha)	Grain loss at 14% M.C (g)	Grain loss at 14% M.C Grain wt./Area (kg/ha)
			(m ²)	(ha)	(gm)	(kg)				
1	12	1.5	18	0.0018	29	0.029	24.25	16.11	25.54	14.19
2	12	1.5	18	0.0018	42	0.042	24.25	23.33	36.99	20.55
3	12	1.5	18	0.0018	46	0.046	25.18	25.56	40.02	22.23
Average	12	1.5	18	0.0018	39	0.039	24.56	21.67	34.18	18.99

The total harvesting loss of a whole feed combine paddy harvester depends on various factors, including the efficiency of the harvester, the crop conditions,

and the operator's skill. Typically, harvesting loss was measured as a percentage of the total crop that was left behind or lost during the harvesting process (Table 5).

Table 5. Total losses occurred by the developed combine harvester.

Location	Pre-harvest loss		Shattering/Cutter bar/ Header loss		Separating/ Cylinder/Rear-end loss		Total loss		Yield (t/ha)
	(kg/ha)	% of losses	(kg/ha)	% of losses	(kg/ha)	% of losses	(Kg/ha)	% of losses	
BARI farm	25.62	0.443	27.79	0.492	18.99	0.336	72.4	1.27	5.65

Total losses for the whole feed combination harvester, including pre-harvest loss, shattering loss, and

separating loss, have been estimated to be 0.443, 0.492, and 0.336%, respectively. The developed combine harvester has total grain losses of 1.27%.

Performance evaluation of BRRI whole feed combine harvester (founded by SFMRA Projected)

The BRRI whole feed combine harvester (model no-BRRI WCH 2021), was originally developed in BRRI under the SFMRA project, and was fabricated using locally available materials (Table 6). The field experiment was conducted to evaluate

the harvesting losses and technical performance in the Rangpur region during the Boro 2022 and Aman 2022 seasons.. This assessment includes several factors such as (i) operational time, (ii) labour requirement for harvesting, (iii) fuel consumption, (iv) field capacity, (v) working speed, (vi) effective harvesting time, (vii) grain yield and (viii) grain losses. Three plots were selected to determine the operational speed of the harvester, field capacity (ha/hr.), fuel consumption, and grain losses due to the combine harvester. Plate 3 shows pictorial view of the combine harvester. Furthermore, for performance evaluation considered varies field parameters and rice varieties (Table 7).



BRRI whole feed combine harvester



Operating of Paddy harvesting



Unloading grain from the grain tank

Plate 3. Pictorial view of the combine harvester.

Table 6. Specification of the BRRI Whole Feed Combined Harvester.

Name	Whole feed combine harvester
Model	BRRI WCH 2021
Dimension, mm (L*W*H) 5200*1800*2600	
Threshing drum (L, Φ)	2000mm, Φ620
Cutting width, mm	1500
Engine power, hp	87
Rubber track (Crawler)	400*90*51
Fuel tank, L	60
Grain tank, kg	600
Power transmission	Mechanical + HST
Total weight, kg	3000
Ground clearance, mm	300
Traction load, kN/m ²	20.7

Traction Area, m ²	1.376 for two crawlers
Harvesting capacity, bigha	3-4
Forward speed, km/h	3-4
Fuel consumption, L/hr	3.5-4
Total harvesting loss, %	Less than 1%
Price, Tk	12-13 lakh

Table 7. Crop and field parameters of different paddy varieties.

Particulars	Plot-1	Plot-2	Plot-3	Plot-1	Plot-2	Plot-3
Variety	Hybrid dhan	Hybrid dhan	BRRRI 74	BRRRI 34	BRRRI 93	BRRRI 95
Soil moisture content, %	16	15.5	16.5	17	16.5	18.5
Grain moisture content (w. b), %	22.3	25.5	23.4	19.4	20.7	23.6
Straw moisture content (w. b), %	24	21.5	25.7	20.3	23.1	24.2
Plant height, cm	115.6	115.2	106.8	135.3	112.3	128.5
Length of panicle, cm	107	108.4	92.3	121.7	101.5	117.2
No. of tillers per panicle, no	11.5	12.3	15.7	15.4	10.8	13.2
The number of hills/m ² , no.	14	13	14	17	14	12
No. of plants per hill	12	13	13	15	13	10
Straw grain ratio	1.24	1.27	1.45	1.40	1.56	1.61

Overall test performance

The findings of the study indicate a direct correlation between the size of the harvesting plot and the harvesting capacity of the combine harvester. This relationship stems from the reduced necessity for turning maneuvers in larger plots. Notably, the smallest field capacity was observed in plots measuring 25.6 meters in length. Consequently, it is recommended that plots exceed a length of 38.6 meters for the BRRRI combine harvester to effectively utilize its 1.5-meter cutting width while minimizing the need for turning. Furthermore, for optimal operation and to mitigate turning losses, plots should encompass an area of no less than 1,200 square meters. In cases where the BRRRI combine harvester is utilized for whole-feed harvesting, a recommended plot size of over 800 square meters ensures efficient operation. Notably, the highest

field efficiency was observed in plots exceeding 1,200 square meters, whereas plots measuring 800 square meters exhibited the lowest field efficiency.

The study also shed light on the operational dynamics of the combine harvester, revealing a range of operating speeds from 3.36 to 4.50 kilometers per hour during the harvesting process (Table 8). Moreover, it was found that the mini combine harvester demonstrated a theoretical field capacity of 0.19 hectares per hour, while the actual field capacity was measured at 0.11 hectares per hour (Table 9). This indicates a notable discrepancy between the theoretical and real-world performance of the mini combine harvester. In contrast, the BRRRI combine harvester exhibited a relatively lower harvesting capacity. Nevertheless, it distinguishes itself by its versatility in accommodating both smaller and larger field sizes, thus rendering it a viable option across a range of agricultural contexts.

Table 8. The technical performance of combined harvester.

Plot	Forward speed	Fuel Consumption	Fuel Consumption	Effective Field Capacity
	(km/h)	(L/ha)	(L/hr)	(ha/h)
1	3.00	7.50	3.5	0.00366
2	3.50	7.00	3.5	0.00263
3	4.00	7.00	3.25	0.00270
Average	3.5	7.17	3.41	0.00210

Table 9. Field capacity and efficiency of combined harvester used in field tests.

Parameters	Plot-1	Plot-2	Plot-3	Plot-1	Plot-2	Plot-3
	Boro/2022			Aman/2022		
Travel speed (km/h)	3.25	3.5	4.0	3.25	3.5	4.0
Working width (m)	1.5	1.5	1.5	1.5	1.5	1.5
Total work time (min)	22.35	15.32	26.07	29.08	20.41	25.2
Delivery time (min)	1.52	1.39	2.36	2.46	1.45	2.13
Operation time (min)	21.23	14.33	24.12	27.03	19.46	23.07
Turning Time (min)	9.23	5.47	8.15	9.45	6.46	8.19
EFC (ha/h)	0.12	0.10	0.07	0.08	0.11	0.09
TFC (ha/h)	0.23	0.16	0.18	0.21	0.19	0.21
FE (%)	52.17	62.5	38.9	38.2	57.9	42.85

Time distribution of combined harvester operation

Time distribution of the BRRI combine harvester during harvesting operation: It spent 58% in harvesting, 23% in turn, and 19% of the total time in repairing, idle, and work stopped due to rain. The turning time of the combine harvester is a loss factor activity that needs appropriate planning to make turns without reducing speed or utilizing additional movement to arrange the next row (Fig. 2).

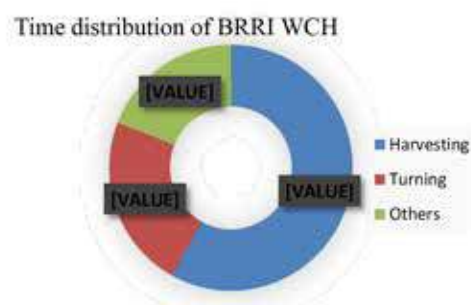
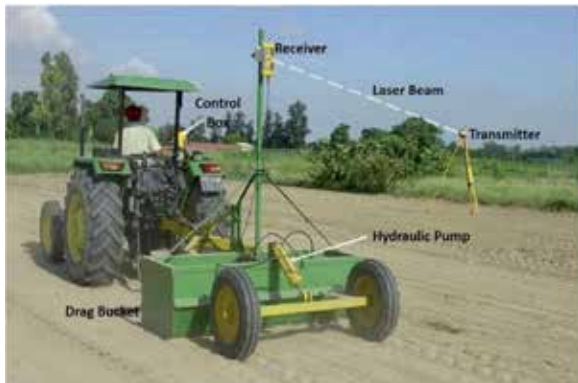


Fig. 2. Operation time of BRRI WCH.

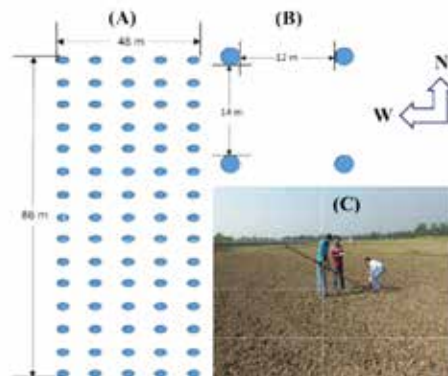
Performance evaluation of laser land leveler

The study assessed laser land leveler effectiveness in rice fields, focusing on accuracy, water conservation, nutrient distribution, and yield. It compared leveling precision to conventional methods, examined water conservation efficiency, and evaluated nutrient distribution and yield. This study was conducted at BRRI RS, Sonagazi, Feni during the Boro season, the study utilized a LAZERLI TESVIYE Model: 1. JNR. 250. CIFT land leveler. Wooden pegs, spirit levels, and measuring tape ensured precise field leveling and distance measurements between reference points (Plate 4a).

The experimental field, measuring 4142.4 m² (86.3 m length, 48.0 m width), was plowed with a tractor to increase topsoil volume. Prior to leveling, it was divided into 24 plots using a 14 m × 12 m grid formation, following standard surveying and leveling procedures (Plate 4b).



a. Prime components of laser land leveler during leveling



b. Formation of the plot before operation of laser land leveler (A) layout of elevation data collection points (B) actual plot size (C) check the leveling height using the spirit level and measuring tape

Plate 4. Prime component of a laser land leveler

The experiment began by marking a base location with wooden pegs for initial height measurements. A SONALIKA tractor (Model: DI-50KX) with a 35 HP engine operated the laser land leveler. The laser transmitter was fixed on a tripod at one corner and the laser receiver was mounted on the land leveler. Reduced levels were recorded at all grid points

with the help of an auto level and leveling staff recorded reduced levels at $14\text{ m} \times 12\text{ m}$ spaced grid points. Initially, the height of instrument surveying determine grid point's reduced level. The field's mean reduced level was calculated by summering all reduced levels and and dividing by the number of grid points. Plate 5 shows the pictorial view of data collection and field operation of the laser leveler.



(A) data collection



(B) loading condition of laser leveler

Plate 5. Pictorial view of the field work.

Initially, the laser leveler was manually operated (two passes) using RAISE and LOWER switches on the control box. It was then switched to AUTO mode. The laser-guided bucket was positioned at the mean field height, with the blade slightly above ground (0.5-1.0 cm). The tractor moved back and forth, optimizing efficiency by going from higher to lower areas. When

the bucket was full, the tractor moved to lower areas; when empty, it returned to higher areas.

After circling the field, a final pass leveled from high to low. Wooden pegs and markers were removed. A post-operation grid survey was done using auto level for leveling assessment. A graph was plotted pre- and post-leveling, using a level field as reference. Laser tech provided accurate, reliable data, enhancing land management and crop productivity.

Figure 3 depicts the field conditions before and after the operation of the laser leveler. The initial assessment revealed varying elevations, ranging from 214 cm at the highest point to 198 cm at the lowest. This disparity was primarily attributed to the presence of a grade or slope within the field, resulting in an uneven soil condition of 16 cm. To address these variations and achieve uniformity, the laser leveler was manually operated with two passes, using the RAISE and LOWER switches on the control box. Subsequently, the mean height of the field was calculated to ensure consistency across the plots. For this purpose, the drag scraper was positioned at the grid point with a mean reduced level of 204.24 cm. This means height of 204.24 cm served as a reference, and the laser land leveler was then switched to AUTO mode in the control box. The study indicated that the initial mean height reduced from 204.24 cm to 203.51 cm, achieving a uniform field shape and optimizing the conditions for rice crop growth. The precision and quality of the land leveling work were assessed using the leveling index parameter, yielding a value of 0.011 for the laser leveler.

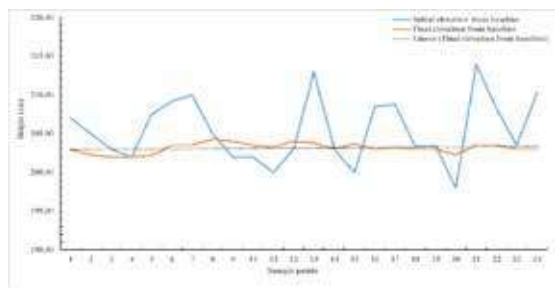


Fig. 3. Field level conditions before and after laser leveler operation.

The successful operation of a lesser land leveler in rice fields requires careful planning, paying close attention to details, and following prescribed

procedures diligently. Skillfully leveling the rice field enables farmers to enhance water distribution and create optimal growth conditions for their valuable rice crops. It is necessary to check the tractor and lesser land leveler for any damages or malfunctions.

Modification of power transmission system of BRRI hydro-tiller

The modification of the hydro-tiller was done with the help of the AutoCAD tool. To increase the strength of the power transmission elements of the hydro-tiller, the thickness of the sprocket and the width of the chain were increased.

Thickness of the sprocket (9 mm) was increased to 11 mm (Fig. 4a).

ASME #60 chain was used instead of ASME #50 chain. Width of the ASME #60 chain is 23 mm (Fig. 4b).

Two bearing was set in combine to the rotary box shaft instead of single bearing to increase the strength of the hydro-tiller in smooth operation at full load condition. Size of each bearing was 62 mm x 16 mm (Figs. 4c and 1d).

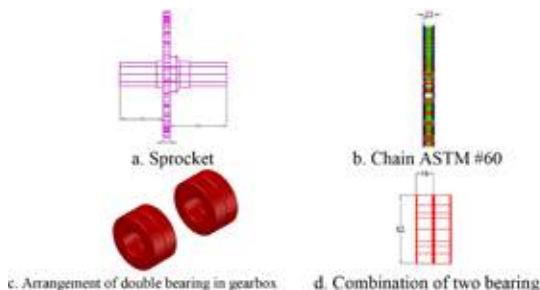


Fig. 4. Modified parts of hydro-tiller.

Developed hydro-tiller

Hydro-tiller is a floating rotary tiller, puddle the low lying fields uniformly with less operations. It is suitable for both primary and secondary tillage when the field has been soaked for at least half a day to soften the soil. The modified hydro-tiller is more suitable for water-logged, marshy lands. It consists of an engine, gear box, pontoon, cage wheel, clutch lever etc. Figure 5 presents its specification. is given in

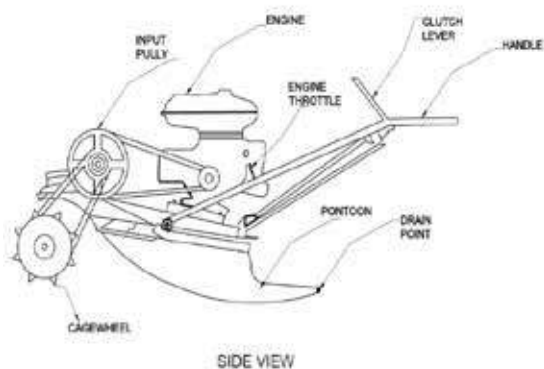


Fig. 5. Schematic diagram of the modified hydro-tiller.

Power transmission system and cage wheel of hydro-tiller

A 8.2 kw engine was used to increase the capacity of the hydro-tiller. RPM of the engine is 2800. It was step down to 2400 rpm in the gear box shaft

through the power transmission elements i.e. v belt, pulley (Fig. 5). Again, it was step down to 1800 rpm in the cage wheel shaft through the power transmission elements i.e. chain, sprocket, bearing (Fig. 6).



Fig. 6. Flow sheet diagram of power transmission system of the modified hydro-tiller.

Cage wheels till and soften the marshy land. Two cage wheel was attached in the gear box shaft. Length of each cage wheel is 478 mm. Diameter of each cage wheel is 270 mm. Figure 7 presents an exploded view of power transmission elements of hydro-tiller.

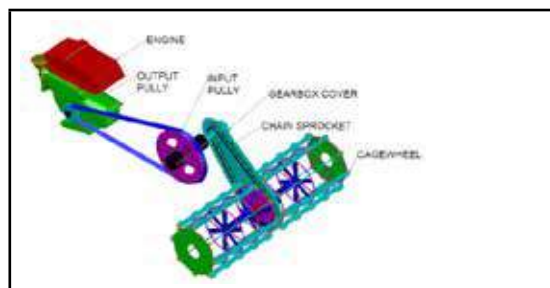


Fig. 7a. Power transmission system of hydro tiller.

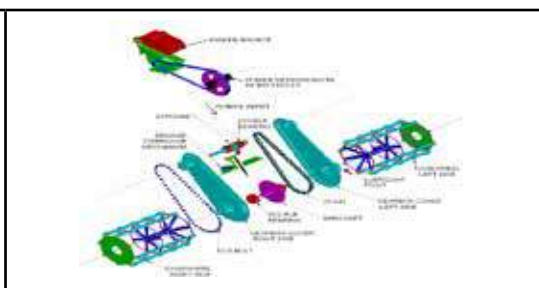


Fig. 7b. Exploded view of power transmission system between gearbox and cage wheel.

Performance of modified hydro-tiller

After that, the modified hydro-tiller was tested at BRRRI West Byde, Gazipur. Data i.e. theoretical field capacity, actual field capacity, field efficiency, fuel consumption was determined during the test. Existing hydro-tiller was tested (Plate 6) and its

capacity was found 0.023 ha/hr. After modification, the capacity of the hydro-tiller was increased to 0.039 ha/hr. Its capacity increased 0.016 ha/hr than that of the existing one. Average fuel consumption of the modified hydro-tiller was 2.01 l/hr (Table 10).



Plate 6. Test of modified hydro-tiller at BRR West Byde, Gazipur.

Table 10. Field performance of the modified hydro-tiller.

Location	No. of trail	Actual rate of area coverage (ha/hr)	Theoretical rate of area coverage (ha/hr)	Field efficiency (%)	Fuel consumption (L/hr)
BRR West Byde Gazipur 1		0.037	0.061	64.0	1.97
	2	0.039		61.7	2.00
	3	0.041		67.4	2.05

Before modification of the hydro-tiller, the average number of chain and belt tearing was about 20 and 16 per year, respectively. The number of chain and belt tearing of the hydro-tiller has been decreased to below 8 per year after the modification. On average, 150 number of engine stopping events due to overloading were found every year in the existing hydro-tiller. After modification of the hydro-tiller, this number sharply fall to around 10 last year. No event of engine stopping due to overloading arose during land cultivation this year. Figure 8 depicted it.

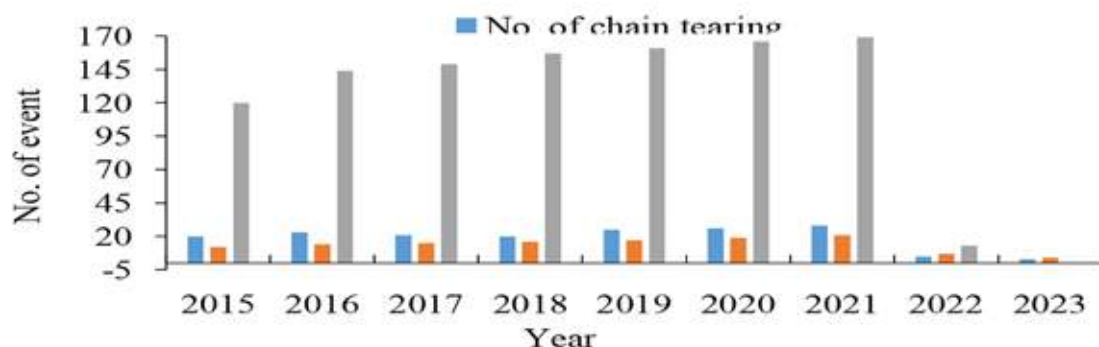


Fig. 8. Chain, belt tearing and engine stopping scenario of the hydro-tiller.

Identification and Fabrication of Fast-Moving Spare Parts of Combine Harvester

In the farmer's field, both the whole feed and head feed combine harvester are working. For this study, various available makes and model, different

popular whole feed and head feed harvesters were selected. Data were collected from users and importers of those harvesters and there were in total 26 respondents. This study was carried out in the Sirajganj and Habiganj districts.

Data Collection

Face-to-face interviews with importers and users of combine harvesters were conducted as part of a survey to gather statistics and pertinent information

on fast-moving spare parts. Face-to-face interviews were chosen because they were thought to be the most efficient and convenient approach to get data from respondents in survey research.

The following activities was conducted under the proposed programme-

a. Machine model and brand selection b. List down the spare parts of the • Engine • Basement and transportation section • Paddy and grain conveying section • Threshing section • Cleaning section • Power conveying section etc. c. Data collection from machine and spare parts importers/companies related to: • Parts failure based on operation hours and seasons • Most frequent failure, frequent failure, medium term	d. Data collection from machine users related to: • Parts failure frequency-based operation hours and seasons • Cost involvement • Parts specification e. Spare category • Maintenance spares • Consumable spares f. Commercially viable numbers identification • Detail specification preparation of the identified parts g. Shortlisting of the local manufacturers h. Documentation

Common list of fast-moving spare parts

Table 11 shows that Kubota and Yanmar combine harvester models were more commonly used in Sirajganj and Habiganj district. The Yanmar model showed the highest operational hours and fast-moving spare parts failure. It is evident that as operational hours increased the failure frequency rate of fast-moving spare parts increased as well. However, failure frequency of combine harvester starts to occur after 250 hours of operation. Prior to it, it was discovered that there was little to no failure frequency of the machines. In comparison to the other models, the Yanmar and Kobuta model of the combine harvester was found to be suitable in the first season.

Table 11 highlights the most commonly used fast-

moving spare parts, including cutting blades, various belts (SB 47, LB37, B53, A48, SC102), fingers, finger belts, threshing teeth, chains, finger chains (140 and 119), and sprockets. In the seventh operational season, cutting blades had the highest failure frequency at 57, followed by 54 belt failures and 32 bearing failures. Spare parts failure was less frequent in the first season compared to subsequent seasons, directly correlating with operational hours. During operation, spare parts failures led to delays due to unavailability. Ensuring clear harvesting plots, free of obstacles like hard branches and metal objects, can reduce cutting blade failures. Operator proficiency is crucial for efficient combine harvester operation and minimizing spare parts failures. Improper adjustments can damage both grains and machinery.

Table 11. A common list of fast-moving spare parts of different makes and models combine harvester.

Parts name	Frequency of damage						
	During 1 st season	During 2 nd season	During 3 rd season	During 4 th season	During 5 th season	During 6 th season	During 7 th season
Cutting blade	10	29	39	45	50	54	57
Belt	6	18	28	39	47	51	54

Bearing	5	14	22	26	28	30	32
Finger	6	17	21	25	28	29	30
Finger belt	1	7	17	19	20	21	24
Threshing teeth	0	4	7	9	12	13	13
Chain	0	5	9	9	13	13	13
Finger chain	1	5	7	8	10	10	12
Sprocket	0	2	7	7	9	10	12

Experienced operators promptly adjust various spare parts to maintain efficiency. To reduce repair time during operation, these commonly used spare parts should be made available locally at affordable prices, ensuring the economic viability of mechanical harvesting. The frequency of combine harvester spare parts failures increased with operational hours and seasons. The Yanmar combine harvester experienced the highest failure rate at 1,450 operational hours. Cutting blades, belts, bearings, fingers, chains, and threshing teeth were the most frequently failing parts. Spare parts failures posed challenges during both peak and off-peak harvesting seasons. It's imperative to promptly establish local availability of these spare parts to sustain and economically support mechanical harvesting.

Validation and comparative analysis of rice transplanter cum mixed fertilizer applicator

Validation and up-scaling of rice transplanting and harvesting technology in the selected sites of Bangladesh (VRTHB), a competitive Grants

Programme (CGP) Interim-2, 2021 Research Project under the KGF-BKGET Fund, Bangladesh Agricultural Research Council (BARC), was officially launched on 4 November 2021, through the signing of the letter of agreement. Holistic research approaches were applied to validate and up-scaling the power weeder, rice transplanter cum fertilizer applicator and combine harvester in the project sites under Habiganj and Sirajganj districts during the Aman 2022 and Boro 2022-23 seasons. Short brief methodologies of the experiments that have been conducted in the project sites are given below. Experiment-1 related to the rice transplanter cum mixed fertilizer applicator, experiment-2 related to the combine harvester and experiment-3 related to the power weeders. BRRI-developed rice transplanter cum mixed fertilizer applicator was used in this experiment for validation. It was designed and fabricated in the FMPT divisional research workshop. Table 12 presents the major specification and features of the machine. Plate 7 shows the photographic view of the weeder.

Table 12. Description of the rice transplanter cum mixed fertilizer applicator.

Country of origin and model		South Korea and ARP-4UM
Type		Walk behind type
Dimensions	Overall length × width × height (mm)	23505×1480×800
	Overall weight (kg)	175
	Maximum output kW rpm ⁻¹	3/1800
	Starting method	Recoil

Transplanting Section	Transplanting mechanism	Rotary
	Number of rows	4
	Row-to-row distance (mm)	300 (fixed)
	Plant-to-plant distance (mm)	110 to 150
	Transplanting speed, m s ⁻¹	0.3 to 0.7
Fertilizer application section	Dispensing mechanism	Screw conveyor type associated with flexible pipe, furrow opener, and closer mechanism
	Fertilizer dose	Simple lever
	Operation	Engage and disengage the lever
	Fertilizer placement depth control	Mechanical
	Hopper capacity (kg)	8-10
	Power transmission	Engine to screw conveyor through belt-pulley and gear mechanism



Plate 7. BRRI developed rice transplanter cum mixed fertilizer applicator.

Treatments

T1: Machine transplanting with 100% urea fertilizer

T2: Machine transplanting with 80% urea fertilizer

T3: Machine transplanting with 70% urea fertilizer

T4: Machine transplanting without fertilizer

T5: Farmers practice

A total of four trials have been set up in the Aman 2022 and Boro 2022-23 seasons, of which 2 were in Habiganj and two in Sirajganj. In trials, more than

3.53 hectares of land in Aman and 4.97 hectares in Boro seasons were covered. Data were analyzed as a factorial design according to Gomez and Gomez using Crop Stat 7.2 software. Means were compared with the least significant difference (LSD) at which level of significant percentage test using Statistix 10 programme.

Field performance of the rice transplanter cum mixed fertilizer applicator during Aman 2022 season.

The field capacity of the developed rice transplanter cum mixed fertilizer applicator was measured with and without fertilizer deep placement mechanism in four locations during Aman 2022 seasons (Table 13). The actual field capacity of the rice transplanter varied from 0.16 to 2.1 ha hr⁻¹ with fertilizer deep placement while it varied from 2.4 to 2.6 ha hr⁻¹ without fertilizer deep placement mechanism in Aman 2022 season, respectively. Field efficiency varied from 68 to 91% with fertilizer deep placement while it varied from 62 to 77% without fertilizer deep placement mechanism. Field capacity was found higher to some extent without fertilizer deep placement mechanism during transplanting due to extra fertilizer re-filling time and slow operation.

Table 13. Field performance of the rice transplanter cum mixed fertilizer applicator tring Aman Season 2022.

No. of trials	Treat	Area (Decimal)	Operation time (hr)	Operation time (min)	Width of cover (m)	FS (km/h)	AFC (ha/h)	TFC (ha/h)	Efficiency (%)
1	Sirajganj-1								
	T ₁	35	0.90	54	1.2	1.92	0.16	0.2304	68.34
	T ₂	35	0.87	52	1.2	1.9	0.16	0.228	71.71
	T ₃	35	0.82	49	1.2	1.9	0.17	0.228	76.10
	T ₄	35	0.78	47	1.2	2.4	0.18	0.288	62.81
	T ₅	21	16.00	1260	0	0	0.005	0	
2	Sirajganj-2								
	T ₁	55	1.20	72	1.2	1.95	0.19	0.234	79.30
	T ₂	55	1.17	70	1.2	2.1	0.19	0.252	75.74
	T ₃	55	1.10	66	1.2	2.3	0.20	0.276	73.34
	T ₄	55	1.00	60	1.2	2.4	0.22	0.288	77.32
	T ₅	45	41.00	48	0	0	0.004	0	
3	Habiganj-1								
	T ₁	70	1.43	86	1.2	1.85	0.20	0.222	89.06
	T ₂	70	1.42	85	1.2	1.82	0.20	0.2184	91.60
	T ₃	70	1.38	83	1.2	2.1	0.20	0.252	81.30
	T ₄	70	1.25	75	1.2	2.6	0.23	0.312	72.67
	T ₅	50	46.00	84	0	0	0.004	0	
4	Habiganj-2								
	T ₁	25	0.63	38	1.2	1.75	0.16	0.21	76.10
	T ₂	25	0.62	37	1.2	1.74	0.16	0.2088	78.61
	T ₃	25	0.57	34	1.2	2.1	0.18	0.252	70.88
	T ₄	25	0.50	30	1.2	2.5	0.20	0.3	67.48
	T ₅	11	7.00		0	0	0.006	0	

Note: Average value of three replications, width covered per pass of the applicator is 1.2 m. FDP- Fertilizer deep placement, AFC-Actual field capacity, TFC-Theoretical Field capacity and FS-Forward speed, T1: Machine transplanting with 100% urea fertilizer, T2: Machine transplanting with 80% urea, fertilizer, T3: Machine transplanting with 70% urea fertilizer, T4: Machine transplanting without fertilizer and T5: Farmers' practice.

Field efficiency vs field length

The field efficiency of the rice transplanter cum mixed fertilizer applicator varied with field length. It is observed in the linear regression curve ($R^2 = 0.95$) that the field performance of the rice transplanter cum mixed fertilizer applicator varied relatively in line with field length in an average of four locations (two locations in Sirajganj and two locations in Habiganj) where 95% variable explained the prediction of field efficiency varied with the field length (Fig. 9).

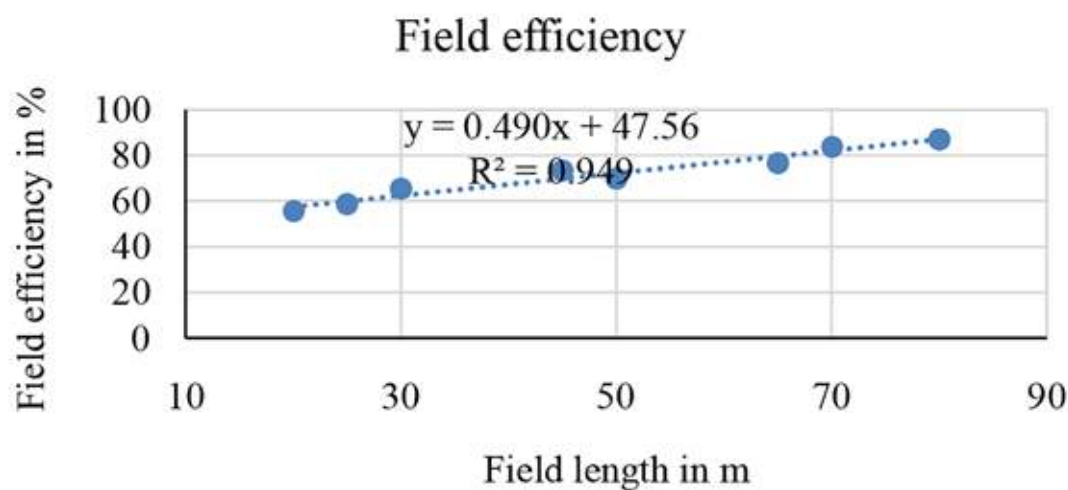


Fig.9. Influences of field length on field efficiency of the rice transplanter.

Field performance of the rice transplanter cum mixed fertilizer applicator (Boro 2022)

The field capacity of the developed rice transplanter cum mixed fertilizer applicator was also measured with and without fertilizer deep placement mechanism in four locations during Boro 2022-23 seasons (Table 14). The actual field capacity of the rice transplanter varied from 0.15 to 0.22 ha hr⁻¹ with fertilizer deep placement while it varied from

0.22 to 0.25 ha hr⁻¹ without fertilizer deep placement mechanism in Boro 2022-23 season, respectively. Field efficiency varied from 63 to 86% with fertilizer deep placement while it varied from 60 to 84% without fertilizer deep placement mechanism. Field capacity was found higher to some extent without fertilizer deep placement mechanism during transplanting due to extra fertilizer re-filling time and slow operation.

Table 14. Field performance of the rice transplanter cum mixed fertilizer applicator Boro season 2023.

Location	Treat	Area (Deci-mal)	Length (m)	Operation time (hr)	Operation time (min)	Width of cover (m)	FS (km/h)	AFC (ha/h)	TFC (ha/h)	Efficiency (%)
Sirajganj-1	T ₁	55	65	1.48	89	1.2	1.62	0.15	0.1944	77.22
	T ₂	45	62	0.97	58	1.2	2.1	0.19	0.252	74.79
	T ₃	48	48	0.95	57	1.2	2.2	0.20	0.264	77.48
	T ₄	42	50	0.73	44	1.2	2.5	0.23	0.3	77.29
	T ₅	40	42	16.00	2500	0	0	0.010	0	76.70
Sirajganj-2	T ₁	49	68	1.23	74	1.2	1.95	0.16	0.234	68.74
	T ₂	50	70	1.18	71	1.2	2.1	0.17	0.252	67.88
	T ₃	50	62	1.10	66	1.2	2.3	0.18	0.276	66.68
	T ₄	48	60	0.87	52	1.2	3.1	0.22	0.372	60.28
	T ₅	45	55	21.67	1300	0	0	0.008	0	65.89

Location	Treat	Area (Deci-mal)	Length (m)	Operation time (hr)	Operation time (min)	Width of cover (m)	FS (km/h)	AFC (ha/h)	TFC (ha/h)	Efficiency (%)
Habiganj-1	T ₁	120	85	2.53	152	1.2	2.52	0.19	0.3024	63.42
	T ₂	85	85	2.20	132	1.2	2.03	0.16	0.2436	64.21
	T ₃	80	80	1.45	87	1.2	2.8	0.22	0.336	66.48
	T ₄	75	75	1.30	78	1.2	2.9	0.23	0.348	67.12
	T ₅	35	72	12.67	760	0	0	0.011	0	65.31
Habiganj-2	T ₁	120	128	2.65	159	1.2	1.78	0.18	0.2136	85.83
	T ₂	100	120	2.20	132	1.2	1.95	0.18	0.234	78.64
	T ₃	75	101	1.53	92	1.2	2.2	0.20	0.264	75.01
	T ₄	35	95	0.57	34	1.2	2.5	0.25	0.3	83.35
	T ₅	30	90	11.23	674	0	0	0.011	0	80.71

Field efficiency vs field length

The field efficiency of the rice transplanter cum mixed fertilizer applicator varied with field length. It is observed in the liner regression curve ($R^2 = 0.90$) that the field performance of the rice

transplanter cum mixed fertilizer applicator varied relatively in line with field length in an average of four locations (two locations in Sirajganj and two locations in Habiganj) where 90% variable explained the prediction of field efficiency varied with the field length (Fig. 10).

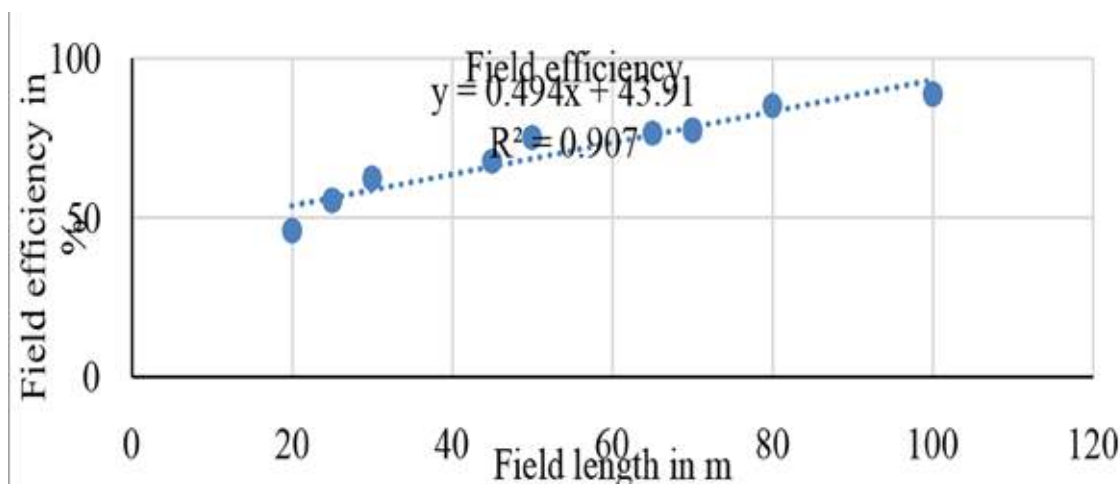


Fig. 10. Influences of field length on field efficiency of the rice transplanter

Validation and grain loss identification of the paddy combine harvester

Head feed and whole feed combine harvesters were studied during the reporting period in Aman 2022 and Boro 2022-23 seasons. Two popular models

(FMWORLD Ruilong and Yanmar AG600A) were used in this study during Aman 2022 (Plate 8). General information on the study, crops, and field conditions is given in Plate 8. Crops and field conditions largely influenced the machine's performance.



a.

a. Whole feed combine harvester at Habiganj

b. Head feed combine harvester at Sirajganj

Field performance of the studied combine harvester evaluated under different field length in the project locations (Table 15). Forward speed (km/h), Effective field capacity (ha/h), Theoretical field capacity (ha/h) and Field Efficiency (%) were measured under different conditions. All the parameters varied with the field length in all locations (Table 15).

Table 15. Field performance evaluation of the head feed combine harvester in the Aman season 2022.

Category	Length, L (m)	Width (m)	Total area A (ha)	Forward speed, S (km/h)	Total operating time (h)	Effective field capacity (ha/h)	Effective cutting width, w (m)	Theoretical field capacity (ha/h)	Field Efficiency (%)
Habiganj-1									
<30	29	20	0.058	3.773	0.183	0.3164	2.2	0.830	38.11
30-40	38	20	0.076	4.188	0.167	0.4560	2.2	0.921	49.49
41-50	44	20	0.088	4.659	0.150	0.5867	2.2	1.025	57.24
51-60	55	20	0.110	4.752	0.117	0.9429	3.2	1.521	62.00
61-65	62	20	0.124	4.817	0.083	1.4880	4.2	2.023	73.54
Habiganj-2									
<30	22	20	0.044	3.600	0.150	0.2933	2.2	0.792	37.04
30-40	39	20	0.078	3.343	0.217	0.3600	2.2	0.735	48.95
41-50	47	20	0.094	3.021	0.233	0.4029	2.2	0.665	60.61
51-60	54	20	0.108	3.471	0.150	0.7200	3.2	1.111	64.81
61-65	64	20	0.128	4.114	0.100	1.2800	4.2	1.728	74.07
Sirajganj-1									
<30	24	20	0.048	2.979	0.250	0.1920	1.5	0.447	42.96
30-40	38	20	0.076	3.600	0.183	0.4145	2.5	0.900	46.06
41-50	42	20	0.084	3.844	0.217	0.3877	1.5	0.577	67.24
51-60	58	20	0.116	3.990	0.267	0.4350	1.5	0.598	72.69
61-65	65	20	0.130	4.307	0.150	0.8667	2.5	1.077	80.49
Sirajganj-2									
<30	17	20	0.034	3.166	0.183	0.1855	1.5	0.475	39.06
30-40	32	20	0.064	3.388	0.267	0.2400	1.5	0.508	47.22
41-50	45	20	0.090	3.951	0.183	0.4909	2.5	0.988	49.70
51-60	55	20	0.110	4.097	0.267	0.4125	1.5	0.614	67.13
61-65	64	20	0.128	4.608	0.150	0.8533	2.5	1.152	74.07

Field efficiency of the head feed and whole feed combine harvester in different locations

The field efficiency of both head feed and whole feed combine harvester was measured with the

length of the field (Table 16). In all locations, the field efficiency of both the head feed and whole feed combine harvester increased with the increase in the field length.

Table 16. Field efficiency of the combine harvester affected by the length of the field.

Length of field in m	Habiganj-1	Habiganj-2	Sirajganj-1	Sirajganj-2
<30	38.11	37.04	42.96	39.06
30-40	49.49	48.95	46.06	47.22
41-50	57.24	60.61	67.24	49.70
51-60	62.00	64.81	72.69	67.13
61-65	73.54	74.07	80.49	74.07

It is observed in the linear regression curve that the field performance of the combine harvester varied relatively in line with field length in Habiganj-1 and 2 and Sirajganj-1 and 2 locations ($R^2 = 0.9665$, $R^2 =$

0.9869 and $R^2 = 0.8598$ and $R^2 = 0.7742$ respectively)

Forward speed

Forward speed also varied with the length of the field (Table 17).

Table 17. Forward speed of the combine harvester affected by the length of the field.

Length of field in m	Habiganj-1	Habiganj-2	Sirajganj-1	Sirajganj-2
<30	3.773	3.600	2.979	3.166
30-40	4.188	3.343	3.600	3.388
41-50	4.659	3.021	3.844	3.951
51-60	4.752	3.471	3.990	4.097
61-65	4.817	4.114	4.307	4.608

It is observed in the liner regression curve that the field performance of the combine harvester varied relatively in line with field length in Habiganj-1 and 2 and Sirajganj-1 and 2 locations ($R^2 = 0.8581$,

$R^2 = 0.1275$ and $R^2 = 0.9199$, respectively) except Habiganj-2 ($R^2 = 0.1275$) where 12.75% variable explained the prediction of field efficiency varied with the field length (Fig. 11).

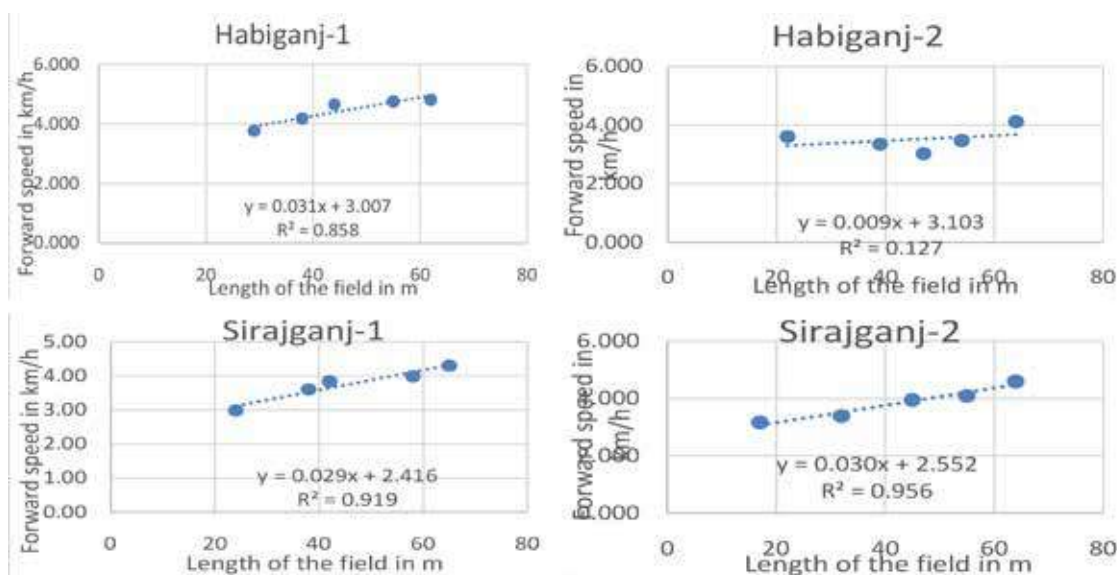


Fig. 11. Influences of field length on forward speed of the combine harvester.

Table 18. Total losses of grain of whole feed combine harvester.

Pre-Harvest Loss, Kg/ha	Shattering loss, Kg/ha	Cylinder loss, Kg/ha	Total loss, Kg/ha	Grain yield (t/ha)	Moisture Content %	Grain loss at 14% M.C. (Kg/ha)	Grain loss in %
4.89	24.42	62.05	91.36	5.14	25.14	79.42	1.80
7.33	22.11	59.32	88.76	5.14	25.14	77.19	1.75
8.56	20.62	65.45	94.63	5.14	25.14	82.30	1.86
Avg.	6.93	22.39	62.27	5.14	25.14	79.64	1.81

Table 19. Total losses of grain of head feed combine harvester.

	Pre-Har- vest Loss, Kg/ha	Shattering loss, Kg/ ha	Cylinder loss, Kg/ ha	Total loss, Kg/ha	Grain yield (t/ ha)	Moisture content %	Grain loss at 14% M.C. (Kg/ ha)	Grain loss in %
	7.00	14.00	15.33	36.33	6.14	26.84	30.91	0.59
	8.75	19.25	12.67	40.67	6.14	26.84	34.60	0.66
	3.50	15.75	14.00	33.25	6.14	26.84	28.29	0.54
Avg	6.42	16.33	14.00	36.75	6.14	26.84	31.26	0.60

Validation of mechanical power weeder

BRRRI developed power weeder was used in this experiment for validation. BRRRI Multi-rows power weeder was designed and fabricated in the FMPH

divisional research workshop. Table 20 presents the major specification and features of the weeder. The photographic view of the weeder is also shown in Plate 9.

Table 20. Description of the power weeder.

Item		Specification
Country of origin and Model		Bangladesh and MRPW-1
Type		Forward motion walking type
Dimensions	Overall length×width×height (mm)	1417×762×807
	Overall weight (kg)	20
	Maximum output kW rpm ⁻¹	1.35/7000
	Engine type	Petrol engine
	Starting method	Recoil
Traveling Section	Crawling	Hand controlling system
	Rotor type	Spike work as lug in the wheel
	Gearshift: Forward	Power engaged with the increase of engine rpm
Weeding Section	Weeding mechanism	Rotary: spike used in the rotor for weeding
	Number of rows	3
	Row to row distance (mm)	200 to 300 (adjustable)
	Field capacity (ha/hr)	0.16-0.20
	Working life (yrs)	3-4

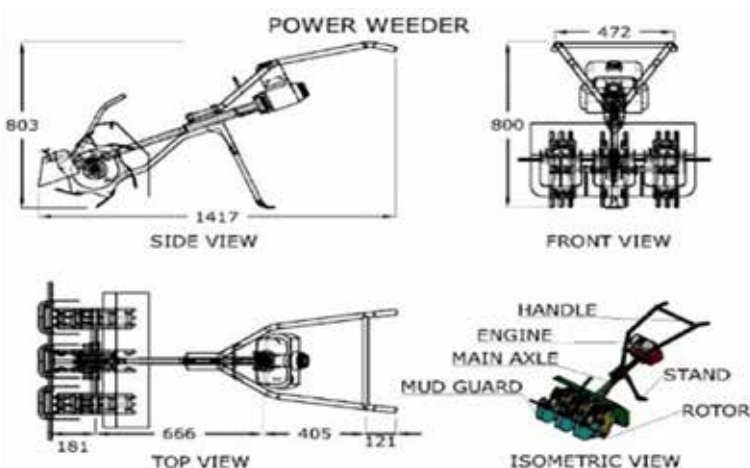


Plate 9. BRR multi-rows power weeder. *Treatments*

T_1 = One weeding by developed power operated weeder (PoW) succeeded by (sb) one hand-weeding (HaW);

T_2 = Herbicide application

T_3 = One weeding by manual weeder sb one HaW (Local practice)

T_4 = No-weed,

T_5 = Unweeded (Control);

Four trials were conducted in the Boro 2022-23 season, of which two were in Habiganj and two in Sirajganj. In each trial, three bigha of land was covered. Line to line and plant to plant spacing were maintained 20 and 15 cm, respectively. Weeding

operation was done according to the treatments.

Field performance of the weeder

Field capacity of the multi-rows power weeder was measured during field operation in four locations under the project sites (Table 21). Theoretical field capacity varied with forward speed of machine operation whereas actual field capacity varied with forward speed, turning time loss, weeder placing in between rows time etc. In all cases, theoretical and actual field capacity of the power weeder varied from 0.38 to 0.66 and 0.26 to 0.43 ha/hr based on soil conditions. Both the capacity was found more in Habiganj. Field efficiency varied from 60.82 to 71.49 irrespective of soil and location.

Table 21. Field performance of the power weeder at different project locations (Boro season, 2022-23).

Time/pass in length wise (s)				Forward speed, S (km/h)	Total operating time (h)			Effective field capacity (ha/h)	Effective cutting width (m)	Theoretical field capacity (ha/h)	Field Efficiency (%)	Area covered
1	2	3	Avg	$S = L/S \times 3.6$	Start time	End time	Total time (h)	$EFC = A/h$	w	$TFC = (S \times W)/10$	$FE = (EFC / TFC) \times 100$	hr/ha
40	35	60	45.00	4.40	1.25	1.73	0.48	0.23	0.60	0.26	86.21	4.39
175	77	104	80.00	3.83	3.22	4.24	1.02	0.21	0.60	0.23	91.07	4.78
82	72	68	74.00	3.65	1.25	2.03	0.78	0.24	0.90	0.33	72.89	4.18
80	75	75	76.67	3.52	1.25	2.12	0.87	0.24	0.90	0.32	76.45	4.13

Note: 1- Habiganj (1), 2- Habinag (2), 3- Sirajganj (1) and 4- Sirajganj (2)

Fuel consumption of the weeder (Boro 2022-23 season)

The fuel tank was full and leveled when the test was conducted. By keeping the machine on a level platform and filling the fuel tank all the way, fuel consumption was calculated. The average fuel consumption rate (l/ha) of the weeding operation at the two locations in Habiganj is lower than the average fuel consumption rate (l/ha) of the weeding

operation at the two locations in Sirajganj. But the average fuel consumption rate (l/h.) of the weeding operation at the two locations in Habiganj is greater than the average fuel consumption rate (l/h.) of the weeding operation at the two locations in Sirajganj. The maximum and minimum specific fuel consumption (l/hp-h) was observed at Habiganj (2) and Sirajganj (2) respectively. The variation of fuel consumption was observed between different locations due to time of operation, turning time loss, mechanical error of the machine, and weed density (Table 22).

Table 22. Fuel consumption of the weeder during field operation (Boro season 2022-23).

No.	Area (ha)	Operating time (h)	Total fuel used (l)	Fuel consump- tion rate (l/ha)	Fuel consump- tion rate (l/hr)	Specific fuel consumption
	A	H	F	$F_c = F/A$	$F_c = F/h$	(l/hp-h)
1	0.110	0.483	0.250	2.273	0.517	0.398
2	0.213	1.017	0.550	2.588	0.541	0.416
Average	0.1615	0.75	0.4	2.4305	0.529	0.407
3	0.188	0.783	0.355	1.893	0.453	0.349
4	0.210	0.867	0.420	2.000	0.485	0.373

Average	0.199	0.825	0.3875	1.9465	0.469	0.361

Weeding efficiency

The data reveal (Table 23) that the maximum and minimum weeding efficiency of the power weeder was at Sirajganj and Habiganj respectively. Similarly, the maximum and minimum weeding efficiency of the manual weeder was at Habiganj. It

was observed that the higher mean value (88.97%) and the lower mean value (88.80%) of weeding efficiency of one weeding by developed power operated weeder (PoW) succeeded by (sb) one hand-weeding (HaW) and one weeding by manual weeder sb one HaW (Local practice) respectively.

Among the two weeders (T_1 and T_3), the highest weeding efficiency was found at 90.00 % in T_1 at Sirajganj(1) and the lower weeding efficiency was obtained at 85.80 % in T_2 at also Sirajganj(1).

Table 23. Weeding efficiency of the mechanical power (Boro, 2022-23 season).

Treatments	Habiganj-1	Habiganj-2	Sirajganj-1	Sirajganj-2	Mean
T_1	88.97	88.80	89.10	90.00	89.22
T_3	91.83	86.70	85.80	81.63	86.49
Mean	90.40	87.75	87.45	85.82	
CV	4.44				
LoS	L=ns, T=ns and $L \times T = ns$				

Note: T_1 = One weeding by developed power operated weeder (PoW) succeeded by (sb) one hand-weeding (HaW); T_3 = One weeding by manual weeder sb one HaW (Local practice); NS-Not significant, *-significant at 5 %, **-significant at 1 %, LoS-Level of significance, L-Locations, T-Weeding methods.

Twelve trials were conducted during the reporting periods on BRRI-developed rice transplanter cum mixed fertilizer applicator, different models of combine harvester and BRRI multi-rows power weeder in the project locations. Eight trials (four

in Aman 2022 and four in Boro 2022-23 season) were conducted on the rice transplanter cum mixed fertilizer applicator for validation. On the other hand, ten trials (four in Boro 2021-22, four in Aman2022 and two in Boro 2022-23) were conducted to observe the field performance of whole feed and head feed combine harvesters under different crops, soil, and field length. Detailed reports of the Aman 2022 trials were presented in the result section. Grain loss of the head feed combine harvester is less than 1% while it was about 1.81% for the whole feed combine harvester. Eight trials (four in Boro 2021-

22 and four in Boro 2022-23) were conducted in the project locations. The height weeding efficiency was observed for treatment one (One weeding by developed power operated weeder (PoW) succeeded by (sb) one hand-weeding) followed by treatment three (One weeding by manual weeder sb one HaW (Local practice).

MILLING AND PROCESSING TECHNOLOGY

Design and development of a mini rice mill for homestead level using

Treatments arranged and design

Factor A: Huller speed	Factor B: Polishing pressure	Factor C: Varieties
R_1 = Huller speed at 1200 rpm. R_2 = Huller speed at 1500 rpm.	P_1 = Polishing pressure at point 3 P_2 = Polishing pressure at point 5 P_3 = Polishing pressure at point 7	V_1 = BRRI Dhan96 V_2 = BRRI Dhan87

Note: There have 1-9 options to increase the polishing pressure gradually. This study was conducted under the pressure point at 3, 5 and 7.

Plate 10 displays the pictorial representation of the developed Mini Rice Mill, presenting its final appearance achieved through the appropriate arrangement of machine components and dyeing process.



Plate 10. Pictorial view of the BRRI Mini Rice Mill

Milling capacity

Milling capacity of the developed Mini Rice Mill significantly varied with variety and rotor rpm individually and the interaction effect of variety

A prototype of a mini rice mill was fabricated in FMPHT divisional research workshop based on design. Existing facilities of the workshop were used to fabricate the all components. The following treatments were arranged to evaluate the developed technology. BRRI dhan87 (L-8.8 mm and B-3.2 mm and L/B ratio: 2.75) and BRRI dhan96 (L-8.3 mm, B-3.7 mm and L/B ratio: 2.24) were used to evaluate the technology. Detailed evaluation report will be presented in next year.

and rotor rpm also while the interaction effect of the variety, rotor rpm and polishing pressure did not vary significantly (Table 24).

Table 24. Combined effect of variety, RPM and Polishing pressure on milling capacity (kg/h).

Variety	RPM	Polishing pressure			Mean
		P_1	P_2	P_3	
V_1	R_1	62.4	59.6	59.0	60.3
	R_2	63.5	62.0	60.3	61.9
V_2	R_1	66.9	63.3	65.9	65.3
	R_2	69.5	65.8	65.3	66.9
Mean		65.6	62.7	62.6	
LoS		$V=***$, $P=**$, $V \times P=***$ and $V \times P \times S=**$			
% of CV		10.3			
LSD _{0.05}		$V=6.2156$, $P=6.2156$, $S=7.6126$, and $V \times P \times S=8.7902$			

Note: * means $M \leq 0.05$, ** means $M \leq 0.01$, *** means $M \leq 0.001$, NS means Non-significant, LoS means level of significance.

Milling recovery

Milling recovery of the developed Mini Rice Mill significantly varied with polishing pressure

individually while the interaction effect of the variety, rotor rpm and polishing pressure did not vary significantly (Table 25).

Table 25. Combined effects of variety, RPM and polishing pressure on milling recovery (%).

Variety		Polishing pressure			Mean
	RPM	S ₁	S ₂	S ₃	
V ₁	P ₁	62.4	59.6	59.0	60.3
	P ₂	63.5	62.0	60.3	61.9
V ₂	P ₁	66.9	63.3	65.9	65.3
	P ₂	69.5	65.8	65.3	66.9
Mean		65.6	62.7	62.6	
LoS		S= ***; V= *** P= **, V×P×S= NS			
% of cv		1.9			
LSD0.05		V=0.83, RPM= 0.83, S=1.02, V×P×S= 2.0436			

Note: * means $M \leq 0.05$, ** means $M \leq 0.01$, *** means $M \leq 0.001$, NS means Non-significant, LoS means level of significance.

the developed Mini Rice Mill significantly varied with variety and rotor speed individually as well as the interaction of rotor speed and polishing pressure while the interaction effect of the variety, rotor rpm and polishing pressure did not vary significantly (Table 26).

Head rice recovery

Head rice obtained from the milling performance of

Table 26. Combined effects of variety, RPM and polishing pressure on head rice recovery (%).

Variety		Polishing pressure			Mean
	RPM	S ₁	S ₂	S ₃	
V ₁	P ₁	71.3	67.0	67.0	68.4
	P ₂	68.7	68.7	62.3	66.6
V ₂	P ₁	73.3	68.7	69.7	70.6
	P ₂	78.7	72.3	67.3	72.8
Mean		73.0	69.2	66.6	
LoS		V= **, P=NS, S=**, V×P×S= NS			
% of cv		6.04			
LSD0.05		V= 2.905, P= 2.905, S=3.5579, V×P×S= 7.1158			

Note: * means $H \leq 0.05$, ** means $H \leq 0.01$, *** means $H \leq 0.001$, NS means Non-significant, LoS means level of significance.

of the BRRI Mini Rice Mill significantly varied with variety and rotor speed individually as well as the interaction of rotor speed and variety while the interaction effect of the variety, rotor rpm and polishing pressure did not vary significantly (Table 27).

Broken rice

Broken rice obtained from the milling performance

Table 27. Combined effects of variety, RPM and Polishing pressure on broken rice (%).

Variety		Polishing pressure			Mean
	RPM	S ₁	S ₂	S ₃	
V ₁	P ₁	17.3	29.3	23.0	23.2
	P ₂	20.0	19.0	28.7	22.6
V ₂	P ₁	22.0	25.0	24.3	23.8
	P ₂	13.3	17.3	23.3	18.0
Mean		18.2	22.7	24.8	
LoS		V= NS, P= NS, S=**, P×S=** V×P×S= NS			
% of cv		21.48			
LSD0.05		V= 3.25, P= 3.25, S=3.98, P×S=5.62, V×P×S= 7.961			

Note: * means $B \leq 0.05$, ** means $B \leq 0.01$, *** means $B \leq 0.001$, NS means Non-significant, LoS means level of significance.

Fine broken rice

Fine broken rice obtained from the milling performance of the BRRI Mini Rice Mill significantly varied with variety and rotor speed individually while the interaction effect of the variety, rotor rpm and polishing pressure did not vary significantly (Table 28).

Table 28. Combined effects of variety, RPM and polishing pressure on fine broken rice (%).

Variety		Polishing pressure			Mean
	RPM	S ₁	S ₂	S ₃	
V ₁	P ₁	11.3	3.3	9.7	8.1
	P ₂	11.3	12.3	9.0	10.9
V ₂	P ₁	4.7	6.7	6.0	5.8
	P ₂	8.0	10.3	9.3	9.2
Mean		8.8	8.2	8.5	
LoS		V=NS, P= **, V×P×S= NS			
% of cv		52			
LSD0.05		V= 3.056, P= 3.056, S= 3.74, V×P×S= 7.48			

Note: * means $F \leq 0.05$, ** means $F \leq 0.01$, *** means $F \leq 0.001$, NS means Non-significant, LoS means level of significance.

Percent of uniformity

Percent of uniformity obtained from the milling performance of the BRRI Mini Rice Mill significantly varied with variety, polishing

pressure and rotor speed individually as well as the interaction of rotor speed and variety, rotor speed and polishing pressure while the interaction effect of the variety, rotor rpm and polishing pressure did not vary significantly (Table 29).

Table 29. Combined effects of variety, RPM and polishing pressure on % of uniformity.

Variety	Polishing pressure				Mean
	RPM	S ₁	S ₂	S ₃	
V ₁	P ₁	75.2	74.6	82.2	77.3
	P ₂	87.2	81.3	83.2	83.9
V ₂	P ₁	63.3	61.2	63.3	62.6
	P ₂	71.9	69.6	60.2	67.2
Mean		74.4	71.7	72.2	
LoS		V= ***, P= ***, S=NS, V×S=**, P×S=** and V×P×S= NS			
% of cv		8.42			
LSD0.05		V= 2.34, P= 2.34, S= 2.87, V×S=4.06, P×S=4.06 and V×P×S=5.742			

Note: * means $U \leq 0.05$, ** means $U \leq 0.01$, *** means $U \leq 0.001$, NS means Non-significant, LoS means level of significance.

Husk

Husk (%) obtained from the milling performance

of the BRRI Mini Rice Mill significantly varied with polishing pressure individually as well as the interaction of rotor speed and polishing pressure, variety and polishing pressure while the interaction effect of the variety, rotor rpm and polishing pressure did not vary significantly (Table 30)

Table 30. Combined effects of variety, RPM and polishing pressure on husk (%).

Variety	Polishing pressure			Mean
	RPM	S ₁	S ₂	S ₃
V ₁	P ₁	23.4	25.7	24.6
	P ₂	23.3	27.0	25.0
V ₂	P ₁	28.9	29.0	30.7
	P ₂	28.0	25.6	29.6
Mean		25.9	26.8	27.5
LoS		V= ***, P= **, S=***, V×P=***, V×S=*** P×S=NS and V×P×S= **		
% of cv		1.66		
LSD0.05		V= 0.30, P= 0.30, S=0.37, V×P=0.43, V×S=0.53 P×S=0.53 and V×P×S= 0.75		

Note: * means $H \leq 0.05$, ** means $H \leq 0.01$, *** means $H \leq 0.001$, NS means Non-significant, LoS means level of significance.

Bran

Bran (%) obtained from the milling performance of the BRRI Mini Rice Mill significantly varied with variety individually as well as the interaction

of rotor speed and polishing pressure, variety and polishing pressure while the interaction effect of the variety, rotor rpm and polishing pressure did not vary significantly (Table 31).

Table 31. Combined effects of variety, RPM and polishing pressure on bran (%).

Variety	Polishing pressure				Mean
	RPM	S ₁	S ₂	S ₃	
V ₁	P ₁	8.2	8.9	9.0	8.7
	P ₂	6.1	6.9	8.1	7.0
V ₂	P ₁	7.1	9.9	7.6	8.2
	P ₂	8.1	9.3	8.1	8.5
Mean		7.3	8.7	8.2	
LoS		V= **, P= ***, S=***, V×P=***, V×S=***, P×S=** and V×P×S= **			
% of cv		3.93			
LSD0.05		V=0.2197 , P=0.2197, S=0.2691, V×S=0.3806, P×S=0.3806 and V×P×S= 0.5382			

Note: * means $B \leq 0.05$, ** means $B \leq 0.01$, *** means $B \leq 0.001$, NS means Non-significant, LoS means level of significance.

A mini rice mill, suitable for household level using, is developed in the Farm Machinery divisional workshop. Locally available materials were used to develop the mill. It was also evaluated using BRRI dhan96 and BRRI dhan87 in un-parboiled condition. The study concludes that optimizing the huller speed and flow rate can improve the overall efficiency and quality of the rice milling process, benefiting both the rice industry and consumers.

Test, evaluation and modification of rubber roll de-husker and friction type polisher

The modified rubber roll de-husker in the FMPHT Division operates with a 4 kW (3-phase 4 wire 1440 rpm) electric motor. The fixed and adjustable rubber rolls measure 230 mm in diameter and 154 mm in length, with RPMs of 1048 and 789, respectively. The blower operates at 1020 RPM. A

stairway constructed from 16 BWG sheet and 50 x 50 mm angle bar facilitates the transportation of paddy into the hopper. A pipe connects the husker's end to a husk aspirator (diameter: 200 mm). The aspirator fan, powered by a 1.5 kW (2840 rpm) motor, has a diameter of 330 mm. To collect husk, a cyclone separator was modified and attached to the de-husker, improving the working environment by reducing dust. The aleuronic layer of paddy remains undamaged with the rubber roll de-husker. An airstream is directed over the grains, allowing immature grains to be discharged into a separate hopper. Paddy and husk are discharged separately. In this experiment, un-parboiled BRRI dhan104 was used, with a moisture content of 11.20% (wb.) and each sample weighing 20 kg. To evaluate milling parameters, de-husked paddy was processed using an MNMP-15 model friction type polisher.



Plate 11a. Modified de-husker



Plate 11b. MNMP-15 friction type polisher in operation

Performance evaluation

Moisture content of grain was determined by a moisture meter (Rice Ter D, Kett). Thousand grain mass (TGM) was determined by counting 1000 grains with machine and hand counting for each variety and weight with a precision digital balance.

For BRRI dhan104 the average de-husking capacity

of the husker was found 769 kg/h and husking efficiency was about 90.97 % (Table 32). Closing the adjustable roller husking efficiency can be increased, however, it increases the broken rice percentage (brown rice). Brown rice percentage was about 77.88% and rest of was husk and embryo. Average fixed and adjustable rubber roll rpm was found 1048 and 789 respectively.

Table 32. Performance of developed husker for BRRI dhan104.

Capacity (one pass) Kg/h	Husking Effi- ciency (one pass) %	Brown Rice, % (based on input paddy)	Adjustable roll speed (rpm)	Fixed roll speed (rpm)	Ratio of fixed and adjustable roller
780	91.50	77.80	785	1045	24.88
768	90.90	78.20	794	1052	24.52
760	90.10	77.65	788	1048	24.81
Avg.	769	90.97	789	1048	24.74

Fixed rubber roll rotates at an average rpm of 1048 which is 24.80 % more rpm than the adjustable rubber roll. The difference in peripheral speed subjects the paddy grain falling between the rolls to a shearing action that strips off the husk. The clearance between the rolls depends on the thickness of the paddy and it should be less than the thickness of the grain.

Evaluation of milling parameter of BRRI dhan104 processed in friction type polisher

Brown rice was polished in friction type polisher (MNMP-15) and average capacity of the polisher for BRRI dhan104 was 740 kg/h and the average milling recovery was 61.8 % (Plate 11b). The average head rice recovery (based on input paddy) was 52.67 % and head rice recovery (based on total milled rice) was 85.27% (Table 33).

Table 33. Milling parameter of BRRI dhan104 processed in friction type polisher.

Capacity of Polisher Kg/h	Milling yield %	Head rice % (Based on input paddy)	Head rice % (Based on total milled rice)	Broken rice % (Based on input paddy)	Broken rice % (Based on total milled rice)
740.0	62.0	52.00	83.87	10.00	16.13
742.0	61.8	52.60	85.11	9.20	14.89
738.0	61.5	53.40	86.83	8.10	13.17
Av.	740.0	61.8	85.27	9.10	14.73

The broken rice percentage was 9.10 % (based on input paddy) and 14.73 % (based on total milled rice).

Husking efficiency and milling recovery was found around 90.97 % and 61.8 % respectively for BRRI dhan104 polished in friction type polisher followed by de-husking. The average head rice recovery

based on input paddy was 52.67 %, which is encouraging for processing of quality rice. Steel engelberg huller may be replaced with one rubber roll de-husker and a polisher for better quality rice. De-husker also separate husk and polisher separate bran. Separately collected husk and bran is suitable for briquette and edible oil production.

RENEWABLE ENERGY

Design and development of a manually operated briquetting machine

Fabrication. The fabrication of the briquette machine followed the procedures (Plate 12). The FMPHT workshop sourced various materials, such as mild steel, pipes, plates, boxes and angles,

from the local market for fabrication. Powered by a scissor jack, the pressing unit was created using a mild steel angle and a 2 cm diameter round rod positioned at the top of the piston. A hand wheel was affixed to a power screw to enhance operational efficiency and convenience. The design also called for constructing and installing a square cylinder based on the pressing unit.



12a. Fabricated prototype of the manually operated briquette machine



12b. Pressing piston



12c. Square shaped Cylinder

Plate 12. Fabricated briquette machine

Working principle

Scissor jacks are simple mechanisms to press or lift large loads short distances. A scissor jack uses a simple theory of gears to get its power (Plate 13). As the handle wheel turns the screw section, two ends of the jack move closer together. Because the gears of the screw are pushing up the arms, the amount of force being applied is multiplied. It takes a very small amount of force to turn the handle wheel, yet that action causes the arms to slide across and together. As this happens, the arms extend downward through the cylinder and press the raw material given into the cylinder. Review and literature show that a simple scissor jack can press or lift a load of approximately 1 to 1.5 tons.



Plate 13. Scissor jack (Pressing unit)

Overall dimension of the device is about 138*56*56 (L*W*H). The weight of device found 43.5kg, it might be varied with material used. Table 34 presents the detailed specifications of different parts of the device.

Table 34. Detailed specifications of the device.

Items	Specification	Material
Overall dimension (L*W*H)	138*56*56	Mild steel pipe, plate, sheet and angle
Total height 138 cm		
Total weight	43.5 Kg	
Piston:		
▪ Area of piston head	9.6*9.6 cm ²	Mild steel pipe and plate
▪ Total length	28.5 cm	
▪ Stroke length	14.5 cm	
▪ Total clearance	11 cm	
Square Cylinder		
▪ Diameter	10*10 cm ²	Mild steel plate
▪ Length	25.5 cm	
Pressing unit (Scissor jack)		
➤ Diameter of the power screw	2 cm	Mild steel round rod
➤ Diameter of hand wheel	26.5 cm	Mild steel rod
➤ Operating length	40 cm	
➤ Height of the jack from cylinder	47 cm	

Lab Test:

Initially manually operated briquette machine was tested in research workshop using charcoal and rice husk.

Charcoal made briquette can be formed without using any binding material under the developed pressure mentioned above diagram while rice husk did not bond.

Plate 14. Charcoal Briquette

The prototype of the machine already has been developed preliminary an observational trial was done in the divisional workshop. There was no fault in the machine. Thorough test need to be done as early as possible. The performance evaluation of the machine will be executed in the upcoming season. Using following mixing ratio of raw materials (Table 35) will be used next to find optimum bonding strength.



Plate 14. Charcoal Briquette

Table 35. Mixing ratio of raw materials.

	Raw materials	Mixing percentage (%)
Trail 1	Rice husk	65
	Grinded maize stem	20
	Cassava stretch	10
	Water	5
Trail 2	Rice husk	60
	Grinded maize stem	20
	Cassava stretch	10
	Water	10
Trail 3	Rice husk	60
	Grinded maize stem	25
	Cassava stretch	10
	Water	5
Trail 4	Rice husk	50
	Grinded maize stem	30
	Cassava stretch	10
	Water	10

Design and development of a solar seed dryer

Structure of a solar-assisted rice seed dryer involves several steps, from manufacturing the individual components to assembling them into a functional system. Fabrication of a PVC flexible plastic sheet solar collector for a solar rice seed dryer involves fabricating the collector and integrating it into the dryer system. The frame was made by combining PVC flexible plastic sheets. The inside of the frame was coated in dark black as a heat-absorbing material. PVC flexible plastic sheets are stretched over the frame. The edges of the PVC sheet are sealed so that no air escapes from the collector. It was painted black to absorb more

solar heat to heat the inside of the collector. The drying chamber was constructed using an MS sheet based on the design and size requirements. Proper insulation was included to reduce heat loss and maintain internal temperatures. A fan or blower was installed behind the solar collector chamber to create controlled airflow. A blower forced hot air into a grain chamber that had a height of 87 cm and a chamber diameter of 57 cm. The cylinder sieve of the drying chamber has a hole size of 3 mm, which was selected according to the size of the rice grain. Solar collector, drying chamber, air circulation system, and integrated into one interconnected unit (plate 15).



Plate 15. Complete view of the developed dryer

Evaluation of the machine

The preliminary performance test was done on the machine to identify faults in the dryer's functional

elements (Plate 16.). Conducting a performance test for a solar paddy seed dryer involves evaluating its efficiency, effectiveness, and overall functionality.



Plate 16. Performance test of the developed dryer

Variation of moisture content and temperature during the drying operation

Paddy seed moisture was started at 28.0% and it was tried to bring it down to 15%. The ambient temperature varied between 27-34.8°C. The test sample was BRRI dhan89. The initial moisture content of the test sample was recorded as more than 28%. More than 10 hours are required to reduce the moisture content from 28.0% to less than 15 % in a newly developed solar dryer (Fig. 12). It was relatively cool in the morning, and solar radiation

was building up. The solar dryer initiates the drying process, and moisture evaporation begins, resulting in a gradual decrease in humidity. By noon, solar radiation and heat from the sun intensified, causing the ambient temperature to rise. It was around 31-33 degrees Celsius depending on weather conditions and time of the year. By this time the drying process is in full swing. Ambient temperature, combined with effective solar drying, significantly reduced the moisture content of rice seeds. By noon the humidity had dropped to 24-26%. By mid-afternoon

(3.0 pm), the ambient temperature was relatively high, recording around 34.8°C. As the intensity of the sun began to decrease, it decreased slightly. The drying process continued and by 3 p.m. the moisture content of the rice seeds further decreased. At this time it was around 17-19%. As evening approaches

(6.0 p.m.), the ambient temperature begins to drop. By 6:00 PM it was around 31 degrees celsius. The solar drying process continues till 6:00 pm. During this period, the moisture content continued to rise, reaching levels below 15%.

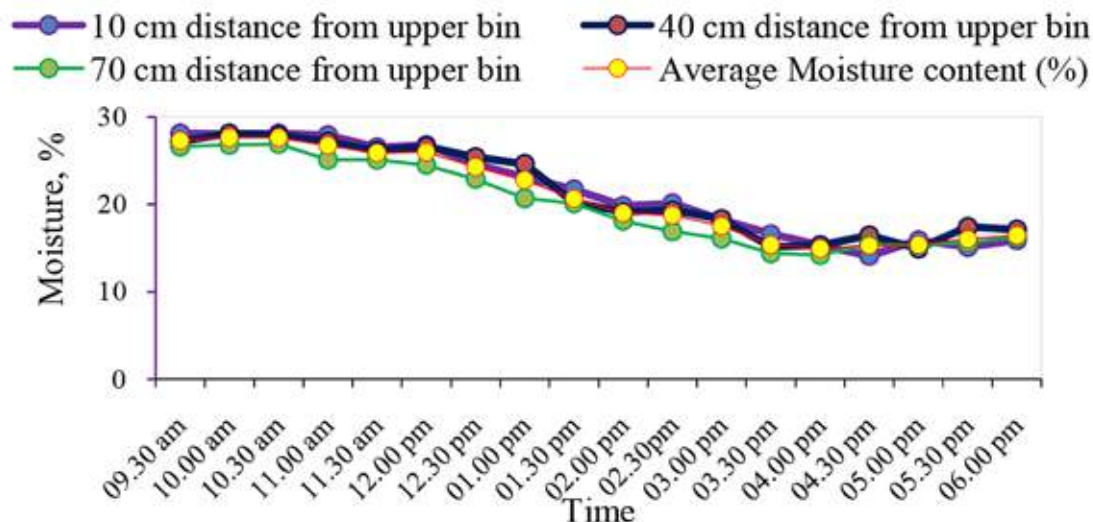


Fig. 12. Variation of moisture content with drying time.

The ambient temperature surrounding a solar paddy seed dryer can vary significantly based on several factors, including geographical location, time of day, season, weather conditions, and local climate patterns (Fig. 13). The ambient temperature directly influences

the drying process inside the solar paddy seed dryer and affects the overall efficiency of the system. The temperature range found during the operation was 27~34.8 °C. At the start of the drying operation (9:30 a.m.), the ambient temperature was 27 °C.

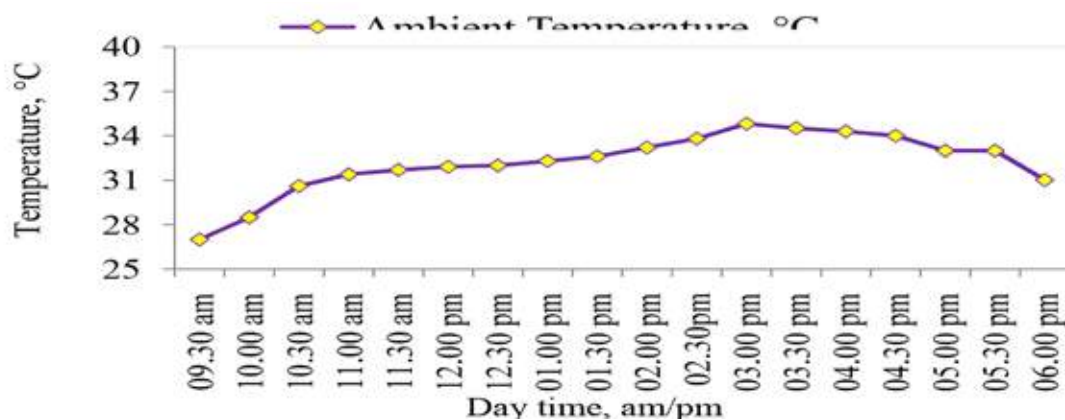


Fig. 13. Variation of temperature with daytime.

Solar-assisted dryer was developed, fabricated, and tested initially for paddy seed. The dryer, powered by a 0.5 hp single-phase electric motor, was able to dry the paddy from an initial moisture level of 28.1% to less than 15%. The dryer can be scaled up for commercial drying of paddy seed. It is advised for usage on a small scale where there is inadequate space for sun drying because it can mix up dust/inert matter or other seeds, attack birds or others, and has the potential for microbial contamination. According to the findings, the solar-assisted paddy dryer provides substantial seed drying and handling advantages. Solar-assisted paddy seed dryers provide a sustainable and environmentally friendly alternative for agricultural communities, particularly in areas with lots of sunlight. Farmers

may improve seed quality, reduce post-harvest losses, and encourage sustainable agricultural practices by efficiently drying paddy seeds with solar energy.

Solar energy utilization for small agricultural machinery

The manufacturing process for the solar panel carrier encompassed various stages, including the identified requirements and specifications. Factors such as size, weight capacity, mounting mechanism, and compatibility with diverse agricultural machinery were carefully considered. To develop the prototype, a reverse engineering approach was employed, allowing for the development of precise 3D models of the carrier (Fig. 14) after its initial design.

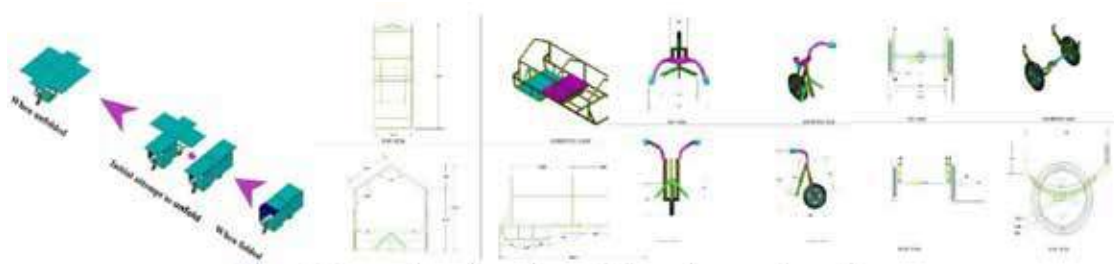


Fig. 14. Some drawing view of the solar panel carrier

Result and discussion

Solar panel array (arrangement) upon the panel carrier (model 1):

Initially, the carrier introduced a novel solar panel mounting system, incorporating five foldable panel combinations. However, this approach posed certain challenges. Unfolding the panels proved to be a labour-intensive process, demanding a significant number of personnel. Additionally, the farmers of the folders exhibited a tendency to flex slightly upon opening. The support bar beneath the folders, bearing the weight of both the panels and the folders, experienced some instability when multiple folders were simultaneously opened.

Solar panel array upon the panel carrier (model 2):

For the second time, three foldable panel combinations were included in the carrier as a solar panel mounting system instead of five foldable panel combinations. Panels were organized into three folders. Opening folders was as difficult as earlier, now with three folders, opening folders was much less difficult than before. Only now two workers are required to open the folders. Folders were no longer curved when open. As there are three folders, the support bar under the folder does not make it difficult to carry the load of the folders.

A mobile solar panel carrier for the utilization of solar energy in small agricultural machinery as well as multipurpose use has several key features to enhance its efficiency and effectiveness (Plate 17).



Plate 17. Solar-powered self-propelled mobile solar panel carrier

Technical specifications

A Self-propelled mobile solar panel carrier designed to utilize solar energy for small agricultural machinery would typically have the following technical specifications (Table 36). The initial design was completed and the experiment has been going on. The details of the findings will be presented in the next internal review.

Table 36. Features of solar panel.

Item description	Value
Rated Max Power, Pmax (Model: XH150P (36))	150Wp
Tolerance	0-3%
The voltage at Pmax (Vmp)	18. 0V
Current at Pmax (mp)	8. 34A
Open-Circuit Voltage (Voc)	22. 1V
Short-circuit Current (Isc)	9.05A
Nominal Operating Cell Temp (NOCT)	47°C ±2°C
Maximum System Voltage	1000 VDC
Maximum Series Fuse Rating	10A
Dimensions, mm	1490*660*30

PRECISION AGRICULTURE

Evaluating the effects of climate change on thermal bioclimatic indices

Data for the study were obtained from 28 meteorological stations in Bangladesh, including observed daily rainfall, maximum temperature (Tmax), and minimum temperature (Tmin) data from 1985 to 2014. Additionally, 18 CMIP6 Global Climate Models (GCMs) were used to project future climate Y276 scenarios for 2015 to 2100 under different Shared Socioeconomic Pathways (SSPs): SSP1-2.6, SSP2-4.5, and SSP5-8.5.

The study analyzed 11 Thermal Bioclimatic

Indicators (TBIs) across Bangladesh to understand their current and projected changes under different future scenarios. These indicators represent various aspects of the thermal environment and are critical for assessing the impacts of climate change on biodiversity and ecosystems. The observed station data applied the downscaling and bias-correction techniques to GCM simulations. A multi-model ensemble mean approach was used to average the results from the 18 GCMs, reducing uncertainties and providing a more comprehensive representation of the TBIs. The spatiotemporal change analysis compared the multi-model ensemble mean values of the TBIs for near future, mid-future, and far future

periods under different SSP scenarios. This analysis aims to provide insights into how these bioclimatic indicators may vary over time and across regions, helping policymakers and stakeholders develop effective climate adaptation strategies.

The study examined the projected climate changes and their impacts on Bangladesh using multiple climate scenarios (Shared Socioeconomic Pathways, SSPs) and future periods. Here are the key findings from the study:

Annual Indicators

- Mean Annual Temperature (Bio-1): Projections show an increasing trend in Bio-1 across all scenarios and future periods. The highest increases are observed in the far future under SSP585. Southeastern and central southern to southeastern regions of Bangladesh are expected to experience the most significant temperature increases.
- Diurnal Temperature Range (Bio-2): All projected periods and SSPs indicate a negative change in Bio-2, indicating a decrease in temperature variability. The most substantial

decreases are anticipated in the northern, central, southern, and southeastern parts of Bangladesh.

- Isothermality (Bio-3): The data indicate a consistent trend of decreasing isothermally percentages, indicating a more uniform annual temperature range with fewer differences between warmest and coldest months. The greatest decline in Bio-3 is projected in the eastern and southern regions of Bangladesh.
- Temperature Seasonality (Bio-4): Projections show minor fluctuations in Bio-4 values for all future periods and scenarios. The largest decline in Bio-4 is projected in the northwestern to southwestern regions of Bangladesh (Fig. 15).
- Annual Temperature Range (Bio-7): Bio-7 is expected to undergo more significant increases or decreases in the far future compared to the near or mid-future. A slight increase in Bio-7 is projected in the northeastern and southeastern regions, while a more substantial decrease is projected for the northwestern, central, and southwestern parts of Bangladesh (Fig. 16).

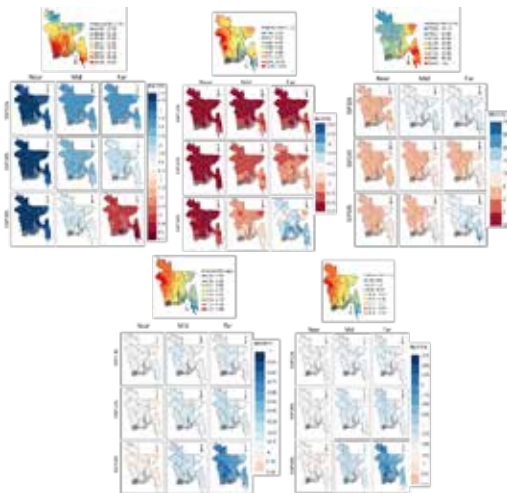


Fig. 15. Annual Indicators.

Seasonal Indicators.

- Mean Maximum and Minimum Monthly Temperature (Bio-5, Bio-6): Projections show increasing trends in both Bio-5 and Bio-6 for

all future periods and scenarios. The monthly minimum temperature (Bio-6) is projected to increase at a faster rate compared to the monthly maximum temperature (Bio-5).

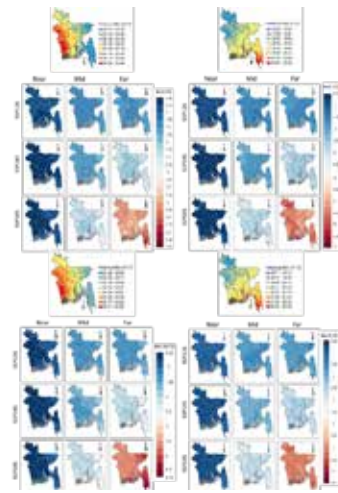


Fig. 16. Seasonal Indicators.

- Mean Temperature of Warmest and Coldest Quarters (Bio-10, Bio-11): Both Bio-10 and Bio-11 are expected to increase under all three SSPs. The temperature increase during the warmest quarter (Bio-10) is projected to be more significant than in the coldest quarter (Bio-11).

Overall, the study highlights the potential climate impacts on Bangladesh, including rising average temperatures, decreasing diurnal temperature ranges, and changes in temperature variability, which could have significant consequences for the environment and ecosystems in the region. These findings provide valuable insights for climate adaptation and mitigation strategies in Bangladesh.

Discussion

Climate-induced changes in Thermal Bioclimatic Indicators (TBIs) may profoundly affect rice cultivation in Bangladesh. Rising average annual temperature (Bio-1) could escalate irrigation needs and deplete ground water, potentially reducing rice yields. Reduced diurnal temperature range (Bio-2) has negative impacts on rice growth, posing a threat to food security and livelihoods. Decreased isothermality (Bio-3) may alter crop behavior, affecting yields and food security. Diminished temperature seasonality (Bio-4) could delay growing seasons, potentially reducing rice production. These findings underscore the urgency of climate-adaptive measures like heat-tolerant crops and sustainable irrigation practices to safeguard food security amidst climate change.

INDUSTRIAL AND FARM LEVEL EXTENSION

Training on operation, repair, and maintenance of BRRI developed farm machinery

BRRI introduced and demonstrated various

agricultural machinery and technologies to trainees, including seed sowers, combine harvesters, rice transplanters, urea applicators, weeders, reapers, threshers, and winnowers. The training covered seedling techniques, operation and maintenance of these machines, as well as hands-on repair of diesel engines. Trainees gained practical experience in field operations at the farm level, ultimately preparing them to serve as operations and entrepreneurs for sustainable mechanization in agriculture.

Mechanic training on repair, operation, and maintenance

Eighteen batches of residential training programme was conducted and in total 360 numbers of participants were trained in the programme and among them 340 were male and 20 were female. Participants of the training programme were from BRRI RS adjacent areas and from its jurisdiction district. An inaugural session was held at the 1st day of the training programme and after that a pre-evaluation of the trainees was done. Lecture and mostly practical sessions were arranged in all the locations. Step by step procedure to raise seedling in tray was shown practically to the participants (Plate 18 and 19). At the end of the training, a post-evaluation and trainee's reactions regarding the training were collected. Certificates, leaflets and a set of tools were distributed among the participants.

A three-day long programme sponsored by the "Strengthening Farm Machinery Research Activity for Mechanized Rice Cultivation project" was also held at Alim Industry Ltd., Sylhet. Ongoing day-long sessions for district farmers provide hands-on experience with BRRI machinery and other agricultural equipment. Participants actively operated machinery, gaining valuable practical experience. Post-training evaluations and feedback were collected, and participants received certificates, honorariums and a set of tools in

recognition of their successful program completion.



Plate 18. Inaugural and Closing session of the training programme.



Plate 19. Practical session of the training programme.

TECHNOLOGY TRANSFER ADAPTIVE RESEARCH DIVISION

368	Summary
368	Technology Validation
385	Technology Dissemination
389	Promotional Activities

SUMMARY

A total number of 49 advanced breeding lines were tested under 14 different categories of Advanced Lines Adaptive Research Trials (ALARTs) during the reporting period which included two rice growing seasons such as Aman and Boro. Trials were conducted at 146 farmers' fields throughout the varied agro-ecological zones of the country depending on ALART categories and representative areas. Considering the yield and yield contributing characters and farmers' choice, only 11 materials were recommended for Proposed Variety Trial (PVT). The salt tolerant genotype BR11716-4R-102 was selected for PVT during T. Aman season. Another breeding line such as BR9158-19-9-6-50-2-HR1 was recommended for submerged eco-system during the same season. The advanced line BRH13-2-4-7-2B was also recommended for PVT as Superior High Yielding Rice during this season. Two advanced lines; BR (Path)12452-BC3-42-22-11-4 and BR (Path)12452-BC6-53-21-11 were recommended as Blast and BLB resistant whereas the lines-BR12454-BC2-69-97-39-5-44 and BR12454-BC2-75-32-31-39-7 were recommended as blast resistant rice during Boro season. Two lines; BR11318-5R-63 and BR11337-5R-72 were selected for PVT from the ALART (FBR-SD). Superior high yielding lines; BRH10-1-14-2-6 & BRH13-2-4-7-2B were recommended for PVT during Boro season. A total of 400 head to head adaptive trial (HHAT) were conducted through public private partnership (PPP) during the reporting period (200 HHAT in Aman 2022 and 200 in Boro 2023) under TRB project. During Aman season, BRRI dhan87 was found as the highest yielder (6.25 t ha⁻¹) having growth duration 132 days in HHAT (Long duration). BRRI dhan88 was found as the highest yielder (6.71 t/ha) having the lowest growth duration 140 days followed by BRRI dhan74.

Seed Production and Dissemination Programmes (SPDP) were conducted by using different BRRI released recent varieties under core programme and TRB project. About 496 demonstrations were conducted in 210 upazilas of the country, from which

about 715 tons of paddy were produced and 200 tons were retained as seeds by the farmers. About 42,000 farmers gained awareness and knowledge about BRRI varieties through demonstrations, knowledge sharing, field days, field visit and interactions with farmers and extension personnel. Among them, about 18,000 farmers were motivated to adopt BRRI varieties.

ARD conducted 71 batches of farmers' training at different locations of the country, in which 2,130 trainees participated on modern rice production technologies. A total of 70 field days were arranged at different locations of the country. At BRRI farm, 4,480 kg of quality seeds of newly released BRRI varieties were produced.

TECHNOLOGY VALIDATION

Advanced Line Adaptive Research Trial (ALART)

T. Aman 2022. Superior High Yielding Rice-1 (SHR-1): Five superior high yielding rice (SHR) advanced lines i.e., BRH15-24-7B, BRH13-1-9-7B, BRH13-2-4-7-2B, BRH10-1-14-6-2B, BR10247-4-7-4B, developed by Plant Breeding Division were evaluated against the check varieties BRRI dhan57 and Jirashail in 11 different locations. Average grain yield of the three advanced lines BRH15-24-7B, BRH13-1-9-7B and BRH13-2-4-7-2B were 5.02, 5.07 and 4.99 t ha⁻¹ respectively which was identical. These three advanced lines produced significantly higher grain than both the check varieties (as a check BRRI dhan57 and Jirashail produced 4.33 and 3.91 t ha⁻¹ grain yield respectively) (Table 1). But growth duration of all the advanced lines was 4 to 6 days higher than the check varieties (Table 1). Irregularities were found both at flowering and maturity stages and uneven plant height in all the advanced lines. Uneven plant height was found in all the advanced lines. Lodging was found in all the tested entries in two locations (West Bye, BRRI Gazipur and Pirganj, Rangpur). The advanced line V3 may be considered for PVT which was with comparatively lower irregularities both at flowering and maturity stage. But this line should be uniform at flowering and maturity stage. Proposed line should also be lodging tolerant.

Table 1. Grain yield (t/ha), growth duration (days), thousand grain weight (g) and plant height (cm) of some rice genotypes under ALART (SHR-1) during T. Aman 2022.

Genotype	Location												GD Mean	TGW Mean	PHT Mean
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	Mean			
	Grain yield (t ha ¹)														
V1=BRH15-24-7B	5.27	4.19	3.96	4.98	4.78	5.94	5.11	5.65	6.33	4.46	4.57	5.02	110	16.75	108
V2=BRH13-1-9-7B	4.71	5.05	3.61	5.21	4.81	6.06	5.13	5.28	5.94	5.02	4.94	5.07	112	16.95	111
V3=BRH13-2-4-7-2B	5.84	3.9	4.04	5.35	5.17	5.98	4.81	5.37	5.75	4.29	4.37	4.99	111	16.86	111
V4=BRH10-1-14-6-2B	5.67	4.05	4.61	5.35	4.14	4.99	5.13	4.9	5.47	3.98	4.35	4.79	111	17.00	110
V5=BR10247-4-7-4B	4.03	3.11	3.64	4.95	3.3	3.35	3.7	4.58	4.17	3.99	4.14	3.91	111	17.15	107
V6=Zirashail (CK)	3.84	2.88	3.35	4.28	3.88	4.48	3.65	4.22	4.85	3.3	4.3	3.91	106	18.02	114
V 7 = B R R I dhan57(CK)	4.4	3.55	4.43	4.74	3.65	4.85	3.79	5.09	4.82	4.21	4.15	4.33	107	17.81	111
LSD0.05	0.67												0.20	0.28	1.12

L1- Satkhira (Sadar), L2- Dinajpur (Parbatipur), L3- Rangpur (Pirganj), L4- Dinajpur (Chiribandor), L-5 Gazipur (West Byde), L6- Bogura (Sadar), L7- Kushtia (Sadar), L-8 Meherpur (Gangni), L9- Rajshahi (Godagari), L10- Natore (Bagatipara), L-11 Naogaon (Mohadebpur). GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

T. Aman 2022. Superior High Yielding Rice-2 (SHR-2). Five superior high yielding advanced lines i.e., BR9392-1-9-7-5B; BR10247-14-18-4; BR9392-40-50-1B; IR12A-177 and BR10238-5-1-4-2, developed by Plant Breeding Division were evaluated against the check varieties BRRI dhan62 and BRRI dhan75. The entries were evaluated in 11 different locations of the country. Interaction of genotypes and environments had significant effect on grain yield, growth duration, plant height and yield components. Among the genotypes the highest mean grain yield (4.79 t ha⁻¹) was obtained in BRRI dhan75 (Std. ck.) followed by

IR12A-177 (4.67 t ha⁻¹), BR10238-5-1-4-2 (4.53 t ha⁻¹), BR9392-1-9-7-5B (4.25 t ha⁻¹), BR10247-14-18-4 (4.18 t ha⁻¹), BR9392-40-50-1B (3.95 t ha⁻¹) and BRRI dhan62 (ck.) (3.92 t ha⁻¹). Compared to standard checks the mean growth duration of the lines V1= BR9392-1-9-7-5B, V4= IR12A-177, V5= BR10238-5-1-4-2 were 2-9 days longer than BRRI dhan75 (ck.). The highest growth duration was observed in V4= IR12A-177 (119 days) line and the lowest was observed in BRRI dhan62 (106 days) (Table 2). Lodging incidence was observed in all the tested lines at West Bide, BRRI Gazipur and irregular flowering and maturity (mixture 5-30%) in case of V1, V3, V4, V5 lines were found in seven locations of Rangpur, Dinajpur, Kushtia, Meherpur and Satkhira. False smut was recorded in all the tested lines in several locations. Regarding other phenotypic and yield component parameters, there are no significant advantages observed in lines compared to the check varieties and not recommended for PVT.

Table 2. Grain yield (t/ha), growth duration (days), thousand grain weight (g) and plant height (cm) of some rice genotypes under ALART (SHR-2) during T. Aman 2022.

Genotype	Location											Mean	GD Mean	TGW Mean	PHT Mean
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11				
	Grain yield (t ha ⁻¹)														
BR9392-1-9-7-5B	5.25	3.46	4.76	4.10	3.96	4.22	3.73	4.50	4.51	4.25	4.05	4.25	111	23	114
BR10247-14-18-4	5.18	4.40	5.59	4.57	3.98	3.79	3.27	3.98	3.92	3.72	3.53	4.18	106	22	107
BR9392-40-50-1B	4.33	3.98	4.46	3.56	3.39	3.39	3.80	4.04	4.67	4.17	3.62	3.95	107	22	111
IR12A-177	5.36	5.07	5.78	4.97	4.05	5.04	4.02	4.10	4.62	4.24	4.15	4.67	119	25	116
BR10238-5-1-4-2	5.80	5.16	5.18	4.72	4.10	4.67	3.92	3.92	4.30	4.04	3.99	4.53	118	26	116
BRRi dhan62 (ck)	4.37	4.29	4.90	3.79	3.09	4.48	3.35	3.51	3.33	3.40	4.63	3.92	106	24	106
BRRi dhan75 (ck)	5.22	5.34	6.60	4.86	4.28	4.43	4.10	4.20	4.10	4.13	5.41	4.79	110	22	107
LSD (0.05)	0.67											0.20	0.29	0.30	1.37

L1- Meherpur (Sadar), L2- Kushtia (Sadar), L3- Rajshahi (Godagari), L4-Naogaon (Mohadebpur), L5-Natore (Bagatipara), L6- Bagura (Sadar), L7- Rangpur (Pirganj), L8- Dinajpur (Parbotipur), L9- Dinajpur (Chirirbandar), L10- Satkhira (Kolaroa), L-11 BRRi H/Q (Gazipur). GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

T. Aman 2022. ALART, Drought Tolerant Rice (DTR). Two drought tolerant advanced lines BR10538-2-1-2-32 and BR10540-4-1-2-41 along with BRRi dhan71 and BRRi dhan75 as checks were evaluated in ten locations of the country. Among all the tested genotypes, the check variety BRRi dhan71 produced statistically higher mean yield (4.78 t ha⁻¹) than both of the two advanced lines (Table 3). Interaction effect of genotypes and environments (location) was highly significant. Growth durations were not significantly varied among the entries due to environmental effect. Mean growth duration of the highest mean yielder check variety BRRi dhan71 was 111 days. On the other hand, mean growth duration of the two

advanced lines (BR10538-2-1-2-32 and BR10540-4-1-2-41) was 110 and 112 days respectively. The mean growth duration of the other check variety BRRi dhan75 was 108 days, which was 2-4 days shorter than the two advanced lines BR10538-2-1-2-32 and BR10540-4-1-2-41. Besides, the advanced lines grains were bold type compared to the check variety V4 (BRRi dhan75) and flowering was irregular. Therefore, none of the entries was recommended for PVT.

Table 3. Grain yield (t/ha), growth duration (day), thousand grain weight (g) and plant height (cm) of some rice genotypes under ALART Drought Tolerant Rice (DTR) during T. Aman 2022.

Genotype	Location											GD Mean	TGW Mean	PHT Mean
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Mean			
	Grain yield (t ha ⁻¹)													
BR10538-2-1-2-32	5.41	3.80	2.67	5.08	5.18	5.69	1.90	4.60	5.96	3.93	4.42	110	23.4	116
BR10540-4-1-2-41	5.94	4.12	2.11	5.15	4.84	5.87	1.51	4.75	6.50	4.74	4.55	112	24.1	119
BRRI dhan71 (ck)	5.85	4.20	4.09	4.95	5.30	5.98	2.43	4.66	6.18	4.18	4.78	111	23.2	122
BRRI dhan75 (ck)	4.54	4.15	2.80	4.92	5.15	5.65	2.51	4.35	5.94	4.32	4.43	108	21.1	106
LSD (0.05)	0.77											0.24	0.38	1.74

L1- Rangpur (Taraganj), L2- Rangpur (Pirganj), L3- Gazipur (WB), L4- Bogura (Sadar), L5- Kushita (Sadar), L6- Meherpur (Gangni), L7- Cumilla (Debiddar), L8- Naogaon (Mohadevpur), L9- Rajshahi (Godagari), L10- Chapainababganj (Nachole). GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

T. Aman 2022. ALART, Premium Quality Rice (PQR). Two advanced rice genotypes having premium qualities were evaluated in different locations of the country along with the two check varieties. The highest mean grain yield (4.44 t ha⁻¹) was obtained in the advanced genotype BR8493-3-5-1-P1 which was statically higher than both the check variety BRRI dhan34 (2.98 t ha⁻¹) and

BRRI dan70 (3.84 t ha⁻¹) and the lowest (2.98 t ha⁻¹) was in BRRI dhan34. The highest plant height was observed in case of BRRI dhan34 (135 cm). Both the tested entries were significantly shorter than the check variety BRRI dhan34 and also than BRRI dhan70. The tested entries had less lodging tendency due to shorter plant height. Thousand-grain weight of both the tested entries was significantly higher than BRRI dhan34. It indicated that grain size and shape of the tested genotypes were not superior to the check variety BRRI dhan34. The phenotypic acceptance of both the entries V1 and V2 was very poor with semi droopy and curled leaves. None of the advanced lines were found for recommendation as PVT.

Table 4. Grain yield (t/ha), growth duration (days), thousand grain weight (g) and plant height (cm) of some rice genotypes under ALART premium quality rice (PQR) during T. Aman 2022.

Genotype	Location								GD Mean	TGW Mean	PHT Mean
	L1	L2	L3	L4	L5	L6	L7	Mean			
	Grain yield (t ha ⁻¹)										
V1= BR8493-3-5-1-P1	4.68	4.46	5.17	5.37	2.90	4.15	4.38	4.44	134	17.70	119
V2= BR9590-45-1-3-2-P2	3.66	5.02	5.02	3.08	4.45	2.93	2.68	3.84	135	19.41	111
V3= BRRI dhan34	3.77	4.29	3.39	1.97	2.69	2.49	2.24	2.98	142	14.77	135
V4= BRRI dhan70	4.24	3.98	4.32	4.42	3.23	4.31	4.38	4.12	126	21.01	130
LSD (0.05)	0.62							0.51	0.24	0.31	1.58

L1- Kushtia (Sadar), L2- Naogaon (Mohadebpur), L3- Rangpur (Parbotipur), L4- Bogura (Sadar), L5- Feni (Sonagazi), L6- Faridpur (Bhanga), L7- Satkhira (Kolaroa). GD: Growth duration (day); TGW: Thousand Grain Weight (g); PHT: Plant height (cm).

T. Aman 2022. ALART, Salt Tolerant Rice (STR):

Three salt tolerant advanced lines: BR11712-4R-218, BR11716-4R-102, BR11723-4R-172 along with BRRI dhan73 (Tol. ck) and BRRI dhan87 (Sus. ck) were evaluated in ten locations. The highest salinity was measured in Satkhira district among the selected locations. Among the genotypes, the highest mean grain yield (4.71 t ha⁻¹)

¹) was obtained in BR11716-4R-102 followed by BR11712-4R-218 (4.47 t ha⁻¹), BR11723-4R-172 (4.32 t ha⁻¹), BRRI dhan87 (4.24 t ha⁻¹) and BRRI dhan73 (3.66 t ha⁻¹). The growth duration of the line BR11716-4R-102 (121 days) was one day earlier than BRRI dhan73 (122 days) and six days earlier than BRRI dhan87 (Table 5). There was significant difference observed in plant height and its range was about 103 cm to 127 cm, 1000-grain weight of tested line BR11723-4R-172 (24.58 gm) was the highest and the lowest was found in tested line BRRI dhan73 (21.60 gm) (Table 5). The advanced BR11716-4R-102 could be recommended for PVT if the irregularity of flowering and maturity can be corrected by any means.

Table 5. Grain yield (t/ha), growth duration (day), thousand grain weight (g) and plant height (cm) of rice genotypes of ALART Salt Tolerant Rice (STR). in T. Aman 2022.

Genotype	Location								GD Mean	TGW Mean	PHT Mean
	L1	L2	L3	L4	L5	L6	L7	Mean			
	Grain yield (t ha ⁻¹)										
V1= BR11712-4R-218	4.05	4.34	4.47	4.57	6.03	4.91	2.89	4.47	120	24.45	104
V2=BR11716-4R-102	4.29	4.42	4.27	4.90	6.52	5.30	3.30	4.71	121	24.21	103
V3=BR11723-4R-172	3.64	4.34	4.37	4.47	5.86	5.11	2.43	4.32	122	24.58	103
V4=BRRI dhan73	1.51	4.08	3.93	4.00	4.82	4.44	2.81	3.66	122	21.60	127
V5=BRRI dhan87	4.17	4.08	4.00	4.43	5.44	5.00	2.58	4.24	127	23.03	118
LSD (0.05)	0.44							0.32	0.58	1.00	3.43

L1- Gazipur (WB), L2- Satkhira (Kaliganj), L3- Satkhira (Debhata), L4- Bagerhat (Sadar), L5- Feni (Sonagazi), L6- Noakhali (Companiganj), L7- Kalapara (Patuakhali). GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

T. Aman 2022. Re- ALART, Long Duration

Submergence Tolerant Rice. Two advanced lines; BR9158-19-9-6-50-2-HR1 and IR13F441 along with BRRI dhan44 (Sus. Ck.) and BRRI dhan52 (Tol. ck.) as checks were tested at farmers' field in 10 representative locations of the country. Irrespective of genotypes and locations, both the advanced lines (BR9158-19-9-6-50-2-HR1 and IR13F441) produced almost similar higher yields (4.89 t ha⁻¹ & 4.92 t ha⁻¹ respectively) than the two check varieties BRRI dhan44 (4.31 t ha⁻¹) and BRRI dhan52 (4.49 t ha⁻¹) (Table 6). Mean growth

duration over 10 locations of the advanced line BR9158-19-9-6-50-2-HR1 (entry no. 1) was 147 days which was higher than the check variety BRRI dhan52 (143 days) and BRRI dhan44 (146 days) (Table 6). The tallest plant height was 159 cm found in the entry no.1 in Gazipur. However, the mean shortest plant height was found in the check variety BRRI dhan52 and in advanced line IR13F441 (117 cm). The mean highest 1000-grain weight (29.47 g) was found in entry no.1 followed by BRRI dhan44 (28.14 g), BRRI dhan52 (27.04 g). Although Both of the advanced line produced higher yields than the check varieties but farmers like the advanced line BR9158-19-9-6-50-2-HR1 due to higher plant height, bold grain which is preferred by the people of Barishal region and also less susceptible to disease and insect. Therefore, BR9158-19-9-6-50-2-HR1 was recommended for PVT.

Table 6. Grain yield (t/ha), growth duration (days), thousand grain weight (g) and plant height (cm) of some rice genotypes under Re- ALART (Sub. Tol.) during T. Aman 2022.

Genotype	Location										GD Mean	TGW Mean	PHT Mean
	L1	L2	L3	L4	L5	L6	L7	L8	L9	Mean			
	Grain yield (t ha ⁻¹)												
V1= BR9158-19-9-6-50-2-HR1	4.91	3.91	4.54	4.75	5.03	5.43	5.35	5.03	5.04	4.89	147	29.47	128
V2= IR13F441	4.62	4.34	4.38	5.51	5.58	5.71	4.07	4.86	5.20	4.92	149	21.44	117
V3= BRRI dhan44 (Sus. ck)	4.01	3.29	3.99	4.90	5.10	4.95	3.73	4.26	4.61	4.31	146	28.14	121
V4= BRRI dhan52 (Tol. ck)	4.21	3.39	4.10	5.12	5.25	5.08	4.58	4.34	4.36	4.49	143	27.09	117
LSD (0.05)	0.67									0.22	0.19	0.95	1.50

L1- Barishal Sadar (Dhopakathi), L2- Barishal Sadar (Dinar), L3- Borguna (Amtoli), L4- Chattogram (Mirsarai), L5- Chattogram (Rangunia), L6- Gazipur (WB) L7- Gopalganj, L8- Jhalakathi (Nalch.iti), L9- Patuakhali (Kolapara). GD: Growth duration ; TGW: Thousand grain weight ; PHT: Plant height.

B. Aman 2022. ALART, Deep Water Rice (DWR). Six advanced breeding lines for deep flooded condition such as BR10230-7-19-2B, BR9892-6-2-2B, BR9376-6-2-2B, BR9392-6-2-1B, BR-KM(Mun)-PL-5-7-3-B and BR-DL(Hbj)-PL-12-4-7-B with Fulkori (local ck.) as checks were tested in seven different locations. All the advanced lines and check varieties were damaged and were not suitable for data collection in two locations;

Cumilla and Habiganj. No flood was occurred in Manikganj. Yield of all the advanced lines was significantly higher than the check variety Fulkori (2.02 t ha⁻¹). Among the advanced lines entry no. 1 and 4 yielded grains over 3.0 tons (3.06 and 3.0 t ha⁻¹ respectively). Other advanced lines BR9892-6-2-2B, BR9376-6-6-2B and BR-KM (Mun)-PL-5-7-3-B also produced statistically significant higher yield (2.49, 2.52 and 2.28 t ha⁻¹ respectively). Mean growth duration of BR-DL (Hbj)-PL-12-4-7-B and Fulkori (ck) was 173 days which was late by one week than the all other advanced lines. However, irregularity was reported in all the lines at Sirajganj and Gazipur trials. Therefore, farmers did not show interest on those advanced lines. These lines may be recommended for Re-ALART in more representative areas.

Table 7. Grain yield (t/ha), growth duration (day), thousand grain weight (g) and plant height (cm) of some rice genotypes under ALART (Deep Water Rice- DWR) during B. Aman 2022.

Genotype	Location					GD Mean	TGW Mean	PHT Mean
	L1	L2	L3	L4	Mean			
	Grain yield (t ha ⁻¹)							
V1= BR10230-7-19-2B	4.09	3.50	2.06	2.58	3.06	168	24.56	181
V2= BR9892-6-2-2B	3.64	2.80	1.14	2.35	2.49	166	22.06	182
V3= BR9376-6-6-2B	3.59	3.10	1.12	2.30	2.52	166	21.00	163
V4= BR9392-6-2-1B	4.31	3.10	1.67	2.99	3.00	168	23.41	168
V5= BR-KM (Mun)-PL-5-7-3-B	2.82	2.60	1.59	2.13	2.28	166	22.81	214
V6= BR-DL (Hbj)-PL-12-4-7-B	2.22	2.40	1.54	1.89	2.01	173	22.09	215
V7= Fulkori (ck)	1.82	2.70	1.86	1.77	2.02	173	22.79	180
LSD (0.05)	0.46				0.21	0.45	0.64	14

L1- Faridpur (Bhanga), L2-Gopalganj (sadar), L3- Sirajganj (Shahjadpur) and L4- Gazipur (BRRI-Shibbari Deep water tank). GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

Boro 2023. ALART (FBR-MD). Two advanced breeding lines IR12A173 and IR17A1694 which were suitable for favourable Boro rice growing eco-system having medium growth duration along with BRRI dhan58 and BRRI dhan96 as checks were tested at 12 locations under irrigated rice eco-system. Among all the locations, the check variety BRRI dhan58 produced the highest grain yield (8.98 t/ha) at Singra upazila of Rajshahi whereas the tested entry IR12A173 produced 7.36 t ha⁻¹ at the same location. The mean grain yield of the tested entry IR12A173 (6.72 t ha⁻¹) was not significantly

higher than the check variety BRRI dhan58 (6.73 t ha⁻¹) nor BRRI dhan96 (6.73 t ha⁻¹). The mean grain yield of the tested entry IR17A1694 produced significantly lower yield (6.45 t/ha) than both of the check varieties BRRI dhan58 (6.73 t/ha) and BRRI dhan96 (6.73 t ha⁻¹). BRRI dhan96 was found eight days earlier than the tested entry IR12A173 and five days earlier than the entry IR17A1694 at Kushtia. In Barishal, both of the tested entries showed significantly higher growth duration (139 days and 137 days) than the check variety BRRI dhan96 (134 days). Similar results were found at Cumilla, Rajshahi, Sirajganj, Rangpur, Habiganj, Feni and Gopalganj. Considering the above factors and other phenotypic acceptance, insect and disease reactions, none of the tested entries were found suitable for PVT.

Table 8. Grain yield (t/ha), growth duration (day), thousand grain weight (g) and plant height (cm) of some rice genotypes under ALART (FBR-MD) during Boro 2023.

Genotyp	Location													GD	TGW	PHT	
	Grain yield (t/ha)													Mean	Mean	Mean	
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	Mean				
IR12A173	5.74	5.12	7.36	7.20	5.90	7.89	7.35	6.20	8.38	7.90	6.11	5.44	6.72	147	24.26	102	
IR17A1694	5.40	5.38	8.07	6.66	5.20	6.35	6.82	6.43	7.69	6.87	5.83	6.56	6.45	147	25.02	96	
BRRI dhan58	5.97	4.95	8.98	8.14	5.72	6.10	6.08	6.08	8.77	7.65	5.26	7.11	6.73	148	23.73	98	
BRRI dhan96	6.08	4.89	8.03	7.93	5.99	8.85	6.93	6.14	7.69	6.89	5.60	5.69	6.73	143	20.15	91	
LSD _{0.05}	0.82													0.23	0.34	0.75	2.26

L1- Kushtia, L2- Cumilla, L3- Rajshahi, L4- Sirajganj, L5- Rangpur, L6- Barishal, L7- Habiganj, L8- Feni, L9- Faridpur, L10- Gopalganj, L11- Manikganj, L12- BRRI, Gazipur. GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

Boro 2023. ALART (Blast Resistant Rice-BRR). Four blast resistant advanced lines were evaluated against the check varieties BRRI dhan29 (Std. and Sus. ck.) and BRRI dhan89 (Std. and Sus. ck.) in 10 different locations of the country. The trial site of Cumilla (Devider) was severely damaged by brown plant hopper and results of this location was treated as experimental out layer and was not included in statistical analysis. Average grain yield of the four BRR advanced lines BR12454-BC2-56-81-27-3-30, BR12454-BC2-69-97-39-5-44, BR12454-BC2-71-91-6-23-26

and BR12454-BC2-75-32-31-39-7 was 7.25, 7.38, 7.52 and 7.48 t ha⁻¹ respectively (Table 9) which was statistically similar. But, these four advanced lines didn't produced significantly higher grain than both the check varieties. Growth duration of entry no.1, 2, 3 and the check variety BRRI dhan29 was same which is 157 days and on the other hand growth duration of entry no.4 and the check variety was 156 days (Table 1). The lowest thousand grain weight was observed in the entry no.2 (20.13 g). and that was the highest in the check variety BRRI dhan89 (23.45 g). More lodging tolerance was observed in V2=BR12454-BC2-69-97-39-5-44 and V4=BR12454-BC2-75-32-31-39-7 than the other entries. Uniformity of flowering and maturity were observed in the entries of V2=BR12454-BC2-69-97-39-5-44 and V4=BR12454-BC2-75-32-31-39-7. Blast resistant Pi9 gene is present both the V2=BR12454-BC2-69-97-39-5-44

and V4=BR12454-BC2-75-32-31-39-7. In addition, blast resistant Pb1 gene is present in V4=BR12454-BC2-75-32-31-39-7 entry. Beside, both the entries have tungro virus resistant gene. Therefore, the

entry no. 2 i.e., BR12454-BC2-69-97-39-5-44 and entry no.4 i.e., BR12454-BC2-75-32-31-39-7 were recommended for PVT.

Table 9. Grain yield (t/ha), Growth duration (day), thousand grain weight (g) and plant height (cm) of some genotypes under ALART- Blast Resistant Rice (BRR) during Boro 2023.

Genotype	Location										GD Mean	TGW Mean	PHT
	L1	L2	L3	L4	L5	L6	L7	L8	L9	Mean			
	Grain yield (t ha ⁻¹)												
V1=BR12454-BC2-56-81-27-3-30	6.69	6.10	8.51	7.35	8.33	6.32	6.43	6.30	9.22	7.25	157	22.43	108
V2=BR12454-BC2-69-97-39-5-44	6.67	6.58	7.56	8.05	8.09	8.48	6.01	6.32	8.70	7.38	157	20.13	101
V3=BR12454-BC2-71-91-6-23-26	6.23	6.68	8.11	8.05	8.08	7.46	6.98	6.50	9.55	7.52	157	21.98	106
V4=BR12454-BC2-75-32-31-39-7	6.85	6.98	7.36	7.39	8.04	7.69	6.25	7.81	8.98	7.48	156	22.29	110
V5=BRR1 dhan29 (Std. & Sus. Ck)	6.78	6.88	6.66	7.73	7.20	7.81	6.86	7.55	7.81	7.25	157	21.54	99
V6=BRR1 dhan89 (Std. & Sus. Ck)	6.66	7.23	6.80	6.75	6.77	7.92	6.63	6.31	8.10	7.02	156	23.45	103
LSD _{0.05}	0.30									0.89	0.65	1.24	4.25

L1- Gazipur (West Byde), L2- Habiganj (Baniachong), L3-Lalmonirhat (Sadar), L4-Rangpur (Sadar), L5-Jashore (Keshobpur), L6-Barishal (Sadar), L7- Bogura (Sadar), L8-Faridpur (Nagarkanda), L0- Rajshahi (Paba). GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

Boro 2023 ALART (SHR-1). Three superior high yielding advanced breeding lines developed by Plant Breeding Division were evaluated against the check varieties BRR1 dhan81 during Boro 2023. Among the genotypes the highest mean grain yield (6.78 t ha⁻¹) was obtained in BRH10-1-14-2-6 followed by BRH13-2-4-7-2B (6.75 t ha⁻¹), BRH15-24-7B (6.10 t/ha), and BRR1 dhan81 (ck.) (5.31 t ha⁻¹). Compared to standard check BRR1 dhan81 (ck.) the mean growth duration of the lines BRH10-1-14-2-

6; BRH13-2-4-7-2B and BRH15-24-7B were 2-4 days longer (Table 10). The highest growth duration was observed in V3= BRH15-24-7B (148 days) line and the lowest was observed in standard check BRR1 dhan81 (144 days). The highest plant height was 92 cm was found in the V1=BRH10-1-14-2-6; V2=BRH13-2-4-7-2B and V4= BRR1 dhan81 (ck.) followed by the advanced line V3=BRH15-24-7B (86 cm). The lowest 1000 grain weight of the tested lines was found in V2=BRH13-2-4-7-2B (18.44 gm), and V3=BRH15-24-7B (19.07 gm) and the highest TGW was found in BRR1 dhan81 (20.98 gm). Considering yield, yield contributing characters, growth duration, disease reactions and phenotypic acceptance, V1= BRH10-1-14-2-6 and V2= BRH13-2-4-7-2B may be recommended for PVT after confirmation of uniform maturity.

Table 10. Grain yield (t/ha), growth duration (day), thousand grain weight (g) and Plant height (cm) of some rice genotypes under ALART (SHR-1) during Boro 2023.

Genotype	Location											GD	TGW	PHT
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Mean			
Grain yield (t ha ⁻¹)														
V1=BRH10-1-14-2-6	5.39	6.57	6.38	7.63	7.43	6.03	5.66	8.01	8.01	6.67	6.78	146	19.14	92
V2=BRH13-2-4-7-2B	5.72	6.56	6.34	7.77	7.62	4.78	5.85	7.95	8.41	6.49	6.75	147	18.44	92
V3= BRH15-24-7B	5.63	5.89	5.55	6.78	6.83	4.8	4.92	6.93	7.55	6.09	6.10	148	19.07	86
V4= BRR1 dhan81 (ck)	5.24	4.23	5.67	6.56	7.09	1.94	3.35	5.43	6.60	6.98	5.31	144	20.98	92
LSD _{0.05}	0.80										0.25	0.26	0.67	1.30

L1- Sherpur (Bogura), L2- Kushtia Sadar, L3- Meherpur, L4- Sharsha (Jessore), L5- Paba (Rajshahi), L6- Baniachang (Habiganj), L7- Sadar (Cumilla), L8- Sadar (Rangpur), L9- Mithapukur (Rangpur) and L10- BRRI HQ Gazipur. GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

Boro 2023, ALART (FBR-SD). Four advanced lines, V1= BR11318-5R-63, V2= BR11337-5R-72, V3= SVIN109 and V4= IR17A1723 supplied from Plant Breeding Division were tested along with the check varieties V5= BRRI dhan81 and V6= BRRI

dhan96 in 12 different locations of the country. However, data from Cumilla were discarded from the analysis due to severe rate damage. Among the genotypes V1= BR11318-5R-63, V2= BR11337-5R-72, V3= SVIN109 produced significantly higher yield than both of the check varieties (Table 11). The growth duration of these three lines was five days longer than the checks. However, some mixture was observed in V3 and V4. Less disease and insect infestation was recorded in all the locations for all the tested lines. Considering all the facts, genotypes V1= BR11318-5R-63, V2= BR11337-5R-72 were recommended for PVT.

Table 11. Grain yield (t/ha), growth duration (day), thousand grain weight (g) and Plant height (cm) of some rice genotypes under ALART (FBR-SD) during Boro 2023.

Genotype	Location												GD	TGW	PHT
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	Mean			
	Grain yield (t ha ⁻¹)														
V1=BR11318-5R-63	6.59	8.17	8.52	6.09	9.31	8.35	6.09	6.32	6.13	7.25	8.33	7.30	144	22.93	110
V2=BR11337-5R-72	5.87	7.81	8.75	6.42	9.49	8.39	6.42	6.28	7.31	6.36	7.05	7.21	145	21.38	103
V3=SVIN109	6.01	7.75	8.22	6.54	8.50	8.64	6.54	6.36	6.48	7.58	8.61	7.25	144	23.48	105
V4=IR17A1723	5.35	6.92	6.21	6.62	7.43	7.61	6.62	5.57	6.00	4.62	8.40	6.21	139	22.89	97
V5=BRRI dhan81 (CK)	5.83	7.14	7.79	6.43	7.23	7.42	6.43	4.46	3.77	5.28	7.60	5.98	140	22.10	96
V6=BRRI dhan96 (CK)	5.08	7.20	7.83	6.48	7.79	9.04	6.48	6.49	6.87	5.81	7.08	6.79	140	20.29	93
LSD _{0.05}	0.92												0.28	1.00	1

L1: Rangpur, L2: Gopalganj, L3: Faridpur, L4: Barishal, L5: Natore, L6: Sirajganj, L7: Feni, L8: Kushtia, L9: Habiganj, L10: Manikganj, L11: Gazipur. GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

Boro 2023. Blast Resistance Rice (BRR, Re-ALART). Four blast resistant high yielding rice advanced lines such as BR (Path)12452-BC3-42-22-11-4, BR (Path)12452-BC6-53-21-11, BR (Path)13784-B C3-61--1-6-HR3 and BR (Path)13784-BC3-63-6-4-HR6 supplied by Plant Pathology Division were evaluated along with the check varieties BRRI dhan28 and BRRI dhan88. The entries were evaluated in ten different locations of the country. The trials were replicated thrice

in each location. Interaction of genotypes and environments had significant effect on grain yield, growth duration, plant height and yield components. Among the genotypes the highest mean grain yield (7.0 t ha⁻¹) was obtained in BR (Path)13784-BC3-63-6-4-HR6 and BR (Path)12452-BC6-53-21-11 followed by BR (Path)12452-BC3-42-22-11-4 (6.8 t ha⁻¹) and BR (Path)13784-BC3-61--1-6-HR3 (6.5 t/ha) (Table 12). Two standard check BRRI dhan28 and BRRI dhan88 produced 5.4 t/ha and 6.9 t ha⁻¹ respectively. Considering blast disease resistance, yield, growth duration, disease reactions and phenotypic acceptance, V1= BR (Path)12452-BC3-42-22-11-4 and V2= BR (Path)12452-BC6-53-21-11 may be recommended for PVT.

Table 12. Grain yield (t ha⁻¹), growth duration (day), thousand grain weight (TGW) and Plant height (cm) of some rice genotypes under Re-ALART (BRR) during Boro 2023.

Genotype	Location											GD	TGW	PHT
	L ₁	L ₂	L ₃	L ₄	L ₅	L ₆	L ₇	L ₈	L ₉	L ₁₀	Mean			
	Grain yield (t ha ⁻¹)													
BR(Path)12452-BC3-42-22-11-4	7.20	6.30	5.70	7.20	8.00	6.70	7.50	6.00	4.70	8.40	6.80	141	22.9	109
BR(Path)12452-BC6-53-21-11	7.70	7.40	6.90	7.50	7.40	6.70	8.00	5.90	5.00	7.80	7.00	143	22.7	111
BR(Path)13784-BC3-61--1-6-HR3	7.60	5.80	6.90	6.20	7.50	6.90	4.70	6.00	5.90	6.90	6.50	141	22.4	99
BR(Path)13784-BC3-63-6-4-HR6	7.50	7.10	7.10	7.30	5.60	6.50	7.70	7.50	5.90	8.00	7.00	141	24.5	96
BRR1 dhan28 (ck)	6.30	5.80	6.00	5.00	6.40	6.70	3.30	5.70	3.30	5.30	5.40	140	22.8	104
BRR1 dhan88 (ck)	6.90	6.70	6.50	7.00	7.50	6.50	8.00	6.00	6.80	7.20	6.90	142	21.9	90
LSD _{0.05}	0.90											0.29	0.62	5.04

L₁=BRR1 H/Q, L₂= Debiddar, Cumilla L₃= Bogura, Sadar L₄= Kesobpur, Jessore L₅= Nagarkanda, Faridpur L₆= Paba, Rajshahi L₇= Baniachang, Habiganj L₈= Mithapukur, Rangpur L₉= Mithamoin, Kishoreganj L₁₀= Sadar, Barishal. GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

Boro 2023. ALART (SHR-2). Three superior high yielding rice (SHR-2) advanced lines i.e., BRH11-2-4-7B, BRH13-2-4-2-1B and BRH238-5-1-4-2, developed by Plant Breeding Division were evaluated against the check varieties BRR1 dhan81. The entries were evaluated in ten different locations of the country. Among the genotypes BRH11-2-4-7B, BRH238-5-1-4-2 and BRR1 dhan81 produced almost similar yield but the yield of BRH11-2-4-7B is statistically higher than the others. The highest mean grain yield (6.35 t ha⁻¹) was obtained from

BRH13-2-4-2-1B followed by BRH238-5-1-4-2 (6.04 t ha⁻¹), BRH11-2-4-7B (6.03 t ha⁻¹), and BRR1 dhan88 (ck.) (5.88 t ha⁻¹). Compared to standard checks the mean growth duration of all the advanced lines were longer. The highest growth duration was observed in V2= BRH13-2-4-2-1B (152 days) line and the lowest was observed in BRR1 dhan88 (145 days) (Table 13). The highest mean plant height was 108 cm found in the V2= BRH13-2-4-2-1B (108cm) followed by the advanced line V3 = BRH238-5-1-4-2 (97 cm), V1 = BRH11-2-4-7B (96 cm) and V4=BRR1 dhan88 (Ck.) (90 cm). The lowest TGW of the tested lines was found in V1 = BRH11-2-4-7B (21.6 g) followed by V4=BRR1 dhan88 (22g) and the highest TGW was found in V3 = BRH238-5-1-4-2 (23.4g). Considering the above factors and other phenotypic acceptance, insect and disease reactions, none of the tested entries were found suitable for PVT.

Table 13. Grain yield (t/ha), growth duration (day), thousand grain weight (g) and plant height (cm) of some genotypes under ALART (SHR-2) during Boro 2023.

Genotype	Location											GD	TGW	PHT
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Mean			
	Grain yield (t ha ⁻¹)													
V1 = BRH11-2-4-7B	6.57	4.71	5.98	5.46	5.71	5.48	6.80	7.30	5.39	6.91	6.03	146	21.60	96
V2 = BRH13-2-4-2-1B	5.66	3.69	5.96	5.72	6.20	6.25	8.25	8.05	7.31	6.40	6.35	152	22.10	108
V3 = BRH238-5-1-4-2	7.52	4.48	5.46	4.87	5.81	5.76	6.34	7.88	5.42	6.90	6.04	147	23.40	97
V4=BRR1 dhan88 (Ck)	6.28	3.50	4.32	6.18	6.28	5.54	7.50	8.14	5.67	5.42	5.88	145	22.00	90
LSD _{0.05}	0.61											0.63	1.30	6.05

L1- Bogura, L2- Cumilla (sadar), L3- Gazipur (brrr wb), L4- Habiganj (baniachang), L5- Kushtia (meherpur), L6- Kushtia (Sadar), L7- Rajshahi (Paba), L8- Rangpur (mithapukur), L9- Rangpur (Sadar), L10- Satkhira (Sadar). GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

Boro 2023. Re-ALART (FBR-Barishal). Four advanced lines along with one check were evaluated in 12 different locations. Irrespective of locations, the advanced line V1= BRBa 1-4-9 produced the mean grain yield (7.71 t ha⁻¹) t ha⁻¹ which was similar to the check variety BRRI dhan89 and the advanced line V2=BRBa14-NGR414-1, V3=BRBa 3-1-7 and V4= BRBa40-NGR1255-1 produced the mean grain yield 7.52 t ha⁻¹, 7.57 t ha⁻¹ and 7.24 t ha⁻¹ respectively which were similar to the check variety BRRI dhan89. The check variety BRRI

dhan58 produced the lowest mean yield (6.37 t ha⁻¹) among all the four advanced lines and check variety BRRI dhan89. The highest grain yield (7.71 t ha⁻¹) was produced by the advanced line V1= BRBa 1-4-9 followed by V3=BRBa 3-1-7 7.57, V2=BRBa14-NGR414-17.52, and BRRI dhan89 (7.50 t ha⁻¹) and the lowest mean grain yield was produced by BRRI dhan58 (ck) (6.37 t ha⁻¹). Mean growth duration of the advanced line V1=BRBa 1-4-9 (entry no. 1) was 154 days which was one day higher than the check variety BRRI dhan89 (153 days) but lower than another check variety BRRI dhan58. Mean growth duration of tolerant check variety BRRI dhan89 was almost similar to the tested genotypes ranged from (150-154 days). There were no significant difference between check variety and advanced lines. So, none of the tested lines was found suitable for PVT.

Table 14. Grain yield (t/ha), growth duration (day), thousand grain weight (g) and Plant height (cm) of some rice genotypes under Re-ALART (FBR-Barishal) during Boro 2023.

Genotype	Location													GD	TGW	PHT	
	Grain yield (t/ha)																
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	Mean				
V1=BRBa 1-4-9	7.73	7.89	8.08	8.35	6.53	9.15	8.10	6.44	7.00	8.24	8.16	6.90	7.71	154	24.27	110	
V2=BRBa 14-NGR414-1	8.38	6.45	6.95	7.79	6.56	9.74	8.53	6.32	6.54	8.16	8.04	6.72	7.52	153	21.01	101	
V3= BRBa 3-1-7	8.11	8.07	8.07	6.87	7.34	9.00	8.19	5.79	7.17	8.00	7.61	6.58	7.57	152	22.72	94	
V4=BRBa 40-NGR1255-1	8.02	6.90	7.73	7.96	7.26	9.17	7.85	3.18	6.80	8.04	7.51	6.47	7.24	152	23.57	106	
V5= BRRI dhan58 (ck)	5.98	6.90	6.27	5.33	6.05	8.79	8.63	2.43	6.83	7.06	5.51	6.61	6.37	150	22.70	100	
V6= BRRI dhan89 (ck)	7.61	7.70	7.47	7.21	6.66	9.15	8.56	5.35	6.97	8.44	7.33	7.52	7.50	153	22.90	105	
LSD _{0.05}	0.95													0.27	0.16	2.75	2.24

L1- BRRI, Gazipur, L2- Gopalganj, L3- Faridpur, L4- Barishal, L5- Rangpur, L6- Natore, L7- Sirajganj, L8- Cumilla, L9- Kushtia, L10- Habiganj, L11- Mymensingh, L12- Feni GD: Growth duration (day); TGW: Thousand grain weight (g); PHT: Plant height (cm).

Head to Head Adaptive Trial (HHAT) during T. Aman 2022. A total of 200 HHAT with eight

categories depending on rice growing eco-system were conducted throughout the country under TRB project. The trials were categorized in eight different such as long duration (LD) rice varieties (Swarna - Growing areas), LD (Dinajpur areas), LD (Rangpur areas), LD (Mymensingh areas), Short growth duration rice varieties Coastal Ecosystem (CE), Flash Flood Submergence (FFS) and Tidal Submergence (TS).

Grain yield, growth durations and the overall performance of tested rice varieties under different categories of HHAT varied significantly at different locations. In HHAT (LD-Swarna), BRRI dhan87 was found as the highest yielder (5.61 t/ha) having growth duration 127 days (Fig. 1). Whereas Local Swarna produced the lowest yield (4.94 t/ha). BRRI dhan93, BRRI dhan94 and BRRI dhan95 produced statistically similar yield with similar growth duration.

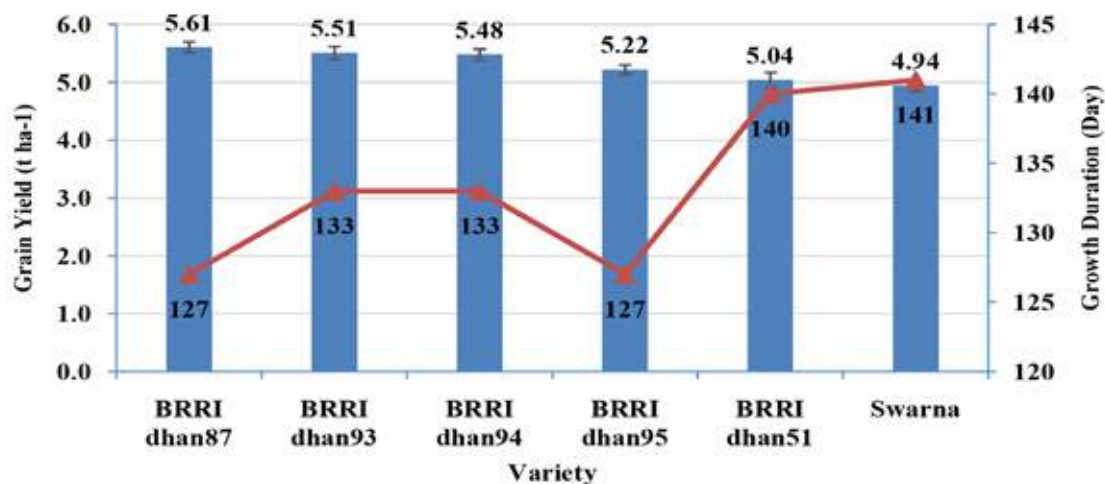


Fig. 1. Average grain yield and growth duration of the tested rice varieties in HHAT (LD-Swarna).

In HHAT (LD-Dinajpur), BRRI dhan80 was found as the highest yielder (4.63 t ha⁻¹) having growth duration 133 days followed by BRRI dhan70 (4.63 t ha⁻¹) (Fig. 2). Whereas, Kataribhog produced the lowest yield (3.49 t ha⁻¹) followed by BRRI dhan34 (3.87 t ha⁻¹).

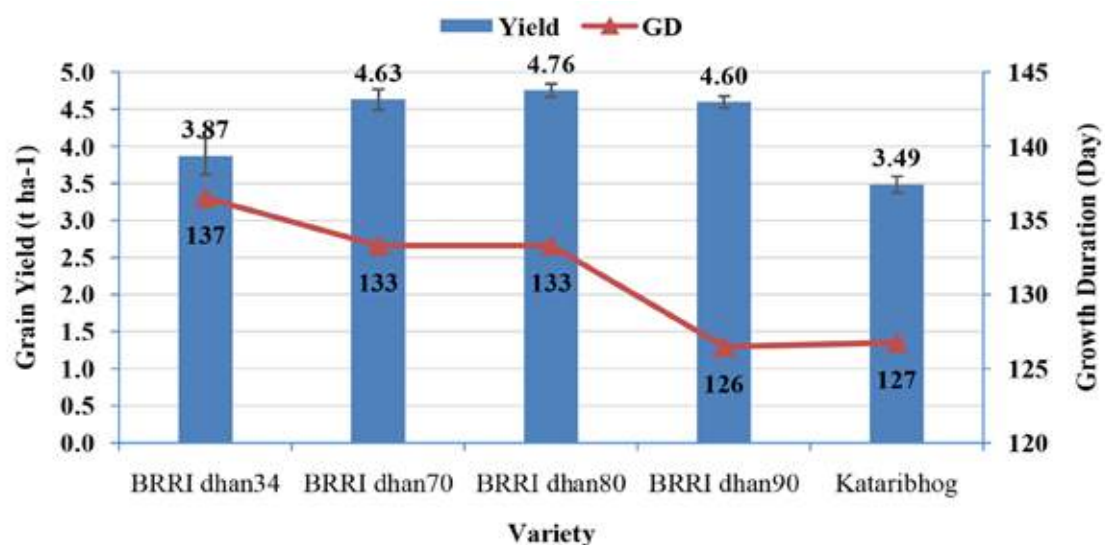


Fig. 2. Average grain yield and growth duration of the tested rice varieties in HHAT (LD-Dinajpur).

In the category HHAT (LD-Rangpur), BRRI dhan87 produced the highest grain yield (5.71 t ha⁻¹) having also the shortest growth duration 128 days only

(Fig. 3) followed by BR11 which produced (5.29 t ha⁻¹). BRRI dhan52 produced the lowest yield (5.01 t ha⁻¹) with longest growth duration 141 days only among of all the tested varieties..

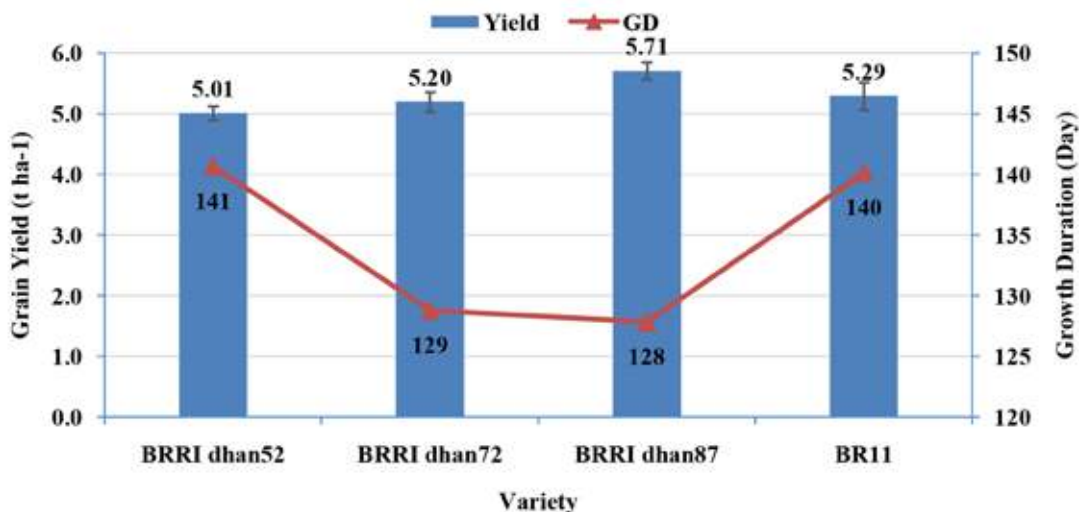


Fig. 3. Average grain yield and growth duration of the tested rice varieties in HHAT (LD-Rangpur).

In the category HHAT (LD-Mymensingh), BRRI dhan49 produced the highest grain yield (5.70 t ha⁻¹) having also the shortest growth duration 126 days only (Fig. 4). BRRI dhan87 and BRRI

dhan94 produced the statistically similar yield with similar growth duration respectively. BRRI dhan32 produced the lowest yield (5.40 t ha⁻¹) having growth duration 131 days.

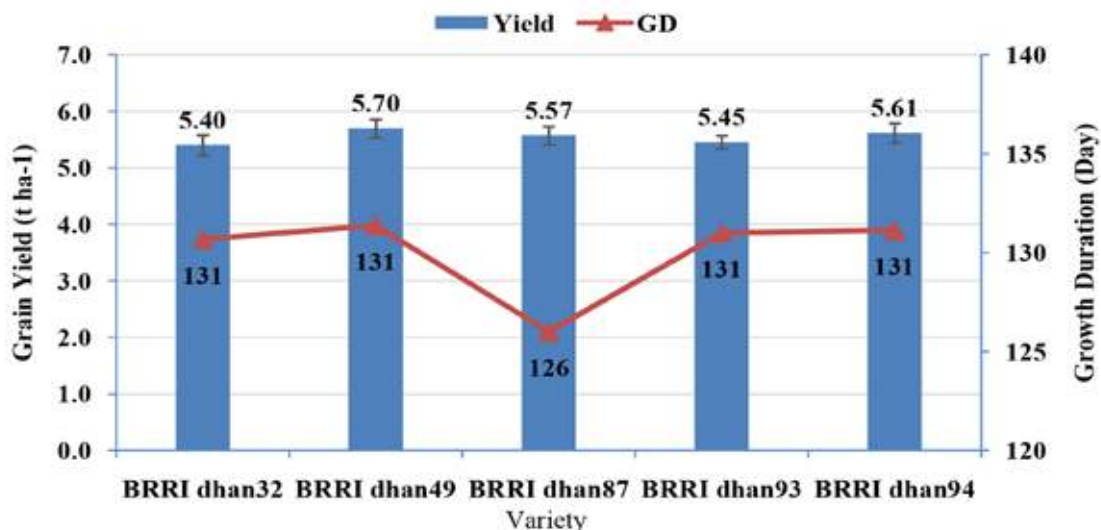


Fig. 4. Grain yield and growth duration of tested rice varieties in HHAT (LD - Mymensingh).

In the category HHAT (SD), average highest yield of Binadhan-17 was recorded 5.57 t ha⁻¹ followed by BRRI dhan75 producing grain yield 5.40 t ha⁻¹. Binadhan-22 also performed well, which produced

grain yield 5.35 t ha⁻¹ having only 114 days growth duration (Fig. 4). Binadhan-7 produced the lowest yield 4.40 t ha⁻¹, which was statistically similar to Binadhan-16. The growth duration was 112 days and 106 days respectively.

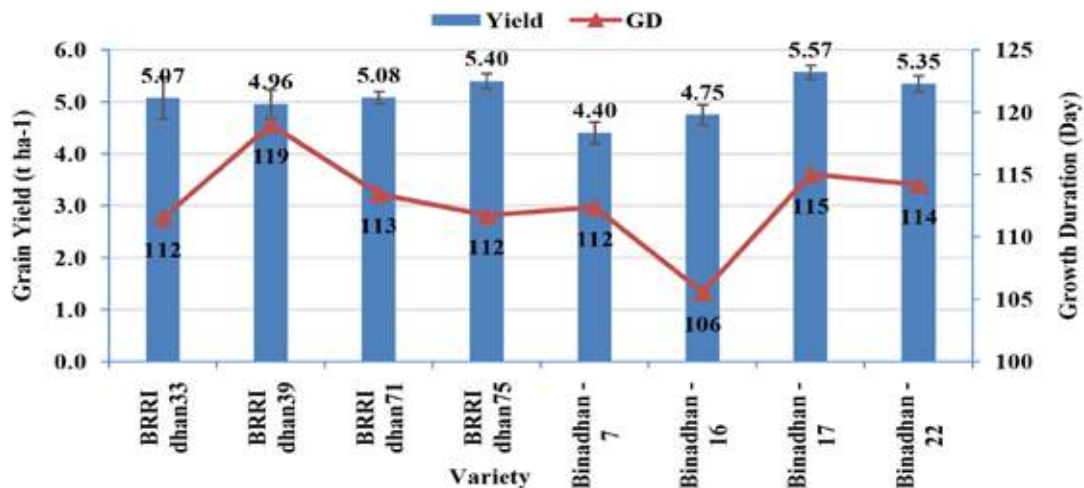


Fig. 5. Average grain yield and growth duration of the tested rice varieties in HHAT (SD).

In coastal ecosystem (CE), the average highest yield of BRRI dhan79 was recorded 5.28 t ha⁻¹ followed by BR10 producing grain yield 5.04 t

ha⁻¹ with longest 146 days growth duration. BRRI dhan73 performed less in Coastal ecosystem, which produced grain yield 4.42 t ha⁻¹ having only 120 days growth duration (Fig. 5).

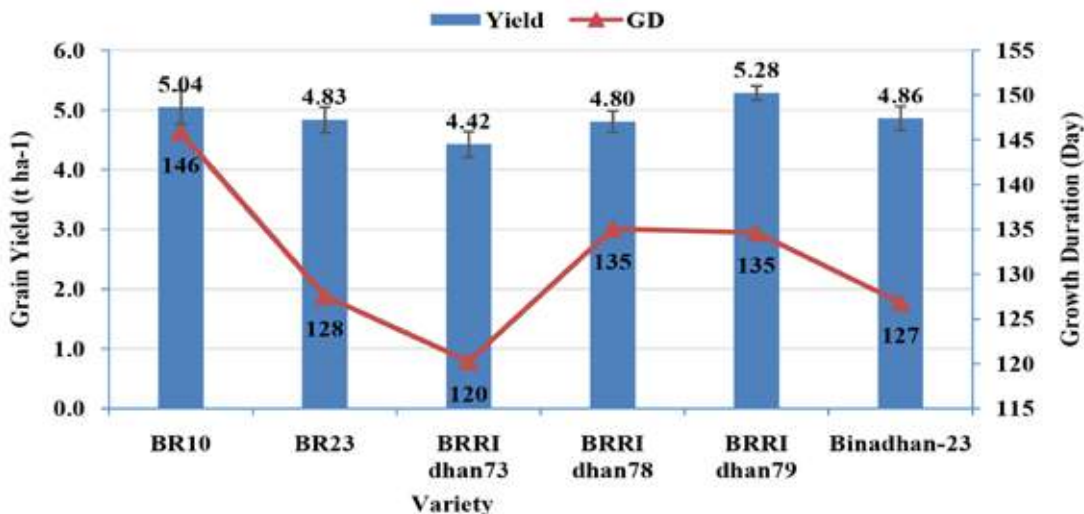


Fig. 6. Average grain yield and growth duration of the tested rice varieties in HHAT (CE).

Among the flash flood submergence tolerant varieties BR11 produced the highest mean yield (5.35 t ha^{-1}) having the GD 144 days followed by BRRI dhan52 producing grain yield 5.30 t/ha with 147 days growth duration (Fig. 6) and the

other tested varieties BRRI dhan51, BRRI dhan79 produced statistically similar yield, which can overcome early flash flood, a major problem in flash flood prone areas. Binadhan-11 produced the lowest yield 4.49 t/ha among all the tested varieties.

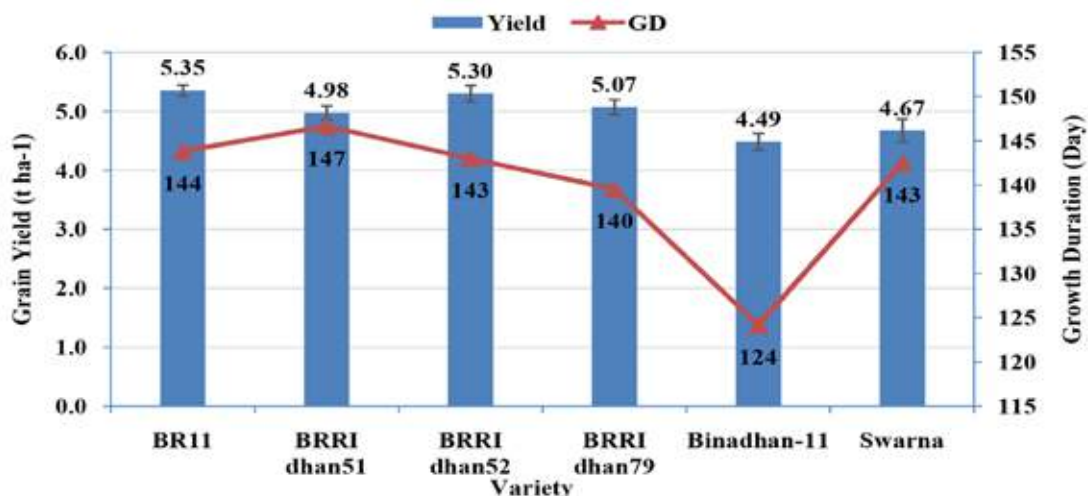


Fig. 7. Average grain yield and growth duration of the tested rice varieties in HHAT (FFS).

Among the Tidal Submergence tolerant varieties BRRI dhan76 produced the highest mean yield 5.27 t ha^{-1} having the GD 155 days followed by BRRI dhan52 producing grain yield 5.04 t/ha with GD 143 days (Fig. 7) and other tested varieties BRRI dhan77, BR23 gave statistically similar yield,

which can overcome tidal submergence, a major problem of the southwest part in Bangladesh. Local variety Lalmota produced the lowest yield 3.82 t ha^{-1} among all the tested varieties having highest growth duration (158 days).

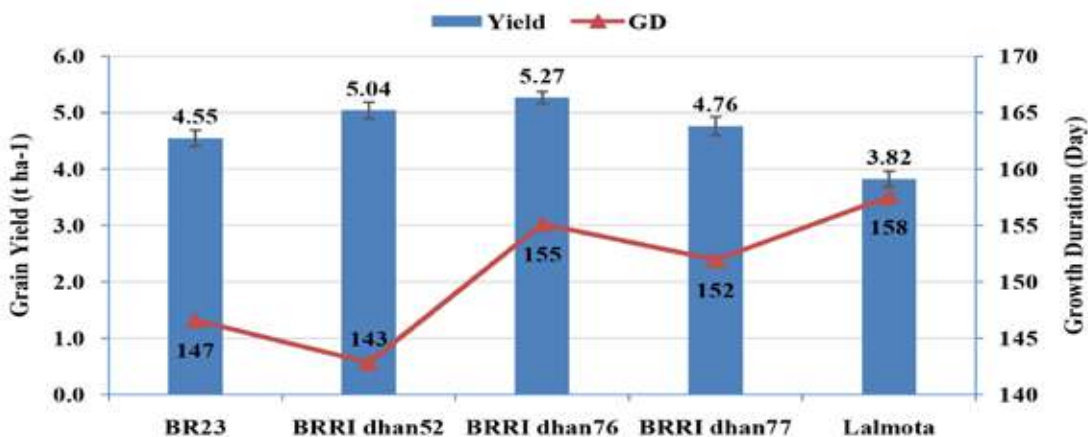


Fig. 8. Average grain yield and growth duration of the tested rice varieties in HHAT (TS).

Head to Head Adaptive Trial (HHAT) during Boro 2023. A total of 200 HHAT with five categories depending on rice growing eco-system were conducted throughout the country such as short GD rice variety (SD), long GD rice variety (LD); saline ecosystem (SE), haor ecosystem (HAE), and hill eco-system (HE). In HHAT (SD), BRR

ri dhan88 was found as the highest yielder (6.71 t ha⁻¹) having growth duration 140 days followed by BRRi dhan74 and Binadhan-25 (6.67 and 6.66 t ha⁻¹). Whereas, BRRi dhan28 produced the lowest yield (5.83 t ha⁻¹). Bangabandhu dhan100 and BAU dhan3 produced good yield and the growth duration were 143 days and 142 days respectively.

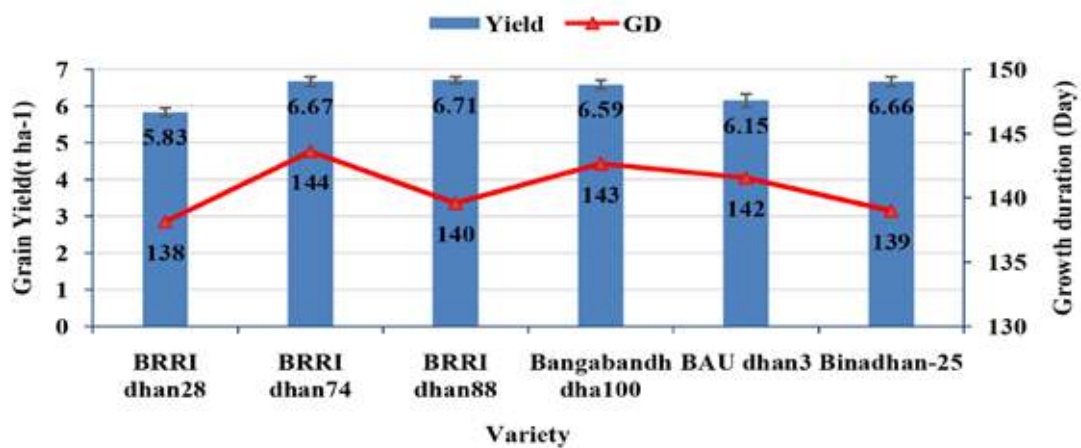


Fig. 9. Average grain yield and growth duration of the tested rice varieties in HHAT (SD).

In the category HHAT (LD), BRRi dhan102 produced the highest grain yield (7.79 t ha⁻¹) followed by BRRi dhan92 which produced (7.67 t ha⁻¹). Binadhan-24 produced the lowest yield (6.47

t ha⁻¹) having also the lowest growth duration 142 days only. The growth duration of BRRi dhan29 was the highest (156 days) of all tested varieties and Binadhan-24 was the lowest (142 days).

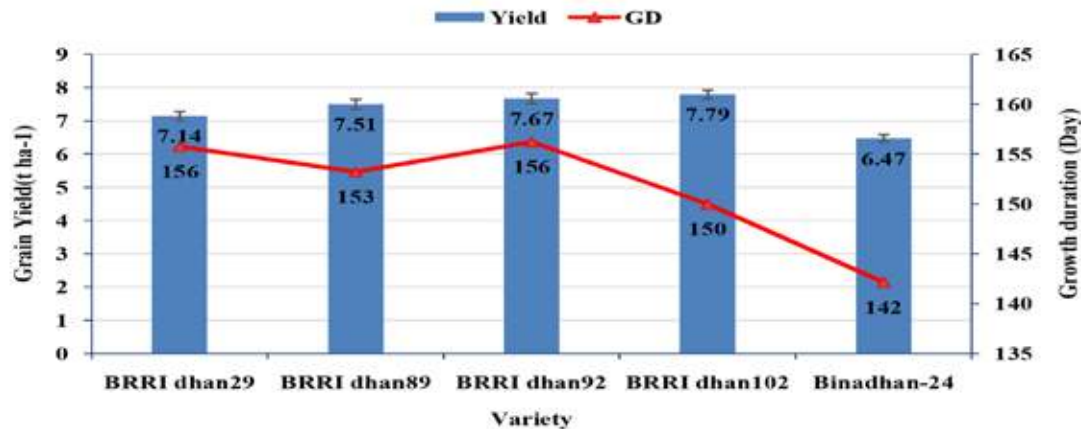


Fig. 10. Average grain yield and growth duration of the tested rice varieties in HHAT (LD).

In single Boro haor areas, the average yield of BRRI dhan96 was recorded 6.67 t/ha followed by BRRI dhan67 producing grain yield 5.89 t ha⁻¹. BRRI dhan101 also performed well in haor eco-system, which produced grain yield 5.85 t ha⁻¹ having only

145 days growth duration. BRRI dhan96 (6.67 t ha⁻¹) was found as the most suitable cultivar with the lowest growth duration 136 days which can overcome early flash flood, a major problem in haor areas.

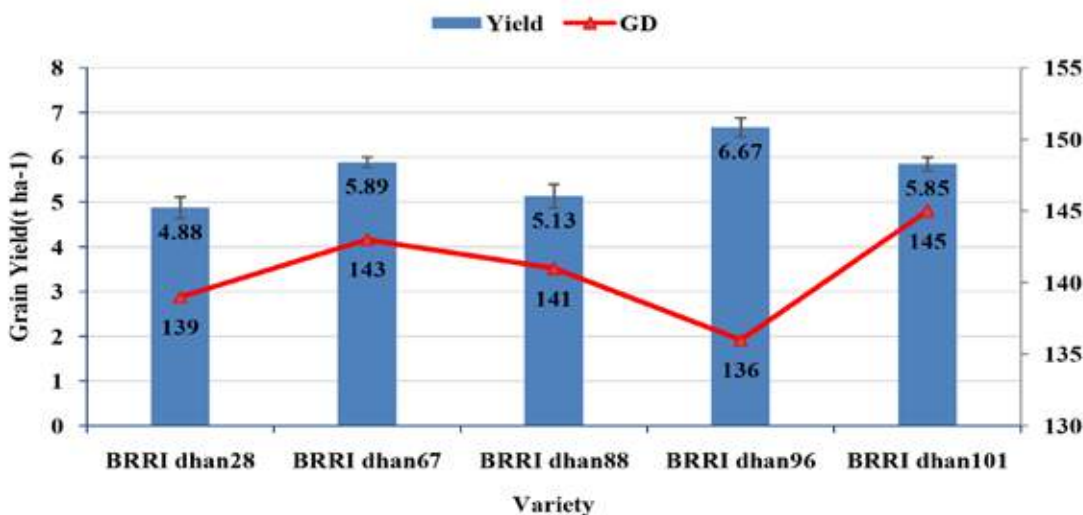


Fig. 11. Average grain yield and growth duration of the tested rice varieties in HHAT (Haor).

Among the salt tolerant varieties BRRI dhan99 produced the highest mean yield (6.79 t ha⁻¹) having the GD 146 days followed by BRRI dhan97 that also performed well and average grain yield was (6.27 t/ha) with same growth duration. Very much poor yield

was observed for BRRI dhan28 in saline eco system (Table 8). BRRI dhan28 was affected by neck blast and this is why yield hampered. The growth duration of BRRI dhan67 was at par BRRI dhan28 and could be cultivated with minimum irrigation.

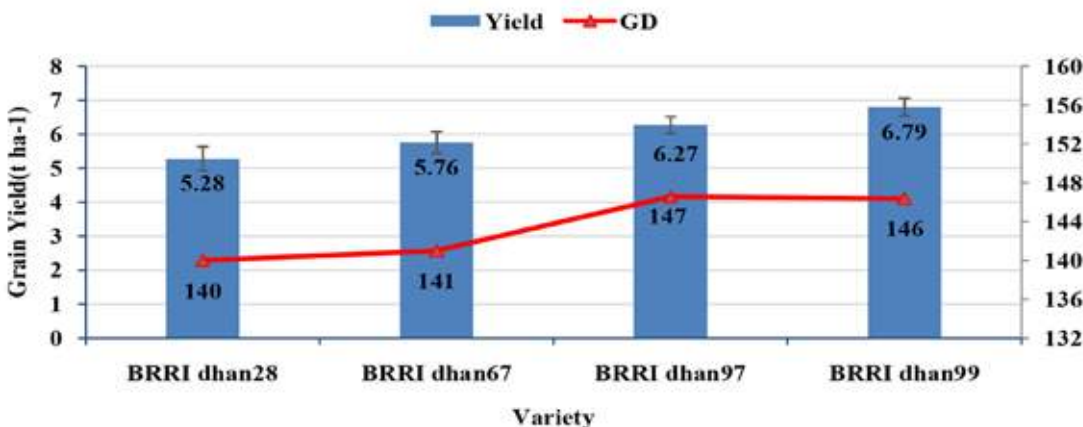


Fig. 12. Average grain yield and growth duration of the tested rice varieties in HHAT (Saline).

In hilly rice eco-system, BRRI dhan74 was the highest yielder (6.69 t ha⁻¹) in HHAT followed by Bangabandhu dhan100 (6.35 t ha⁻¹). BRRI dhan88 also performed well in hilly eco-system, which

produced grain yield (6.19 t ha⁻¹) having only 142 days growth duration. Irrigation water was scarce at hilly areas, and very often surface water was used for irrigation.

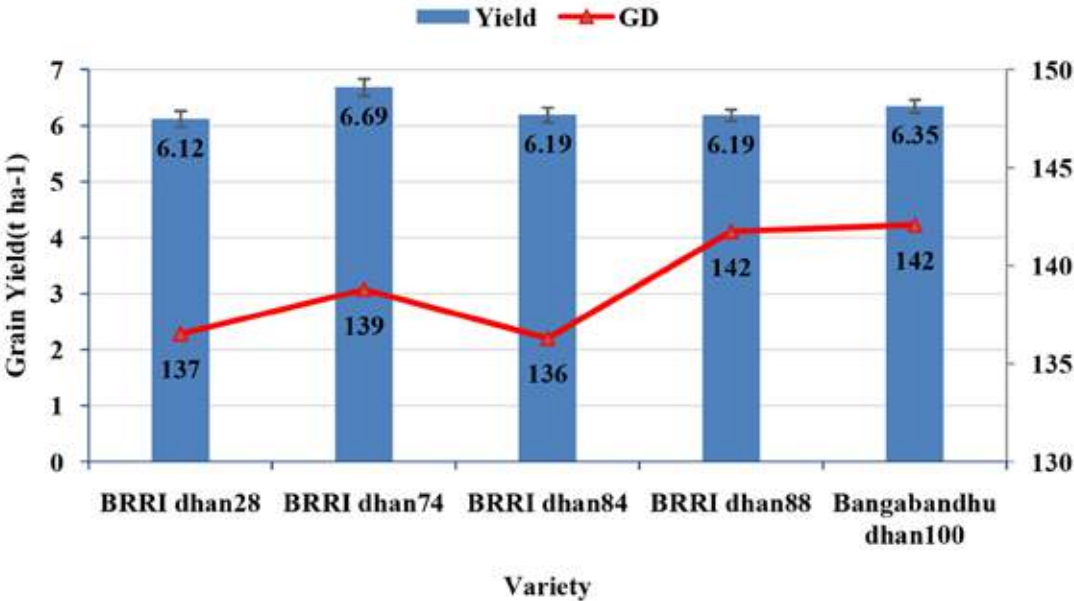


Fig. 13. Average grain yield and growth duration of the tested rice varieties in HHAT (Hilly).

Validation trial of Polythene Covered Dry Seedbed in the late Boro growing Areas. Four Varieties BRRI dhan67, BRRI dhan88, BRRI dhan89 and BRRI dhan92 were used in four upazilas of two districts namely Gazipur (Kapasia), Narsingidhi (palash), Habiganj (Sadar, Nabiganj) during Boro 2023. Across all the locations, regardless of the rice varieties used, there was a reduction in the growth duration. The average lifespan of BRRI dhan67, BRRI dhan88, BRRI dhan89 and BRRI dhan92 was notably shorter than the standard conditions, with durations of 130, 129, 141, and 143 days, respectively. Remarkably, there was no seedling mortality in the dry seedbed due to cold injury, a common issue during late Boro cultivation. Furthermore, the seedlings remained robust and were easily uprooted for transplanting. All the seedlings were ready within 28 days, and the transplanting process was completed within 31 days.

TECHNOLOGY DISSEMINATION

Seed production and dissemination programme (SPDP). Scientists of ARD conducted different demonstration trials and involved in different promotional activities for rapid dissemination of BRRI developed technologies. Among them, SPDP was very important activity where BRRI developed different promising rice varieties were demonstrated at farmers' field in different seasons for rapid dissemination. SPDPs were conducted in collaboration with DAE.

Special SPDP at Bhola district during B. Aus 2022. Seed production and dissemination programme (SPDP) in B. Aus 2022 were conducted in six upazilas of Bhola district. BRRI dhan83 was used as the cultivar. A total of 24 demonstrations were established in six upazilas of Bhola. The average yield of BRRI dhan83 was 3.9 t/ha. The average growth duration was 106 days. Total

produced seeds were 3115 kg from which retained seeds were 720 kg for next year cultivation. The total number of motivated farmers were 70.

Seed production and dissemination program in Jhum cultivation during B. Aus 2022. Seed Production and dissemination programme in B. Aus 2022 were conducted in six upazilas of three Hill Tract districts like Bandarban, khagrachari and Rangamati where BRRI dhan83 was used in the programme. The average yield was 3.0 t ha⁻¹. The minimum and maximum growth duration of BRRI dhan83 was 101 and 113 days respectively. Minimum total production was 268 kg, maximum 685 Kg seeds were produced, the average 458 kg seed was produced per location and in total 19,220 kg seeds were produced from all of the demonstrations. Farmers retained seed after harvesting, minimum and maximum 10 kg and 200 kg seeds were retained by the farmers respectively. The average retained seed was 45 kg and in total 1,741 Kg seeds were retained by the farmers.

Seed production and dissemination programme during T. Aus 2022. Seed production and dissemination programme T. Aus 2022 were conducted in 29 upazilas of 10 districts of the country. A total of 70 demonstrations were conducted where three modern rice varieties (BRRI dhan48, BRRI dhan82 and BRRI dhan98) were used as cultivar. Among the varieties, BRRI dhan98 produced the highest mean grain yield 5.0 t ha⁻¹ followed by BRRI dhan48 (4.9 t ha⁻¹) and the lowest mean rice grain yield was 4.3 t ha⁻¹ in case of BRRI dhan82. BRRI dhan98 produced the highest yield 4.0 t ha⁻¹ followed by BRRI dhan48 and the yield was 3.8 t/ha. Total grain production of BRRI dhan48, BRRI dhan82 and BRRI dhan98 were 5,287 kg, 16,108 kg and 23,573 kg respectively. The retained seeds by the participant and associated farmers of BRRI dhan48, BRRI dhan82 and BRRI dhan98 were 325 kg, 1,425 kg and 2,655 kg respectively. A total of 44,968 kg grains were produced from all the demonstrated plots and 4,405 kg quality seeds were retained by the farmers as seed for the next year cultivation.

Seed production and dissemination program in valley during T. Aus 2022. Seed production and

dissemination programme was conducted in the valley of six upazilas of three hill districts. Three modern rice varieties; BRRI dhan48, BRRI dhan82 and BRRI dhan98 were used in the programme. A total of 18 demonstrations were established in three hill districts. Among the varieties, BRRI dhan98 produced the highest mean grain yield 5.6 t ha⁻¹ followed by BRRI dhan82 (5.2 t ha⁻¹). The retained seeds by the participant and associated farmers of BRRI dhan48, BRRI dhan82 and BRRI dhan98 were 188 kg, 310 kg and 430 kg respectively. A total of 11,242 kg grains were produced from all the demonstrated plots and 928 kg quality seeds were retained by the farmers. About 681 farmers gained knowledge about the varieties through field visits, discussion and knowledge sharing. A total of 153 farmers were motivated and showed their interest to cultivate these varieties in the next year.

Special programme of BRRI hybrid dhan7 during T. Aus 2022. Special dissemination Programme of BRRI hybrid dhan7 in T. Aus 2022 were conducted in 21 upazilas of eight districts. The minimum yield of BRRI hybrid dhan7 was 4.6 t ha⁻¹, the maximum yield was 6.9 t ha⁻¹ and the average yield was 5.4 t ha⁻¹. The minimum and maximum growth duration of BRRI hybrid dhan7 was 105 and 113 days respectively and the average growth duration was 108 days. From this demonstration many of the farmers gained knowledge about BRRI hybrid dhan7, minimum 6 and maximum 172 farmers and on average 58 and a total of 2,027 farmers gained knowledge from all the demonstrations. The farmers who gained knowledge about BRRI hybrid dhan7 were among the 220 farmers those were motivated to cultivate this variety in the next year if the seeds are available.

Special programme of BRRI hybrid dhan7 in valley during T. Aus 2022. Special dissemination Programme of BRRI hybrid dhan7 in T. Aus 2022 were conducted in six upazilas of three hilly districts. BRRI hybrid dhan7 was used in the programme. A total of 12 demonstrations were established in three hilly districts of Bangladesh. The minimum yield of BRRI hybrid dhan7 was 4.2 t/ha, the maximum yield was 6.8 t/ha and the average yield was 5.7 t ha⁻¹. The minimum and maximum growth duration of BRRI hybrid dhan7 was 105 and 113

days respectively and the average growth duration was 109 days. From this demonstration many of the farmers gained knowledge about BRRI hybrid dhan7, minimum 10 and maximum 80 farmers as well as the average 41 and a total of 488 farmers gained knowledge about the variety.

Seed production and dissemination programme during T. Aman 2022. SPDPs in Aman 2022 were conducted in 30 upazilas of 15 districts. Twelve modern rice varieties (BRRI dhan52, BRRI dhan71, BRRI dhan72, BRRI dhan75, BRRI dhan78, BRRI dhan80, BRRI dhan87, BRRI dhan93, BRRI dhan94, BRRI dhan95, BRRI hybrid dhan4 and BRRI hybrid dhan6) were used in the programme. A total of 714 demonstrations were established in 15 districts of the country. Among the varieties, BRRI dhan93 produced the highest mean grain yield 6.0 t ha^{-1} followed by BRRI dhan94 (5.5 t ha^{-1}) and BRRI dhan72 (5.3 t ha^{-1}). The lowest mean rice grain yield was 4.1 t ha^{-1} in BRRI dhan75 followed by 4.3 t ha^{-1} in BRRI dhan71 and BRRI dhan78 respectively. Total grain production of BRRI dhan52, BRRI dhan71, BRRI dhan72, BRRI dhan75, BRRI dhan78, BRRI dhan80, BRRI dhan87, BRRI dhan93, BRRI dhan94 and BRRI dhan95, were 1,204 kg, 53,394 kg, 1,419 kg, 1,092 kg, 1,138 kg, 47,786 kg, 94,051 kg, 1,69,833 kg and 21,179 kg, respectively. The retained seeds by the participant and associated farmers of BRRI dhan52, BRRI dhan71, BRRI dhan72, BRRI dhan75, BRRI dhan78, BRRI dhan80, BRRI dhan87, BRRI dhan93, BRRI dhan94, BRRI dhan95 were 80 kg, 6,206 kg, 460 kg, 6,480 kg, 530 kg, 4,545 kg, 8,559 kg, 15,334 kg, 2,120 kg, 400 kg and 10,309 kg respectively.

Performance of BRRI hybrid dhan4 and BRRI hybrid dhan6 in different locations during T. Aman 2022. Demonstrations were conducted during T. Aman 2021 at 17 upazilas of nine districts using two hybrid rice varieties (BRRI hybrid dhan4 and BRRI hybrid dhan6). BRRI hybrid dhan4 produced the highest mean grain yield (5.95 t ha^{-1}) than BRRI hybrid dhan6 (5.91 t ha^{-1}). About 2,463 farmers acquired awareness and gained knowledge about the varieties through field visits, discussion and knowledge sharing. A total of 687 farmers were motivated and showed their interest to cultivate these varieties in the next year.

Performance of BRRI dhan71 and BRRI dhan75 in T. Aman-Potato-Boro cropping pattern during T. Aman 2022. Trials were conducted in Potato growing areas of northern part of Bangladesh to introduce short duration T. Aman rice varieties during T. Aman season. Two modern rice varieties, BRRI dhan71 and BRRI dhan75 having the growth duration less than 120 days, were cultivated in eight upazilas of four districts. The average yield of BRRI dhan71 and BRRI dhan75 was 5.15 t ha^{-1} and 4.99 t ha^{-1} respectively. A total of about 10.86 tons of seeds were produced from all demonstration plots and 1,430 kg quality seeds were retained by the farmers for the next year cultivation.

Performance of BRRI dhan80 and BRRI dhan87 in valley during T. Aman 2022. Demonstrations were conducted at six upazilas of three districts in hill tracts (Khagrachari, Rangamati and Bandarban) under GoB. Two rice varieties (BRRI dhan80 and BRRI dhan87) were used as cultivar. Between the demonstrated varieties, BRRI dhan87 produced the highest mean grain yield (5.65 t ha^{-1}) than BRRI dhan80 (4.63 t ha^{-1}). A total of 8,253 kg grains were produced from all the demonstrated plots from which 912 kg was retained as seed for next year cultivation. About 784 farmers acquired awareness and gained knowledge about the varieties through field visits, discussion and knowledge sharing. A total of 211 farmers were motivated and showed their interest to cultivate these varieties in the next year.

Special SPDP (Muzibborsho) during T. Aman 2022. Special SPDPs were conducted in 14 upazilas of 11 districts of Bangladesh for rapid dissemination of BRRI varieties. Eight modern rice varieties, BRRI dhan75, BRRI dhan76, BRRI dhan79, BRRI dhan87, BRRI dhan90, BRRI dhan93 and BRRI dhan95 were cultivated in this programme. Plot size of each variety was three bigha and two varieties were demonstrated in each location in cluster. The average yield of BRRI dhan75, BRRI dhan76, BRRI dhan87, BRRI dhan90, BRRI dhan93 and BRRI dhan94 was 4.94 t ha^{-1} , 5.59 t ha^{-1} , 4.2 t ha^{-1} , 5.625 t ha^{-1} , 5.1 t ha^{-1} and 5.76 t ha^{-1} respectively. A total of about 35.452 ton seeds were produced from all the demonstration plots and 1,680 kg quality seeds were retained by the farmers for the next year cultivation.

Performance of BRRI dhan91 during early T. Aman 2022: Thirty-nine SPDPs were conducted in low land areas of Manikganj, Narayanganj, Munsiganj, Pabna and B.Barria districts using BRRI dhan91. Plot size of each variety was three bighas in cluster/upazila. The growth duration varies from 150 to 195 days and average yield was 2.36 t ha⁻¹. Crops were damaged in four locations due to higher water depth. A total of about 8,525 kg paddy were produced from all demonstration plots and 1,070 kg quality seeds were retained by the farmers for the next year cultivation.

Seed production and dissemination programme during T. Aman 2022 under TRB. A total of 60 SPDPs were conducted in 16 upazilas of 13 districts under TRB project during Aman 2022. BRRI dhan71, BRRI dhan73, BRRI dhan75, BRRI dhan80 and BRRI dhan87 were demonstrated in the SPDPs. Area of each SPDP was three bighas and total area of SPDP was 60 bighas. Irrespective of varieties and locations, BRRI dhan87 produced the highest mean grain yield (6.02 t ha⁻¹) followed by BRRI dhan73 (5.63 t ha⁻¹) and the lowest mean grain yield was found in BRRI dhan80 (4.81 t ha⁻¹). Total production of all the varieties was 44,244 kg from which 5,465 kg was retained as seeds (12% of total production) by the farmers for next season cultivation. About 3,330 farmers gained awareness and knowledge about the varieties and 576 farmers (16% of total farmers) were motivated to cultivate the varieties.

Seed production and dissemination programme during Boro 2023 under TRB: A total of 30 SPDPs were conducted in 16 upazilas of 10 different districts under varied rice growing eco-systems of the country funded by Transforming Rice Breeding project managed by Adaptive Research Division. BRRI dhan67, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92 and Bangabandhu dhan100 were used in the SPDP. The programme was executed in collaboration with DAE. Irrespective of variety and location, BRRI dhan92 produced the highest yield (7.50 t/ha) in Monohordi, Norsigdi while the lowest yield (5.10 t ha⁻¹) obtained in BRRI dhan84 at Shibganj, Bagura. Total production of all the varieties was 75,729 kg from which 4,319 kg was retained as seeds (9 % of total production) by the farmers for next season cultivation. About 6,750

farmers gained awareness and knowledge about the varieties and 1,253 farmers (23% of total farmers) were motivated to cultivate the varieties.

Seed production and dissemination programme during (SPDP) in Boro 2023. Dissemination programme were conducted in 28 upazilas of 14 districts. Ten modern rice varieties (BRRI dhan67, BRRI dhan74, BRRI dhan81, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, BRRI dhan99 and Bongabondhu dhan100) were used in the programme. BRRI provided quality seeds, fertilizer and signboard while the rest of the managements were done by the farmers. A total of 736 demonstrations were established in 14 districts of Bangladesh. Among the varieties, BRRI dhan92 produced the highest mean grain yield 7.7 t ha⁻¹ followed by BRRI dhan89 (7.5 t ha⁻¹) and the lowest mean rice grain yield was 6.2 t ha⁻¹ in BRRI dhan67 followed by 6.3 t ha⁻¹ in BRRI dhan74, BRRI dhan81 and BRRI dhan99 respectively. Yield of the highest grain BRRI dhan92 varied from 5.7-10.3 t ha⁻¹ in different locations depending on soil fertility, salinity, cropping pattern and management practices. A total of 7,98,265 kg grains were produced from all the demonstration plots and 1,10,817 kg quality seeds were retained by the farmers as seed for the next year cultivation. About 43,903 farmers acquired awareness and knowledge about the varieties through field visits, discussion and knowledge sharing. A total of 15,889 farmers were motivated and showed their interest to cultivate these varieties next year. BRRI dhan92 and BRRI dhan89 were highly preferred by the farmers for its higher yield. Bangabondhu dhan100 and BRRI dhan96 were also preferred by the farmers for their higher paddy production, good taste, quality grain and shorter life cycle.

Special programme of BRRI hybrid dhan3 and BRRI hybrid dhan5 during Boro 2023. Special dissemination programme of BRRI hybrid dhan3 and BRRI hybrid dhan5 during Boro 2023 were conducted in 28 upazilas of 14 districts. The minimum yield of BRRI hybrid dhan3 was 6.2 t/ha, the maximum yield was 9.5 t/ha and the average yield was 7.8 t/ha. The minimum and maximum growth duration of BRRI hybrid dhan3 was 132 and 157 days respectively and the average growth duration was 145 days. About 1,175 farmers gained

knowledge about the varieties through field visits, discussion and knowledge sharing. A total of 542 farmers were motivated and showed their interest to cultivate BRRI hybrid dhan3 next year. Around 28 demonstrations were conducted in the different locations of 28 upazilas under 14 districts using BRRI hybrid dhan5. The minimum yield of BRRI hybrid dhan5 was 6.6 t/ha, the maximum yield was 9.3 t/ha and the average yield was 7.9 t/ha. The minimum and maximum growth duration of BRRI hybrid dhan5 was 133 and 147 days respectively and the average growth duration was 143 days. The farmers who gained knowledge about BRRI hybrid dhan5, among the farmers some of them were motivated to cultivate this variety next year if the seeds are available in the market in proper time. About 1,234 farmers acquired awareness and gained knowledge about the varieties through field visits, discussion and knowledge sharing. A total of 552 farmers were motivated and showed their interest to cultivate BRRI hybrid dhan5.

Seed production and dissemination programme in valley during Boro 2023. Demonstrations were conducted in six upazilas of three hill districts using the seven modern rice varieties such as BRRI dhan74, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, BRRI dhan99 and Bongabondhu dhan100. BRRI provided quality seeds, fertilizer and signboard while the rest of the managements were done by the farmers. A total of 72 demonstrations were established in three hill districts of Bangladesh. Among the varieties, BRRI dhan92 produced the highest mean grain yield 7.2 t ha⁻¹ followed by Bongabondhu dhan100 (7.1 t ha⁻¹). Yield of the highest producing grain BRRI dhan92 varied from 6.5-7.9 t ha⁻¹ in different locations of different upazilas of hill districts. The retained seeds by the participant and associated farmers of BRRI dhan74, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, BRRI dhan99 and Bongabondhu dhan100 were 600 kg, 1,165 kg, 935

kg, 570 kg, 415 kg, 305 kg and 425 kg respectively. A total of 48,735 kg grains were produced from all the demonstration plots and 4,415 kg quality seeds were retained by the farmers as seed for the next year cultivation.

PROMOTIONAL ACTIVITIES

Farmers' training. During the reporting period 71 farmers' trainings were arranged by Adaptive Research Division (ARD) at different locations of the country in collaboration with DAE in which 1923 farmers and 207 SAAOs participated and updated their knowledge regarding modern rice production technology.

Field day. Field days were arranged on best performing SPDPs for the purpose of rapid dissemination of demonstrated rice varieties as well as required and recommended management practices among the targeted farmers, neighbouring farmers, DAE personnel, public representatives, local leaders and NGO workers. Nearly 7,000 participants from heterogeneous groups of people joined in 70 field days those were successfully arranged during Aus, 2022, Aman 2022 and Boro 2023 seasons covering reporting period.

Seeds production at BRRI farm. A total of 4,480 kg quality seeds of different BRRI varieties were produced at BRRI farms during the reporting period for the enrichment of own seed stock.

Farmers' seed centre: Four farmers' seed centers were established during the reporting period. TRB-BRRI provided six plastic drums in each center. A total of 80 kg seeds can be stored in each drum.

Seed support programme. A total of 10.28 tons of seeds were distributed among the different stakeholders such as farmers, NGO workers and BRRI employees. Complete production packages were also provided among the stakeholders so that they can adopt all required and recommended practices for the cultivation of supplied varieties.

TRAINING DIVISION

- 392 Summary**
- 392 Capacity building and technology transfer**
- 396 Effectiveness of imparted rice production training**

SUMMARY

Training Division has conducted 36 training programmes in the reporting year with course duration from two days to two months. Need based course curriculum was developed for these courses. Total number of participants was 863. The participants were Sub-Assistant Agriculture Officer (SAAO), Agriculture Extension Officer (AEO) of the Department of Agriculture Extension (DAE), Scientists of BRRI, Officers of different seed companies in the country, Officer Incharge (LSD) of the ministry of food and advanced farmers. The highest number of participants was from the DAE. All the training programmes were successfully completed. Most of the BRRI's speakers' performance was very good to excellent.

CAPACITY BUILDING AND TECHNOLOGY TRANSFER

Training on modern rice production technologies (Regular)

Sixteen training courses on modern rice production technologies were conducted during the reporting period. The main objective of the course was to train the grass root level extension workers (SAAO) of DAE. The course curriculum was designed based on the priority of field problems related to rice production and rice based technologies. Duration of the course was one week. A total of 396 SAAOs were trained. Among the participants 367 and 29 were male and female, respectively (Table 1).

Six training courses on hybrid rice and seed production technologies for SAAO of DAE was conducted during the reporting period. Duration of the course was five days. A total of 165 SAAOs were trained. Among the participants 149 and 16 were male and female, respectively (Table 2).

Four training programmes on modern agriculture machinery operating and maintenance training course were conducted at that time for advanced farmers under the programme of Rice Farming System Division. A total of 80 advanced farmers were trained. All of them were male participants (Table 3). The course duration was one week.

One training programme on hybrid rice and seed production technology for the officers of different seed companies functioning at Bangladesh were successfully completed at that time. Duration of the course was five days. Nineteen participants were trained through this course. Table 4 presents the particulars of the trainings.

Twenty-five Officers Incharge (LSD) of the ministry of food were trained on Quality Control/Quality Assurance of Biofortified Zinc rice. Duration of the course was two days. Among the participants, 24 were male and one female completed the training (Table 5).

Two months rice production training course

In the year 2022-23, two months modern rice production technology training course for BRRI scientists was successfully completed. Twenty-four BRRI scientists (SO) were the participants of this training. Among the participants 12 were male and 12 were female (Table 6).

Five days training on hybrid rice and seed production technology were successfully completed at that time for nineteen BRRI Scientists (Table 7) under the project of Hybrid Rice Division.

One month rice production training course

Another training course on modern cultivation technique of rice production and integrated pest management for DAE officers was held for one month. A total of 30 DAE officers were trained through this course. Among the participants 23 and 7 were male and female, respectively (Table 8). Different evaluation tools in different times were applied to assess the knowledge improvement of individual participants.

Another Training programme on theoretical and practical sessions on advanced Biotechnology for BRRI scientists were conducted during the reporting period. Forty-one participants in two batches were trained through this course. Table 9 presents the particulars of the trainings.

Training of the trainers (TOT) for SAAO, DAE were conducted in the year of 2022-23. Duration of the course was three days. A total of 50 participants were trained in two batches. Table 10 presents the particulars of the trainings.

Three days training-workshop on identification of rice arthropods were completed for 14 BIRRI Scientists. Among the participants 10 and four were male and female, respectively (Table 11).

During the reporting period, 36 training programmes have been conducted by the Training Division. Through this training a total of 863 participants were trained. Table 12 presents the summaries of the trainings.

Table 1. Particulars of one week modern rice production training course for SAAO of DAE.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	6-11 August 2022	25	25	0
2.	6-11 August 2022	25	25	0
3.	20-25 August 2022	25	25	0
4.	20-25 August 2022	25	25	0
5.	27 August-1 September 2022	25	21	4
6.	27 August-1 September 2022	24	21	3
7.	3-8 September 2022	25	25	0
8.	3-8 September 2022	24	24	0
9.	26 Nov-1 December 2022	25	21	4
10.	26 Nov-1 December 2022	23	21	2
11.	3-8 December 2022	25	21	4
12.	3-8 December 2022	25	22	3
13.	10-15 December 2022	22	21	1
14.	10-15 December 2022	25	23	2
15.	17-22 December 2022	26	24	2
16.	17-22 December 2022	27	23	4
	Total	396	367	29

Table 2. Particulars of five days Hybrid rice and seed production technology training course for SAAO of DAE.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	26 February-2 March, 2023	28	25	3
2.	26 February-2 March, 2023	28	25	3
3.	5-9 March, 2023	26	24	2
4.	5-9 March, 2023	27	23	4
5.	12-16 March, 2023	28	27	1
6.	7-11 May, 2023	28	25	3
	Total	165	149	16

Table 3. Particulars of weekly modern agriculture machinery operating and maintenance training course for advanced farmers.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	4-9 February, 2023	20	20	0
2.	18-23 March, 2023	20	20	0
3.	27 May-1 June, 2023	20	20	0
4.	3-8 June, 2023	20	20	0
	Total	80	80	0

Table 4. Particulars of five days hybrid rice and seed production technology training course for officers of different seed companies.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	16-20 October 2022	19	18	1

Table 5. Training on Quality Control/Quality Assurance of Biofortified Zinc Rice for Officer Incharge, LSD of the ministry of Food.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	3-4 May 2023	25	24	1

Table 6. Particulars of two months long trainings course on modern technology of rice production for BRRI scientists.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	20 September-18 November 2022	24	12	12

Table 7. Five days training on hybrid rice and seed production technology for BRRI scientists

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	7-11 May 2023	19	10	9

Table 8. Particulars of one month modern rice production technique and integrated pest management training course for DAE Officers.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	14 May-12 June 2023	30	23	7

Table 9. Training on theoretical and practical sessions on advanced biotechnology for BRRI scientists.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	2-6 April 2023	19	16	3
2.	6-16 April 2023	22	15	7
	Total	41	31	10

Table 10. Particulars of three days training of the trainers (TOT) on Biofortified rice.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	22-24 October, 2022	25	23	2
2.	25-27 October, 2022	25	22	3
	Total	50	45	5

Table 11. Particulars of three days Training-Workshop on Identification of Rice Arthropods for BRRI Scientists.

Batch no.	Duration	No. of participants		
		Total	Male	Female
1.	24-26 January, 2023	14	10	4

Table 12. Total trainings conducted by Training Division in the reporting period.

Name of the training	No. of training	Duration	No. of participants			Designation
			M	F	Total	
Modern rice production training	16	1 week	367	29	396	SAAO, DAE
Modern agriculture machinery operating and maintenance training course for advanced farmers.	4	1 week	80	0	80	Advanced farmers
Hybrid rice and seed production technology training course	6	5 days	149	16	165	SAAO, DAE
Hybrid rice and seed production technology training course	1	5 days	18	1	19	Seed Company Officers

Name of the training	No. of training	Duration	No. of participants			Designation
			M	F	Total	
Training on quality control/quality assurance of biofortified zinc rice	1	2 days	24	1	25	Officer Incharge, LSD
Modern technology of rice production training course	1	2 months	12	12	24	SO, BRRI
Training on hybrid rice and seed production technology	1	5 days	10	9	19	SO, SSO, BRRI
Modern cultivation technique of rice production and Integrated pest management training course	1	One month	23	7	30	DAE Officers
Training on theoretical and practical sessions on advance biotechnology	2	5 days	31	10	41	SO, SSO, BRRI
Training of the trainers (TOT) on Biofortified rice	2	3 days	45	5	50	SAAO, DAE
Training-Workshop on Identification of Rice Arthropods	1	3 days	10	4	14	SO, SSO, BRRI
Total	36		769	94	863	

EFFECTIVENESS OF IMPARTED RICE PRODUCTION TRAINING

It is important to determine the impact of different aspects of imparted rice production training for its better planning and execution in future. This study was conducted at the end of each batch to collect the relevant information. After the completion of data collection, information was compiled and analyzed. This study reveals that all the training programmes on modern rice production were very much helpful for the trainees to build up their capacity for modern rice production related activities.

BRRI RS, Barishal

398	Summary
393	Variety Development
402	Pest Management
405	Disease Management
408	Crop Soil Water Management
411	Socio Economic And Policy Programme Area
414	Technology Transfer

SUMMARY

BRRI RS, Barishal operates a strong breeding programme to develop suitable high yielding rice varieties for tidal submergence in T. Aman and favourable Boro seasons. To achieve the goal, 86 new crosses were made, and 57 crosses were confirmed. The numbers of plants selected during T. Aman 2022 were 257 and 600 from F2- and F3-populations, respectively. During Boro 2022-23, the number of progenies selected were 1516 from F4 and 304 from F6-generations. To explore the attributes of new generation rice (NGR) in exotic populations, 145 and 1,042 progenies were selected from F2- and F5-populations, respectively, for further evaluation. One observational yield trial (OYT) was conducted during T. Aman 2022, in which 36 lines were selected based on their better performances out of 215 advanced breeding lines along with four checks. During Boro 2022-23, one OYT consisting of 245 lines along with five checks were tested, in which 49 entries were selected. One preliminary yield trial (PYT) was conducted during T. Aman 2022, from which, four entries were selected for further trial out of 11 advanced breeding lines and five checks. During Boro 2022-23, one PYT was conducted with 15 advanced breeding lines and four checks. Based on their better performance five lines were selected for further trials. A total of 19 regional yield trials (RYTs) were conducted during 2022-23 including one RYT for non-saline tidal ecosystem in Aus 2022, four RYT for T Aman 2022 (zinc enriched rice, short slender grain, long slender grain and tall materials), and 14 RYT for favourable Boro (long, medium and short duration, Bio, extra-long slender grain, Jira type Zinc enriched rice, PQR, DRR_BB, DRR_Blast_BB, Antioxidant medium and short duration, Barishal_FBR-1 and Barishal_FBR-2). Seven advanced yield trials (AYTs) were conducted during T. Aman and Boro 2022-23 including tidal submergence tolerance, high yielding genotypes, and favourable Boro rice. A total of 163 entries in four sets were evaluated in International Network for Genetic Evaluation of Rice (INGER) trials during T. Aman 2022, in which 13 entries outyielded the check variety in the respective sets of trial.

Likewise, 16 lines outyielded the lowest yielded check variety, BRRI dhan88 in INGER trials during Boro 2022-23, in which 40 entries along with the five checks were evaluated.

Twenty-one hybrid varieties of different companies and six checks were evaluated in the yield performance study of released hybrids at Charbadna farm, BRRI RS, Barishal during Boro 2022-23. Only two hybrids, ACI hybrid dhan-6 (6.84 t/ha) and hybrid dhan HQ-950 (7.22 t/ha) outyielded the highest yielded check variety BRRI hybrid dhan5 (6.80 t/ha). A total of 370 local Aman germplasm were grown for characterization, utilization and maintenance during T. Aman 2022.

In the light trap during 2022-23, the appearance of insect pest was lower than the previous reporting year in BRRI RS, Barishal. The highest infestation was of yellow stem borer (YSB) followed by green leafhopper (GLH), white leafhopper (WLH), and brown plant hopper (BPH). The trapped insect pest count was higher than that of natural enemy. Among the insect pests of rice seedbeds, GLH, BPH, WBPH and thrips were observed in higher numbers. In case of natural enemies, the population of green mirid bug, damselfly, carabid beetle was higher. The effect of frequency of insecticide application on rice grain yield during Boro 2022-23 in Sagardi farm showed that the highest yield was found in treatment with two times use of insecticide, followed by sweeping at seven days interval. In Barishal Boro 2022-23, the average brown spot incidence (20.9%) was predominant followed by bacterial blight and sheath blight. In an experiment with biopesticide, the highest yield was recorded in plots where insecticide was sprayed followed by treatment with *Bacillus thuringiensis* was sprayed. Yield increased (0.5-0.75 t/ha) in treated plots with *Achromobacter xylosoxidans* compared to control plots. In another trial, neem leaf mediated silver nano particle was effective to manage bakanae disease.

In an experiment to study the effect of inorganic or organic supplement in addition to soil test-based fertilizers on the grain yield of HYV, BRRI dhan87 responded strongly to STB+more N or STB+vermicompost treatments. During Boro

season, BRRI dhan92 yielded the highest with STB+more N. In nitrogen response study, the optimum N rate for BRRI dhan76 and BRRI dhan77 was found to be 90 kg/ha, while for BRRI dhan74 and BRRI dhan89 it was 198 kg N/ha, in Char Badna farm. The sediments of BRRI RS farm, Sagordi was slightly acidic (pH=6.74) with high organic matter content (2.42%). Among the inorganic nutrients, the quantity of sulfur (16.75 μgg^{-1}) and zinc (4.44 μgg^{-1}) was quite noticeable. In an experiment to determine the optimum planting time seeding of BRRI dhan74 and BRRI dhan89 on 1st December and transplanting on 9th January produced higher grain (5.45 t/ha and 5.80 t/ha, respectively) than the delayed transplanting.

Head to Head trial under TRB project in the Barishal region revealed that BRRI dhan76 gained wide popularity for its higher yield under tidal submergence. For Boro season, BRRI dhan74, BRRI dhan89 and BRRI dhan99 were widely accepted HYVs by the farmers as short duration, long duration and salinity tolerant varieties, respectively.

A total of seven ALARTs were conducted at different sites of the Barishal region, including two for T. Aman 2022 (Submergence tolerant rice, Salt tolerant rice), and five for Boro 2021-22 (Favourable Boro Rice_Barishal: re-ALART, Blast Resistant Rice: re-ALART, Favourable Boro Rice, medium duration and short duration, Blast Resistant Rice). In T. Aman, highest grain yield was obtained by BR9158-19-9-6-50-2-HR1 as submergence tolerant rice and BR11716-4R-102 as salt tolerant rice. In Boro 2022-23, BRBa3-1-7 (8.04 t/ha) showed the highest grain yield in re-ALART of Favourable Boro Rice_Barishal. Among the blast resistant rice advanced lines, BR12454-BC2-69-97-39-5-44 (8.48 t/ha) showed superior grain yield performance. Among the advanced lines and check varieties of

short duration favourable Boro rice, SVIN109 (7.29 t/ha) showed superior yield. In re-ALART of blast resistant rice, BR(Path)12452-BC3-42-22-11-4 (8.35 t/ha) showed the highest grain yield.

Among the BRRI released HYVs demonstrated under GoB and other projects, BRRI dhan44, BRRI dhan52, BRRI dhan72, BRRI dhan76, BRRI dhan77 and BRRI dhan87 were demonstrated during T. Aman 2022, in 220 acres of land as block demonstration which covered 25 upazilas of six districts of Barishal Division. Most of the farmers were motivated with varieties BRRI dhan76 in T. Aman, and BRRI dhan74 and BRRI dhan89 in Boro. In Aus, 9,590 kg seed in total was produced in Charbadna farm, Barishal, including 7,030 kg breeder seed. In T. Aman 2022, a total of 45,358 kg and in Boro, 54,400 kg seeds with a total of 55,470 kg breeder seeds were produced in two seasons. Moreover, 40 trainings and 20 field days were conducted by BRRI RS, Barishal during this year. Besides, a regional seminar was also arranged in BRRI RS, Barishal, related to increasing rice production in tidal ecosystem.

VARIETY DEVELOPMENT

Hybridization and pedigree nursery

Development of varieties for tidal submergence.

Forty-three new crosses were made using thirty parents, and 1,602 F1 seeds were collected to develop tidal submergence tolerant rice varieties (Table 1). Out of 27 crosses 23 were confirmed and registered in the BRRI RS, Barishal cross-list with station code BRBa195 to BRBa217. Two hundred fifty-seven progenies were selected from 24 crosses of F2 population. Moreover, 600 progenies were selected from 24 crosses of F3 population during T. Aman 2022.

Table 1. List of F₁ seeds produced in T. Aman 2022.

Cross combination	seed	Cross combination	seed
BRBa23-4-3-1-1-P1 $\times$ SV1168	5	BRBa23-4-3-1-1-P1 $\times$ BRRI dhan76	4
BRBa23-4-2-1-1-P2 $\times$ BRRI dhan52	21	BRBa23-4-3-1-1-P1 $\times$ BRRI dhan77	5
BRBa23-4-2-1-1-P2 $\times$ BRBa23-4-3-1-1-P1	17	BRBa23-4-2-1-1-P2 $\times$ BRRI dhan76	23

BRBa13-49-1-5-2 × BRRI dhan49	153	BRBa23-4-2-1-1-P2 × Shornogoda	19
BRBa13-49-1-5-2 × BRRI dhan52	235	Moulata × BRRI dhan52	15
BRBa13-49-1-5-2 × BRRI dhan76	67	Moulata × BRBa13-49-1-5-2	4
BRBa13-49-1-5-2 × BRRI dhan77	180	Kajolshail × BRRI dhan76	41
BRBa13-49-1-5-2 × BRRI dhan87	50	Kajolshail × BRRI dhan77	9
BRRI dhan52 × BRBa11-44-2-2-1	69	Balam × BRBa13-49-1-5-2	15
BRRI dhan52 × Azij IRRI	107	Balam (516) × Local variety (14)	15
BRRI dhan87 × BRBa11-44-2-2-1	13	Balam (516) × Sadamota	29
BRRI dhan87 × BRRI dhan44	11	BR23 × Mothamata	66
SV1168 × BRRI dhan52	7	BR23 × Kajolshail	31
SV1168 × BRRI dhan77	10	Mothamata × BR23	17
BRRI dhan52 × BRRI dhan76	8	Mothamata × BR9392-12-6-2-4B	5
BRRI dhan52 × BRRI dhan77	9	BR9392-12-6-2-4B × BR23	7
BRRI dhan52 × Sahi Balam	3	BR9392-12-6-2-4B × BRRI dhan52	67
BRRI dhan52 × Sorno-masuri	6	BR9392-12-6-2-4B × Balam (516)	83
BRRI dhan76 × Sahi Balam	6	BR9392-12-6-2-4B × Thormuckra	130
BRRI dhan76 × Vojan	5	Kajolshail × BR23	17
BRRI dhan76 × Hori dhan	4	Balam (516) × Sahi Balam	5
BRBa23-4-3-1-1-P1 × BRRI dhan52	9		
		Total	1,602

Breeding for favourable ecosystem

A total of 43 crosses were done using 20 parents and 5,581 F₁ seeds were obtained to develop high yielding Boro rice varieties during Boro 2022-23 (Table 2). Besides, 33 out of 39 crosses were confirmed and registered in BRRI RS, Barishal cross list with station code BRBa 218 to BRBa 250 in Boro 2022-23. A total of 1,516 plant progenies from 43 F₄ populations for generation advancement and 304 plant progenies from 5 F₆ populations selected as bulk for further evaluation in OYT. One hundred forty-five progenies were selected from 44 F₂ hybrid lines and 1,042 plant progenies from 1,551 F₆ hybrid populations were selected for further evaluation in Boro 2023-23.

YIELD TRIAL 2022-23

Observational yield trial (OYT), T. Aman 2022.

One OYT was conducted to select high yield potential as well as tidal submergence tolerant genotype (s) during T. Aman 2022. The experiment was consisted of 215 advanced breeding lines along with four checks BR23, BRRI dhan52, BRRI dhan76 and BRRI dhan77 were grown in BRRI Charbadna farm, Barishal. Based on plant height, growth duration and phenotypic acceptability, 36 genotypes were selected for further evaluation in preliminary yield trial. The highest yield (4.96 t/ha) was found in BRBa32-1-1-1-1 which is 51.57% higher than the best yielding check variety BRRI dhan77 (3.27 t/ha).

Observational yield trial (OYT) Boro 2022-23. One OYT was conducted in Charbadna farm, Barishal during Boro 2022-23. The experiment was consisted of 245 entries along with five checks, BRRI dhan58, BRRI dhan67, BRRI dhan88, BRRI dhan89 and BRRI dhan92. Based on phenotypic acceptability (4-5) and grain yield performance (4.35-6.17 t/ha) forty-nine genotypes were selected for further evaluation. Among these selected

genotypes, only six entries found out yielded (1.91-7.76%) over the highest yielding check variety BRRI dhan89 (5.73t/ha) whereas 43 entries produced higher yield over the lowest yielded check BRRI dhan88 (4.31t/ha). The genotype BRBa72-14-1-2-1-1 produced the highest yield (6.17t/ha) with a growth duration of 142 days which is six days shorter than the highest yielded check variety BRRI dhan89.

Table 2. List of F₁ seeds produced in Boro 2022-23.

Cross combination	No. of seeds	Cross combination	No. of seeds
NGR 467-2X BRRI dhan89	103	NGR 1255-1 X BRRI dhan74	130
NGR 467-2X BRRI dhan92	65	NGR 1019-1X BRRI dhan89	110
NGR 522-2X BRRI dhan74	99	NGR 1019-2XBRRI dhan74	100
NGR 224-1X BRRI dhan89	95	BRRI dhan74X BRBa1-4-9	21
NGR 325-1X BRRI dhan89	129	BRRI dhan74X BRBa3-4-7	45
NGR 1255-1X BRRI dhan84	25	BRRI dhan74X BRBa2-5-3	21
NGR 758-1X BRRI dhan84	98	BRRI dhan89X NGR 730-1	101
BRBa1-4-9 xBRRI dhan74	195	BRRI dhan89X NGR 1025-1	75
BRBa3-4-7 X BRRI dhan74	269	BRRI dhan89X NGR 1019-1	85
BRBa2-5-3 x BRRI dhan74	296	NGR994-1X BRRI dhan92	275
BRBa1-4-9X BRRI dhan84	155	NGR 730-1X BRRI dhan92	271
BRBa3-4-7X BRRI dhan84	199	NGR 325-1X BRRI dhan92	165
BRBa2-5-3X BRRI dhan84	165	NGR 758-1XBRRI dhan89	177
NGR 1394-2X BRRI dhan74	95	NGR 1210-3X BRRI dhan89	75
NGR 1394-2X BRRI dhan92	209	BRRI dhan97 × BRRI dhan89	77
BRRI dhan84X NGR 224-1	120	BRRI dhan97 X NGR 1255-1	21
BRRI dhan84X NGR 325-1	98	NGR 1025-1X BRRI dhan89	99
NGR 736-1X BRRI dhan89	238	NGR 730-1X BRRI dhan74	92
NGR 736-1X BRRI dhan92	357	NGR 527-1X BRRI dhan89	70
NGR 1331-1X BRRI dhan74	241	NGR 1019-2XBRRI dhan89	108
NGR 1331-1X BRRI dhan92	205	NGR 1019-2 X BRRI dhan92	176
NGR994-1 X BRRI dhan74	128	Total 5581	

Preliminary yield trial (PYT)

One PYT was conducted during T. Aman 2022 which consisted with 11 advanced breeding lines along with five checks, BRRI dhan23, BRRI dhan52, BRRI dhan72, BRRI dhan76, and BRRI dhan87 were evaluated at Charbadna farm of BRRI RS, Barishal.

Among the tested materials growth duration was ranged from 118 to 133 days. Shortest plant height was observed in BRBa25-3-9-1-1 (105 cm) while the longest plant height was found in BRBa22-5-B-2-1 (123 cm). Effective tillers number was ranged from 7 to 9. Four entries were selected comparing with better yielding check variety BR23 (3.22 t/ha). The yield range of the tested entries found 2.48 to 3.49 t/ha. The highest yield was obtained from BRBa27-1-3-1-3 (3.49 t/ha) followed by BRBa22-5-B-2-1 (3.48 t/ha) and BRBa22-1-2-2-2 (3.33 t/ha) and the lowest yield was obtained from BRBa27-4-B-1-2-P2 (3.17 t/ha). Due to natural calamities like high tide effect during maximum tillering stage and Chitrang prior to harvesting period caused lower yield of the advanced lines. The selected four entries will be tested again in T. Aman 2023.

One PYT was conducted during Boro 2022-23. The experiment consisting of 15 advanced breeding lines along with four checks, BRRI dhan58, BRRI dhan88, BRRI dhan89 and BRRI dhan92 were evaluated at Charbadna farm of BRRI RS, Barishal. Among the tested materials, BRBa24-2-4-1-1-B (7.49 t/ha), BRBa27-1-3-3-1-1-B (7.26 t/ha), BRBa24-8-2-1-1-2-1 (7.22 t/ha), BRBa24-9-2-1-1-1-B (7.15 t/ha) and BRBa22-3-2-1-1-2-1 (7.04 t/ha), were selected comparing with the highest yielded check variety BRRI dhan89 (6.97 t/ha). The growth duration range of the tested entries was 136-152 days whereas it was found 144 days in BRRI dhan89. The plant height varied in the tested entries was 94-129 cm whereas it was 102 cm for BRRI dhan89.

Regional yield trial (RYT)-T. Aus 2022

RYT-2 for Non-saline tidal condition comprised seven entries along with three checks BRRI dhan27, BRRI dhan48 and BRRI dhan98 were grown at Charbadna farm of BRRI RS, Barishal. None of the tested entries outyielded the checks. The yield range of the tested entries was 3.43-3.76 t/ha whereas the yield range of the checks was 3.89-

5.18 t/ha. The growth duration range of the tested genotypes varied from 107-111 days whereas it was found for check varieties from 103-104 days.

Regional yield trial (RYT)-T Aman 2022

A RYT for Zinc Enriched Rice comprising of four entries along with two checks BRRI dhan72 and BRRI dhan87 was grown at Charbadna farm of BRRI RS, Barishal. None of the tested entries outyielded the checks. The yield range of the tested entries was 3.44-3.74 t/ha whereas the yield range of the checks was 4.17-4.21 t/ha. Most of the tested entries were severely affected by rats and birds at vegetative and reproductive stages respectively. The growth duration range of the tested genotypes varied from 117-120 days whereas it was found for check varieties from 125 to 128 days.

A RYT for Tall comprising five entries along with a check BRRI dhan91 was grown at Charbadna farm of BRRI RS, Barishal. The entry BR9392-12-6-2-4B (3.62 t/ha) outyielded the check BRRI dhan91 (1.96 t/ha). The growth duration of the selected genotype was 174 days which was 11 days longer than the check variety BRRI dhan91. Less yield was found due to acute lodging at reproductive stage after Cyclone Chitrang.

A RYT for Short Slender comprising of four entries along with a check BRRI dhan49 was grown at Charbadna farm of BRRI RS, Barishal. None of the tested entries found better comparing with check variety BRRI dhan49 (3.26 t/ha). The growth duration of the tested genotype varied from 105 to 122 days whereas the growth duration of the check variety was 133 days. Lower yield was caused due to severe infestation of rats and birds at vegetative and reproductive stages respectively. Moreover, the trial was flooded by two times high tide and remained submerged for more than a week in every time.

A RYT for Long Slender comprising of seven entries along with two checks BRRI dhan87 and BRRI dhan94 was grown at Charbadna farm of BRRI RS, Barishal. The genotype BR9396-6-2-2B (3.50 t/ha) outyielded the highest yielded check variety BRRI dhan94 (2.99 t/ha). The growth duration of the tested genotypes varied from 133 to

151 days whereas the growth duration of the check variety was ranged from 126-136 days. Lower yield was caused due to severe infestation of rats and birds at vegetative and reproductive stages respectively. Moreover, the trial was flooded by two times high tide and remained submerged for more than a week in every time.

Regional yield trial (RYT)-Boro 2022-23

A RYT for Favourable Boro (long duration) comprising eight entries along with the three checks BRRI dhan81, BRRI dhan89 and BRRI dhan92 was grown at Charbadna farm of BRRI RS, Barishal. The genotype BR11318-5R-84 produced the highest yield (7.49 t/ha) that is 1.12% higher than the highest yielded check variety BRRI dhan92 (7.41 t/ha). The growth duration of the positive yielded genotype was similar with the highest yielded check variety (147 days).

A RYT for Favourable Boro (short duration) rice was conducted at Charbadna farm of BRRI RS, Barishal during Boro 2022-23. The trial was consisted with eleven entries along with two check varieties BRRI dhan28 and BRRI dhan96. The yield range was found 5.06-6.55t/ha. whereas growth duration range was found 130-140 days. All the tested entries showed higher yield over the check varieties except two i.e; BR11637-5R-140(4.54 t/ha) and BR12208-5R-274(5.06 t/ha). The highest yield (6.55 t/ha) was obtained from both BR11900-5R-24 and BR11903-5R-56 with a yield advantage of 27.75% over the highest yielded check BRRI dhan 96(5.13 t/ha).

A RYT for favourable Boro (medium duration) consisted of 11 genotypes along with two checks viz BRRI dhan81 and BRRI dhan89 were evaluated at Charbadna farm of BRRI RS, Barishal. The yield range among the tested entries was varied from 5.34 to 6.46 t/ha. None of the tested entries was found out yielded over the highest yielded Check variety BRRI dhan89 (7.17 t/ha). Three entries were found outyielded the second highest yielding check variety BRRI dhan81(5.45 t/ha).

A RYT for Favourable Boro (Extra long slender) consisted of nine genotypes along with three checks viz BRRI dhan50, BRRI dhan63 and BRRI dhan86 was evaluated at Charbadna farm of BRRI RS,

Barishal. Three entries were found outyielded the highest yielded check BRRI dhan63 (6.48 t/ha). Among the tested entries BR9945-5R-21 produced the highest yield (7.18 t/ha) with a growth duration of 142 days.

In RYT for Favourable Boro (Bio), seven entries along with two checks BRRI dhan86 and BRRI dhan96 were tested at Charbadna farm, of BRRI RS, Barishal, during Boro 2022-23. The growth duration range was 132-138 days and the yield range was 3.80-5.20 t/ha. Three tested entries outyielded the highest yielded check variety BRRI dhan96 (4.60 t/ha) with a yield advantage of 3.98 to 14.03%. The test line BR(Bio)-130281-AC24-1-2 produced the highest yield (5.2 t/ha) with a growth duration of 137 days over the highest yielded check BRRI dhan96 (4.60 t/ha, 131 days).

A RYT for Zirashail, consisting of seven genotypes along with two checks Zirashail and BRRI dhan28 was tested at BRRI Charbadna farm, Barishal, during Boro 2022-23. The average yield range of the tested entries was 5.46-6.99t/ha. Four entries viz BRH-13-7-9-3-2B (6.99t/ha), BRH-9-3-14-2B (6.47 t/ha), BRH-13-9-5-3B (6.19 t/ha) and BR10247-4-7-4B (5.93 t/ha) were found out yielded the highest yielded check variety Zirashail (5.69 t/ha) with a yield advantage of 4.30-22.86%. The growth duration range of the tested entries was observed 136-145 days whereas it was found in the checks 135-136 days.

A RYT#1 for DRR_BB, Twenty-two lines along with four standard checks BRRI dhan58, BRRI dhan89, BRRI dhan92 and BRRI dhan101 were tested at BRRI Charbadna farm, Barishal, during Boro 2022-23. The average yield range of the tested entries was 4.58-7.54 t/ha. The test line BR (path) 13800-BC3-109-10 (7.54 t/ha) found to be out yielded the highest yielded check BRRI dhan89 (7.45 t/ha) with a yield advantage of 1.21% having five days shorter growth duration (139 days) than the checks except BRRI dhan58 (136 days).

A RYT#2 for DRR_Blast and BB consisting of 12 lines along with two checks BRRI dhan89 and BRRI dhan92 were tested at BRRI Charbadna farm, Barishal, during Boro 2022-23. The average yield range of the tested entries were 6.71-7.75t/ha. Among the tested entries four genotypes i.e., BR

(path)13800-BC3-8-5(7.70t/ha),BR(path)13800-BC3-134-8 (7.75t/ha), BR(path)13800-BC3-8-11 (7.62t/ha) and BR(path)13800-BC3-224-44(7.72t/ha) produced higher yield over the highest yielded check BRRI dhan89 (7.49t/ha) with a yield advantage of 1.70-3.48%. The growth duration range of the tested entries was 146-151 days which was similar to the checks.

A RYT_PQR consisting of 26 lines along with six checks (BRRI dhan50, BRRI dhan63, BRRI dhan81, BRRI dhan104, Tepiboro, Rataboro) was conducted at Charbadna farm, Barishal, during Boro 2022-23. The average yield range of the tested entries were 2.3-6.9(t/ha) whereas the yield range of the check varieties varies from 4.5 to 6.7 t/ha. One entry i.e., Basmati (1230) produced higher yield (6.9 t/ha) over the highest yielded check variety BRRI dhan63 (6.7 t/ha) with a growth duration of 142 days which is similar to the check variety.

In RYT for Zinc Enriched Rice, six entries along with three checks BRRI dhan29, BRRI dhan74 and BRRI dhan84 were tested at BRRI Charbadna farm, Barishal, during Boro 2022-23. None of the tested entries outyielded the highest yielded check variety BRRI dhan29 (7.89 t/ha) whereas all the tested lines found to be outyielded the second highest yielded check variety BRRI dhan74 (6.14 t/ha) with a yield advantage of 0.74 to 28.17%. The growth duration range of the tested entries was 142-145 days.

A RYT for Antioxidant (medium duration) rich black rice consisting of ten entries along with two checks viz Indonesian black rice and BRRI dhan88 was conducted at Charbadna farm during Boro 2022-23. The yield range of the tested entries was varied from 5.91 t/ha to 6.60 t/ha. Among the tested entries four genotypes viz BR12839-4R-93 (6.41 t/ha), BR12839-4R-47-1(6.56 t/ha), BR12839-4R-90-1(6.60 t/ha) and BR12839-4R-48-1(6.34 t/ha) performed better than the highest yielded check variety BRRI dhan88 (6.33 t/ha) with a yield advantage of 0.24-4.26%. The growth duration range of the tested entries was 140-146 days where as it was found in checks as 137-141 days.

Another RYT for Antioxidant (Short duration) rich black rice consisting of four entries along

with a check viz BRRI dhan84 was conducted at Charbadna farm during Boro 2022-23. The yield range of the tested entries was varied from 5.17t/ha to 5.86 t/ha. None of the tested entries out yielded the check variety BRRI dhan88 (5.88t/ha). The growth duration range of the tested entries was 139-145 days whereas it was found in check as 131 days.

RYT_FBR Barishal -2. Twenty-two entries along with two checks BRRI dhan88 and BRRI dhan89 were evaluated at Sagardi and Charbadna farm of the BRRI regional station, Barishal during Boro, 2022-23. The plant height was ranged at Sagardi from 98-108 cm whereas it was found for the tested entries from 91-104 cm at Charbadna farm. The average growth duration of the tested entries were varied to 136-150 days at Sagardi farm and 134-143 days at Charbadna farm respectively. From an average yield data of the two locations, six entries viz NGR 749-2 (9.22 t/ha), NGR 467-2 (9.15 t/ha), NGR750-1 (9.64 t/ha), NGR796-2 (9.47 t/ha), NGR 1308-2 (9.34 t/ha) and NGR 1161-3 (9.38 t/ha) produced more yield compared to the highest yielding check variety BRRI dhan89 (9.11 t/ha) (Table 3).

RYT_FBR Barishal-1. Eleven entries along with two checks BRRI dhan88 and BRRI dhan89 were evaluated in 12 locations of the BRRI regional stations and BRRI HQ during Boro 2022-23. Among the tested materials, the plant height ranged from 80.73 cm of NGR 994-1 at Cumilla to 105.27 cm of NGR745-2 at Rajshahi. NGR 416-1 took the shortest period (134 days) at Satkhira to get matured while NGR 270-3 took the longest period (160 days) at Rangpur to get matured (location wise). The highest average grain yield (11.35 t/ha) was found in NGR 522-2 at Bhanga and the lowest average grain yield (4.70t/ha) was found in NGR416-1 at Gazipur. The check yields of BRRI dhan 88 ranged from 4.73 t/ha at Gazipur to 8.52 t/ha at Bhanga, whereas another check variety BRRI dhan89 produced 5.37 t/ha at Gazipur to 10.36 t/ha at Bhanga. There was significant yield variation found among 12 test locations. On average, the check variety BRRI dhan89 (7.76 t/ha) produced the highest yield over the locations and all of the tested entries showed 7.02 to 16.34% higher yield than the check variety BRRI dhan 88 (6.62 t/ha) (Table 4).

Table 3. Yield and ancillary characters of RYT_FBR (Barishal)-2 genotypes, Boro 2022-23.

Designation	Average PH (cm)	Average GD (day)	Average Yield (t/ha)
NGR 991-2	96.13	138.83	8.55
NGR 696-1	96.30	138.00	7.84
NGR 528-1	94.50	140.50	8.50
NGR 1210-3	95.90	140.50	8.70
NGR 223-2	95.97	141.50	8.42
NGR 566-2	97.53	143.50	8.48
NGR 710-2	96.80	141.67	8.22
NGR 749-2	96.90	142.50	9.22
NGR 521-1	96.67	139.00	8.60
NGR 521-2	95.50	138.33	8.91
NGR 522-1	97.07	138.83	8.90
NGR 418-1	96.90	136.00	8.01
NGR 467-2	96.03	145.83	9.15
NGR 750-1	104.27	143.83	9.64
NGR 796-2	98.60	142.33	9.47
NGR 1161-3	97.93	142.50	8.84
NGR 1308-2	96.60	139.83	9.34
NGR 1019-2	103.63	143.00	8.17
NGR 1161-2	97.73	143.67	8.21
NGR 1161-3	96.13	141.67	9.38
BRRI dhan88	95.20	134.50	7.38
BRRI dhan89	106.80	149.67	9.11
LSD at 0.05	4.64	6.89	0.96
CV (%)	2.91	3.01	6.81

L1= BRRI RS, Barishal Sagardi farm; L2= BRRI RS, Barishal Charbadna farm

Table 4. Yield and ancillary characters of RYT_FBR (Barishal)-1 genotypes, Boro 2022-2023.

Designation	Average PH (cm)	Average GD (day)	Yield (t/ha)		
			Lowest (location)	Highest (location)	Avg.
NGR 522-2	95.44	148	5.40 (Gazipur)	11.35 (Bhanga)	7.52
NGR 270-3	95.34	148	5.19 (Gazipur)	10.72 (Bhanga)	7.37
NGR 418-1	94.59	147	5.38 (Gazipur)	9.83 (Bhanga)	7.34
NGR 416-1	95.04	147	4.70 (Gazipur)	9.26 (Bhanga)	7.30
NGR 968-1	95.72	146	5.00 (Gazipur)	10.86 (Bhanga)	7.52
NGR 994-1	95.46	149	5.62 (Gazipur)	10.52 (Bhanga)	7.70
NGR 745-2	94.47	150	5.63 (Gazipur)	9.97 (Barishal)	7.65
NGR 590-2	94.38	148	5.30 (Gazipur)	9.88 (Bhanga)	7.25
NGR 710-1	94.49	148	4.90 (Gazipur)	8.94 (Bhanga)	7.09
BRRI dhan88 (ck)	91.10	141	4.73 (Gazipur)	8.52 (Bhanga)	6.62
BRRI dhan89 (ck)	104.21	153	5.37 (Gazipur)	10.36 (Bhanga)	7.76
LSD at 0.05	5.08	4.83			0.53
CV (%)	3.20	1.96			4.33

L1= BRRI RS, Barishal; L2= BRRI RS, Gopalganj; L3= BRRI HQ, Gazipur; L4= BRRI RS, Habiganj; L5= BRRI RS, Satkhira; L6= BRRI RS, Sonagazi; L7= BRRI RS, Cumilla; L8= BRRI RS, Sirajganj; L9= BRRI RS, Rajshahi; L10= BRRI RS, Kustia; L11= BRRI RS, Rangpur; L12 =Bhanga

Advanced yield trial (AYT)

AYT-1, T. Aman 2022. Twelve entries along with four checks BR23, BRRI dhan52, BRRI dhan72 and BRRI dhan76 were grown at Charbadna farm, BRRI RS, Barishal. Growth duration of the tested entries was ranged from 124 days to 140 days. Six entries produced higher yield over the highest yielded check BRRI dhan72 (3.70 t/ha). Due to natural calamities like high tide effect during maximum tillering stage and cyclone Chitrang prior to harvesting period causing lower yield of the advanced lines. The experiment will be tested again in T. Aman 2023.

AYT-2, T. Aman 2022. Twenty entries along with four checks BR23, BRRI dhan52, BRRI dhan76 and BRRI dhan77 were grown at Charbadna farm, BRRI RS, Barishal during T. Aman 2022. Growth duration of the tested entries ranged from 119 days to 132 days. None of the entries found out yielded over the highest yielded check BRRI dhan23 (3.34t/ha). But only six entries produced higher yield over

the lowest yielded check BRRI dhan76 (2.92 t/ha). Due to natural calamities like high tide effect during maximum tillering stage and cyclone Chitrang prior to harvesting period causing lower yield of the advanced lines. The experiment will be retested in T. Aman 2023.

AYT-3, T. Aman 2022. Fourteen entries along with five checks BR23, BRRI dhan52, BRRI dhan72, BRRI dhan76 and BRRI dhan87 were grown at Charbadna farm, BRRI RS, Barishal during T. Aman 2022. Growth duration of the tested entries was ranged from 114 days to 133 days. The entry SV1787 (3.81t/ha) outyielded the highest yielded check BRRI dhan87 (3.64t/ha) and another entry SV1104 produced higher yield (3.32 t/ha) than BRRI dhan52 (3.16 t/ha). Due to natural calamities like high tide effect during maximum tillering stage and cyclone Chitrang prior to harvesting period causing lower yield of the advanced lines. The selected two entries of the experiment will be retested in T. Aman 2023.

AYT-1, Boro 2022-23. One advanced yield trial of favourable Boro rice consisted of 13 entries along with three checks BRRI dhan88, BRRI dhan89 and BRRI dhan92 was conducted at Sagordi Farm of BRRI RS, Barishal. The growth duration of the tested materials was ranged from 138 to 141 days whereas the growth duration of the check varieties ranged from 134 (BRRI dhan88) to 143 days (BRRI dhan89). The plant height of the tested entries was varied from 111 to 115cm. The yield range was 8.11t/ha (NGR 1230-1) to 5.45t/ha (NGR 1203-1). None of the tested entries outyielded the check varieties. Yield loss of all the tested entries occurred due to severe infestation of BLB causing pathogen.

AYT-2, Boro 2022-23 comprising of 18 entries along with three checks BRRI dhan88, BRRI dhan89 and BRRI dhan92 was grown at Sagardi farm, BRRI RS, Barishal. Among the tested entries, NGR472-2 (9.00t/ha), NGR398-1 (8.92 t/ha), NGR350-2(8.91t/ha), NGR314-2(8.85t/ha), NGR325-1(8.86t/ha) produced higher yield than the highest yielded check BRRI dhan89 (8.83t/ha) and yield advantage was ranged from 0.16 to 1.95%. Growth duration of the tested entries ranged from 132 to 140 days whereas, in BRRI dhan89 it was 143days. Plant height range of the tested entries was 99 to 103cm whereas, in BRRI dhan89 it was 108cm.

AYT-3, Boro 2022-23 comprising of 18 entries along with three checks BRRI dhan88, BRRI dhan89 and BRRI dhan92 was grown at Sagardi farm, BRRI RS, Barishal RS. Among the tested entries, NGR745-3(9.35t/ha), NGR736-1(8.47 t/ha), NGR736-3(8.46t/ha), NGR1256-1(8.33t/ha), NGR721-1(8.24t/ha) produced higher yield than the highest yielded check BRRI dhan92 (8.22t/ha) and yield advantage was ranged from 0.3 to 13.8%. Growth duration of the tested entries was ranged from 135 to 143 days whereas in BRRI dhan92 it was 142 days. Plant height range of the tested entries was 101 to 114 cm whereas, in BRRI dhan92 it was 115 cm.

AYT-4, Boro 2022-23 comprising of 17 entries along with four checks BRRI dhan58, BRRI dhan88, BRRI dhan89 and BRRI dhan92 was grown at Charbadna farm, BRRI RS, Barishal.

Among the tested entries, BRBa21-13-2-2-1(8.30t/ha), BRBa23-11-5-2-1-P2 (8.11t/ha), BRBa21-4-1-2-1-P2 (7.77t/ha), BRBa26-1-1-1-2 (7.48t/ha) and BRBa23-5-3-3-5 (7.17 t/ha), produced the higher yield than the highest yielded check BRRI dhan89 (7.15t/ha) and yield advantage was ranged from 0.28 to 16.08%. Growth duration of the tested entries was ranged from 135 to 150 days whereas, in BRRI dhan89 it was 143days. Plant height range of the tested entries was 98 to 121cm whereas, in BRRI dhan89 it was 103cm.

International network for genetic evaluation of rice (INGER) and IRLON

Aman 2022

Set-1. A total of 17 entries along with two checks BRRI dhan87 and Kumragoir were grown at BRRI Charbadna farm, Barishal during T. Aman 2022. None of the tested entries found out yielded over the highest yielded check BRRI dhan87 (4.52 t/ha). Three entries produced more yield over the lowest yielded check Kumragoir (3.87 t/ha). The yield range of the tested entries was ranged from 2.37 to 4.38 t/ha and growth duration was varied from 111-132 days.

Set-17. A total of 31 entries along with three checks BRRI dhan75, BRRI dhan52 and T-27A were grown at BRRI Charbadna farm, Barishal during T. Aman 2022. Five entries were found out yielded the highest yielded check BRRI dhan75 (4.03 t/ha). The yield range of the tested entries varied from 0.91 to 4.81t/ha with a growth duration range of 117-136 days. The test entry SV0057 produced the highest yield (4.81 t/ha) with a growth duration of 123 days which is 19.35% higher yield and five days longer than the check variety BRRI dhan75.

Set-19. A total of 60 entries along with two checks BRRI dhan52 and BRRI dhan101 were grown at BRRI Charbadna farm, Barishal during T. Aman 2022. Three entries found outyielded the highest yielded check BRRI dhan101 (5.30 t/ha). The yield range of the tested entries varied from 0.74 to 6.62t/ha with a growth duration range of 111 -135 days. The test entry SV0015 produced the highest yield (6.62 t/ha) with a growth duration of 123 days which is 24.91% higher yield and 16 days shorter than the check variety BRRI dhan101.

Set-26. A total of 55 entries along with two checks BRRI dhan33 and BRRI dhan34 were grown at BRRI Charbadna farm, Barishal during T. Aman 2022. Five entries were found out yielded over the highest yielded check BRRI dhan33 (4.67 t/ha). The yield range of the tested entries varied from 0.39 to 5.09 t/ha with a growth duration range of 95 to 141 days. The tested entry SV0016 produced the highest yield (5.09 t/ha) with a growth duration of 124 days which is 10% higher yield with a similar growth duration to the check BRRI dhan101.

Boro 2022-23

A total of 40 entries along with five checks BRRI dhan58, BRRI dhan88, BRRI dhan89, BRRI dhan92 and BRRI dhan106 were grown at BRRI Charbadna farm, Barishal during Boro 2022-23. The data of ancilliary characteristics of INGER materials were recorded, the plant height was between 79 cm to 101cm, the panicles per hill were ranged between 8-24, the growth durations were ranged between 132 to 157 days. None of the materials found outyielded over the highest yielded check variety BRRI dhan89 (8.56t/ha). Sixteen genotypes were found outyielded over the lowest yielding check variety BRRI dhan88 (6.05t/ha). Among the tested entries SV0185 (7.46t/ha) produced the highest yield with a growth duration of 146 days.

Characterization and use of local germplasms

A total of 370 local Aman germplasms were grown during T. Aman 2022 with six-line in each plot for characterization, utilization and maintenance. Ten local germplasms viz, Kajolshail, Moulata, Shornogoda, Sahi Balam, Sadamota, Balam, Vojan, Horidhan, Thormucra, Shorni-masuri and Mothamota were utilized in hybridization in breeding programme for developing tidal submergence tolerant rice variety. Seeds were harvested and preserved for further evaluation and utilization.

Performance study of the released hybrid rice varieties

Boro 2022-23

Twenty-one hybrids of different companies and six checks viz BRRI dhan74, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI hybrid dhan3 and BRRI hybrid dhan5 were evaluated at Charbadna farm, BRRI RS, Barishal during Boro 2022-23. The yield range of the tested hybrids varied to 5.45 t/ha to 7.22t/ha whereas it was found 5.21t/ha to 6.80 t/ha for check varieties. Only two hybrids, ACI hybrid dhan-6 (6.84t/ha) and hybrid dhan HQ-950 (7.22 t/ha) were found higher yielded over the highest yielded check variety BRRI hybrid dhan5 (6.80t/ha) with similar growth duration. The growth duration range of the tested hybrid was 134-145 days whereas for check varieties it was 130-153 days.

PEST MANAGEMENT

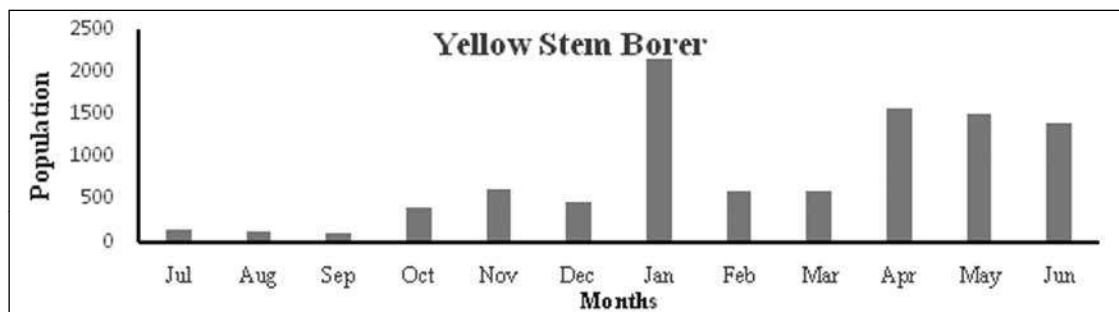
Incidence of Insect Pests and Natural Enemies in light trap

Data were collected from July 2022 to June 2023 at Sagordi farm, BRRI RS, Barishal. Light trap was set up at east side of Sagardi farm in BRRI RS, Barishal. Everyday light trap was switched on in the evening and switched off at dawn. After that dead insects were collected from the light trap, sorted and recorded manually. Appearance of insect pest was found lower than previous reporting year. The highest yellow stem borer (YSB) followed by green leafhopper (GLH), white leafhopper (WLH), and brown planthopper (BPH) was recorded in the reporting year. In case of natural enemy the highest staphylinid beetle (STPB) followed by green miridbug (GMB) and earwig (EW) was observed. Insect pest was trapped higher in the reporting year than natural enemy (Table 5).

Table 5. Insect pests and natural enemy population in the period of 22 July to 23 June.

Insect pest	Population	Natural enemy	Population
GLH	6870	CDB	1174
WLH	1619	LBB	887
ZLH	1788	STPD	6890
BPH	3088	GMB	4933
WBPH	2032	Dam. Fly	576
YSB	9733	SPD	312
DHB	454	EW	1280
RLF	1205	TB	1063
CW	153	Total	17115
SHG	699		
LHG	46		
LHC	177		
MC	353		
RB	832		
Total	29049		

The first peak of insect pest infestation was observed in October, November, December 2022 and January 2023 and the second peak in April, May and June 2023. Natural enemy abundance was found higher in January and February 2023 (Fig. 1). Although insect pest abundance was found throughout the reporting year but higher insect pest was observed in Boro season compared to T. Aman season.



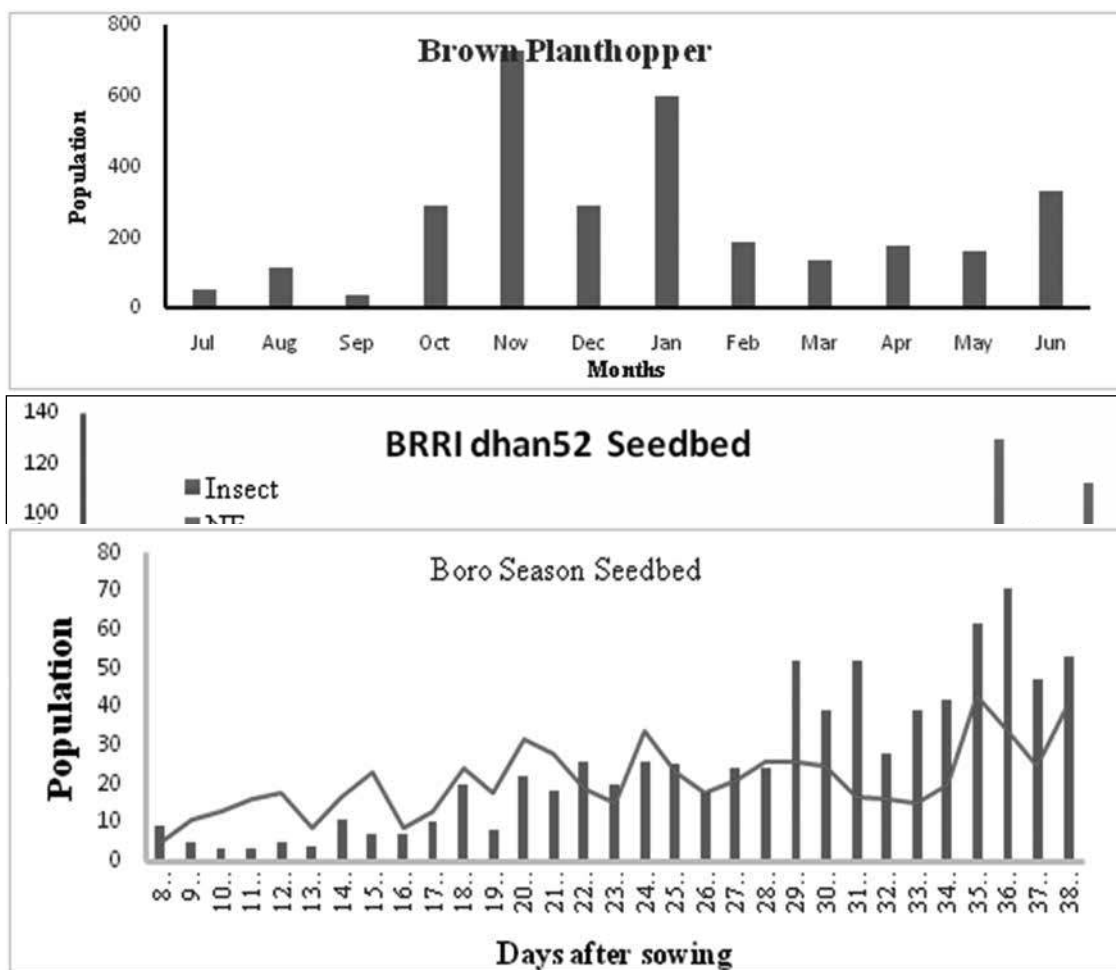


Fig. 5. Insect pest and natural enemy scenario of Boro variety BRRI dhan74.

Effect of cartap on grain yield of rice

Cartap, an insecticide branded as Suntap of McDonald company was used in this experiment to study the effect of application frequency on rice grain yield. Five treatments (T1: application of insecticide three times, T2: application of insecticide two times, T3: application of insecticide once, T4: sweeping at seven days interval from 15 DAT to panicle initiation, T5: without insecticide

application or sweeping) following RCB design with three replications. The test variety was BRRI dhan74 and unit plot size was 20 m². The results showed that the highest yield (7.14 t/ha) was found in T2 treatment followed by T4, T1, T5, T3 treatments (Table 6). No significant difference was found among the grain yield of different treatments. Sweeping at seven days interval was found as a satisfactory insect control measure without any insecticide application.

Table 6. Effect of cartap application frequency on the grain yield of rice, Barishal. Boro 2022-23.

Treatment	Yield (t/ha)
T1= Three times use of insecticide	6.93
T2: Two times use of insecticide	7.14
T3: One time use of insecticide	6.76
T4: Sweeping at seven days interval from 15 DAT to panicle initiation	6.98
T5: Control (without insecticide/sweeping)	6.91
CV (%)	3.66

DISEASE MANAGEMENT**Survey report of Barishal (Boro 2022-23)**

Average brown spot incidence (20.9%) was predominant in Boro 2022 at Barishal followed by

bacterial blight and sheath blight and their incidence were 20.9% and 15.9% respectively (Table 7). The average severity score was 2.5, 2.8 and 4.0 in BLB, brown spot and sheath blight respectively (Table 7).

Table 7. Disease incidence and severity in different varieties in Barishal region during Boro 2022-23.

Upazila/ variety	BB		ShB		Blast		BS		ShR	
	In	Sev	In	Sev	In	Sev	In	Sev	In	Sev
Sadar:										
BRRI dhan74, BRRI dhan100,	0	0	11	6	0	0	16	4	2	10
Babugonj:										
BRRI dhan74, BRRI dhan89 BRRI dhan89, BRRI dhan29	23.75	3.5	15	4	56.7	3.0			5.0	3.0
Ujirpur:										
BRRI dhan89, BRRI dhan74 Hybrid sathi, BRRI dhan29, Hybrid unknown	38.9	3.9	27.4	5.0	4.8	3.1	35.2	3.1		
Mean	20.9	2.5	15.9	4.0	1.6	1.0	33.3	2.8	2.0	2.7

Disease survey was also carried out at two farms of BRRI RS, Barishal. It was observed that there was no bacterial blight and panicle blast infection at both farms of BRRI RS, Barishal. Sheath blight and brown spot was observed most frequently at

both the farms and both diseases were observed slightly higher at Charbodna farm compared to Sagordi farm. The highest brown spot incidence (8.5, 7.5%) and severity (2.3, 2) was observed at Char Badna and Sagordi farms, respectively. Sheath

blight incidence was observed (5.6, 5) and severity (3.3) recorded at Char Badna and Sagordi farms, respectively (Table 7).

Evaluation of biopesticides for management of leaf folder and stem borer in field condition

This preliminary experiment was set up at Charbodna Farm, Barishal based on net house test at BRRI Gazipur trial. Four treatments (T1= *Bacillus thurigiensis* @25 mL/L, T2= *Serattia* sp.@25 mL/L, T3=Insecticide @0.5 mL/L, and T4=control) were used for controlling stem borer. BRRI dhan74 was used for this trial. An area of 1 m² was covered with mosquito net for each trial at maximum tillering stage when stem borer attack was observed in field. Twenty stem borer moth/plot was inoculated for 1 m² area. Each trial was replicated thrice. Both Entomo-

pathogenic bacterial biopesticide was formulated at Plant Pathology Laboratory and sprayed the plants two days after inoculation with stem borer. The entomopathogenic bacterial biopesticide was sprayed @25ml/L H₂O. Insecticide @0.5ml/L H₂O (Belt Expert, Bayer) was used at the same time when entomopathogenic bacterial biopesticide was sprayed. Control plots were sprayed with water only. After 14 days of treatment application data were recorded on dead heart/hill, white head/hill and yield/hill. It was observed that the highest dead heart was observed in control (T3) treatment compared to the other treatments (Fig. 6). The highest yield was recorded in plots where insecticide (T4) was sprayed followed by T1 where *Bacillus thurigiensis* was sprayed (Fig 6). This experiment will be further evaluated to get more conclusive result.

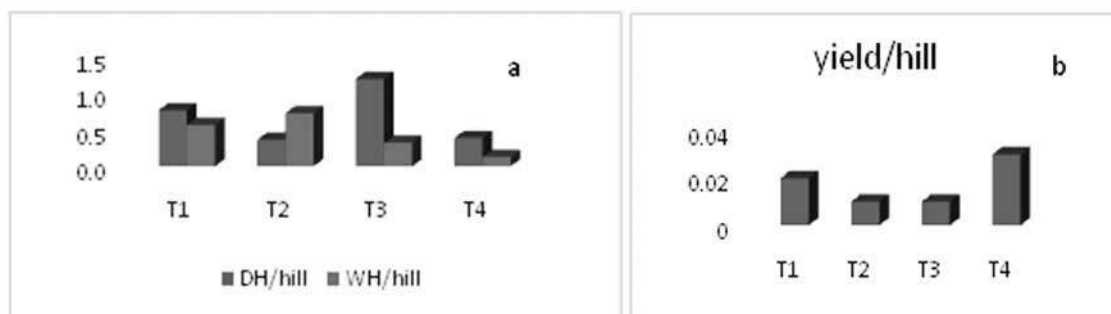


Fig. 6. Scenario of dead heart, white head formation per hill (a) and yield/hill (b) after application of entomopathogenic bacterial biopesticide for stem borer management.

Bioaccumulation and detoxification of As (III) and disease management by *Achromobacter xylosoxidans* and increase rice yield in As-contaminated soil

Achromobacter xylosoxidans is a bacterium that significantly contribute to arsenic detoxification, accumulation and immobilization approach that contribute in designing a green in situ bioremediation. Two experiments were set up for conducting this trial. One experiment was carried out at Bhanga, Regional Station, BRRI whereas other experiment was set up in farmers' field, at Nagarkanda, Bhanga in Boro 2022-23. The soil samples of both locations were assumed contaminated with As. Bacterial biopesticide with *Achromobacter xylosoxidans* was developed and

formulated at Plant Pathology Laboratory, BRRI, Gazipur. *Achromobacter xylosoxidans* was applied @20 mL/L H₂O at seedling stage two weeks after transplant. BRRI dhan58 was used at BRRI RS, Bhanga, whereas, BRRI dhan92 was used at farmers field, Nagarkanda, Faridpur. Soil sample was collected from both fields for analysis for arsenic contamination before and after application treatment. At harvest, plant height (PH), total tiller/hill (TT/hill), panicle/hill and yield contributing characters were recorded.

From the results it was observed that plant height, total tiller, panicle length/hill and effective tiller/hill was increased in treated plot compared to control plot (Fig. 7).

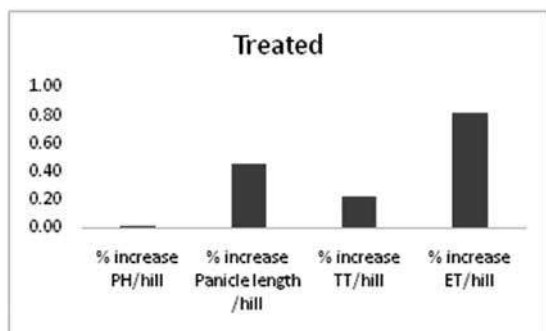


Fig. 7. Effect of *Achromobacter xylosoxidans* application on different parameters of BRRI dhan58, BRRI RS, Bhanga .

Moreover, yield increased (0.5 t/ha) in treated plots compared to control plots which was gained due to increased filled grain/tiller, decreased unfilled grain/tiller and increased the grain weight in treated plots compared to the control plots (Fig. 8).

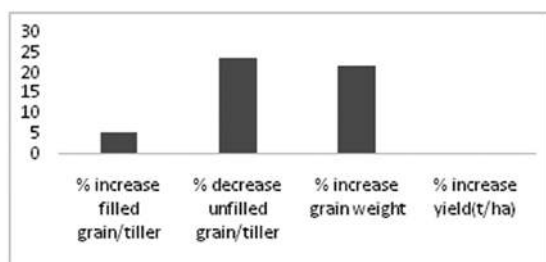


Fig. 8. Effect of application of *Achromobacter xylosoxidans* on different yield contributing characters of BRRI dhan58 at Bhanga regional station, BRRI.

In farmers' field at Bhanga, it was observed that yield increased (0.75 t/ha) in treated plots compared to control plots of BRRI dhan92 (Fig. 9).

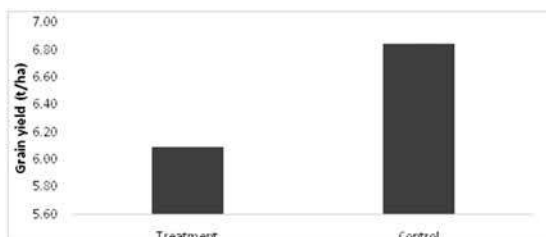


Fig. 9. Effect of application of *Achromobacter xylosoxidans* on grain yield of BRRI dhan92 at farmers' field, Nagarkanda, Faridpur.

Effect of plant extract mediated silver nano particle on bakanae disease management

This experiment was conducted in net house of Plant Pathology Division, BRRI, Gazipur. Pre-germinated seeds of susceptible variety BRRI dhan92 was inoculated with *Fusarium proliferatum* (10^6 conidia/mL). Silver nitrate (AgNO_3) (1 mM) was used along with neem leaf mediated silver nano particle to observe the effect of AgNO_3 on bakanae disease development. Neem leaf mediated silver nano particle was prepared at Islamic University, Kushtia. Inoculation method with silver nano particle using neem leaf extract and AgNO_3 treatment was lasting for overnight. Fifty seedlings/ tray and ten seedlings/rows were transplanted for each treatment. Data were recorded on % infected and % healthy seedlings after 14 days of nano treatment. Plant height and root length was also noted for comparison with inoculated versus neem nano treatment and inoculated versus AgNO_3 treatment. Moreover, biochemical analysis of GA_3 , IAA, ABA was done from the treated and untreated plants using HPLC method at BRRI Central Laboratory for more confirmation of the effect of plant extract mediated silver nano particle on bakanae disease management.

In this trial, no bakanae symptom (0%) was observed when neem leaf mediated silver nano particle used and the result was similar to the healthy control (Fig. 10). On the other hand the highest plant height was increased in diseased control (8.2%) followed by AgNO_3 (5.2%) treated seeds (Fig. 11). Plant height was somewhat shorter (-2.4%) in silver nano (neem leaf extract mediated) treated plants compared with healthy control plants (Fig. 11). In case of root length, it was observed that root length somewhat increased (6.4%) in silver nano (neem leaf extract mediated) treated plants compared to healthy control plants (Fig. 11).

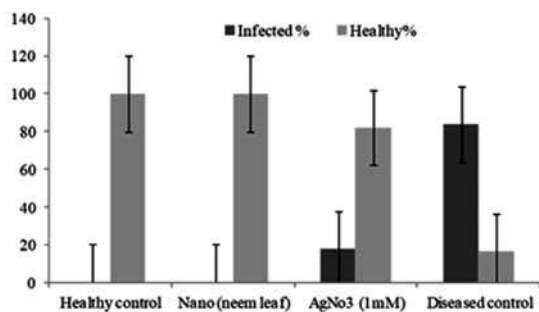


Fig. 10. Bakanae incidence (%) under different treatments.

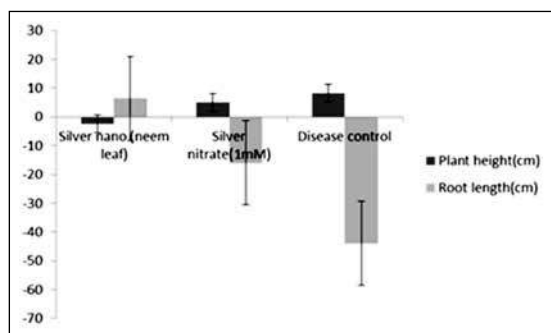


Fig. 11. Effect of treatments on plant height and root length in comparison to non-inoculated healthy control plants.

From the results it was observed that silver nano (neem leaf) is effective to manage bakanae disease as GA₃ (12.01), IAA (3.93) and ABA (0.57) decreased compared with control when treated with developed silver nano particle. It was also found that healthy control plants have higher amount of IAA (29.5) whereas GA₃ (1.61) and ABA (0.45) was minimal (Fig. 12). On the other side, bakanae symptom expressed (Internode elongated highly) and turned to death where GA₃ (21.07) and ABA (1.16) increased highly and IAA (1.42) decreased in inoculated plants when the seeds were inoculated with *F. fujikuroi* (Fig. 8). At the same time plant looks pale and turned to senescence and this was observed because GA₃ (1.71) decreased but IAA (16.96) and ABA (0.82) increased when inoculated with AgNO₃ (Fig. 12).

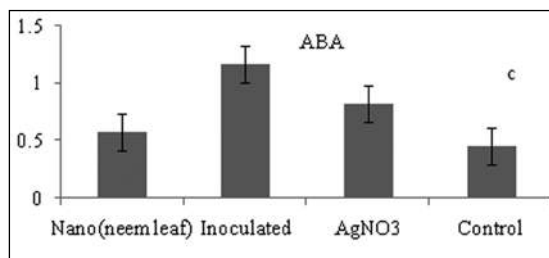
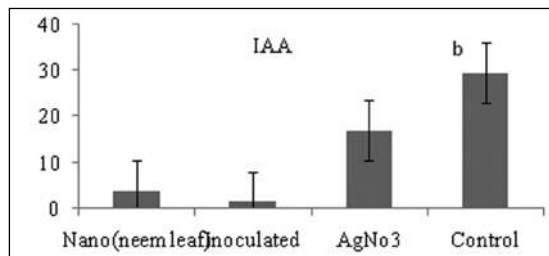
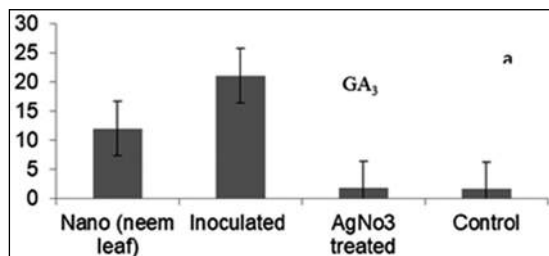


Fig. 12. Amount of plant hormone in nano-treated and untreated plants. GA₃ (a), IAA (b) and ABA (c).

CROP SOIL WATER MANAGEMENT

Soil management to maximize the yield of newly released rice varieties

The experiment was conducted to maximize the yield of newly released rice varieties in tidal ecosystem with organic and inorganic soil amendments during 2022-23. The treatments were soil test based (STB) fertilizer, STB+20% more nitrogen (N), STB+20% more potassium (K) and STB+vermicompost@ 3 t/ha arranged in split plot design with three replications. The test varieties for T. Aman season were BRRI dhan52, BRRI dhan76 and BRRI dhan87, while for Boro season, the varieties were BRRI dhan89, BRRI dhan92 and BRRI dhan96. Results showed that

during T. Aman season, there was insignificant effect of the treatments on rice grain yield. The variation in grain yields due to added amendment interacted with rice variety. Among the three tested varieties, BRRI dhan87 responded more to added N and vermicompost than the other two varieties (Fig. 13a). The treatments STB+more N and STB+vermicompost resulted in higher grain yield than STB only, while STB+more K could not increase yield in this soil (Fig. 13a). Deposition of nutrient enriched sediments by the tidal floodwater may be the reason for low K requirement of the HYV rice during T. Aman season. Unlike T. Aman,

the soil amendments significantly affected grain yields of HYV rice during Boro 2022-23. There was interaction between the treatments and rice variety. Thus, BRRI dhan92 yielded the highest with STB+more N, while BRRI dhan89 yielded higher in the other three treatments (STB only, STB+more K, and STB+vermicompost) than the other varieties (Fig. 13b). Like T. Aman season, no significant effect of STB+more K was not reflected among the varieties, implying that K supplement is only required for maintenance of soil K level in this tidal flooded soil.

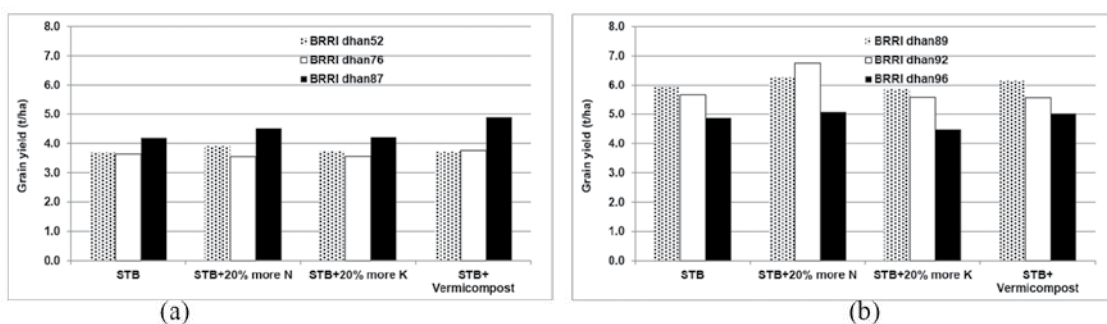


Fig. 13. Effect of inorganic or organic supplement in addition to soil test based fertilizer on grain yield of HYV, T. Aman and Boro 2022-23, BRRI RS, Barishal.

Determination of nitrogen requirement for modern rice variety under tidal ecosystem

This experiment was conducted at BRRI RS, Charbodna farm, Barishal to find out the optimum nitrogen rate for HYV rice in tidal ecosystem. Treatments were 0, 30, 60, 90 and 120 kg N/ha in T. Aman and 0, 50, 100, 150 and 200 kg N/ha in Boro season. The experiment was laid down in split-plot design, where nitrogen rate was set in the main plot and the varieties were in the sub-plot with three replications. The tested varieties were BRRI dhan76 and BRRI dhan77 for T. Aman and BRRI dhan74 and BRRI dhan89 for Boro season. All

other nutrients were applied as basal as per BRRI recommendation. The results show that during T. Aman, the highest grain yield was recorded in 90 kg N/ha both for BRRI dhan76 and BRRI dhan77 (Fig. 14). Similarly, during Boro season, the highest grain yields of BRRI dhan74 and BRRI dhan89 were obtained near 200 kg N/ha. The response trend of the grain yield followed a quadratic pattern both in T. Aman and Boro seasons, from which the optimum N rate for T. Aman season was derived. The optimum N rate for BRRI dhan76 and BRRI dhan77 was 90 kg/ha, while for BRRI dhan74 and BRRI dhan89 it was 198 kg N/ha.

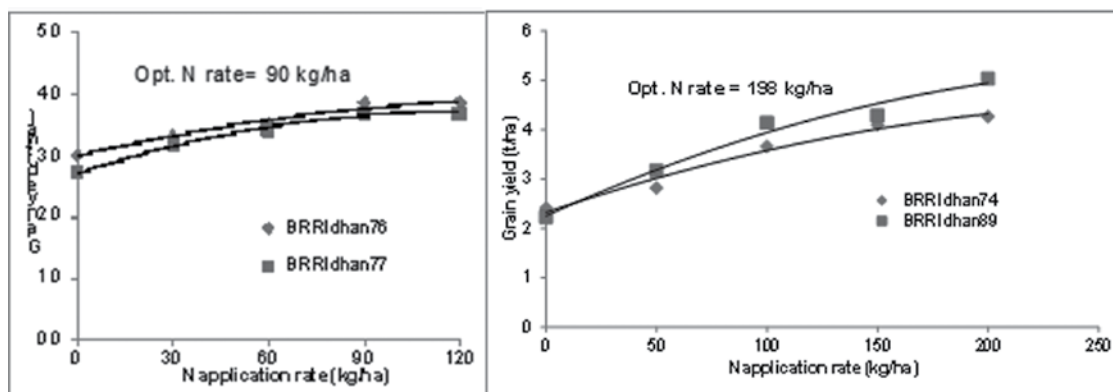


Fig. 14. Response of HYVs to applied nitrogen in T. Aman and Boro seasons 2022-23, Char Badna, Barishal.

Standardization of nitrogen application method for modern rice variety under tidal ecosystem

The experiment was conducted at Char Badna farm, BRRI RS, Barishal during Boro season 2022-23. The experiment comprised of seven treatments following RCB design with three replications. The treatments N0 = 0 kg N/ha, N52 (TD)= 52 kg N/ha (top dress), N52 (DP)=52 kg N/ha (deep placement), N78 (TD)=78 kg N/ha (top dress), N78(DP)=78 kg N/ha (deep placement), N104 (TD) =104 kg N/ha (top dress), N104 (DP)=104 kg N/ha (deep placement). The tested variety was BRRI dhan74. The results showed that the highest grain yield was recorded in N104 (DP) (5.37 t/ha) which was statistically similar to N78 (DP) (4.90 t/ha) (Table 8). Hence, 78 kg N/ha can be applied in BRRI dhan74 for achieving satisfactory yield in tidal ecosystem in Barishal. However, results need to be tested further for confirmation of the findings.

Table 8. Effect of nitrogen application method on the yield of BRRI dhan74 during Boro2022-23 at BRRI farm, Charbadna, Barishal.

Treatment	Yield (t/ha)*
N0	2.14 d
N52 (Topdress)	3.66 c
N52 (Deep placement)	3.92 c
N78 (Topdress)	4.29 bc
N78 (Deep placement)	4.90 ab

N104 (Topdress)	4.75 ab
N104 (Deep placement)	5.37 a
CV(%)	6.33

*values followed by same letter do not differ significantly.

Effect of planting date on the growth and yield of newly developed BRRI varieties in Barishal region

The experiment was conducted at BRRI RS Barishal, Char Badna farm, during Boro season 2022-23, aimed at identifying a suitable planting date for short and long duration Boro rice cultivars to maximize grain yield. The selected cultivars were transplanted from 29 December to 26 February. The seedling age was 35-40 days. The design of experiment was factorial RCB with three replications. The treatment combinations were A. Variety: i. BRRI dhan74, ii. BRRI dhan88, iii. BRRI dhan89 and B. Planting date: i. seeding date (DS): 16 November and transplanting date (DT): 29 December, ii. DS: 1 December and DT: 9 January, iii. DS: 16 December and DT: 21 January, iv. DS: 1 January and DT: 7 February, v. DS: 16 January and DT: 26 February. The results showed that seeding of BRRI dhan74 and BRRI dhan 89 on 1 December and transplanting on 9 January produced higher grain (5.45 t/ha, 5.80 t/ha, respectively) than the delayed transplanting. In case of BRRI dhan88, seeding on 16 December and transplanting on 21

January yielded higher (5.61t/ha) (Table 9). The tested varieties seeded on 1 January and transplanted on 7 February were found to have decreased grain yield.

Table 9. Effect of time of planting on the yield of BRRI dhan74, BRRI dhan88, BRRI dhan89 during Boro 2022-23 at BRRI farm, Char Badna, Barishal.

Seeding date	Transplanting date	Yield(t/ha)		
		BRRI dhan74	BRRI dhan88	BRRI dhan89
16 Nov	29 Dec	4.54	4.25	5.62
01 Dec	9 Jan	5.45	5.02	5.80
16 Dec	21 Jan	5.21	5.61	5.39
01 Jan	7 Feb	3.90	4.24	3.39
16 Jan	26 Feb	1.04	2.69	1.21
% CV		11.47		
LSD _(0.05)		0.8102		

Exploring sediment deposition from tidal water in Barishal regional station

Huge quantity of sediments deposit in the rivers, canals and agricultural fields through tidal water. Sediment is a blessing for farmers as it is enriched with nutrients. To find out the sediment deposition rate in agricultural land in BRRI RS farm, Barishal and the quality of sediment, an experiment was set up in Sagardi. Tidal water flow was trapped from fixed points at Sagardi farm, BRRI RS, Barishal. To trap the water, a pot was fixed in the field of Sagardi station. After a high tide and low tide, the pot was kept in a room for further deposition. When the deposition ceased, clear water was removed and the sediments were kept for drying in room temperature. The deposited silt was analyzed for organic and inorganic elements. Results showed that the good quality of sediment with respect to plant nutrients, implies that the soils of the farm are enriched. Results showed that the sediment was slightly acidic (pH=6.74) and organic matter was high in amount (2.42%). Among inorganic nutrients the amount of sulfur (16.75 µg g⁻¹) and zinc (4.44 µg g⁻¹) was quite noticeable (Table 10). The good quality of sediment with plant nutrients indicated that the soils of the farm were nutrient-enriched.

Table 10. Nutrient quality of sediments in Sagardi Farm BRRI RS, Barishal in 2022-23.

pH	Salinity (EC) (ds/m)	Organic matter (%)	Nitrogen (%)	Potassium (me%)	Phosphorus (µg g ⁻¹)	Sulfur (µg g ⁻¹)	Zinc (µg g ⁻¹)
6.74	0.872	2.42	0.121	0.45	50.81	16.75	4.44

Every year the addition of tidal sediments makes the farm fertile during Aman season. Thus, the supplementation of nutrients by tidal sediments may reduce the requirement of huge fertilizer for T. Aman rice in the tidally flooded areas of the country. The experiment needs to be continued to draw a final conclusion.

SOCIO ECONOMIC AND POLICY PROGRAMME AREA

Stability analysis of BRRI released variety

Aus 2022: The study was accomplished at Char

Badna farm, BRRI RS, Barishal during Aus 2022 season. Thirteen BRRI released varieties were tested (Table 11). The design of experiment was RCB with three replications. Twenty-one days old seedlings were transplanted. Crop management practices were done according to BRRI recommendation. Among the tested 13 varieties BRRI dhan83 produced the highest yield (5.97t/ha) followed by BRRI hybrid dhan7 (5.8 t/ha), BRRI dhan98 (5.64 t/ha) and BRRI dhan82 (5.22 t/ha). The lowest yield was observed in BR24 (4.23 t/ha) (Table 11).

Table 11. Stability analysis of BRRI released variety in Aus 2022.

Variety	GD(days)	Yield(t/ha)*
BR21	100 f	4.51 abc
BR24	103 de	4.23 c
BR26	109 b	5.03 abc
BRRI dhan27	115 a	5.27 abc
BRRI dhan42	96 g	4.75 abc
BRRI dhan43	95 g	4.98 abc
BRRI dhan48	101 ef	4.62 abc
BRRI dhan65	100 f	4.96 abc
BRRI dhan82	100 f	5.22 abc
BRRI dhan83	104 cd	5.97 a
BRRI dhan85	110 b	4.36 bc
BRRI dhna98	106 c	5.64 abc
BRRI Hybrid dhan7	111 b	5.8 ab
% CV	3.9	10.2

*Values followed by the same letter are not significantly different.

T. Aman 2022

Study was accomplished at Char Badna farm, BRRI RS, Barishal during T. Aman 2022 season. Forty-seven BRRI released varieties were tested with three groups namely short duration variety (15 nos.), medium duration variety (21 nos.) and long duration variety (11 nos.) (Tables 12, 13 and 14). Among the tested short duration varieties, the highest yield was observed in BRRI dhan87 (5.13 t/ha) followed by BRRI dhan95 (4.4 t/ha), BRRI dhan71 (4.13 t/ha) and BRRI dhan73 (4.13 t/ha). The lowest yield was found in BRRI dhan75 (2.15 t/ha) (Table 11). In medium duration varieties, the highest yield was found in BRRI dhan94 (3.95 t/ha) followed by BRRI dhan94 (5.61 t/ha), and BR25 (3.9 t/ha). The lowest yield was observed in BRRI dhan78 (2.3t/ha) (Table 13). Finally, in the long duration varieties, the highest yield was in BRRI dhan22 (4.09 t/ha) followed by BRRI dhan46 (3.61 t/ha) and the lowest yield was in BRRI dhan34 (2.12 t/ha) (Table 14).

Table 12. Stability analysis of BRRI released short duration varieties in T. Aman 2022.

Variety	GD (day)	Yield (t/ha)*
BRRI dhan33	123 bc	4.02 abc
BRRI dhan39	117 c	3.53 bcde
BRRI dhan53	121 bc	4.02 abc
BRRI dhan56	119 bc	2.88 cde
BRRI dhan57	118 bc	2.56 de
BRRI dhan62	118bc	2.29e
BRRI dhan66	118bc	3.14bcde
BRRI dhan71	121bc	4.13abc
BRRI dhan73	122bc	4.13abc
BRRI dhan75	118bc	2.15e
BRRI dhan87	140a	5.13a
BRRI dhan90	122bc	2.96cde
BRRI dhan95	126b	4.40ab
BRRI hybrid dhan4	121bc	2.89cde
BRRI hybrid dhan6	122bc	3.97abce
% CV	2.3	13.5

*Values followed by the same letter are not significantly different

Table 13. Stability analysis of BRRI released medium duration variety in T. Aman 2022.

Variety	GD (day)	Yield (t/ha)*
BR11	140 bcd	2.91 def
BR25	134 de	3.90 ab
BR3	134 de	2.62 ef
BR4	130 e	2.83 def
BRRI dhan30	144 bc	2.96 cdef
BRRI dhan31	134 de	2.67 ef
BRRI dhan32	134 de	3.3 abcde
BRRI dhan40	145 b	3.16 abcdef
BRRI dhan44	140 bcd	3.01 bcdef
BRRI dhan49	140 bcd	3.27 abcde
BRRI dhan51	146 b	2.97 bcdef
BRRI dhan52	140 bcd	3.1 abcdef
BRRI dhan54	136 de	2.9 def

Variety	GD (day)	Yield (t/ha)*
BRRi dhan70	134 de	3.48 abcde
BRRi dhan72	134 de	3.66 abcd
BRRi dhan77	145 b	3.25 abcde
BRRi dhan78	153 a	2.3 f
BRRi dhan79	138 cd	2.74 def
BRRi dhan80	134 de	2.6 ef
BRRi dhan93	140 bcd	3.85 abc
BRRi dhan94	140 bcd	3.95 a
% CV	1.7	9.63

*Values followed by the same letter are not significantly different

Table 14. Stability analysis of BRRi released long duration variety in T. Aman 2022.

Variety	GD (day)	Yield (t/ha)*
BR10	145 b	3.16 bcd
BR22	152 a	4.09 a
BR23	152 a	2.64 cde
BR5	141 c	2.9 bcde
BRRi dhan34	141 c	2.12 e
BRRi dhan37	141 c	2.58 de
BRRi dhan38	141 c	3.35 abcd
BRRi dhan41	141 c	3.40 abc
BRRi dhan46	145 b	3.61 ab
BRRi dhan76	144 b	3.59 ab
BRRi dhan91	152 a	3.04 bcd
% CV	0.50	8.48

*Values followed by the same letter are not significantly different

Boro 2022-23

Forty-nine varieties were evaluated at Charbadna farm, BRRi-Barishal during Boro 2022-23 season. The experiment was laid out in RCB design with three replications. The varieties were grouped into short duration variety (23 nos.) and long duration variety (26 nos.) (Table 15 and 16). Among the tested short duration varieties, the highest yield was observed in BRRi hybrid dhan2 (5.76 t/ha) followed by BRRi dhan68 (5.65t/ha) and BR1

(5.63 t/ha). The lowest yield was found in BRRi dhan81(3.91 t/ha) (Table 15). In case of the long duration varieties, the highest yield was in BRRi dhan60 (5.15 t/ha) followed by BRRi dhan47 (4.72 t/ha) and BRRi dhan50 (4.6t/ha). The lowest yield was observed in BR8 (3.33 t/ha) (Table 16).

Table 15. Yield and ancillary characters of short duration genotypes, Boro 2022-23, BRRi RS, Barishal.

Variety	GD (day)	Yield (t/ha)*
BR1	148 a	5.63 ab
BR6	144 abcde	4.59 def
BRRi dhan101	144 abcde	5.49 abc
BRRi dhan26	140 f	4.76 cde
BRRi dhan27	147 ab	4.09 ef
BRRi dhan28	140 f	4.53 def
BRRi dhan36	142 cdef	4.74 cde
BRRi dhan45	141ef	4.16 ef
BRRi dhan55	142 def	4.39 def
BRRi dhan61	147 ab	4.51 def
BRRi dhan63	143 bcdef	4.78 cde
BRRi dhan67	144 abcde	4.4 def
BRRi dhan68	145 abcd	5.65 ab
BRRi dhan74	145 abcd	5.38 abc
BRRi dhan81	143 cdef	3.91 f
BRRi dhan84	142 cdef	3.95 f
BRRi dhan86	142 cdef	4.58 def
BRRi dhan88	142 cdef	4.73 cde
BRRi dhan96	140 f	3.95 f
Bangabandhu dhan100	146 abc	4.48 def
BRRi hybrid dhan2	147 ab	5.76 a
BRRi hybrid dhan3	145 abce	4.97 bcd
BRRi hybrid dhan5	146 abc	5.01 abcd
% CV	5.26	

*values followed by the same letter are not significantly different

Table 16. Yield and ancillary characters of long duration genotypes, Boro 2022-23, BRRI RS, Barishal.

Variety	GD (day)*	Yield (t/ha)*
BR12	152 defg	4.46 ab
BR14	151efgh	3.49 b
BR15	161 a	4.19 ab
BR16	154 cde	3.93 ab
BR17	147 hi	3.43 b
BR18	151 defg	3.40 b
BR19	153 def	3.97 ab
BR2	154 cd	3.58 b
BR3	157 bc	3.56 b
BR7	159 ab	3.77 ab
BR8	161 a	3.33 b
BR9	159 ab	4.10 ab
BRRI dhan102	150 efghi	3.96 ab
BRRI dhan29	151 defg	4.59 ab
BRRI dhan35	151 defg	4.16 ab
BRRI dhan47	151 defg	4.72 ab
BRRI dhan50	147 i	4.60 ab
BRRI dhan58	150 efghi	4.34 ab
BRRI dhan59	149 ghi	4.38 ab
BRRI dhan60	150 fghi	5.15 a
BRRI dhan64	149 ghi	4.30 ab
BRRI dhan69	151 defg	3.75 ab
BRRI dhan89	160 ab	4.15 ab
BRRI dhan92	160 ab	3.52 b
BRRI dhan97	151 defg	3.73 ab
BRRI dhan99	153 def	4.11 ab
% CV	0.6901	12.2

*Values followed by the same letter are not significantly different

TECHNOLOGY TRANSFER

Varietal replacement through head to head trial (TRB project)

Nine modern rice varieties with one local cultivar were tested at six locations of Barishal region during T. Aman 2022 under two groups. Tidal submergence group, comprising of BR23, BRRI dhan52, BRRI dhan76, BRRI dhan77 and Lalmota, were tested in six locations namely Rosnabad, Kolapara, Patukhali; Gotkhali, Amtoli, Borguna; Dinnar and Dopakathi, Sadar Barishal; Daserkathi, Kaukhali, Pirojpur and Dapdapia, Nalchity, Jhalokathy. The average yield ranged from 3.21 t/ha (Lalmota) to 5.71 t/ha (BRRI dhan76). The average highest yield was found in BRRI dhan76 (5.71 t/ha) at Gotkhali and Dapdapia and the lowest yield was observed in local cultivar Lalmota (3.21 t/ha) at Gotkhali. Costal ecosystem group, comprising of BRRI dhan30, BRRI dhan73, BRRI dhan78, BRRI dhan79 and Bina dhan-23 were tested in other two locations namely Dopakathi, Sadar Barishal and Dapdapia, Nalchity, Jhalokathy. The average yield ranged from 3.75 t/ha (BRRI dhan73) to 4.82 t/ha (BRRI dhan79). The average highest yield was found in BRRI dhan79 (4.82 t/ha) at Dopakathi and the lowest yield was observed in BRRI dhan73 (3.75 t/ha) also at Dopakathi. The trials suggested that the highest yielding modern rice variety BRRI dhan76 for tidal submergence and BRRI dhan79 for costal ecosystem could be popular than local cultivar and can be disseminated among the farmers. This fact is also reflected in the farmer's choice since farmers stored 40 kg of BRRI dhan76 and 15 kg of BRRI dhan79 seed for use in the next T. Aman season.

Boro 2022-23

Fifteen modern rice varieties were tested at four locations of Barishal region during Boro 2022-23. Saline tolerant BRRI dhan28, BRRI dhan67, BRRI dhan97 and BRRI dhan99 were evaluated at two locations of Pakhimara of Kalapara upazilas in Patuakhali district. The average yield ranged from 3.86 t/ha (BRRI dhan28) to 7.89 t/ha (BRRI dhan99). The average highest yield was found in BRRI dhan99 (7.89 t/ha) and the lowest yield was observed in BRRI dhan28 (3.86 t/ha). BRRI

ghan28 produced the lowest yield due to several attack of blast at vegetative and reproductive stage. Eleven varieties consisting of two groups that is long duration and short duration, long duration consisting of BRRI dhan29, BRRI dhan89, BRRI dhan92, BRRI dhan102 and Bina dhan-24, were tested in two locations namely Dinner and Solna village under Sadar upazila in Barishal district. The average yield was varied from 6.32 t/ha of Bina dhan-24 to 8.83t/ha of BRRI dhan89. The average highest yield was found in BRRI dhan89 (8.83 t/ha) at Solna village whereas the lowest yield was observed in Bina dhan-24 (6.32 t/ha) at solna village. Short duration group consisting of BRRI dhan28, BRRI dhan74, BRRI dhan88, Bangabandhu dhan100, BAU dhan3 and Bina dhan-25 were tested in other two locations namely Dinner and Solna village under Sadar upazila in Barishal district. The average yield was varied from 5.48 t/ha of BAU dhan3 to 8.76 t/ha of BRRI dhan74. The average highest yield was found in BRRI dhan74 (8.76 t/ha) at Dinnar village whereas the lowest yield was observed in BAU dhan3 (5.48 t/ha) also at Dinnar village. The trials suggested that the highest yielding modern rice variety BRRI dhan74 for short duration, BRRI dhan89 for long duration and BRRI dhan99 for saline tolerant could be popular and BRRI RS, Barishal disseminated them among the farmers. This fact is also reflected in the farmers' choice since farmers stored 20 kg of BRRI dhan74, 15 kg of BRRI dhan89 and 20 kg of BRRI dhan99 seed for use in the next Boro season.

Advanced line adaptive research trial (ALART)

ALART, Submergence Tolerant Rice (SubTr-LD), T. Aman 2022. Two advanced lines viz BR9158-19-9-6-50-2-HR1 and IR13F441 with two check varieties viz BRRI dhan44 and BRRI dhan52 were evaluated in six locations of Barishal region. The locations were Barishal Sadar (two locations at Dinar and Dhopakathy), Barishal; Nalchity, Jhalakathy; Amtoli, Barguna; Kaukhali, Pirojpur and Kolapara, Patuakhali. Among the six locations, data collection from Kaukhali, Pirojpur was not possible due to several natural calamities. In case of the remaining five locations, the performance of the advanced lines were superior than the check

varieties in almost all the locations. The highest grain yield was obtained from the advanced line BR9158-19-9-6-50-2-HR1 in Dhopakathy, Barishal Sadar (4.91 t/ha); Nalchity, Jhalakathy (5.03 t/ha) and Amtoli, Barguna (4.54 t/ha) while the advanced line IR13F441 performed better in Dinar, Barishal Sadar (4.34 t/ha) and Kolapara, Patuakhali (5.20 t/ha). In terms of growth duration, the highest was observed in the advanced line IR13F441 while the lowest was observed in check variety BRRI dhan52 in all the locations. Average plant height was the highest in the advanced line BR9158-19-9-6-50-2-HR1 and the lowest in the check variety BRRI dhan52 considering all the locations.

ALART, Salt Tolerant Rice (STR), T. Aman 2022. Three advanced lines viz BR11712-4R-218, BR11716-4R-102 and BR11723-4R-172 along with two check varieties viz BRRI dhan73 and BRRI dhan87 were evaluated in two locations i.e. Amtoli, Barguna and Kolapara, Patuakhali. Between the two locations, the experiment was severely damaged by rats and birds in Amtoli, Barguna. So data collection at harvest was not possible from there. In Kolapara, the highest grain yield was observed in the advanced line BR11716-4R-102 (3.30 t/ha) followed by the advanced line BR11712-4R-218 (2.89 t/ha) while the yield of the better check (BRRI dhan78) was 2.81 t/ha. Growth duration was the highest in the check variety BRRI dhan87 (128 days) and the lowest in the advanced line BR11712-4R-218 (122 days). The longest average plant height was noticed in the check variety BRRI dhan73 (121 cm) while the shortest was observed in the advanced line BR11723-4R-172 (91 cm).

ALART, Favourable Boro Rice- Barishal (FBR-Barishal Re-ALART), Boro 2022-23. An ALART was conducted in Solna, Barishal Sadar, Barishal. Four advanced lines viz BRBa 1-4-9, BRBa14-NGR414-1, BRBa 3-1-7 and BRBa40-NGR1255-1 along with two advanced lines BRRI dhan58 and BRRI dhan89 were evaluated. Among the entries advanced line BRBa 3-1-7 (8.04 t/ha) showed the highest grain yield followed by the advanced line BRBa40-NGR1255-1 (7.59 t/ha). Growth duration of the entries ranged from 141 days to 148 days. Plant height ranged from 98 cm to 116 cm while the highest was observed in the advanced line BRBa 1-4-9.

ALART, Blast Resistant Rice (BRR), Boro 2022-23. Four advanced lines viz BR12454-BC2-56-81-27-3-30, BR12454-BC2-69-97-39-5-44, BR12454-BC2-71-91-6-23-26 and BR12454-BC2-75-32-31-39-7 with two check varieties viz BRRI dhan29 and BRRI dhan89 were evaluated in Barishal Sadar. Among the advanced lines, BR12454-BC2-69-97-39-5-44 (8.48 t/ha) showed superior grain yield performance than the better check BRRI dhan89 (7.92 t/ha). Growth duration of the evaluated entries varied from 142 days to 148 days. In case of plant height, the highest was observed in the advanced line BR12454-BC2-75-32-31-39-7 (110.7 cm) and the lowest was observed in the check variety BRRI dhan29 (96.6 cm).

ALART, Favourable Boro Rice- Short Duration (FBR- SD), Boro 2022-23. Four advanced lines BR11318-5R-63, BR11337-5R-72, SVIN109 and IR17A1723 along with two check varieties BRRI dhan81 and BRRI dhan96 were tested in Barishal Sadar. Among the advanced lines and check varieties only the advanced line SVIN109 (7.29 t/ha) showed superior yield performance than the better check BRRI dhan96 (6.99 t/ha). The highest growth duration was observed in BRRI dhan81 (140 days) and the lowest growth duration was observed in the advanced line BR11337-5R-72 (130 days). Plant height varied from 91 cm to 109 cm among the entries.

ALART, Favourable Boro Rice- Medium Duration (FBR-MD), Boro 2022-23. Two advanced lines viz IR12A173 and IR17A1694 along with two check varieties BRRI dhan58 and BRRI dhan96 were evaluated in Barishal Sadar. None of the advanced lines showed superior performance than the better check BRRI dhan96 (8.85 t/ha).

ALART, Blast Resistant Rice Re-ALART (BRR Re-ALART), Boro 2022-23. An ALART was conducted in Barishal Sadar during Boro 2022-23. There were four advanced lines viz BR (Path)12452-BC3-42-22-11-4, BR (Path)12452-BC6-53-21-11, BR (Path)13784-BC3-61-1-6-HR3 and BR (Path)13784-BC3-63-6-4-HR6 and two check varieties viz BRRI dhan28 and BRRI dhan88. Three advanced lines i.e. BR (Path)12452-BC3-42-22-11-4 (8.35 t/ha), BR (Path)13784-

BC3-63-6-4-HR6 (7.96 t/ha) and BR (Path)12452-BC6-53-21-11 (7.79 t/ha) showed superior yield performance than the better check BRRI dhan88 (7.21 t/ha). On average, all the entries matured within 126-137 days. Plant height of the entries varied from 91 cm to 113 cm.

Establishment of Techno-village in Barishal region

Five BRRI released varieties viz BRRI dhan22, BRRI dhan52, BRRI dhan76, BRRI dhan77 and BRRI dhan87 were distributed among seven farmers of Dinar village of Barishal sadar upazila. Farmers were given proper advice about cultivation technique. The varieties were transplanted according to land types. Proper doses of fertilizer were also distributed and applied. For each variety, crop cut of 10 m² area was performed with three replications. Average grain yield was the highest in BRRI dhan87 (6.57 t/ha) followed by BRRI dhan52 (5.73 t/ha). These results were higher than locally popular cultivars in that area i.e. Sadamota (3.63 t/ha), Sakkhorkhara (3.33 t/ha). So, farmers were motivated to cultivate modern varieties in the following years.

Demonstration, seed production and scaling up of BRRI rice varieties

New HYVs of BRRI i.e. BRRI dhan44, BRRI dhan52, BRRI dhan72, BRRI dhan76, BRRI dhan77 and BRRI dhan87 were demonstrated during T. Aman 2022, in 220 acres of land as block demonstration which covered the 25 upazilas of six districts of Barishal Division under GOB fund. Among them 120 acres of land were supported by seed and fertilizer and the rest 100 acres were demonstrated with free seed support. From the demonstrated varieties, BRRI-Barishal tried to motivate farmers to replace farmers' local varieties to BRRI released latest Aman varieties. The highest yield was obtained by BRRI dhan87 (6.25 t/ha) followed by BRRI dhan52 (5.12 t/ha) and BRRI dhan76 (4.25 t/ha). As Barishal region is under tidal submergence ecosystem and is difficult to grow BRRI dhan87 and its growth duration is about 125-130 days only. However, in medium lowland (Phase-1) specially Uzirpur, Gournadi, and Bhola

Sadar it produced comparatively higher yield than the others. However, it was chosen by those farmers who wanted to do oil crop after Aman season. The other farmers' preferred BRRI dhan52 and BRRI dhan76 and wanted to cultivate these varieties for the next year along with neighbouring farmers.

Boro 2022-23

A total of 525 number of demonstrations were conducted where 350 were both seed and fertilizer supported and the rest were supported only with seed by BRRI RS, Barishal. The activity covered 300 acres land of 20 upazilas of Barishal Division. BRRI released HYV (BRRI dhan29, BRRI dhan47, BRRI dhan50, BRRI dhan67, BRRI dhan74, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, and BRRI dhan97) and hybrid varieties (BRRI hybrid dhan3, BRRI hybrid dhan5) were allocated for distribution. Farmers under the demonstration were advised for maximizing yield. At maturity, the crop cut data were collected for each variety of every demonstration plot.

The hybrid varieties BRRI hybrid dhan5 produced the highest average yield (8.12 t/ha) among the hybrid varieties. In HYV, BRRI dhan89 and BRRI dhan92 produced about same yield which is 8.12 t/ha and 7.93 t/ha respectively. However, BRRI dhan74 attracted farmers a lot for its coarseness, tastiness and zinc enriched virtue. Overall, its life duration is lower than BRRI dhan89 and BRRI dhan92. Among the saline tolerant varieties BRRI dhan97 did well and farmers liked for its boldness. Farmers also preferred BRRI dhan67 due to its cold tolerance and high fertility percentage.

Breeder seed and TLS production

For breeder seed production, single seedling was transplanted at 20 x 20 cm spacing. BRRI recommended practices for crop cultivation was followed. In Aus, 9,590 kg seeds were produced in Char Badna farm, Barishal where 7,030 kg was breeder seed (Table 17). In T. Aman 2022, a total of 45,358 kg and 54,400 kg in Boro 2022-23 along with a total of 31,440 kg breeder seed were produced (Table 18). In T. Aman 2022, a total of 15,275 kg TLS and in Boro 2022-23, a total of 12,055 kg BRRI released varieties was disseminated to the farmers of this region.

Table 17. Breeder seed and TLS production in Aus 2022.

Variety	Breeder seed (kg)	TLS (kg)
BRRI dhan48	4520	880
BRRI dhan82	-	1680
BRRI dhan85	750	-
BRRI dhan98	1760	-
Total	7030	2560

Table 18. Breeder seed and TLS production in T. Aman 2022.

Variety	Breeder seed (kg)	TLS (kg)
BR22	-	874
BR23	4400	2926
BRRI dhan34	2500	6850
BRRI dhan48	4440	-
BRRI dhan41	-	398
BRRI dhan44	-	551
BRRI dhan49	-	1007
BRRI dhan52	4000	1406
BRRI dhan72	-	389
BRRI dhan75		437
BRRI dhan76	1250	6080
BRRI dhan77	1,000	589
BRRI dhan85	1140	
BRRI dhan87	2500	1406
BRRI dhan90	-	133
BRRI dhan93		589
BRRI dhan94		513
Total	21230	24148

Table 19. Breeder Seed and TLS Production in Boro 2022-23.

Variety	Breeder seed (kg)	TLS (kg)
BR23		
BRRI dhan26	2000	1200
BRRI dhan28	7040	110
BRRI dhan29	5500	810
BRRI dhan47	1200	920
BRRI dhan48	-	25
BRRI dhan50	-	410
BRRI dhan67	-	1400
BRRI dhan74	10000	9500
BRRI dhan84	-	1080
BRRI dhan88		840
BRRI dhan89	5500	1500
BRRI dhan92	3000	930
BRRI dhan96	-	550
BRRI dhan97	-	360
BRRI dhan99		230
Bangabondhu dhan100	-	320
Total	34240	20160

Farmers' training under different projects/GoB

Farmers' training programmes were conducted at different locations of Barishal region with the collaboration of DAE. The farmers were selected with the assistance of local SAAOs from different villages of the mentioned locations. The training module was developed considering modern rice production techniques, appropriate rice cultivar for tidal non-saline ecosystem, and pest, disease, irrigation and fertilizer management for better rice production. The training courses were delivered using colourful slides and videos through multimedia projector for easy understanding to the trainees. BRRI RS, Barishal conducted farmers' training in different locations of Barishal region during the reporting period. Forty farmers' trainings were conducted under GoB. A total of 750 male, 220 female farmers, 30 SAAO/SA were trained under GoB training programme. These programmes certainly helped the farmers to create awareness for adopting the BRRI rice production technologies. Trainees were learned on eco-friendly pest management and the dissemination rate of BRRI varieties, cutting edge technologies of farming systems research was accelerated in those areas. Thus, trainings on modern rice production confidently increase the farmers' income as well as improve the livelihood through practicing the farming systems approach.

Table 20. Daylong farmers' trainings at Barishal region on modern rice production technology during 2022-2023.

Training programme	Duration	Total training	Participant				Total
			Male	Female	SAAO/SA	NGO personnel	
Modern rice production training	1 day	40	750	220	30	00	1000

Farmers' field day under different projects/GOB

Ten field days were conducted in collaboration with DAE at different locations of Barishal region. Farmers, researchers, extension providers, NGO personnel, administrative people, public leaders were sincerely participated in this programme. Firstly, the participants gathered and visited the rice field together. A sample area of 10 m² was harvested followed by threshing, weighing by the presence. Later on, a fruitful discussion was held among the participants. It was perceived that a noticeable number of female farmers were also present and participated on these field days. About 1,200 (650 male and 350 female) farmers, extension personnel, administrative peoples, public leaders were targeted to participate on these programmes. Farmers liked BRRI dhan76 for its tolerance to tidal surge and BRRI dhan87 or its higher yield.

Recommendations were as follows:

1. Irrigation facility area has to be increased.
2. Need integrated and co-ordinated works among all departments related to agriculture.
3. Need to improve the present cropping pattern (Aman-Fallow-Fallow or Boro-Fallow-Fallow) and another new crop has to be introduced in these cropping patterns.
4. Sweet water rivers in Barishal region should be used properly for irrigation purpose.
5. Maintenance and operation of sluice gate have to be managed properly.
6. Projects may be taken to increase irrigation command area.
7. Balance is needed between inbreed and hybrid varieties.
8. High yielding rice varieties of BRRI have to be introduced for increasing cropping intensity.
9. Demonstration and training must be increased on saline tolerant variety.
10. More agricultural machinery should be supplied to Barishal region to improve rice productivity.

BRRI RS, BHANGA, FARIDPUR

428	Summary
429	Variety Development
433	Farming Systems Research
435	Crop-Soil-Water Management
438	Socio-Economics And Policy
438	Technology Dissemination

SUMMARY

In T. Aman 2022-23, five crosses were made using seven parents and 368 F_1 seeds were produced for deepwater rice and six crosses were made using seven parents and 110 F_1 seeds were produced for high yielding Aman rice. Ten crosses were confirmed. In total 2,549 segregating progenies from 32 crosses of F_3 - F_4 generation were grown following field rapid generation advanced (FRGA) technique and 2,221 progenies of F_4 - F_5 generation were harvested. In Boro 2022-23, twenty-one crosses were made and 833 F_1 seeds were produced for developing high yielding Boro rice varieties for single Boro ecosystem. Eight crosses were confirmed. A total of 790 segregating progenies of F_2 , F_3 and F_5 generation were grown following FRGA technique and 633 progenies of F_3 , F_4 and F_6 generation were harvested.

In proposed variety trial (PVT), four sets of inbred trials were conducted under BRRI Regional Station (RS) Bhanga. Among four sets, two sets (Set-I and II for deep water Aman rice) were established at Rashidpur (on farm condition) and two sets (Set-III and IV for high yielding Aman rice) were established at BRRI RS, Bhanga farm during T. Aman 2022-23. Two ALARTs were implemented during T. Aman 2022-23, where six entries of deep water rice were evaluated against local check Fulkari and two advanced breeding lines of premium quality rice (PQR) were evaluated against BRRI dhan34 and BRRI dhan70. During Boro 2022-23, four sets of PVT inbred trials were established and evaluated in BRRI RS, Bhanga. Five ALART sets were established in farmer's field under the supervision of BRRI RS, Bhanga. A total of 14 regional yield trials (RYTs) were conducted in BRRI RS, Bhanga during Boro 2022-23.

An experiment was conducted on introduction of intercropping system in different farmers led cropping pattern to increase the cropping intensity and productivity of the existing Onion-Jute-T. Aman cropping pattern in Faridpur region. Among the tested cropping patterns, the highest rice

equivalent yield (31.63 t/ha) was found in CP_2 (Onion+Pumpkin (Relay)-Jute-T. Aman) which was statistically different from the others. The highest gross margin (4,02,040 tk/ha) was also found in CP_2 (Onion+Pumpkin (Relay)-Jute-T. Aman) cropping pattern followed by CP_3 (3,81,920 tk/ha) and CP_4 (3,64,850 tk/ha) cropping patterns.

An experiment was conducted in Aus season on planting time of BRRI varieties to adjust planting time for escaping the crop from the flood at Charland areas. Grain yield of BRRI dhan82 planting on 5 April produced significantly higher irrespective of planting time and variety. The minimum growth duration was found in local varieties Porangi compared to inbred varieties BRRI dhan82 and BRRI dhan83. Another experiment was conducted for weed control techniques in single Boro cropping pattern to develop cost effective and eco-friendly weed control practices for sustainable weed management. In Boro season, BRRI dhan89 exhibited no significant effect on grain yield in the combination of herbicide application and hand-weeding treatments. The lowest weed density was found in three hand weeding and pre-emergence herbicide + post-emergence herbicide + hand weeding treatments.

In total 25.75 tons of seed produced in BRRI RS, Bhanga farm. Out of them, 13.75 tons Breeder Seed of BRRI dhan29, BRRI dhan89 and BRRI dhan92 and around 12 tons TLS of Aman varieties such as BRRI dhan39, BRRI dhan71, BRRI dhan75, BRRI dhan79 and BRRI dhan87 as well as Boro varieties of BRRI dhan29, BRRI dhan50, BRRI dhan58, BRRI dhan67, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, BRRI dhan97, BRRI dhan99, Bangabandhu dhan100, BRRI dhan101 and BRRI dhan102 during Boro 2022-23.

Three hundred and ninety farmers of greater Faridpur region were trained on modern rice production technologies through 13 training programmes in BRRI RS, Bhanga with the cooperation of DAE and the financial assistance of GOB. A total of 620 demonstration trials using BRRI varieties were implemented through BRRI RS, Bhanga and 33 field days were conducted during the year of 2022-23.

VARIETY DEVELOPMENT

Hybridization. In T. Aman 2022 season, six crosses were made and 110 F_1 seeds were produced for developing high yielding T. Aman rice varieties with desirable characters with emphasis on water stagnation tolerance, anaerobic tillering, earliness and good grain quality (Table 8). For deepwater rice variety development, five crosses were made and 368 F_1 seeds were produced with desirable characters with emphasis on kneeing ability, nodal tillering, earliness and awnless, good grain quality (Table 8). Total ten crosses were confirmed as true hybrid.

In Boro 2022-23, total 21 crosses were made and 833 F_1 seeds were produced with the objective of developing high yielding boro rice varieties for single boro ecosystem (Table 9). Total eight crosses were confirmed from 11 crosses as true hybrid.

Progeny advancement through FRGA. During T. Aman 2022-23, 1409 F_3 progenies from 16 crosses were grown following field RGA technique and 1304 F_4 progenies were harvested (Table 10). A total of 1140 progenies from F_4 generation were grown and 917 progenies of F_5 generation were harvested under breeding program of high yielding rice varieties for semi deep water ecosystem (Table 11).

In Boro 2022-23, total 410 F_2 progenies from seven crosses were grown following field RGA technique and 330 F_3 progenies were harvested (Table 12). A total of 108 progenies from F_3 generation were grown and 72 progenies of F_4 generation were harvested (Table 13). Total 150 progenies of F_5 generation were grown and 147 progenies of F_6 generation were harvested with the objective of developing high yielding Boro rice varieties for single boro ecosystem (Table 14).

PVT (T. Aman). Four sets of inbred trial (Aman 2022) were evaluated in PVT under the supervision of BRRI Regional Station, Bhanga, Faridpur (Table 15).

In Set- I, test entry I-044 was tested against check entry I-046 and gave higher yield (3.354 t/ha) than the check entry (3.144 t/ha). Growth duration of the test entry was 197 days whereas the check entry's was 160 days.

In Set- II, test entry I-045 was tested against check entry I-046 and gave higher yield (3.7 t/ha) than the check entry (3.143 t/ha). The test entry had a growth duration of 197 days whereas the check entry's was 160 days.

In Set- III, test entry I-047 was tested against check entry I-048 and gave higher yield (6.38 t/ha) than the check entry (4.92 t/ha). Both the entries had similar growth duration.

In Set- IV, test entry I-049 was tested against check entry I-050 and gave lower yield (5.47 t/ha) than the check entry (5.524 t/ha).

PVT (Boro). Four sets (Set-I, Set-II, Set- III and Set- IV) of inbred trial were carried out at BRRI RS, Bhanga, Faridpur during Boro 2022-23 (Table 16).

Set-I: One advanced breeding line I-053 along with check I-054 were tested. The line I-053 produced 7.3 t/ha which was 9.4% lower yield than the check variety coded as I-054 (8.06 t/ha).

Set-II: One advanced breeding line I-055 was evaluated along with check I-056. Both the entries produced similar yield (7.51 t/ha). The test entry I-055 was almost 15 days late than the check entry I-056.

Set-III: One advanced breeding line I-057 along with check I-058 were tested. The line I-057 (7.914 t/ha) produced 10.02 % higher yield than the check I-058 (7.193 t/ha). Both the entries had similar growth duration.

Set-IV: One advanced breeding line I-059 along with check I-060 were tested. The line I-059 (9.38 t/ha) produced 13.42 % higher yield than the check I-060 (8.27 t/ha). The test entry I-059 was almost 10 days late than the check entry I-060.

ALART (DWR) T. Aman. ALART (DWR) was evaluated using six advanced lines along with Fulkari as check at on farm condition in Rashidpur, Bhanga, Faridpur. All six entries produced higher yield than the check Fulkari. Test entry BR9392-6-2-1B produced the highest yield of 4.31 t/ha, followed by entry BR10230-7-19-2B which also produced higher yield (4.09 t/ha) than Fulkari (1.82 t/ha). Growth duration of all the entries varied from

160-162 days (Table 17). Due to severe drought, the test entries did not face any water stress at all.

ALART (PQR) T. Aman. Two advance breeding lines BR8493-3-5-1-P1 and BR9590-45-1-3-2-P2 were evaluated against two checks BRRI dhan34 and BRRI dhan70. All two entries gave lower yield due to severe drought stress. None of the entries outyielded the checks and BR8493-3-5-1-P1 was badly infected by false smut disease (Table 18).

ALART (FBR_SD) Boro. Four advanced lines i.e. BR11318-5R-63, BR11337-5R-72, SVIN109 and IR17A1723 were evaluated along with BRRI dhan81 and BRRI dhan96 as checks at farmer's field at Krishnanagar, Nagarkanda, Faridpur. Among the four entries, three of them BR11318-5R-63 (8.52 t/ha), BR11337-5R-72 (8.75 t/ha) and SVIN109 (8.22 t/ha) out yielded both the checks BRRI dhan81 (7.79 t/ha) and BRRI dhan96 (7.83 t/ha) (Table 19).

ALART (FBR_MD) Boro. Two advanced lines IR12A173 and IR17A1694 were evaluated along with BRRI dhan58 and BRRI dhan96 as checks at farmer's field at Krishnanagar, Nagarkanda, Faridpur. The tested entries, IR12A173 (8.38 t/ha) and IR17A1694 (7.69 t/ha) gave lower yield than BRRI dhan58 (8.77 t/ha) (Table 20).

ALART (FBR_Barishal) Boro. Four advanced breeding lines i.e BRBa 1-4-9, BRBa 14-NGR 414-1, BRBa 3-1-7 and BRBa40-NGR 1255-1 were evaluated against two check varieties BRRI dhan58 and BRRI dhan89. Three test entries BRBa 1-4-9 (8.09 t/ha), BRBa 14-NGR 414-1 (8.06 t/ha) and BRBa40-NGR 1255-1 (7.72 t/ha) gave higher yield than the both checks varieties BRRI dhan58 (6.27 t/ha) and BRRI dhan89 (7.47 t/ha). Mean growth duration of all the six entries varied from 151-154 days. Neck blast disease infection was observed in both the check varieties and in test entry BRBa 3-1-7. Around 5% rat damage was recorded in all six entries (Table 21).

ALART (BRR) Boro. Four advanced lines i.e. BR12454-BC2-56-81-27-3-30, BR12454-BC2-69-97-39-5-44, BR12454-BC2-71-91-6-23-26 and BR12454-BC2-75-32-31-39-7 along with checks BRRI dhan29 and BRRI dhan89

were tested at farmers' field at Krishnanagar, Nagarkanda, Faridpur. The test entry BR12454-BC2-75-32-31-39-7 produced higher yield (7.81 t/ha) than both the check varieties BRRI dhan29 (7.55 t/ha) and BRRI dhan89 (6.32 t/ha). Mean growth duration of the test entries was similar (148 days to 152 days) and the check variety BRRI dhan89 (152 days) had GD of 2 to 6 days earlier than the BRRI dhan29 (154 days). Uniform flowering and maturity were observed in these lines. Due to lodging at early ripening stage and rat infestation yield was affected in some entries (Table 22).

ALART (BRR_Re-ALART) Boro. Four advanced lines i.e. BR(Path)12452-BC3-42-22-11-4, BR(Path)12452-BC6-53-21-11, BR(Path)13784-BC3-61-1-6-HR3 and BR(Path)13784-BC3-63-6-4-HR6 along with BRRI dhan28 and BRRI dhan88 as checks were tested at farmers' field at Krishnanagar, Nagarkanda, Faridpur. The test entry BR (Path) 12452-BC3-42-22-11-4 produced higher yield (8.0 t/ha) than both the check varieties BRRI dhan28 (6.35 t/ha) and BRRI dhan88 (7.51 t/ha). Mean growth duration of all the test entries and check varieties was similar (136 days to 139 days). Uniform flowering and maturity were observed in the test entries (Table 23).

RYT (FBR_LD). A total of five advanced lines were evaluated against three check varieties BRRI dhan81, BRRI dhan89 and BRRI dhan92. Advanced line BR11318-5R-84 produced higher yield (9.61 t/ha) than the check varieties BRRI dhan81 (5.6 t/ha), BRRI dhan89 (8.21 t/ha) and BRRI dhan92 (8.84 t/ha). BRRI dhan81 produced lower yield due to severe neck blast infestation (Table 24).

RYT (FBR_SD). Nine advanced lines were evaluated against two check varieties BRRI dhan28 and BRRI dhan96. Five among the nine advanced lines BR11894-5R-376 (8.83 t/ha), BR11903-5R-56 (8.72 t/ha), BR11900-5R-24 (8.60 t/ha), BR12208-5R-402 (8.52 t/ha) and BR12180-5R-29 (8.49 t/ha) produced higher yield than both the check varieties BRRI dhan96 (7.88 t/ha) and BRRI dhan28 (6.06 t/ha) (Table 25).

RYT (FBR_MD). Nine test entries along with two check varieties were grown. Five among the nine advanced lines IR18A1907 (9.88 t/ha), BR8899-14-

4-1-2-2-1 (8.92 t/ha), BR11342-5R-23 (8.81 t/ha), IR17A1275 (8.77 t/ha) and IR18A2119 (8.35 t/ha) produced higher yield than both the check varieties BRRI dhan89 (8.20 t/ha) and BRRI dhan81 (6.48 t/ha) (Table 26).

RYT (FBR_ELS). Six advanced breeding lines along with three check varieties BRRI dhan50, BRRI dhan63 and BRRI dhan86 were evaluated. Advanced line BR7528-2R-19-16-RIL-52 produced higher yield (8.51 t/ha) than the checks varieties (Table 27).

RYT (DRR_BB). Eighteen advanced lines were evaluated against four check varieties, BRRI dhan58, BRRI dhan89, BRRI dhan92 and BRRI dhan101. Six advanced lines BR11866-5R-73 (9.87 t/ha), BR11867-5R-154 (9.97 t/ha), BR(Path)13800-BC3-8-1 (10.20 t/ha), BR(Path)13800-BC3-8-6 (10.46 t/ha), BR(Path)13800-BC3-109-10 (9.96 t/ha) and BR(Path)13800-BC3-224-28 (10.16 t/ha) produced higher yield than all the check varieties BRRI dhan58 (8.90 t/ha), BRRI dhan89 (9.44 t/ha), BRRI dhan92 (9.65 t/ha) and BRRI dhan101 (9.23 t/ha) (Table 28).

RYT (DRR_Blast). Ten advanced lines were evaluated along with two check varieties BRRI dhan89 and BRRI dhan92. Among ten, four advanced lines BR (Path)13800-BC3-224-17 (9.16 t/ha), BR (Path)13800-BC3-134-25 (9.04 t/ha), BR (Path)13800-BC3-110-4 (9.48 t/ha) and BR (Path)13800-BC3-224-44 (9.49 t/ha) produced higher yield than both the check varieties BRRI dhan89 (8.25 t/ha) and BRRI dhan92 (8.43 t/ha) (Table 29).

RYT (STR). Seven advanced lines were evaluated against three standard check varieties BRRI dhan67, BRRI dhan89 and BRRI dhan99. All of the seven advanced lines BR11712-4R-44 (8.73 t/ha), BR11712-4R-93 (8.56 t/ha), BR11717-4R-12 (8.90 t/ha), BR11727-4R-6 (8.56 t/ha), BR11712-4R-346 (8.77 t/ha), BR11713-4R-70 (8.28 t/ha) and BR11722-4R-398 (8.59 t/ha) produced higher yield than all the three checks BRRI dhan67 (7.36 t/ha), BRRI dhan89 (8.16 t/ha) and BRRI dhan99 (8.27 t/ha) (Table 30).

RYT (ZER). Three advanced lines along with three checks BRRI dhan29, BRRI dhan74 and BRRI

dhan84 were grown. Advanced line BR9674-1-4-1-3-P2 produced higher yield (8.99 t/ha) than all the three checks BRRI dhan29 (8.75 t/ha), BRRI dhan74 (8.09 t/ha) and BRRI dhan84 (4.16 t/ha). The poor yield of the check variety BRRI dhan84 was due to severe neck blast infection. Tested entry BR9674-1-4-1-3-P1 produced higher yield (8.46 t/ha) than the check variety BRRI dhan74 and BRRI dhan84 but lower than the check BRRI dhan29 (Table 31).

RYT (Antioxidant rice_MD). Eight advanced breeding lines along with two checks BRRI dhan88 and Indonesian black rice were evaluated. Among the eight test entries, only BR12839-4R-78-1 produced higher yield (8.2 t/ha) than both the check entries BRRI dhan88 (7.6 t/ha) and Indonesian black rice (6.7 t/ha). Yield of the other seven test entries varied from 5.8-7.2 t/ha. The entry BR12839-4R-90-1 was severely infected by neck blast disease in all three replications (Table 32).

RYT (Antioxidant rice_SD). Three advanced breeding lines along with one check variety BRRI dhan84 were evaluated. None of the test entries produced higher yield than the check variety BRRI dhan84 (7.5 t/ha). The yield of the test entries BR12839-4R-137, BR12839-4R-72 and BR12839-4R-73 were 6.9, 7.0 and 7.2 t/ha, respectively (Table 33).

RYT (Water Saving Rice). Two test entries were tested against check variety BRRI dhan58. Both the test entries BR11204-5B-224 (5.4 t/ha) and BR11206-5B-351 (4.7 t/ha) produced higher yield than the check BRRI dhan58 (4.0 t/ha). Low yield was observed in entries and check variety due to low soil fertility (Table 34).

RYT (FBR_Barishal). Nine advanced breeding lines along with two check varieties were evaluated. Four test entries NGR 270-3 (9.0 t/ha), NGR 522-2 (9.5 t/ha), NGR 968-1 (9.2 t/ha) and NGR 994-1 (9.1 t/ha) produced higher yield than both the checks BRRI dhan88 (7.3 t/ha) and BRRI dhan89 (8.8 t/ha) (Table 35).

RYT (SHR_Zirasail). Five advanced breeding lines along with two check varieties were evaluated. Four out of five test entries BRH10247-4-7-4B (8.4

t/ha), BRH12-1-7B-P1 (9.0 t/ha), BRH13-7-9-3-2B (8.2 t/ha) and BRH13-9-5-3B (9.2 t/ha) produced higher yield than both the checks BRRI dhan28 (7.9 t/ha) and Zirasail (8.1 t/ha) (Table 36).

RYT (Haor). Six advanced breeding lines along with one check variety were evaluated. Four out of six test entries BR9392-6-2-1-3-4 (7.0 t/ha), BR9396-6-2-2B (7.1 t/ha), BRH13-7-9-3-2B (7.0 t/ha) and BRH18-7-14B (7.1 t/ha) produced higher yield than the check variety BR18 (6.9 t/ha) (Table 37). The entry BR9392-6-2-1B showed photosensitivity hence did not flower.

Development of Anoxia Tolerant Rice

Experiment 1. Screening and identification of anaerobic germination/Anoxia tolerant rice germplasm in Bangladesh

Objective

- To identify donor for anaerobic germination tolerance in rice germplasm

The experiment was conducted in control condition using 42 rice germplasm comprising of local landraces, *AG1* and *AG2* QTLs introgressed lines and some advanced lines suitable for direct seeded condition. Seeds were sown directly in seedling tray where the holes were filled with soil. Randomized Complete Block Design (RCBD) was followed as experimental design with three replications. About nine cm water level was maintained above the soil surface where the seeds were sown. Seedling survivability data were collected on 14 and 21 days after sowing. Data on seedling height were also collected on the 21st day after sowing.

Results. Out of 42 genotypes, eight genotypes showed more than 50% survivability. Survivability of Shishumoti and Lal Aman was 75% and 69%, respectively (Table 1). Screening result will be reconfirmed in T. Aman 2023.

Table 1. Seedling survivability (%) and seedling height (cm) of tested 42 germplasm

Designation	Survivability (%)		Seedling height (cm)
	14 DAS	21 DAS	
IR18R1103	27.8	14.3	27.8
IR18R1066	25.0	13.7	27.8
IR18R1117	19.4	15.6	13.9
IR18R1137	27.8	14.0	27.8
IR18R1145	22.2	17.0	19.4
IR18R1148	11.1	16.0	13.9
IR18R1153	47.2	12.6	38.9
IR18R1154	38.9	14.8	33.3
IR18R1156	30.6	12.8	33.3
IR18R1160	5.6	8.5	2.8
IR18R1162	5.6	3.9	8.3
IR18R1040	0	-	0
BRRI dhan75	25.0	9.9	19.4
IR18R1068	25.0	15.1	19.4
IR18R1073	55.6	14.8	55.6
IR18R1119	16.7	16.8	16.7
IR18R1121	11.1	12.6	11.1

IR18R1123	33.3	14.9	30.6
IR18R1181	19.4	15.3	19.4
IR18R1164	13.9	15.0	5.6
IR18R1089	41.7	16.0	41.7
IR18R1111	25.0	15.4	27.8
IR19L1007	13.9	10.5	16.7
BRRI dhan81	5.6	20.0	5.6
Ciherang Sub1-AG2	13.9	12.1	13.9
Ciherang Sub1-AG1-AG2	13.9	18.8	13.9
BR8210-10-3-1-2	22.2	18.5	22.2
Ciherang Sub1	19.4	12.2	27.8
KHO	55.6	19.6	44.4
Hatisail	50.0	24.4	44.4
Indrasail	58.3	18.9	58.3
Khirari	63.9	18.2	58.3
Joli Aman	22.2	12.4	25.0
Lal Aman	66.7	20.7	69.4
Nizersail	50.0	15.1	52.8
Ratasail	47.2	14.1	36.1
Halid Jaran	0	-	0
Modhusail	13.9	12.3	27.8
Dharial	30.6	12.1	27.8
Chaita Boro	16.7	14.7	13.9
Banajira	13.9	17.1	13.9
Shishumati	77.8	17.6	75.0

FARMING SYSTEMS RESEARCH

Experiment 1: Introduction of intercropping system in different farmer led cropping pattern for medium high land area in Faridpur region

The study was conducted in farmers' fields at Nagarkanda, Faridpur during 2022-23 to increase the cropping intensity and productivity of the existing Onion-Jute-T. Aman cropping pattern in Faridpur region. The tested cropping patterns were: CP₁: Potato+Maize-Jute-T. Aman, CP₂: Onion+Pumpkin (Relay)-Jute-T. Aman, CP₃: Lentil+Muskmelon (Relay)-Jute-T. Aman, CP₄: Mustard+Watermelon-Mung bean-Jute-T. Aman and CP₅: Onion-Jute-T. Aman (Ck) following RCB design and dispersed farmers were considered as

replication. Recommended fertilizer dose and other recommended management practices for rice and non-rice crops were followed. To compare system productivity, yield of non-rice crops was converted to rice equivalent yield (REY).

Results and Discussion

Table 29 presents Individual crop yield and REY of respective cropping patterns. Considering the REY, there were significant difference ($P \leq 0.01$) among the cropping patterns. Significantly the highest REY (31.63 t/ha) was observed in CP₂: Onion+Pumpkin (Relay)-Jute-T. Aman. CP₁: Potato+Maize-Jute-T. Aman and CP₄: Mustard+watermelon-Mungbean-Jute-T. Aman resulted statistically similar REY 28.15 t/ha and 29.45 t/ha, respectively. The lowest

significant REY (25.91 t/ha) was found from CP₅: Onion-Jute-T. Aman (ck) which was statistically similar to CP₃: Lentil+Muskmelon (Relay)-Jute-T. Aman (Table 29). From the economic analysis it was observed that the highest gross margin (GM) was obtained from CP₂ (4,02,040 Tk/ha) followed

by CP₃ (3,81,920 Tk/ha) and CP₄ (3,64,850 Tk/ha) (Table 30). The lowest GM was observed in CP₁ (2,84,720 Tk/ha). The pattern CP₂, CP₃ and CP₄ produced 18%, 12% and 7% higher GM compared to the existing pattern CP₅ (Table 30).

Table 2. Yield performance of different improved cropping pattern for medium high land area in Faridpur district.

Cropping pattern	Yield (t/ha)											REY (t/ha)
	Potato	Mustard	Maize	Onion	Pumpkin	Lentil	Muskmelon	watermelon	Mung bean	Jute	T. Aman	
CP ₁	16.36	-	7.7	-	-	-	-	-	-	3.10	5.22	28.15 bc
CP ₂	-	-	-	11.8	10.1	-	-	-	-	3.00	5.12	31.63 a
CP ₃	-	-	-	-	-	1.39	10.6	-	-	3.16	5.05	27.13 cd
CP ₄	-	1.24	-	-	-	-	-	10.4	1.06	3.02	5.08	29.45 b
CP ₅	-	-	-	12.5	-	-	-	-	-	3.21	4.42	25.91 d
CV (%)	6.80											

Means with the same letter are not significantly different.

Market price: Mustard: 80 Tk/kg; Potato: 10 Tk/Kg; 20Tk/kg; Onion: 30 Tk/kg; Lentil: 85; Jute: 75 Tk/kg; Maize: 25 Tk/kg; Pumpkin: 20 Tk/kg; Mungbean: kg; Rice: 25 Tk/Kg 95 Tk/kg; Muskmelon: 20 Tk/kg; Watermelon:

Table 3. Cost-return analysis of different crops combinations under intercropping system, Nagarkanda, Faridpur, 2022-23.

Cropping pattern (CP)	GR (‘000 Tk/ha)	TVC (‘000 Tk/ha)	GM (‘000 Tk/ha)	% GM increase
CP ₁ : Potato+Maize-Jute-T.Aman	703.75	419.03	284.72	-17
CP ₂ : Onion+Pumpkin-Jute-T. Aman	790.75	388.71	402.04	18
CP ₃ : Lentil+Muskmelon-Jute-T.Aman	678.25	296.33	381.92	12
CP ₄ : Mustard+W.melon-M.bean-Jute-T. Aman	736.25	371.40	364.85	7
CP ₅ : Onion-Jute-T.Aman (CK)	647.75	306.75	341.00	-

CROP-SOIL-WATER MANAGEMENT

Experiment 1: Effects of planting time on *Aus* rice in Charland area of Faridpur, Bangladesh

Objectives

1. To achieve sustainable rice production under char land environment conditions.
2. To adjust planting time for escaping the crop from the flood.

Planting materials. BRRI dhan82, BRRI dhan83, and Porangi

Planting method. Broadcast and Seed rate: 150 gm per plot

Experimental design. RCB design

Fertilization. Fertilization was done according Modern Rice Cultivation (BRRI 2019)

Plant protection. Insecticide and pesticide were applied when necessary.

Cropping patterns. Onion-B. Aus-Fallow, Garlic-B. Aus-Fallow, Lentil-Aus-B. Aman

Treatments. A. 05 April, 2022 B. 15 April, 2022 and C. 25 April, 2022

Results. The inbred varieties BRRI dhan82 produced maximum grain yield compared to other two variety in all the treatments (Table 1). The treatments had significant effect on grain yield and yield components but had no effect on grains per panicle and % sterility (Table 2). However, the minimum growth duration was found in local varieties Porangi compared to inbred varieties BRRI dhan82 and BRRI dhan83 for all treatments (Table 1). Considering all the treatments and weather condition, the experiment should run minimum for five years and the previous weather data should be studied to discover the optimum time range for Aus rice cultivation in Faridpur region.

Table 4. Grain yield and growth duration of the evaluated rice varieties during Aus 2022.

Variety	Grain yield (t/ha)			Harvesting time		
	5-April (T1)	15-April (T2)	25-April (T3)	5-April (T1)	15-April (T2)	25-April (T3)
BRRI dhan82	3.62	3.42	3.01	18-July (104 days)	27-July (105 days)	7-August (106 days)
BRRI dhan83	3.40	2.81	2.72	17-July (103 days)	26-July (104 days)	7-August (106 days)
Porangi	1.81	1.19	0.99	23-June (80 days)	3-July (81 days)	16-July (83 days)

Table 5. Mean performances for yield related traits of 4 rice genotypes evaluated at Shibchar, Madaripur.

Variety	Treatment	Plant height (cm)	Tiller/ m ²	Panicle/ m ²	Panicle length (cm)	Grain/ panicle	% Sterility	1000-gw (g)	Yield (t/ha)
BRRI dhan82	T1	96.59 b	180.33 a	169.00 a	22.84 a	66	27.86	23.53 b	3.62 a
	T2	99.45 a	164.33 b	164.67 a	22.64 b	68	23.85	23.22 b	3.42 b
	T3	98.60 ab	167.33 b	157.00 b	22.82 a	69.33	17.45	22.89 c	3.01 bc
BRRI dhan83	T1	96.48 a	172.00 a	158.33 b	22.29 d	75.67	20.9	22.47 d	3.40 b

Variety	Treatment	Plant height (cm)	Tiller/ m ²	Panicle/ m ²	Panicle length (cm)	Grain/ panicle	% Sterility	1000-gw (g)	Yield (t/ha)
BRRI dhan83	T2	98.44 a	158.33 b	142.33 c	22.27 d	70.67	18.03	22.84 c	2.81 c
	T3	97.92 a	156.67 b	150.67 bc	22.63 b	64.67	18.86	22.65 c	2.72 c
Porangi	T1	99.31 a	144.00 c	129.00 d	22.45 c	43	27.66	23.64 a	1.81 d
	T2	98.70 a	132.33 c	114.00 e	22.31 c	33.33	25.03	23.59 b	1.19 d
	T3	92.40 b	134.67 c	121.00 d	22.42 c	26.33	25.65	23.42 b	0.99 e
Mean		97.54	156.67	145.11	22.52	57.44	22.81	23.14	2.55
CV (%)		1.5	5.74	5.89	0.61	12.54	17.54	1.15	9.33
LSD (<0.05)		2.6	9.23	8.78	0.14	NS	NS	0.27	0.24

Experiment 2. Development of weed control techniques in Boro-Fallow-Fallow cropping pattern

Introduction. The average yield of Boro rice (4.03 t ha⁻¹) is comparatively higher than that of Aus and Aman rice. The increased rice production has been possible largely through the adoption of modern technology. Hand weeding is the popular weed control method in Bangladesh. But weed control is often imperfect or delayed due to unavailability of labour during the peak period. Based on the above facts an experiment was conducted with the objectives to develop cost effective and eco-friendly weed control for sustainable weed management in Boro-Fallow-Fallow cropping systems.

Materials and Methods. The experiment was conducted at the Research Field at BRRI RS, Bhanga, Faridpur during Boro 2022-23 to evaluate the weed control techniques for sustainable weed management. The experiment was in RCB design replicated thrice with seven treatments. In this experiment, BRRI dhan89 was used as plant material. The unit plot size was 18 m². Spacing of 20 cm × 20 cm and 2-3 seedlings per hill were maintained. To save the seedlings from cold injury proper fertilization and water management were maintained in the seedbed. Forty-day-old seedlings were transplanted into the main field on 29 January 2023. All the fertilizers were applied during the final land preparation (DAP: MoP: Gypsum: Zinc sulfate @ 105: 150: 105: 11 kg ha⁻¹). However, three equal splits of urea (262 kg ha⁻¹) were applied as a top dress on 15, 30, and 45 days on transplanting. Cultural management like weeding, irrigation and

drainage, insecticide and pesticide application were done when necessary. The treatments were T1= Farmer practice (15 DAT, 30 DAT and 45 DAT), T2= BRRI Rice weeder (20 DAT, and 45 DAT) + Hand weeding (30 DAT), T3= Pre emergence herbicide (5 DAT) + Hand weeding (30 DAT) , T4= Post emergence herbicide-1 (14 DAT) + Hand weeding (45 DAT), T5= Pre emergence herbicide (5 DAT) + Post emergence herbicide (14 DAT) + Hand weeding (40 DAT), T6= Pre emergence herbicide (5 DAT) + Post emergence herbicide (30 DAT) and T7= Control (no weeding). Pre-emergence herbicide applied Bensulfuron-methyl (4%) + Acetochlor (14%) @ 100 g/33 decimal (1.12 g/plot) and Post-emergence herbicide Bensulfuron-methyl (12% w/w) + Bispyribac-sodium (18% w/w) @ 19.08 g/33 decimal (0.213 g/plot).

Data collection

Weed data. At 45 DAT, a quadrat (1 m × 1 m) was placed randomly in one places of each plot for collecting weed samples. Weeds were clipped at ground level, identified, and counted by species, and dried in an oven at 70°C until the weight became constant. Weed density (plant/m²), weed fresh and dry biomass (g/m²), relative weed density (%) and Relative weed biomass (%) were measured.

Crop data. Data were recorded on plant height and tiller no. m⁻² at 25, 50, 80 DAT and at maturity. Moreover, data on date of sowing (days), date of transplanting (days), no. of tiller and panicles m⁻², panicle length (cm), grains panicle⁻¹ (no.), 1000 grain weight (g) and grain yield (kg/plot) were recorded from research plot.

Results. BRRI dhan89 exhibited significant differences in plant height at 50 DAT but no significance difference was found at 25 DAT, 80 DAT and at maturity. There were no significant differences observed for tiller no. m⁻² (Table 3). The treatments had no significant effect on grain yield (t ha⁻¹) and yield contributing traits of panicle no. m⁻², grains panicle⁻¹, % sterility and 1000 gw (g) except panicle length. All the treatments showed higher grain yield compared to control. The highest

grain yield (8.49 t ha⁻¹) was found in treatment T4 and the lowest (7.83 tha⁻¹) observed in control (T7). Grass weeds contributed 55% of the total dry matter compared to broadleaf and sedge (42 and 4%) respectively and 48% of total density of broadleaf compared to grass (42%) and sedges (10%) (Fig. 1). The experiment requires further research to develop suitable and cost-effective weed control technology in a single *Boro* cropping system.

Table 6. Effect of treatments on plant height and tiller no./m² of BRRI dhan89.

Treatment	Plant height (cm)				Tiller no. (m ²)			
	25 DAT	50 DAT	80 DAT	at maturity	25 DAT	50 DAT	80 DAT	at maturity
T1	36.3	80.6 ab	102.2	106.6	217	335	323	340
T2	35.4	80.6 ab	101.0	107.1	209	355	356	318
T3	36.6	81.7 ab	103.1	106.8	214	357	353	346
T4	34.8	79.6 ab	100.3	104.6	190	339	335	330
T5	37.8	85.5 a	106.7	106.2	217	383	350	346
T6	33.9	78.2 b	100.6	104.8	194	369	352	349
T7	39.5	85.8 a	108.3	107.3	223	358	366	316
Mean	36.33	81.71	106.2	106.19	209	357	348	335
HSD (0.05)	NS	7.17	NS	NS	NS	NS	NS	NS
CV (%)	5.33	3.07	2.31	2.31	11.39	6.70	6.03	5.23

Table 7. Effects of treatments on yield and yield components of BRRI dhan89.

Treatment	Panicle no. m ⁻²	PL (cm)	Grain panicle ⁻¹	% Sterility	1000 gw (g)	GY (t ha ⁻¹)
T1	323	24.13 ab	122.60	20.97	24.37	8.02
T2	312	23.53 b	120.33	23.26	23.73	7.87
T3	318	24.2 ab	117.83	26.71	21.85	8.4
T4	315	23.67 b	122.27	21.49	23.9	8.49
T5	337	25.0 a	121.67	23.61	21.16	8.05
T6	322	24.07 ab	130.30	20.76	21.73	8.32
T7	310	23.8 b	100.10	23.05	22.6	7.83
Mean	319	24.06	119.13	22.84	22.76	8.14
HSD (0.05)	NS	0.99	NS	NS	NS	NS
CV (%)	5.06	1.44	10.69	18.90	13.22	7.20

T1= Farmer practice (15 DAT, 30 DAT and 45 DAT), T2= BRRI Rice weeder (20 DAT, and 45 DAT) + Hand weeding (30 DAT), T3= Pre emergence herbicide (5 DAT) + Hand weeding (30 DAT), T4= Post

emergence herbicide-1 (14 DAT) + Hand weeding (45 DAT), T5= Pre emergence herbicide (5 DAT) + Post emergence herbicide (14 DAT) + Hand weeding (40 DAT), T6= Pre emergence herbicide (5 DAT) + Post emergence herbicide (30 DAT) and T7= Control (no weeding)

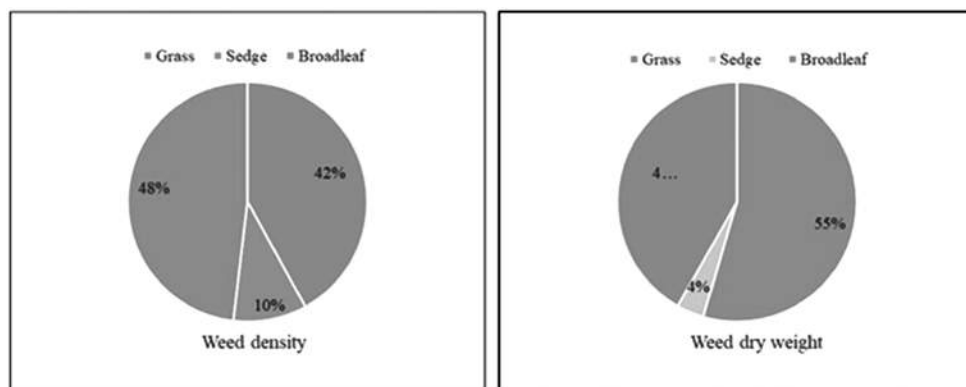


Fig. 1. Weed density and weed dry weight of different weed group.

SOCIO-ECONOMICS AND POLICY

Stability analysis of BRRI released Aman and Boro varieties during T. Aman and Boro 2022-23

For short duration Aman varieties, BRRI dhan39, BRRI dhan66 and BRRI dhan71 produced 4.48 t ha⁻¹, 3.90 t ha⁻¹ and 3.76 t ha⁻¹ which was higher yield than the other varieties like BRRI dhan33 (Table 38). In medium duration Aman varieties based on yield BRRI dhan78, BRRI dhan52 and BRRI dhan72 produced the highest grain yield 5.74 t ha⁻¹, 5.04 t ha⁻¹ and 4.94 t ha⁻¹ followed by BRRI dhan72 (2.29 t/ha), BRRI dhan44 (2.22 t/ha) and BRRI dhan49 (2.18 t/ha). (Table 39). In long duration T. Aman varieties BRRI dhan34 yielded high (4.25 t ha⁻¹) followed by BRRI dhan37 (1.95 t ha⁻¹) and BRRI dhan38 (2.25 t ha⁻¹) (Table 40).

In Boro season, among the short duration varieties, the highest yield was found in BRRI hybrid dhan5 (9.65 t/ha) followed by BRRI hybrid dhan3 (8.92 t/ha), BRRI hybrid dhan2 (8.49 t/ha) and Bangabandhu dhan100 (8.31 t/ha) (Table 41). In long duration Boro varieties, BRRI dhan92 produced the highest (8.95 t/ha) yield followed by BRRI dhan99 (8.60 t/ha) and BRRI dhan89 (8.59 t/ha) (Table 42).

TECHNOLOGY DISSEMINATION

Demonstrations of modern rice varieties during Aus 2022, T. Aman 2022 and Boro 2022-23

were conducted at Sadar, Nagarkanda, Saltha, Sadarpur, Bhanga and Madhukhali, Faridpur; Sadar, Goalandha, Pangsha and Kalukhali, Rajbari; Sadar, Rajoir, Kalkini, Shibchar, Madaripur; Sadar and Zajira, Shariatpur under BRRI RS, Bhanga, Faridpur with the financial assistance of GoB.

In Aus 2022, a total of 50 demonstrations were established under the supervision of BRRI RS, Bhanga. Newly released high yielding varieties BRRI dhan83, BRRI dhan98 and BRRI hybrid dhan7 were used. Yield of BRRI dhan83 varied from 2.93-3.28 t/ha with the average of 3.11 t/ha. Yield of BRRI dhan98 varied from 4.88-5.68 t/ha with the average of 5.25 t/ha. Yield of BRRI hybrid dhan7 varied from 4.95-6.08 t/ha with the average of 5.41 t/ha.

Similarly, in T. Aman 2022, total 120 demonstrations were carried out using BRRI dhan39, BRRI dhan75, BRRI dhan87 and BRRI hybrid dhan6. Yield of BRRI dhan39 varied from 3.03-4.94 t/ha with the average of 3.95 t/ha. Yield of BRRI dhan75 varied from 3.99-6.58 t/ha with the average of 5.08 t/ha. Yield of BRRI dhan87 varied from 4.83-6.79 t/ha with the average of 5.91 t/ha. Yield of BRRI hybrid dhan6 varied from 4.78-5.97 t/ha with the average of 5.32 t/ha.

In Boro 2022-23, a total of ten varieties such as BRRI dhan58, BRRI dhan67, BRRI dhan89,

BRRi dhan92, BRRi dhan96, BRRi dhan97, BRRi dhan99, Bangabandhu dhan100, BRRi hybrid dhan3, BRRi hybrid dhan5 were included in 450 demonstrations at six upazilas of four districts namely Faridpur, Shariatpur, Madaripur and Rajbari under BRRi RS, Bhanga. A total of 450 crop cut was done in different upazilas. The highest grain yield in different locations were: 10.43 t ha⁻¹ with BRRi hybrid dhan5; 8.27 t ha⁻¹ with BRRi hybrid dhan3; 9.22 t ha⁻¹ with BRRi dhan92 in Saltha; 8.0 t ha⁻¹ with BRRi dhan99 in Bhanga; 8.34 t ha⁻¹ BRRi dhan89 in Saltha. The trial farmers stored their seeds except hybrid seed according to their demand for growing in the next Boro season.

In Aman 2022 five varietal replacement of short duration T. Aman varieties through Head to Head trials were conducted at five upazilas of two districts namely Faridpur and Madaripur under the supervision of BRRi RS, Bhanga and with the financial assistance of BRRi-TRB project. Six genotypes i.e. BRRi dhan33, BRRi dhan39, BRRi dhan75, BRRi dhan71, Binadhan-16, Binadhan-17 and Binadhan-22 were included in this trial. The highest grain yield in different locations were as follows: 7.39 t/ha in BRRi dhan33 at Bhanga, Faridpur; 6.73 t/ha in BRRi dhan33 at Nagarkanda, Faridpur. The lowest yield was found in Binadhan-16 (4.77 t/ha) at Kalkini, Madaripur.

Similarly, in Boro 2022-23, a total of six varieties such as BRRi dhan28, BRRi dhan74, BRRi dhan88, BAU dhan-3, Binadhan-25 and Bangabandhu dhan100 were included in BRRi dhan28 group while BRRi dhan29, BRRi dhan89, BRRi dhan92, BRRi dhan102 and Binadhan-24 are included in BRRi dhan29 group. Five (two BRRi dhan28 group

and three BRRi dhan29 group) varietal replacement through head to head trials were conducted at three upazilas of Faridpur district under BRRi RS, Bhanga with the financial assistance of BRRi-TRB project. The highest grain yield with growth duration in different locations were as follows: in short duration group 9.71 t/ha with BRRi dhan74 in Raynagar, Bhanga, Faridpur; 8.9 t ha⁻¹ with Bangabandhu dhan100 in Raynagar, Bhanga, Faridpur. BRRi dhan28 produced the lowest yield of 6.61 t/ha in Kaolibera, Bhanga, Faridpur. In long duration group, BRRi dhan92 in Naoapara, Bhanga, Faridpur produced the highest yield of 9.28 t/ha, followed by BRRi dhan29 which produced 9.19 t/ha yield. The lowest yield of 6.51 t/ha was produced by Binadhan-24 in Nagarkanda, Faridpur. The trial farmers stored their seeds according to their choice for growing in the next Boro season.

In total 25.75 tons of seeds were produced in BRRi RS, Bhanga farm. Out of them, 13.75 tons of breeder seed of BRRi dhan29 (5.5 t/ha), BRRi dhan89 (5.5 t/ha) and BRRi dhan92 (2.75 t/ha) and the rest about 12.0 were TLS of short duration T. Aman varieties such as BRRi dhan39, BRRi dhan71, BRRi dhan75, BRRi dhan79 and BRRi dhan87 as well as Boro varieties of BRRi dhan29, BRRi dhan50, BRRi dhan58, BRRi dhan84, BRRi dhan88, BRRi dhan89 and BRRi dhan92, BRRi dhan100, BRRi dhan101 and BRRi dhan102 during Boro 2022-23 season.

Three hundred and ninety farmers of greater Faridpur region trained on modern rice production technologies through 13 training programmes in BRRi RS, Bhanga with the cooperation of DAE and the financial assistance of GOB.

Table 8. List of crosses made during T. Aman 2022-23.

Cross	F ₁ seed	Objective
BRRi dhan39/Shishumoti	100	Stem elongation, high yield and photosensitivity
BRRi dhan39/Nizersail	141	High yield and photosensitivity
BRRi dhan75/Shishumoti	3	Stem elongation, high yield and photosensitivity
BRRi dhan75/Nizersail	17	High yield and photosensitivity
BRRi dhan87/Bashiraj	107	Stem elongation, high yield and photosensitivity
BRRi dhan87/I-0049	15	High yielding T. Aman

Cross	F ₁ seed	Objective
BRRI dhan92/BR12177-5R-156	46	High yielding T. Aman
BRRI dhan89/BR11910-4R-94	4	High yielding T. Aman
BRRI dhan89/BR11723-4R-172	6	High yielding T. Aman
BRRI dhan92/BR12177-4R-11	25	High yielding T. Aman
BRRI dhan92/BR12180-4R-62	8	High yielding T. Aman

Table 9. List of crosses made during Boro 2022-23.

Cross	F ₁ seed	Objective
BR11593-5R-70/BRRI dhan89	165	High yielding boro rice
BR11593-5R-70/ BRRI dhan29	70	High yielding boro rice
BR11593-5R-70/NGR 1255-1	37	High yielding boro rice
BR11595-5R-24/ BRRI dhan29	80	High yielding boro rice
BR11595-5R-24/BRRI dhan89	31	High yielding boro rice
BR11318-5R-63/NGR 1255-1	11	High yielding boro rice
BR10317-5R-57/BRRI dhan92	9	High yielding boro rice
BR11595-5R-24/BRRI dhan92	80	High yielding boro rice
BR10317-5R-57/BR11318-5R-63	18	High yielding boro rice
BR11318-5R-63/NGR 1255-1	10	High yielding boro rice
NGR1255-1/ BR11593-5R-70	5	High yielding boro rice
BR12180-5R-29/BRRI dhan89	80	High yielding boro rice
BR12180-5R-29/BRRI dhan29	80	High yielding boro rice
BR12208-5R-402/ BRRI dhan89	6	High yielding boro rice
BR12208-5R-394/BRRI dhan29	12	High yielding boro rice
BRRI dhan50/Indonesian Black Rice	6	Antioxidant enriched rice
Vietnamese Black Rice/BRRI dhan50	78	High yielding boro rice
I-059/BRRI dhan89	6	High yielding boro rice
I-059/BRRI dhan29	13	High yielding boro rice
BRH 13-9-5-3B / BRRI dhan89	12	High yielding boro rice
BRH 12-1-7B-P1/ BRRI dhan89	24	High yielding boro rice

Table 10. List of F₄ generation advanced through FRGA, T. Aman 2022-23.

BR Reg No.	Cross	Progeny grown	Progeny harvested
BRBh16-3R	BRRI dhan29/ Lal Digha	78	55
BRBh17-3R	BRRI dhan49/ Lal Digha	91	80
BRBh18-3R	BRRI dhan79/ Lal Digha	115	110

BR Reg No.	Cross	Progeny grown	Progeny harvested
BRBh19-3R	BRRi dhan87/ Lal Digha	85	81
BRBh20-3R	BRRi dhan75/ Lal Digha	89	82
BRBh21-3R	BRRi dhan52/ Lal Digha	110	105
BRBh22-3R	BRRi dhan79/ Laxmi Digha	120	112
BRBh23-3R	BRRi dhan75/ Laxmi Digha	75	49
BRBh24-3R	BRRi dhan49/ Laxmi Digha	80	77
BRBh25-3R	BRRi dhan52/ Laxmi Digha	50	45
BRBh26-3R	BRRi dhan87/ Khaiya motor	50	28
BRBh27-3R	BRRi dhan79/ Khaiya motor	120	105
BRBh28-3R	BRRi dhan52/ Khaiya motor	96	84
BRBh29-3R	BRRi dhan49/ Khaiya motor	90	90
BRBh30-3R	BRRi dhan87/ Laxmi Digha	70	67
BRBh31-3R	BRRi dhan75/ Khaiya motor	90	84
Total		1409	1304

Table 11. List of F₅ generation advanced through FRGA, T. Aman 2022-23.

BR reg no.	Cross	Progeny grown	Progeny harvested
BRBh16-4R	BRRi dhan29/ Lal Digha	46	32
BRBh17-4R	BRRi dhan49/ Lal Digha	70	58
BRBh18-4R	BRRi dhan79/ Lal Digha	52	39
BRBh19-4R	BRRi dhan87/ Lal Digha	61	40
BRBh20-4R	BRRi dhan75/ Lal Digha	80	70
BRBh21-4R	BRRi dhan52/ Lal Digha	82	69
BRBh22-4R	BRRi dhan79/ Laxmi Digha	35	24
BRBh23-4R	BRRi dhan75/ Laxmi Digha	120	107
BRBh24-4R	BRRi dhan49/ Laxmi Digha	49	35
BRBh25-4R	BRRi dhan52/ Laxmi Digha	60	47
BRBh26-4R	BRRi dhan87/ Khaiya motor	34	26
BRBh27-4R	BRRi dhan79/ Khaiya motor	79	68
BRBh28-4R	BRRi dhan52/ Khaiya motor	100	92
BRBh29-4R	BRRi dhan49/ Khaiya motor	56	42
BRBh30-4R	BRRi dhan87/ Laxmi Digha	78	60
BRBh31-4R	BRRi dhan75/ Khaiya motor	138	103
Total		1140	917

Table 12. List of F₂ generation advanced through FRGA, Boro 2022-23.

BR Reg#	Crosses	Progeny Grown	Progeny harvested
BRBh51	BR9918-10-4-5/BR10601-5R-74	9	6
BRBh52	NGR 796-2/ BR12645-4R-71	61	46
BRBh53	NGR 418-1/ BRRi dhan89	112	95
BRBh54	BRH9-3-2B/ BRRi dhan67	7	4
BRBh55	NGR 521-2/ BRRi dhan58	66	48
BRBh56	NGR 1308-2/ BRRi dhan58	94	36
BRBh57	BRRi dhan29/ BRRi dhan67	61	50
Total		410	330

Table 13. List of F₃ generation advanced through FRGA, Boro 2022-23.

	BR Reg#	Cross	Progeny grown	Progeny harvested
	BRBh32	BRRi dhan79/ Sadapajam	4	4
	BRBh33	BRRi dhan75/Noroidhan	34	24
	BRBh34	Binadhan-22/I-025	9	4
	BRBh35	BRRi dhan99/ I-025	1	1
	BRBh36	Binadhan-17/ Sadapajam	38	19
	BRBh37	BRRi dhan79/BRRi dhan34	2	1
	BRBh38	BRRi dhan75/BRRi dhan67	5	5
	BRBh47	BRRi dhan67/ Sadapajam	11	8
	BRBh48	BRRi dhan87/ Laxmidigha	7	5
	BRBh50	BRRi dhan99/ Sadapajam	1	1
Total			108	72

Table 14. List of F₅ generation advanced through FRGA, Boro 2022-23.

BR Reg No.	Cross	Progeny grown	Progeny harvested
BRBh13-4R	BR11716-4R-113 / DR(6)	40	40
BRBh14-4R	IR107989-13-BRGA-BRGA-396 / WAXXIAN7777-P8	50	47
BRBh15-4R	BR11723-4R172 / IR58443-6B-10-3	60	60
Total		150	147

Table 15. Performance of Proposed Variety Trial at BRRI RS, Bhanga during T. Aman 2022-23.

PVT_Set	Location	Code no.	Growth duration (day)	Yield (t/ha)	Yield advantage (%)
Set-1	Rashidpur, Bhanga	I-044	197	3.4	9.6
		I-046	160	3.1	
Set-2	Rashidpur, Bhanga	I-045	197	3.7	19.4
I-046			160	3.1	
Set-3	BRRI_Bhanga	I-047	114	6.4	30
		I-048	111	4.9	
Set-4	BRRI_Bhanga	I-049	123	5.5	0
		I-050	128	5.5	

Table 16. Performance of Proposed Variety Trial at BRRI RS, Bhanga during Boro 2022-23.

PVT_Set	Location	Code no.	Growth duration (day)	Yield (t/ha)	Yield advantage (%)
Set-1	BRRI_Bhanga	I-053	140	7.3	-
		I-054	142	8.1	
Set-2	BRRI_Bhanga	I-055	157	7.5	-
		I-056	142	7.5	
Set-3	BRRI_Bhanga	I-057	147	7.9	10.0
		I-058	146	7.1	
Set-4	BRRI_Bhanga	I-059	155	9.4	13.4
		I-060	144	8.2	

Table 17. Grain yield and agronomic characters of ALART DWR at Rashidpur, Bhanga, T. Aman 2022.

Designation	PH (cm)	Panicle/sqm	GD (day)	Yield (t/ha)
BR10230-7-19-2B	164.5	487	192	4.1
BR9892-6-2-2B	169.6	487	192	3.6
BR9376-6-6-2B	180.5	424	193	3.6

Designation	PH (cm)	Panicle/sqm	GD (day)	Yield (t/ha)
BR9392-6-2-1B	156.2	545	192	4.3
BR-KM (Mun)-PL-5-7-3-B	158.5	489	192	2.8
BR-DL (Hbj)-PL-12-4-7-B	160.2	557	192	2.2
Fulkori (ck)	138.8	568	190	1.8

* There was no flooding, severe drought prevailed throughout the season

Table 18. Grain yield and agronomic characters of ALART PQR at Rashidpur, Bhanga, T. Aman 2022.

Designation	PH (cm)	Panicle/Sqm	GD (day)	Yield (t/ha)
BR8493-3-5-1-P1	118.0	265	125	4.1
BR9590-45-1-3-2-P2	116.7	271	133	2.9
BRRI dhan34 (ck)	129.8	348	137	2.5
BRRI dhan70 (ck)	146.0	451	122	4.3

Table 19. Grain yield and agronomic characters of ALART_SD at Nagarkanda, Faridpur, Boro 2022-23.

Designation	PH(cm)	Panicle/m ²	GD (day)	Yield(t ha ⁻¹)
BR11318-5R-63	106.9	337	148	8.52
BR11337-5R-72	89.3	358	147	8.75
SVIN109	101.2	307	145	8.22
IR17A1723	82.0	327	144	6.21
BRRI dhan81 (ck)	88.2	302	145	7.79
BRRI dhan96 (ck)	90.9	328	147	7.83
Mean	93.1	326	146	7.89
LSD (0.05)	9.85	30.46	0.80	1.92
CV (%)	6.62	5.83	0.35	14.76

Table 20. Grain yield and agronomic characters of ALART MD at Nagarkanda, Faridpur, Boro 2022-23.

Designation	PH (cm)	Panicle/m ²	GD (day)	Yield (t ha ⁻¹)
IR12A173	105.4	328	149	8.38
IR17A1694	93.5	315	151	7.69
BRRI dhan58 (ck)	93.7	318	149	8.77
BRRI dhan96 (ck)	89.5	276	149	7.69
Mean	95.6	309	150	8.13
LSD (0.05)	7.09	31.36	1.76	1.3
CV (%)	4.93	6.22	0.74	10.77

Table 21. Grain yield and agronomic characters of ALART_FBR_Barishal at Nagarkanda, Faridpur, Boro 2022-23.

Designation	PH (cm)	Panicle/sqm	GD (day)	YLD (t/ha)
BRBa 1-4-9	103.2	276.67	153	8.09
BRBa 14-NGR 414-1	92.4	275.67	153	6.95
BRBa 3-1-7	90.13	295	154	8.06
BRBa40-NGR 1255-1	104.6	256.67	154	7.74
BRRI dhan58 (ck)	93.5	255	151	6.27
BRRI dhan89 (ck)	104.8	293.67	153	7.47
Mean	98.11	275.44	153	7.43
LSD (0.05)	5.33	33.67	-	0.73
CV (%)	3.4	8.26	-	6.15

Table 22. Grain yield and ancillary characters of ALART (BRR) at Nagarkanda, Faridpur, Boro 2022-23.

Designation	PH (cm)	Pan/m ²	GD (day)	Yield (t/ha)
BR12454-BC2-56-81--27-3-30	103.7	282	148	6.30
BR12454-BC2-69-97-39-5-44	102.4	334	151	6.32
BR12454-BC2-71-91-6-23-26	104.9	266	150	6.50
BR12454-BC2-75-32-31-39-7	99.1	328	152	7.81
BRRI dhan29 (Std. & Sus.ck)	97.9	286	154	7.55
BRRI dhan89 (Std. & Sus.ck)	99.9	260	150	6.32
Mean	101.3	293	151	6.80
LSD (0.05)	3.1	24.65	0.47	1.05
CV (%)	1.91	5.27	0.19	9.72

Table 23. Grain yield and ancillary characters of ALART (BRR_Re-ALART) at Nagarkanda, Faridpur, Boro 2022-23.

Designation	PH (cm)	Pan/m ²	GD (day)	Yield (t/ha)
BR (Path) 12452-BC3-42-22-11-4	95.1	310	139	8.00
BR (Path) 12452-BC6-53-21-11	96.8	332	136	7.36
BR (Path) 13784-BC3-61-1-6-HR3	95.3	322	138	7.52
BR (Path) 13784-BC3-63-6-4-HR6	93.7	304	138	5.58
BRRI dhan28 (ck)	98.9	280	136	6.35

Designation	PH (cm)	Pan/m ²	GD (day)	Yield (t/ha)
BRRI dhan88 (ck)	90.5	327	139	7.51
Mean	95.1	312	138	7.05
LSD (0.05)	6.5	32.55	-	1.65
CV (%)	4.25	7.1	-	14.44

Table 24. Grain yield and ancillary characters of RYT (FBR_LD) at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	Plant height (cm)	GD (day)	Yield (t/ha)
BR11894-5R-260	105.27	156	8.20
BR11660-5R-6	104.73	153	6.39
BR11318-5R-148	104.87	157	8.56
BR11318-5R-84	105.67	163	9.61
BR10301-5R-89	105.47	160	7.40
BRRI dhan81 (ck)	90.67	147	5.60
BRRI dhan89 (ck)	102.07	157	8.21
BRRI dhan92 (ck)	109.2	161	8.84
Mean	5.24	157	7.85
LSD (0.05)	8.27	1.22	1.42
CV (%)	103	0.512	11.93

Table 25. Grain yield and ancillary characters of RYT (FBR_SD) at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	Plant height (cm)	GD (day)	Yield (t/ha)
BR11637-5R-140	134.6	144	7.41
BR11894-5R-376	115.8	149	8.83
BR11900-5R-24	102.7	152	8.60
BR11903-5R-56	106.6	140	8.72
BR12180-5R-17	121.9	153	8.28
BR12180-5R-29	115.3	152	8.49
BR12208-5R-274	130.1	144	7.65
BR12208-5R-394	90.9	147	8.23
BR12208-5R-402	94.5	146	8.52
BRRI dhan28 (ck)	102.1	143	6.06
BRRI dhan96 (ck)	96.7	144	7.88
Mean	110.12	147	8.06
LSD (0.05)	2.17	1.15	0.95
CV (%)	1.24	0.50	7.52

Table 26. Grain yield and ancillary characters of RYT (FBR_MD) at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	Plant height (cm)	GD (day)	Yield (t/ha)
IR17A1275	98.2	140	8.77
IR17A1694	95.6	153	7.94
IR17A1735	94.73	140	7.11
IR18A1398	111.2	153	8.13
IR18A1907	115.0	150	9.88
IR18A2119	102.2	145	8.35
BR8899-14-4-1-2-2-1	92.73	146	8.92
BR11342-5R-23	121.0	147	8.81
BR12177-5R-43	121.47	157	8.05
BRRI dhan81 (ck)	108.53	142	6.48
BRRI dhan89 (ck)	114.27	157	8.20
Mean	106.81	148	8.24
LSD (0.05)	5.68	1.95	0.73
CV (%)	3.40	0.85	5.57

Table 27. Grain yield and ancillary characters of RYT (FBR_ELS) at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	Plant height (cm)	GD (day)	Yield (t/ha)
BR9945-5R-21	104.2	146	6.96
BR10604-5R-58	99.7	147	7.39
IR18A2102	100.7	143	6.12
BR7528-2R-19-16-RIL-52	104.2	153	8.51
BR7528-2R-19-16-RIL-55	101.9	154	7.87
BR7528-2R-19-16-RIL-59	98.5	152	7.92
BRRI dhan50 (ck)	82.7	154	7.17
BRRI dhan63 (ck)	88.6	144	4.83
BRRI dhan86 (ck)	91.9	143	8.07
Mean	96.94	149	7.21
LSD (0.05)	2.69	1.29	0.96
CV (%)	1.83	0.54	8.35

Table 28. Grain yield and ancillary characters of RYT (DRR_BB) at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

	Designation	PH (cm)	GD (day)	Yield (t/ha)
	BR11604-4R-24	112.7	148	9.02
	BR11607-4R-2	98.7	154	8.58
	BR11607-4R-258	95.7	150	8.74
	BR11866-5R-73	94.4	152	9.87
	BR11866-5R-136	97.0	152	8.08
	BR11866-5R-223	104.0	156	9.16
	BR11866-5R-277	99.7	154	8.47
	BR11867-5R-117	99.3	150	8.89
	BR11867-5R-140	98.9	154	9.01
	BR11867-5R-154	91.8	148	9.97
	BR11867-5R-347	97.2	140	9.61
	BR11868-5R-9	112.0	142	7.38
	BR(Path)13800-BC3-8-1	103.3	151	10.20
	BR(Path)13800-BC3-8-6	101.8	155	10.46
	BR(Path)13800-BC3-109-10	106.2	150	9.96
	BR(Path)13800-BC3-8-7	105.5	156	9.54
	BR(Path)13800-BC3-8-9	105.1	153	9.46
	BR(Path)13800-BC3-224-28	108.8	152	10.16
	BRRI dhan58 (Std. ck)	97.0	147	8.90
	BRRI dhan89 (Std. ck)	104.2	152	9.44
	BRRI dhan92 (Std. ck)	106.9	156	9.65
	BRRI dhan101 (Res. ck)	112.3	145	9.23
	Mean	102.39	151	9.26
	LSD (0.05)	1.05	0.73	1.46
	CV (%)	0.53	0.25	8.22

Table 29. Grain yield and ancillary characters of RYT (DRR_Blast) at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)
BR(Path)13800-BC3-8-5	104.5	161	8.37
BR(Path)13800-BC3-134-8	101.3	157	7.55
BR(Path)13800-BC3-8-11	98.50	162	8.21
BR(Path)13800-BC3-110-19	104.8	155	8.25
BR(Path)13800-BC3-12-13	107.0	160	8.32
BR(Path)13800-BC3-224-17	101.0	153	9.16
BR(Path)13800-BC3-134-25	102.8	155	9.04
BR(Path)13800-BC3-8-37	99.9	159	8.09
BR(Path)13800-BC3-110-4	105.2	154	9.48
BR(Path)13800-BC3-224-44	96.20	154	9.49
BRRI dhan89 (ck)	106.5	153	8.25
BRRI dhan92 (ck)	107.5	159	8.43
Mean	102.94	157	8.55
LSD (0.05)	2.07	0.66	1.03
CV (%)	1.28	0.27	7.48

Table 30. Grain yield and ancillary characters of RYT_STR at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)
BR11712-4R-44	122.7	146	8.73
BR11712-4R-93	119.1	145	8.56
BR11717-4R-12	115.1	146	8.90
BR11727-4R-6	97.4	149	8.56
BR11712-4R-346	98.2	145	8.77
BR11713-4R-70	115.5	147	8.28
BR11722-4R-398	88.1	153	8.59

Designation	PH (cm)	GD (day)	Yield (t/ha)
BRRI dhan67 (T. ck)	105.7	143	7.36
BRRI dhan89 (S. ck)	110.4	151	8.16
BRRI dhan99 (T. ck)	95.1	152	8.27
Mean	106.7	148	8.42
CV (%)	0.68	0.38	7.66

Table 31. Grain yield and ancillary characters of RYT_ZER at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)
BR9674-1-4-1-3-P1	103.0	154	8.46
BR9674-1-4-1-3-P2	105.5	157	8.99
BR9674-7-3-2-1-P2	102.3	154	7.62
BRRI dhan29 (ck)	99.4	155	8.75
BRRI dhan74 (ck)	97.2	143	8.09
BRRI dhan84 (ck)	102.2	139	4.16
Mean	101.6	151	7.68
CV (%)	0.26	0.27	10.4

Table 32. Grain yield and ancillary characters of RYT_Antioxidant rice_MD at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)
BR12839-4R-138-4	100.5	149.0	7.0
BR12839-4R-157-2	102.4	148.7	7.1
BR12839-4R-21	102.9	149.3	6.0
BR12839-4R-47-1	101.8	150.7	7.2
BR12839-4R-5-2	102.6	148.0	6.9
BR12839-4R-78-1	102.9	152.7	8.2
BR12839-4R-90-1	94.9	148.3	3.0
BR12839-4R-93	99.4	148.7	5.8
BRRI dhan88 (ck)	96.6	141.3	7.6
Indonesian Black Rice (ck)	105.0	148.3	6.7
Mean	100.9	148.5	6.6
LSD (0.05)	1.5	1.0	0.8
CV (%)	0.9	0.4	7.4

Table 33. Grain yield and ancillary characters of RYT_Antioxidant rice_SD at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)
BR12839-4R-137	101.4	141.3	6.9
BR12839-4R-72	96.4	142.3	7.0
BR12839-4R-73	95.6	147.0	7.2
BRRI dhan84 (ck)	100.9	143.0	7.5
Mean	98.6	143.4	7.1
LSD (0.05)	4.5	1.9	0.5
CV (%)	3.2	0.9	4.6

Table 34. Grain yield and ancillary characters of RYT_Water Saving Rice at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)
BR11204-5B-224	92.1	156.3	5.4
BR11206-5B-351	87.2	151.7	4.7
BRRI dhan58 (ck)	88.9	147.3	4.0
Mean	89.4	151.8	4.7
LSD (0.05)	1.9	0.5	1.1
CV (%)	1.3	0.2	14.2

Table 35. Grain yield and ancillary characters of RYT_FBR_Barishal at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)
NGR 270-3	102.0	147.3	9.0
NGR 418-1	97.9	145.0	8.4
NGR 522-2	101.7	152.3	9.5
NGR 590-2	99.4	147.7	8.4
NGR 710-1	100.9	148.7	7.5
NGR 745-2	99.6	151.3	8.4
NGR 968-1	101.4	148.0	9.2
NGR 994-1	98.0	151.3	9.1
NGR416-1	100.7	146.7	7.9
BRRI dhan88 (ck)	98.9	140.7	7.3
BRRI dhan89 (ck)	102.5	155.0	8.8
Mean	100.3	148.6	8.5
LSD (0.05)	1.8	1.4	0.9
CV (%)	1.2	0.6	6.7

Table 36. Grain yield and ancillary characters of RYT_SHR_Zirasail at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)
BRH10247-4-7-4B	104.5	153.0	8.4
BRH12-1-7B-P1	91.2	151.0	9.0
BRH13-7-9-3-2B	105.4	145.0	8.2
BRH13-9-5-3B	90.9	153.0	9.2
BRH9-3-14-2B	96.0	151.0	6.7
BRRI dhan28 (ck)	95.6	142.7	7.9
Zirashail (ck)	109.5	143.0	8.1
Mean	99.0	148.4	8.2
LSD (0.05)	1.7	0.4	0.8
CV (%)	1.1	0.2	5.9

Table 37. Grain yield and ancillary characters of RYT_Haor at BRRI RS, Bhanga, Faridpur, Boro 2022-23.

Designation	PH (cm)	GD (day)	Yield (t/ha)
BR9390-6-2-1B	105.8	150.3	6.2
BR9392-6-2-1-3-4	123.1	163.0	7.0
BR9396-6-2-2B	105.3	153.0	7.1
BRH13-7-9-3-2B	114.4	158.3	7.0
BRH18-7-14B	105.7	145.0	7.1
BR18 (ck)	118.6	166.3	6.9
Mean	112.1	156.0	6.9
LSD (0.05)	4.5	0.9	0.7
CV (%)	2.6	0.4	6.7

Table 38. Grain yield and growth duration of BRRI released short duration T. Aman varieties under stability analysis at BRRI RS, Bhanga, Faridpur during T. Aman 2022.

Variety	Growth Duration (day)	Yield (t/ha)
BRRI dhan33	114	2.16
BRRI dhan39	117	4.48
BRRI dhan53	120	3.29
BRRI dhan56	115	3.14
BRRI dhan57	111	2.84
BRRI dhan62	108	3.28
BRRI dhan66	119	3.90
BRRI dhan71	116	3.76

BRRI dhan73	116	2.52
BRRI dhan75	114	3.28
BRRI dhan87	121	1.90
BRRI dhan90	114	3.04
BRRI dhan95	119	2.60
BRRI hybrid dhan4	112	2.24
BRRI hybrid dhan6	114	2.73
Mean	115	3.01
LSD (0.05)	2.18	0.36
CV (%)	1.18	7.51

Table 39. Grain yield and growth duration of BRRI released medium duration T. Aman varieties under stability analysis at BRRI RS, Bhanga, Faridpur during T. Aman 2022.

Variety	GD (day)	Yield (t/ha)		Variety	GD (day)	Yield (t/ha)
BR3	135	3.59		BRRI dhan54	130	3.17
BR4	138	3.71		BRRI dhan70	127	4.41
BR11	135	4.14		BRRI dhan72	125	4.94
BR25	133	4.27		BRRI dhan77	139	3.79
BRRI dhan30	138	4.46		BRRI dhan78	132	5.74
BRRI dhan31	136	3.74		BRRI dhan79	130	4.49
BRRI dhan32	131	3.68		BRRI dhan80	129	3.26
BRRI dhan44	141	4.48		BRRI dhan93	134	3.92
BRRI dhan44	137	3.96		BRRI dhan94	132	3.45
BRRI dhan49	129	4.41		Mean	133	4.15
BRRI dhan51	137	4.46		LSD (0.05)	2.16	0.45
BRRI dhan52	136	5.04		CV (%)	1.01	6.94

Table 40. Grain yield and growth duration of BRRI released long duration T. Aman varieties under stability analysis at BRRI RS, Bhanga, Faridpur during T. Aman 2022.

Variety	Growth duration (day)	Yield (t/ha)
BR5	144	2.19
BR10	146	3.25
BR22	151	3.15
BR23	154	2.97
BRRI dhan34	135	4.25
BRRI dhan37	137	1.95
BRRI dhan38	135	2.25

BRRI dhan41	140	2.23
BRRI dhan46	140	2.99
BRRI dhan76	150	2.01
BRRI dhan91	151	2.03
Mean	144	2.66
LSD (0.05)	1.39	0.27
CV (%)	0.60	6.36

Table 41. Grain yield and agronomic characters of BRRI released short duration Boro varieties under stability analysis at BRRI RS, Bhanga, Faridpur during Boro 2022-23.

Variety	GD (day)	Yield (t/ha)		Variety	GD (day)	Yield (t/ha)
BR6	143	5.82		BRRI dhan84	144	6.87
BR26	147	5.33		BRRI dhan86	143	7.31
BRRI dhan27	145	6.13		BRRI dhan88	143	7.56
BRRI dhan28	144	7.32		BRRI dhan96	146	7.36
BRRI dhan36	143	5.73		Bangabandhu dhan100	146	8.31
BRRI dhan45	139	6.35		BRRI dhan101	147	7.98
BRRI dhan55	147	7.07		BRRI hybrid dhan2	147	8.49
BRRI dhan61	150	7.13		BRRI hybrid dhan3	147	8.92
BRRI dhan63	146	7.23		BRRI hybrid dhan5	147	9.65
BRRI dhan67	146	6.96		Mean	146	7.23
BRRI dhan68	150	6.98		HSD (0.05)	10.03	1.39
BRRI dhan74	147	7.83		CV (%)	2.19	6.17
BRRI dhan81	146	6.65				

Table 42. Grain yield and agronomic characters of BRRI released long duration Boro varieties under stability analysis at BRRI RS, Bhanga, Faridpur during Boro 2022-23.

Variety	GD (day)	Yield (t/ha)		Variety	GD (day)	Yield (t/ha)
BR1	149	6.49		BRRI dhan47	148	6.93
BR2	158	6.12		BRRI dhan50	155	6.15
BR3	168	6.29		BRRI dhan58	149	7.97
BR7	155	5.97		BRRI dhan59	147	7.36
BR8	158	6.26		BRRI dhan60	146	7.12
BR9	156	5.83		BRRI dhan64	152	7.01
BR12	165	6.27		BRRI dhan69	151	6.83
BR14	159	5.91		BRRI dhan89	156	8.59

Variety	GD (day)	Yield (t/ha)		Variety	GD (day)	Yield (t/ ha)
BR15	162	6.18		BRRI dhan92	159	8.95
BR16	159	6.08		BRRI dhan97	150	6.02
BR17	153	6.06		BRRI dhan99	155	8.60
BR18	169	5.93		BRRI dhan102	151	8.33
BR19	169	6.22		Mean	156	6.82
BRRI dhan29	157	8.52		HSD	4.92	1.43
BRRI dhan35	159	6.21		CV (%)	0.99	6.60

REGIONAL STATION, CUMILLA

458 SUMMARY

459 Results: Varietal Development Programme Area

462 Pest Management Programme Area

464 Crop-Soil-Water Management

466 Technology Transfer Programme Area

466 Brri Cumilla Karmasuchi

SUMMARY

In RYT#1, one (BR11864-5R-31) entry performed better and produced higher yield than the check varieties in T. Aus 2022. In RYT (DWR), one entry (BR7730-1-1-2B) performed better than check varieties and in PVT (DWR), two entries (I-0044 and I-0045) performed better than the check varieties during B. Aman 2022. In T. Aman 2022, thirty-three crosses were made. A total of eight crosses were confirmed in T. Aman 2022. Through FRGA method 9,800, 14,700 27,300, 12,600 and 9800 plants were advanced from F_2 F_3 , F_4 , F_5 and F_6 generation. In total seven and four entries performed better than the check varieties in OYT (Cum) and PYT (Cum) trial respectively. Similarly, two, two, two, two and two entries performed better than check varieties in RYT(RLR), RYT (ZER), RYT (SS), RYT (LS), RYT (DRR) and RYT (SD/MD) trial respectively. In Boro 2022-23 season, 17 crosses were made. A total of 21 crosses were confirmed in Boro 2022-23 season. In total 11200, 9100 1400, 9800 and 17500 plants were advanced from F_2 F_3 , F_4 , F_5 and F_6 generation through FRGA method. In total 36 and seven entries performed better than the check varieties in OYT (Cum) and PYT (Cum) trial respectively. In SYT#1 (Cum) and SYT#2 (Cum) trial, one and three entries performed better than the check varieties. one and two entries performed better than the check varieties in AYT#1 (Cum) and AYT#1 (Cum) trial respectively. Two, three, five, one, three, four, one, two, six, two, three, one, one and two entries showed better performance than the standard check varieties in RYT_LD_FBR, RYT_MD_FBR, RYT_SD_FBR and RYT_ELS_FBR, RYT (Zira), RYT#1 (DRR_BB), RYT#2 (DRR_BB), RYT(ZER), RYT#1 (PQR), RYT#2 (PQR), RYT#1 (AER_MD), RYT#2 (AER_SD), RYT_WS and RYT (Barishal) trial respectively. There was no entries that performed better than the check varieties in RYT (GxE Basmati) and RYT (Biotech) trial. In Transforming Rice Breeding (TRB) project trial, 51 entries of OYT, 24 entries of AYT#1 and five entries of AYT#3 performed better and produced higher yield than the check varieties during Aus 2022. Fourteen of OYT (DRR-BB), 33 of OYT (IRR-BPH), 17 of PYT#1 (IRR),

18 of PYT#2 (IRR), seven of AYT (IRR-BPH), seven of AYT (DRR), six of AYT#1(RLR), nine of AYT#2 (RLR) were selected during T. Aman 2022 season. During Boro 2022-23 season, 33 OYT_FBC, 158 OYT-DRR, 128 OYT-IRR-BPH, 44 PYT-IRR-BPH and 18 PYT-IRR-BPH, five AYT_FBR_AGGRiNet, 23 AYT-DRR and 16 AYT-IRR-BPH entries performed better than the check varieties. These entries performed better than check varieties during Boro 2022-23 season. Among AGGRi Alliance project materials, eight entries in stage-1, 1 (IR19A5111) in stage-2 advanced lines performed better than the check varieties during T. Aman 2022. In total seven advanced lines performed better than the check varieties and these lines may be selected for further advancement in QTL trial during T. Aman 2022 season.

During Boro 2022-23, in stage-1, two advanced lines performed better than the check varieties and these lines may be selected for further advancement. In total three advanced lines performed better than the check varieties and these lines may be selected for further advancement in QTL trial during Boro 2022-23 season.

Digital disease survey was conducted from 518 spots (T. Aman) of eight upazilas: and 330 spots (Boro) of six upazilas in Cumilla district using ODK mobile Apps. The disease incidence of sheath blight, bacterial blight, false smut, Sheath rot and leaf scald were 28-65 (DS 3-7), 10-50 (DS 3-7), 0.1-5 (DS 1), 1-60 (DS 3-9) and 3-11 (DS 3-5) respectively in Aman season. Neck blast, bacterial blight, sheath blight diseases were recorded as 1-100 % DI (DS 3-9), 3-70 % DI (DS 3-7) and 10-80 % DI (DS 3-7) respectively in Boro season. Rice yield loss was saved 56-87 % (T. Aman) and 36-88% (Boro) by managing neck blast disease. Tungro disease 1-90% (Aman), 2-90% (Boro) was found in the farmers practice (no spray in the seedbed). Disease incidence was found 50-100% and yield loss was determined 75-99% by Tungro.

In, T. Aman, BRRI dhan87 produced higher grain yield (5.8 t/ha) upto 5 August planting. In Boro, grain yield and growth duration of short duration varieties showed less difference irrespective of sowing dates. On the other hand, long duration variety BRRI dhan92 produced significantly

higher yield (7.68 t/ha) up to 25 December of transplantation. In T. Aman the highest number of grains/panicle was observed in basal with additional application of potassium in 45 DAT (T5), grain yield was also significantly higher (5.19 t/ha). In Boro season, basal application of potassium produced the highest number of grain yield. Lower seeding density with seedbed nutrient management produced higher seedling strength of BRRI dhan76. Three split urea produced maximum yield (6.27 t/ha). Two-third N splitting with additional 20 kg/ha MOP produced better in older seedling than three splittings. Nitrogen was the most yield limiting factor for T. Aman and Boro seasons. In T. Aman 2022 season, 20 kg/ha rate of P produced the highest grain yield (5.47 t/ha) and 30 kg/ha rate of P produced the highest grain yield (6.34 t/ha) during Boro 2022-23 season.

RESULTS

VARIETAL DEVELOPMENT PROGRAMME AREA

In OYT#1, 51 entries were selected and given higher yield than the check varieties. The heritability obtained from yield was 71%, indicating higher level of precision of this experiment. In AYT#1, twenty-four entries performed better producing higher yield than the check varieties and in AYT#3, five entries performed better and produced higher yield than the check varieties. The heritability obtained from yield was 93%, 97%, indicating acceptable level of precision of AYT#1 and AYT#3 trial respectively. In RYT#1, one (BR11864-5R-31) entry performed better and produced higher yield than the check varieties (Table 1). The heritability obtained from yield was 87%, indicating higher level of precision of RYT#1 trial.

Table 1. Yield and agronomic performances of breeding materials in regional yield trial (RYT#1), T. Aus 2022.

Designation*	GD (day)	PH (cm)	ET	Yield (t/ha)
BR11864-5R-31**	109	88	9	5.40
BRRI dhan48 (ck)	110	107	11	4.90
BRRI dhan98 (ck)	111	101	12	5.39
LSD (0.05)	1.18	1.88	ns	0.69
Heritability	0.99	0.99	0.00	0.87

*In total 12 materials were tested

**Selected line

During T. Aman 2022, thirty-three crosses were made using 24 parents. Eight crosses were confirmed out of 25 crosses and registered in BRRI RS, Cumilla cross list with station code BRC826 to BRC833. A total of 9,800 progenies were advanced from population of 14 crosses. In total 14,700 27,300, 12,600 and 9,800 plants were advanced from F₃, F₄, F₅ and F₆ generations through FRGA method. In OYT (Cum), seven entries performed better than the check varieties on the basis of yield and the heritability obtained from yield was 77%, indicating higher level of precision of this experiment. In PYT (Cum), four entries performed better than the check varieties on the basis of yield and the heritability obtained from yield was 79%, indicating higher level of precision of this experiment. In RYT (RLR), BR10458-20-

2-3-1-3 and BR10475-1-2-3-5-5 performed better than the check varieties on the basis of yield and the heritability obtained from yield was 58%. In RYT (ZER), BR10490-1-2-3-8-7 and BR9674-1-1-5-2-P4-HR1 performed better than the check varieties on the basis of yield and the heritability obtained from yield was 80%, indicating higher level of precision of this experiment. In RYT (SS), BRH13-2-14-2-1B and BRH13-7-9-3-2B performed better than check varieties on the basis of yield and the heritability obtained from yield was 87%, indicating higher level of precision of this experiment. In RYT (LS), BRH9392-6-2-1-3-4 and BR9396-6-2-2B performed better than the check varieties on the basis of yield and the heritability obtained from yield was 86%, indicating higher level of precision of

this experiment. In total two (BR11869-5R-72 and BR11874-5R-109) entries produced higher yield than the check and these entries may be selected for further advancement. The heritability obtained from yield was 90%, indicating higher level of precision of this experiment. In RYT (SD/MD), IR14T156 and IR19A7068 performed better than the check varieties on the basis of yield and the heritability obtained from yield was 63%. In total, 14 entries performed better than the standard check varieties and these entries may be selected for further advancement. In total, 33 entries produced higher yield than the

standard check varieties and these entries may be selected for further advancement. In PYT#1_IRR, 17 entries produced higher yield than the check varieties and in PYT#2_IRR, 18 entries produced higher yield than the check varieties. These entries may be selected for further advancement. In AYT (IRR-BPH), seven entries produced higher yield than the check and these entries may be selected for further advancement. In AYT (BB), seven entries produced higher yield than the check and these entries may be selected for further advancement (Table 2).

Table 2. Yield and agronomic performances of lines in Advanced Yield trial (AYT) for BB resistance, development of disease resistant rice (DRR), T. Aman 2022.

Designation*	GD (day)	PH (cm)	Yield (t/ha)
BR11995-4R-1-1**	119	118	5.91
BR11986-4R-123-1**	129	122	6.58
BR12098-4R-25-1**	128	114	6.72
BR12098-4R-117-1**	127	112	6.60
BR12121-4R-49-1**	128	126	6.23
BR12121-4R-53-1**	127	120	6.65
BR12442-4R-49-1**	116	115	6.42
BRRI dhan75 (ck)	113	101	5.47
BRRI dhan87 (ck)	124	127	5.87
IRBB60 (ck)	123	101	4.52

*In total 17 materials were tested

**Selected lines

In AYT#1 (RLR) six entries produced higher yield than the check varieties and in AYT#2 (RLR) nine entries produced higher yield than the check varieties. These entries may be selected for further advancement. In AGGRiNet Trial, in stage 1, eight advanced lines performed better than the check varieties and in stage-2, one entry (IR19A5111) performed better than the check varieties and these lines may be selected for further advancement. In AGGRiNet (QTL) trial, total seven advanced lines performed better than the check varieties and these lines may be selected for further advancement.

During Boro 2022-23 season, totally 2,284 F₁ seeds were obtained from 17 crosses. These were recorded and labeled properly. Twenty-one crosses were confirmed out of 31 and registered in BRRI cross. Eleven thousand two hundred progenies

were advanced from F₂ population of 16 crosses. In total 9,100 1,400, 9,800 and 17,500 plants were advanced from F₃, F₄, F₅ and F₆ generations through FRGA method. In OYT (Cum), 36 entries were selected out of 90 entries on the basis of yield, growth duration and other agronomical characteristics. The heritability obtained from yield was 81%, indicating high level of precision of this experiment. In PYT (Cum), seven entries were selected out of 11 entries based on yield and growth duration. The heritability obtained from yield was 82%, indicating acceptable level of precision of this experiment. In SYT#1 (Cum), BRC472-19-1-1-B1 was selected out of five genotypes based on yield and growth duration and the heritability obtained from yield was 42%, indicating high level of precision of this experiment. In SYT#2 (Cum),

three entries (BRC491-5-2-1-B1, BRC491-5-2-1-B2, BRC491-5-2-1-B3) were selected out of five genotypes based on yield and other parameters and the heritability obtained from the yield was 80%, indicating high level of precision of this experiment. In AYT#1 (Cum), one entry (BRC546-5-1-5) was selected out of five genotypes based on yield and growth duration and the heritability obtained from yield was 61%, indicating high level of precision of this experiment. In AYT#2 (Cum), two entries (BRC548-22-1-6, BRC480-2-1-1-2) were selected out of three genotypes based on yield and growth duration and the heritability obtained from yield was 85%, indicating high level of precision of this experiment. Two entries (BR11318-5R-148, BR11318-5R-84), three entries (IR17A1694, IR18A1398, BR 12177-5R-43), five entries (BR11637-5R-140, BR11894-5R-376, BR11903-5R-56, BR 12180-5R-29, BR 12208-5R-402) and one entry (BR7528-2R-19-16-RIL-52) showed better performance than the standard check varieties in RYT_LD_FBR, RYT_MD_FBR, RYT_SD_FBR and RYT_ELS_FBR. The heritability obtained from yield was 91%, 77%, 83%, 64% indicating high level of precision of RYT_LD_FBR, RYT_MD_FBR, RYT_SD_FBR and RYT_ELS_FBR trials respectively. In total three (BRH13-9-5-3B, BRH12-1-7B-P1, BR10247-4-7-4B) entries performed better than the check varieties and the heritability obtained from yield was 90% indicating high level of precision in RYT (Zira). Four Entries such as (BR11866-5R-73,

BR11866-5R-223, BR(Path)13800-BC3-8-9) and one entry BR(Path)13800-BC3-8-11 showed better performance than the standard check varieties in RYT#1 (DRR_BB) and RYT#2 (DRR_BB) respectively. The heritability obtained from yield was 85%, 69% indicating high level of precision in RYT#1 (DRR_BB) and RYT#2 (DRR_BB) respectively. Two entries (BR9674-1-4-1-3-P1, BR9674-1-4-1-3-P2) showed better performance than the standard check varieties and the heritability obtained from yield was 67% indicating high level of precision in RYT (ZER). Six (Lomba Zira Tanor, Zira Nachol, BR10646-3-2-2-4-3, BR10646-3-2-2-4-4, BR10646-3-3-3-1-4, Koushik-Hili) and two (Katari, Shibganj, Shova (TH)) entries showed better performance than the standard check varieties and the heritability obtained from yield was 81%, 71% indicating high level of precision in RYT#1 (PQR) and RYT#2 (PQR). Three entries such as BR12839-4R-93, BR12839-4R-47-1, BR12839-4R-78-1 and one entry BR12839-4R-137 showed better performance than the standard check varieties in RYT#1 (AER_MD), and RYT#2 (AER_SD). The heritability obtained from yield was 89%, 85% indicating high level of precision in RYT#1 (AER_MD), and RYT#2 (AER_SD) trial respectively. One entry (BR11204-5B-224) showed better performance than the standard check variety and the heritability obtained from yield was 90% indicating high level of precision in RYT_WS (Table 3).

Table 3. Performance of entries in RYT_WS, Boro 2022-23.

Designation	GD (day)	PH (cm)	ET	Yield (t/ha)
BR11204-5B-224**	148	94	13	6.78
BRRI dhan58 (ck)	150	104	13	6.47
LSD (0.05)	0.53	1.20	1.14	0.41
Heritability	0.99	1.00	0.00	0.90

*In total two materials were tested

**Selected line

Two (NGR 416-1, NGR 416-1) entries showed better performance than the standard check varieties and the heritability obtained from yield was 91% indicating high level of precision in this trial in RYT (Barishal). In total 33 entries, 158 entries, 128 entries performed better than the

check varieties in OYT (FBC), OYT (DRR) and OYT (IRR-BPH) respectively, these entries may be selected for further advancement. Considering the yield and growth duration 44 entries performed better than the check varieties and the heritability obtained from yield was 77% indicating high level

of precision. In PYT (IRR-BPH), five breeding lines performed well than the check varieties and in AYT_FBR_(AGGRiNet). In AYT (DRR) 23 entries performed well than the check varieties and the heritability obtained from yield was 75% indicating high level of precision. Considering the yield and growth duration 16 entries performed better than the check varieties and the heritability obtained from yield was 93% indicating acceptable level of precision in AYT (IRR-BPH) (Table 4).

Table 4. Yield and agronomic performances of breeding materials of AYT (IRR-BPH), Boro 2022-23.

Designation	GD (day)	PH (cm)	Yield (t/ha)
BR 12177-5 R-1**	149	108	7.24
BR 12180-5 R-7**	150	102	6.86
BR 12180-5 R-77**	149	104	6.96
BR 12208-5 R-19**	146	101	6.91
BR 12208-5 R-31**	143	88	7.11
BR 12208-5 R-87**	142	96	7.35
BR 12208-5 R-107**	143	89	6.91
BR 12208-5 R-227**	145	98	6.97
BR 12208-5 R-278**	146	88	7.05
BR 12208-5 R-326**	144	86	7.07
BR 11957-4 R-180**	151	98	7.57
BR 12279-4 R-10**	151	101	7.14
BR 11948-4 R-162**	150	102	7.81
BR 12279-4 R-146**	151	101	7.06
BR 12279-4 R-170**	150	93	7.03
BR 11949-4 R-137**	146	103	6.98
BRRI dhan88 (ck)	142	94	6.78
BRRI dhan89 (ck)	158	106	6.82
BRRI dhan92 (ck)	159	107	6.80
LSD (0.05)	1.96	9.02	0.71
Heritability	0.97	0.76	0.93

*In total 30 materials were tested **Selected lines

Two entries (IR19A9230, IR19A9134) performed better than the standard check varieties in AGGRiNet trial and the heritability obtained from

yield was 72% indicating high level of precision in this trial. In total three advanced lines (22QWS-03, 22QWS-13, 22QWS-15) performed better than check varieties in AGGRiNet (QTL) trial and these lines may be selected for further advancement. The heritability obtained from yield was 67% indicating high level of precision in this trial (Table 5).

Table 5. Yield and agronomic performances of breeding materials in AGGRi Network Trial (QTL), Boro 2022-23.

Designation	GD (day)	PH (cm)	Yield (t/ha)
22QWS-03**	146	104	7.33
22QWS-13**	139	97	6.69
22QWS-15**	145	102	6.66
22QWS-19 (BRRI dhan28)	142	92	6.09
22QWS-20 (BRRI dhan67)	145	102	6.15
22QWS-21 (BRRI dhan99)	151	112	6.63
22QWS-22 (Binadhan-10)	134	117	5.39
LSD (0.05)	1.72	8.55	0.98
Heritability	0.98	0.77	0.67

*In total 15 materials were tested **Selected lines

□ Investigators: A K M Shalahuddin, N Jahan, M R Islam and K M Iftekharuddaula

PEST MANAGEMENT PROGRAMME AREA

Survey and monitoring of rice diseases in selected areas during 2022-23. Digital disease survey was conducted from 518 spots of eight upazilas; Burichang (184), Nangalkot (110), Chandina (72), Sadar Dakshin (17), Barura (66), Debidwar (38), Laksam (27), Adarsha Sadar (4) during T. Aman 2022 season and 330 spots of six upazilas; Burichang (24), Chandina (61), Sadar Dakshin (50), Laksam (85), Adarsha Sadar (88), Lalmai (22) during Boro 2022-23 season in Cumilla district using ODK mobile Apps to know the present status of different rice diseases under various climatic environments. Disease incidence and disease severity data of major rice diseases were recorded following SES, IRRI 2013. During T. Aman 2022, neck blast disease was found predominant in the aromatic rice varieties of BRRI dhan34 (Avg DI 27%, and DS 9) and in

Kalijira (Avg. 2% DI, DS 5). Rice tungro disease was found severe in Binadhan-7, Binadhan-16, Binadhan-17, Binadhan-22, BRRI dhan75, BRRI dhan87, local Bajal varieties (60-100 %DI, DS 9) in Chandina, Debidwar, Laksam and Nangalkot. False smut disease was found mostly in BRRI dhan30, BRRI dhan32, BRRI dhan49, BRRI dhan52, BRRI hybrid dhan4 varieties (5% DI, DS 1). The disease incidence of sheath blight, bacterial blight, false smut, Sheath rot and leaf scald were 28-65 (DS 3-7), 10-50 (DS 3-7), 0.1-5 (DS 1), 1-60 (DS 3-9) and 3-11 (DS 3-5) respectively. During Boro 2022-23 season, major rice diseases neck blast, bacterial blight, sheath blight diseases were recorded as 1-100 % DI (DS 3-9), 3-70 % DI (DS 3-7) and 10-80 % DI (DS 3-7) respectively.

- Investigators: M M Rashid, M Hossain, M A I Khan, T H Ansari, A Islam, M R Islam, M A Latif.

Validation of rice neck blast disease management technology under farmers' field condition. Rice blast disease management technology (5 kg MOP/ bigha additionally apply during last top dress of urea, spray Fungicide Trooper or Tricyclazole group fungicides @ 1 g/L water for two times as preventive 1st at split booting stage and 2nd at flowering stage in the evening) was validated to build up farmers' awareness on rice blast disease management and minimize yield loss in BRRI RS farm, Cumilla, Burichang and Nangalkot, Cumilla during T. Aman 2022 season using highly susceptible T. Aman rice variety BRRI dhan34. Disease incidence of neck blast was found 30-95 % in BRRI dhan34 at farmers' practice and 0.1-3% DI to BRRI practice. Rice yield loss was saved 56-87 % by managing neck blast disease following BRRI developed blast disease management technology in all the areas. During Boro 2022-23 season, 4 field demonstrations were conducted in the farmers field condition using highly susceptible BRRI dhan81 variety in Adarsha Sadar, Burichang, Sadar Dakshin and Debidwar upazila of Cumilla. Farmers yield was saved 36-88% by protecting neck blast disease using rice blast management technology.

- Investigators: M M Rashid, M Hossain, A Islam, M R Islam, M A I Khan, T H Ansari, M A Latif

Validation of rice tungro disease management technology in Cumilla region. Tungro management technology is seedbed along with surroundings should be free from GLH by five days interval hand sweeping along with light trapping Or, seedbed along with surroundings should be free from GLH by insecticide spray. First spray at 10, 10-15, 15-20 days after seeding during Aus, Aman and Boro season and 2nd spray at 3-5 days before transplanting for each season. To validate the technology 50 seedbeds of 62 farmers were selected in Nangalkot, Laksam, Burichang, Debidwar during T. Aman 2022 season. Disease was not found in the BRRI technology followed rice field whereas, 1-90 % disease was found in the farmers' practice (no spray in the seedbed). During Boro 2022-23 season disease was found 2-90 % DI in the farmers' practice rice field.

- Investigators: M M Rashid, M Hossain, M R Islam, M A I Khan, T H Ansari, M A Latif

Evaluation of new chemicals against sheath blight and blast diseases of rice. During T. Aman 2022, five new fungicides for sheath blight and 13 fungicides for blast showed better performance and reduced rice diseases above 80%.

- Investigators: M M Rashid, A Ara, H A Dilzahan, M Hossain, M A I Khan, T H Ansari, M A Latif, M R Islam

Yield loss estimation of tungro devastation during T. Aman 2022. An experiment was conducted in the Head to Head Trial in Debidwar, Cumilla during T. Aman 2022 using 6 rice varieties BRRI dhan71, BRRI dhan75, Binadhan-7, Binadhan-16, Binadhan-17, Binadhan-22 to estimate the actual yield loss due to rice tungro disease in farmers' field condition. Disease incidence was found 50-100% and yield loss was determined 75-99%. The yield losses of BRRI dhan71, BRRI dhan75, Binadhan-7, Binadhan-16, Binadhan-17, Binadhan-22 were 75, 94, 99, 97, 96 and 83% respectively.

- Investigators: M M Rashid, S A I Nihad, M A I Khan, T H Ansari, M A Latif, M R Islam

CROP-SOIL-WATER MANAGEMENT

Effect of planting time on the growth and grain yield of newly released BRRI varieties:

This study was taken to determine the effect of variable planting time on the growth and yield of newly released varieties and to identify the suitable planting time and variety for Cumilla area. During T. Aman 2022, the treatments were A. Time of planting, eg. T1: 05 July, T2: 20 July, T3: 05 August, T4: 20 August and T5: 05 September; and B. Varieties: V1: BRRI dhan75, V2: BRRI dhan87, V3: BRRI dhan90, V2: BRRI dhan95, V2: BRRI dhan49 (ck) and V3: BR22 (ck). In Boro 2022-23, the tested seven varieties were BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, Bangabandhu dhan100, BRRI dhan28 (ck) and BRRI dhan29 (ck). All the entries were transplanted on five transplanting times such as: 10 December, 25 December, 10 January, 25 January and 10 February 2022-23 in the BRRI RS, Cumilla research field. The experiment was laid down in the split plot design with three replications where planting dates were in the main plot and varieties were in the sub-plot. Fertilizer were applied N-P-K-S @ 76-20-42-9 kg/ha in T. Aman 2022 and N-P-K-S-Zn @ 145-31-77-13-1.5 kg/ha in Boro 22-23 respectively.

In T. Aman 2022, the result indicated that from 05 August to 20 August of transplanting, BRRI dhan87 and BRRI dhan95 produced similar grain yield and growth duration. After 20 August grain yield was decreasing but growth duration was increasing gradually. Whereas, in case of BRRI dhan95 growth duration as well as grain yield was decreasing from 20 July to 05 September transplanting. BRRI dhan87 showed the highest grain yield (5.8 t/ha) in 05 August transplanting but the lowest was found in 05 September.

In Boro 2022-23, BRRI dhan89, BRRI dhan92 and BRRI dhan29 produced higher grain yield within 155-158 days in first two planting times. BRRI dhan88, BRRI dhan96 and BRRI dhan28 showed expected higher yield with varying range of planting times. It was observed that the best planting time for long varieties (>140 days) was last week of December to first week of January.

□ Investigators: T Ferdous, B Saha, M M Rashid and M R Islam

Effect of Potassium Fertilizer Management at Different Growth Stages of BRRI dhan87:

An experiment was conducted at the research field, BRRI RS, Cumilla, during July 2022 to December 2022 to study the growth performance of BRRI dhan87 in response to growth stage based additional potassium fertilization. The treatments were T1 = K0 (No Potassium), T2 = K Basal (RD), T3 = T2 + K20 15 DAT (20kg K/ha), T4 = T2 + K20 30 DAT, T5 = T2 + K20 45 DAT. The experiment was laid out in a randomized complete block design with three replications. The results revealed that potassium fertilization exerted significant influence on growth performance of BRRI dhan87. Basal application with additional potassium @20 kg/ha produced the tallest plant (122.67cm), the highest number of tillers/hill (214.33), grains/panicle (122.57) and grain yield 5.19 t/ha. Therefore, application of T5 appeared as the promising practice in BRRI dhan87 cultivation in terms of growth performance.

Effect of potassium fertilizer management at different growth stages of BRRI dhan88.

During Boro season 2022-23, the treatments were T1 = K0 (No Potassium), T2 = K Basal (RD) Recommended dose as basal, T3 = T2+K2015 DAT 20kg k/ha at tillering stage (TS), T4 = T2+K20 30 DAT at maximum tillering stage (MTS), T5 = T2+K20 50 DAT at panicle Initiation Stage (PIS), T6 = T2+K2015 DAT + K20 30 DAT, T7 = T2+K2015 DAT + K20 50 DAT, T8 = T2+K2015 DAT + K20 30 DAT+ K20 50 DAT, T9 = T2 + K20 30 DAT+ K20 50 DAT, T10 = Two-third of T2 as basal + One-third at PIS. An increased application of potassium from 0 to 137 kg/ha increased tiller/m², number of panicle/m² and increased grain yield over the control, T1. The highest number of grains/panicle was observed in T4 where potassium was applied basally as well as additional application in maximum tillering, grain yield was also significantly higher (6.4 t/ha) in this treatment. Potassium application significantly increased the number of filled grains/panicle, 1000-grain weight, grain yield and harvest index. Basal application along with two additional applications of potassium showed superiority over split application of 1, 2 and 4 additional applications. Grain yields of T4, T8 were not significant varied from T2 (K Basal).

Therefore, application of T2 can be economically justified.

- Investigators: T Ferdous, B Saha, M M Rashid A Islam and M R Islam

Effect of nursery management on the performance of rice variety grown under water stagnant condition. The productivity of rice in most sub-tropical areas of Asia is low because of the predominance of several abiotic and biotic stresses, use of traditional landraces or old varieties and suboptimal management practices. A combination of high-yielding, stress-tolerant rice varieties and good management practices is necessary to enhance the productivity of these areas. Nursery management practices that suit the new stress-tolerant varieties recently becoming available need to be developed to increase the productivity of rice. In T. Aman 2022 season, on-station trials on nursery management were conducted using improved rice variety BRRI dhan76 to study the effect of seed density, nutrient management in the nursery. Lower seed density and application of balanced nutrients produced healthy and taller seedlings with high seedling strength (g/cm) in the nursery and with subsequent increase in grain yield after transplanting in the main field. Combining inorganic and organic fertilizers in the seedbed (N1: Urea-TSP-Mop@ 7-0-0 g/m² + 500g/m² FYM, N2: Urea-TSP-Mop@ 11-15-3 g/m² + 500g/m² FYM, N3: Urea-TSP-Mop@ 7-15-3 g/m² + 500g/m² FYM, N4: Urea-TSP-Mop@ 0-15-3 g/m² + 500g/m² FYM) enhanced shoot length, dry weight, seedling strength. These cost-effective nursery management approaches have great potential for enhancing yield in stress-prone rainfed coastal areas and will help sustain rice yield while ensuring sustainability of the cropping system.

- Investigators: T Ferdous, B Saha, M M Rashid and M R Islam

Effect of Seedling age and nutrient management in BRRI dhan87

In T. Aman 2022 season, a field experiment was conducted at the research field at BRRI RS Cumilla from July 2022 to December 2022 to find out the effect of seedlings age and different nitrogen (N) and potassium (K) levels on the yield performance of transplant Aman rice (BRRI dhan87). The

experiment comprised four seedlings ages viz 20, 30, 40-day-old and six treatments T1=Full dose of urea at two equal splits, ½ at 15 DAT + ½ at 30 DAT, T2=Full dose of urea at two equal splits+20 kg/ha K, ½ at 15 DAT + ½ at 30 DAT, T3=Full dose of urea at two equal splits, 2/3 at 15 DAT + 1/3 at 45 DAT, T4=Full dose of urea at two equal splits +20 kg/ha K, 2/3 at 15 DAT + 1/3 at 45 DAT, T5=Full dose of urea at three equal splits, 1/3 at 15 DAT + 1/3 at 30 DAT+ 1/3 at 45 DAT, T6=Full dose of urea at three equal splits +20 kg/ha K, 1/3 at 15 DAT + 1/3 at 30 DAT+ 1/3 at 45 DAT, following randomized complete block design (RCBD) with three replications. The effect of seedling age, treatments and their interactions were significant on growth, yield and yield contributing characters of transplant Aman rice. The treatment T6 produced higher yield (6.1 t/ha) from 20 day-old seedling, 30-day-old seedling. Forty-day-old seedling produced lower yield from all six treatments. T3, T4 performed better than the other treatments in 40 days.

- Investigators: T Ferdous, B Saha, M M Rashid and M R Islam

Long-term missing element trial at BRRI RS, Cumilla 2022-23. The experiment was conducted to assess long-term yield trend of rice under different nutrients managements. For this trial, seven fertilizer treatments viz T₁= N-P-K-S-Zn (all), T₂ = N omission (-N), T₃ = P omission (-P), T₄ = K omission (-K), T₅ = S omission (-S), T₆ = Zn omission (-Zn) and T₇ = N-P-K-S-Zn (all missing) were imposed following RCBD design with three replications both in T. Aman 22 and Boro 2022-23 season. Fertilizer doses were NPKSZn @ 110-15-42-9-1.5 kg/ha in T. Aman and NPKSZn @ 145-31-77-13-1.5 kg/ha in Boro season respectively. During T. Aman 2022, BRRI dhan87 produced the highest grain yield (6.07 t/ha) and straw yield (6.65 t/ha) with NPKZnS fertilizers and the lowest grain yield (3.31 t/ha) and straw yield (3.70 t/ha) with all missing element fertilizers. The N and K omission from complete fertilizer significantly reduced the grain yield. The highest grain yield and straw yield reduction was found in N omission plot, which was 3.81 t/ha and 4.68 t/ha respectively indicating that a soil test-based dose of fertilizer is enough for this

variety. In Boro 2022-23, BRRI dhan88 produced the highest grain yield (6.30 t/ha) and straw yield (6.49 t/ha) with NPKZnS fertilizers and the lowest grain yield (3.01 t/ha) and straw yield (3.24 t/ha) with all missing element fertilizers. Omission of N from complete treatment had a significant effect on grain yield (3.54 t/ha) and straw yield (3.67 t/ha) among the treatments. The omission of P, K, S and Zn produced statistically similar grain and straw yield like complete fertilizer treatment.

- Investigators: A K M Shalahuddin, T. Ferdous, B Saha, M M Rashid and M R Islam

Effects of P rates on the yield of BRRI released new variety in BRRI RS Farm, Cumilla. The experiment was conducted to update the P rates of BRRI released new varieties in BRRI Farm Cumilla. Six doses of P (0, 5, 10, 15, 20 and 25 kg/ha) were tested with BRRI dhan87 in T. Aman 2022 and BRRI dhan88 in Boro 2022-23 season. In T. Aman season, 20 kg/ha rate of P produced the highest grain yield (5.47 t ha⁻¹) and 30 kg/ha rate of P produced the highest grain yield (6.34 t ha⁻¹) during Boro 2022-23 season. Grain yield was increased with the increasing rate of phosphorus up to a level and then produced the statistically similar grain yield.

- Investigators: B Saha T Ferdous, M M Rashid, M R Islam

TECHNOLOGY TRANSFER PROGRAMME AREA

Varietal dissemination through field demonstration (GoB). In Aus 2022 season, 50 field demonstrations of BRRI dhan85 (3.56-5.01 t/ha), BRRI dhan98 (3.83-5.75) were conducted. Average yield of BRRI dhan98 was 4.93. The highest yield was displayed by BRRI dhan98 (5.75 t/ha). During T. Aman 2022 season, 100 field demonstrations were conducted in different upazilas of Cumilla region. The yield range of BRRI dhan87, BRRI dhan93, BRRI dhan94 and BRRI dhan95 were 3.54-6.36, 3.46-6.22, 4.74-4.77, 4.74-4.77 and 2.93-6.14 t/ha respectively. Farmer's acceptance of BRRI dhan93 and BRRI dhan95 was found very high respectively those respective areas for its grain

size, panicle length and high yield. The highest grain yield observed in BRRI dhan87 (6.36 t/ha) followed by BRRI dhan93 (6.22t/ha). Moreover BRRI dhan93 performed better in Brahmanbaria.

In Boro 2022-23 season, a total of 300 field demonstrations (1 bigha each) of newly released BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96 and Bangabandhu dhan100 were conducted in 34 upazilas of Cumilla, Brammanbaria and Chandpur districts. The yield range of BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96 and Bangabandhu dhan100 were 3.82-7.02, 4.57-8.48, 4.6-7.78, 4.29-7.05 and 4.9-7.33 t/ha respectively. The highest grain yield observed in BRRI dhan89 (8.48 t/ha) followed by BRRI dhan92 (7.78 t/ha). On the other hand, short duration variety, BRRI dhan96 performed well all over Cumilla region.

- Investigators: T Ferdous, B Saha, M M Rashid and M R Islam

Farmer's training, field day and fair. Twenty farmers' training programmes were conducted in different locations of Cumilla region. A total of 540 farmers and 60 SAAOs were trained up. Five field days were conducted in the field demonstration areas at Cumilla region. About 500 farmers as well as extension personnel attended in the field days. Most of the farmers got interested to cultivate new rice varieties in their areas specially BRRI dhan87, BRRI dhan95, BRRI dhan88, BRRI dhan89, BRRI dhan92 BRRI dhan96 and Bangabandhu dhan100. BRRI Cumilla also participated in development fair.

Investigators: T. Ferdous, B Saha, A K M Shalahuddin, M M Rashid and M R Islam

BRRI CUMILLA KARMASUCHI

Varietal dissemination through field demonstration (Karmasuchi). Sixty field demonstrations were conducted using BRRI dhan85 and BRRI dhan98 and yield range was 3.83-5.75 t/ha and 3.21-5.57 t/ha respectively. During T. Aman 2022 season, total 70 field demonstrations with three varieties BRRI dhan87, BRRI dhan93, BRRI dhan95 were conducted in different upazilas of Cumilla region and the yield range were 3.15-3.68

t/ha, 3.67-6.06 t/ha and 2.99-6.22 t/ha respectively. During Boro 2022-23 season, 50 demonstrations were conducted using BRRI dhan74, BRRI dhan81, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, BRRI dhan101, BRRI dhan102 and Bangabandhu dhan100 and the yield ranges were 6.67-8.5 t/ha, 5.13-6.66 t/ha, 5.4-6.9 t/ha, 7.25-8.39 t/ha, 6.7-7.9 t/ha, 6.1-7.9 t/ha, 6.16 t/ha, 7.34-8.12 t/ha and 6.21-7.5 t/ha respectively.

Training, field day, seminar (Karmasuchi).

Twenty farmers' trainings and 8 Officers trainings were conducted in different locations of Cumilla region. A total of 600 farmers and 240 Sub Assistant Agricultural Officers, Research/Scientific Assistants were trained up. Four field days were conducted in the block demonstration areas at Cumilla region. About 400 farmers as well as extension personnels attended in the field days. Most of the farmers got interested to cultivate new rice varieties in their areas. One seminar was conducted with Research-Extension-Other Organization about "Current Status and Future Planning of Enhancement the Research and Development Facilities of BRRI Regional Station Cumilla and Ensure Food Security" on 20 March 2023.

- Investigators: M M Rashid, B Saha, T Ferdous, A Islam and M R Islam:

dhan89, BRRI dhan92 and Bangabandhu dhan100) were purchased from farmers funded by MoA.

- Investigators: A K M Shalahuddin, T. Ferdous, B Saha, M M Rashid and M R Islam

Seed Production. During Aus 2022 season, in total 4.45 tons TLS seeds of BRRI dhan48, BRRI dhan85, BRRI dhan98 was produced. During T. Aman 2022 season, 12.44 tons of breeder seeds (BR22, BRRI dhan49, BRRI dhan94, BRRI dhan95) and 8.45 tons of TLS seeds (BR22, 23 BRRI dhan34, BRRI dhan71, BRRI dhan75, BRRI dhan76, BRRI dhan87, BRRI dhan90, BRRI dhan93, BRRI dhan95) were produced. During Boro 2022-23, 40.35 tons of breeder seeds (BR23, BRRI dhan28, BRRI dhan29, BRRI dhan58, BRRI dhan74, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, Bangabandhu dhan100) 7.23 tons of TLS seeds (BRRI dhan28, BRRI dhan29, BRRI dhan58, BRRI dhan74, BRRI dhan81, BRRI dhan84, BRRI dhan86, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, Bangabandhu dhan100) were produced in BRRI Cumilla farm and 30 tons of TLS seeds (BRRI dhan88, BRRI dhan96, BRRI

BRRI RS, Habiganj

470	Summary
470	Varietal Development
473	Crop-Soil-Water Management
474	Pest Management
475	Technology Transfer

SUMMARY

In B. Aman 2022 season, one RYT focused on the deep-water ecosystem, while three RYT were conducted during T. Aman 2022. A total of 12 crosses were made for the improvement of local popular cultivars during the Boro 2022-23 season. Additionally, two OYTs, 15 RYT, and one IIRON (Set#38) trial were carried out during Boro 2022-23. Nine BRRI varieties were evaluated to identify suitable planting time and variety for Haor areas. BRRI dhan67 and Bangabandhu dhan100 had less spikelet sterility and higher grain yield than BRRI dhan28. Long duration varieties BRRI dhan29, BRRI dhan89 and BRRI dhan92 escaped cold stress at reproductive phase in early planting due to their longer growth duration. Application of 140 kg N/ha with 50 kg K/ha had significantly higher grain yield than other combination of N and K fertilization. Result of long-term missing element trial revealed that N is the most yield limiting nutrient element followed by K in BRRI RS, farm, Habiganj. PHS tolerance of 26 BRRI developed modern Boro varieties were evaluated. BRRI dhan96 was the most susceptible to pre-harvest sprouting, with 76% germinated seed followed by BRRI dhan50 (51%) and BRRI dhan86 (36%). BRRI dha35, BRRI dha55, BRRI dhan92 and BRRI dhan97 showed tolerance to PHP. Among the insect pests and their natural enemies recorded in light trap, BPH population was found the highest followed by GLH, green mirid bug and YSB the highest peak of BPH, GLH and YSB were recorded in October- November. A total of eight ALARTs were conducted. Three blast resistant lines, a FBR (MD) line and a FBR (SD) line were recommended for PVT. BRRI regional station, Habiganj conducted 10 farmers' training and 10 field days. In produced 25,750 kg breeder seed during Boro 2022-23, 900 kg, 6250 kg and 15,730 kg TLS in Aus 2022, T. Aman 2022 and Boro 2022-23 season, respectively.

VARIETAL DEVELOPMENT

RYT, Aman 2022

A single RYT was carried out for deep-water ecosystem during B. Aman 2022 season, while three RYT were conducted during T. Aman 2022 season. RYT#Deep water rice consisted of three genotypes, along with standard check BRRI dhan91 and a local

check (Dud laki, Ghigaj, Hijal digha, Sada Jabra, Lal laki) in each trial. These trials were conducted at five different locations under BRRI Habiganj, BRRI Cumilla, BRRI Bhanga, BRRI Gopalganj, and BRRI Gazipur. Unfortunately, the trial at BRRI Habiganj was damaged due to an early flood. The data from the trials conducted at BRRI Bhanga and BRRI Gazipur have been omitted due to rat infestation. The advanced breeding line BR7730-1-1-2B (2.79 t/ha) produced the highest grain yield followed by genotypes BR7919-1-1-3B (2.32 t/ha) and BR7918-1-2-3B (2.09) than the standard check BRRI dhan91 (1.94 t/ha) and local checks (1.59 – 2.07 t/ha). The RYT#Tall comprises a total of four entries along with one check BRRI dhan91. Among these entries, the genotype BR10247-14-18-7-3B (5.56 t/ha) produced the highest grain yield followed by genotypes BR9892-8-2-2B (5.35 t/ha) and BR10238-5-1-9-3B (5.30) than the check BRRI dhan91 (3.42 t/ha). The RYT for short slender consists of three genotypes along with one check BRRI dhan49. However, one genotype, namely BRH13-7-9-3-2B did not successfully grow in the main field due to germination failure. The genotype BRH13-2-14-2-1B (5.19 t/ha and 131 days) produced the highest grain yield and five days earlier growth duration than the check BRRI dhan49 (5.03 t/ha and 136 days). The RYT of Swarna and long slender type comprises a five genotypes along with two checks BRRI dhan87 and BRRI dhan94. Among these, the genotype BR9392-6-2-3-4 (5.36 t/ha and 133 days) showed the highest grain yield than the checks BRRI dhan94 (5.00 t/ha and 134 days) and BRRI dhan87 (5.05 t/ha and 136 days). Furthermore, the genotype BR10238-5-1-4-2 (5.01 t/ha and 135 days) produced a comparable grain yield and growth duration to the check BRRI dhan94 (5.00 t/ha and 134 days).

Improvement of local popular cultivars, Boro 2022-23

BRRI RS, Habiganj has initiated a new breeding programme for the improvement of local popular cultivars during Boro 2022-23 season. To achieve the goal, 12 crosses were made using seven indigenous cultivars (Pashushail, Tepi boro, Rata boro, Lal beruin, Kalo beruin, Pani beruin, and Mihi beruin) with two high-yielding rice varieties (BRRI dhan88 and BRRI dhan92) (Table 1).

Table 1. List of F₁ seeds produced in Boro 2022-23.

Cross combination	No. of seeds
Pashushail x BRRI dhan88	89
Pashushail x BRRI dhan92	245
Tepi boro x BRRI dhan88	137
Tepi boro x BRRI dhan92	200
Rata boro x BRRI dhan88	215
Rata boro x BRRI dhan92	172
Total	

Cross combination	No. of seeds
Lal beruin x BRRI dhan88	242
Lal beruin x BRRI dhan92	36
Kalo beruin x BRRI dhan88	111
Kalo beruin x BRRI dhan92	156
Pani beruin x BRRI dhan92	99
Mihi beruin x BRRI dhan92	33
	1735

OYT, Boro 2022-23

Two OYTs were carried out during Boro 2022-23 at BRRI RS, Habiganj. One OYT for BPH resistance comprising 66 entries along with four checks BRRI dhan28, BRRI dhan67, BRRI dhan89, and BRRI dhan92 were evaluated. None of the evaluated entries exhibited superior performance compared to the check BRRI dhan89 (7.62 t/ha) and BRRI dhan92 (7.88 t/ha). Notably, the genotype BR12679-4R-111 (7.50 t/ha and 153 days) produced a higher grain yield but 8-11 days longer growth duration than the checks BRRI dhan67 (6.33 t/ha and 145 days) and BRRI dhan28 (5.52 t/ha and 142 days). Furthermore, the three genotypes BR12670-4R-93 (6.61 t/ha and 147 days), BR12679-4R-168 (6.62 t/ha and 147 days), and BR12682-4R-46 (6.71 t/ha and 148 days) produced a comparable grain yield and growth duration with the check BRRI dhan67 (6.33 t/ha and 145 days). In OYT#Barishal, a total of 100 entries along with the four checks BRRI dhan88, BRRI dhan67, BRRI dhan89 and BRRI dhan92 were evaluated. None of the evaluated entries exhibited superior performance compared to the check BRRI dhan92 (7.58 t/ha). Notably, the two genotypes NGR 453-1 (6.97 t/ha and 139 days) and NGR 240-1 (7.28 t/ha and 138 days) produced a similar grain yield with 12 days earlier growth duration than the check BRRI dhan89 (6.93 t/ha and 151 days). The nine genotypes (6.28–6.63 t/ha) produced a higher grain yield than the check BRRI dhan67 (5.67 t/ha). Furthermore, the 18 genotypes (5.69–6.26 t/ha and 138-145 days) produced comparable grain yield and growth duration with the check BRRI dhan67 (5.67 t/ha and 139 days).

RYT, Boro 2022-23

A total of fifteen regional yield trials (RYTs) were conducted at BRRI RS, Habiganj during Boro 2022-2023. Among them, the five RYT were assessed by focusing on favourable Boro rice (FBR). In RYT#FBR-SD, nine entries along with the two checks BRRI dhan28 and BRRI dhan96 were evaluated. The tested entries did not exhibit superior performance in comparison to the check BRRI dhan96. In RYT#FBR-MD, nine entries along with the two checks BRRI dhan81 and BRRI dhan89 were evaluated. None of the evaluated entries exhibited superior performance compared to the check BRRI dhan89. Notably, the genotype BR8899-14-4-1-2-2-1 (7.67 t/ha and 149 days) produced a similar grain yield but with eight days earlier growth duration than the check BRRI dhan89 (7.57 t/ha and 157 days). In RYT#FBR-LD, five entries along with the three checks BRRI dhan81, BRRI dhan89, and BRRI dhan92 were evaluated. Among all the tested entries, only the genotype BR11894-5R-260 (8.86 t/ha and 151 days) exhibited a significantly superior grain yield compared to all the check varieties (5.78-8.12 t/ha). In RYT#FBR-ELS, six entries along with the three checks BRRI dhan50, BRRI dhan63, and BRRI dhan86 were assessed. Among the examined genotypes, four genotypes IR18A2102 (5.62 t/ha), BR10604-5R-58 (5.63 t/ha), BR7528-2R-19-16-RIL-55 (5.82 t/ha), and BR9994-5R-21 (6.31 t/ha) produced the highest grain yield than all the check varieties (4.80-5.28 t/ha). In RYT#FBR-Barishal, nine genotypes along with the two checks BRRI dhan88 and BRRI dhan89 were assessed. None of the genotypes performed better than the check

BRRi dhan89. Although five genotypes, namely NGR 418-1 (6.80 t/ha), NGR 994-1 (6.84 t/ha), NGR 522-2 (7.02 t/ha), NGR 745-2 (7.39 t/ha) and NGR 590-2 (7.44 t/ha) produced the highest grain yield but took 4-8 days longer growth duration than the check BRRi dhan88 (6.48 t/ha).

Two RYT for antioxidant-enriched rice were conducted. In RYT#MD black rice genotypes, eight genotypes along with the two checks Indonesian black rice and BRRi dhan88 were evaluated. The grain yield of the entries was reduced significantly as a result of severe infection by blast disease. That's why, no genotype exhibited superior performance compared to the check varieties Indonesian black rice and BRRi dhan88. In RYT#SD black rice genotypes, three genotypes along with the two checks BRRi dhan84 were evaluated. The grain yield of the entries was reduced significantly as a result of severe infection by blast disease. That's why, no genotype exhibited superior performance compared to the check BRRi dhan84. In RYT for water saving (WS) rice genotypes, two genotypes along with the check BRRi dhan58 were evaluated. No genotype exhibited superior performance compared to the check BRRi dhan58.

The RYT#Tall for haor areas consisting of six genotypes along with the check BR18 were conducted. The genotype BR9396-6-2-2B (5.60 t/ha and 146 days) exhibited the highest grain yield and 12 days earlier than the check BR18 (5.03 t/ha and 158 days). Furthermore, the genotype BR9392-6-2-1-3-4 (5.32 t/ha and 157 days) produced a higher grain yield coupled with a comparable growth duration to the check BR18 (5.03 t/ha and 158 days). In RYT#Zira types, five genotypes along with the two checks Zirashail and BRRi dhan28 were evaluated. Among these genotypes, the three genotypes BR10247-4-7-4B (5.13 t/ha), BRH9-3-1-14-2B (5.33 t/ha) and BRH13-9-5-3B (6.33 t/ha) produced the highest grain yield than the checks BRRi dhan28 (4.10 t/ha) and Zirashail (4.39 t/ha). In RYT#STR genotypes, a total of seven genotypes along with the three checks BRRi dhan67, BRRi dhan89 and BRRi dhan99 were evaluated. No genotype exhibited superior performance compared to the standard check BRRi dhan89. Notably, the genotype BR11712-4R-12 (6.73 t/ha) produced

a higher grain yield with similar growth duration compared to the tolerant check BRRi dhan99 (6.51 t/ha). Similarly, the genotype BR11712-4R-6 (6.10 t/ha) produced a higher grain yield but with four days longer growth duration than the tolerant check BRRi dhan67 (5.77 t/ha).

The two RYT under disease resistance rice (DRR) were conducted. The RYT#DRR-BB consisting 18 entries along with the four checks BRRi dhan58 BRRi dhan89, BRRi dhan92, and BRRi dhan101. None of the genotypes exhibited superior performance in comparison to the standard checks BRRi dhan89 and BRRi dhan92. However, the genotype BR(Path)13800-BC3-8-7 (7.17 t/ha and 154 days) produced a similar grain yield and three days earlier growth duration than the check BRRi dhan92 (7.17 t/ha and 157 days). The genotype BR(Path)13800-BC3-224-28 (6.90 t/ha and 153 days) produced a higher grain yield with comparable growth duration than the checks BRRi dhan58 (6.49 t/ha and 153 days) and BRRi dhan101 (6.53 t/ha and 153 days). In RYT for BB and blast, ten genotypes along with the two checks BRRi dhan89 and BRRi dhan92 were assessed. None of the genotypes exhibited superior performance in comparison to the standard checks BRRi dhan92. The genotype BR (Path)13800-BC3-110-4 (7.26 t/ha and 152 days) exhibited a higher grain yield and three days earlier growth duration than the check BRRi dhan89 (7.02 t/ha and 155 days). Similarly, the genotype BR (Path)13800-BC3-8-11 (7.05 t/ha and 151 days) produced a comparable grain yield but with four days earlier growth duration than the check BRRi dhan89 (7.02 t/ha and 155 days).

The RYT for zinc-enriched rice (ZER) consisting of three genotypes along with the three checks BRRi dhan29, BRRi dhan74 and BRRi dhan84 were conducted. The grain yield of BRRi dhan84 was reduced due to infection of blast disease. No genotype exhibited superior performance compared to the check BRRi dhan29. While the genotype BR9674-1-4-1-3-P1 (6.11 t/ha) produced a comparable grain yield but took 14 days longer to mature than the check BRRi dhan74 (6.03 t/ha).

GxE interaction of Basmati rice genotypes

The trial for GxE interaction of Basmati rice genotypes consisted of 20 genotypes along with the

six checks namely, BRRI dhan50, BRRI dhan63, BRRI dhan81, BRRI dhan104, Tepi Boro, and Rata Boro. Among these entries, the entry Basmati (1230) (7.76 t/ha) produced the highest grain yield of all the checks (4.34-6.58 t/ha). Similarly, the genotype Indian Basmati (6.04 t/ha and 156 days) produced a significantly higher grain yield but with six days longer growth duration than the check BRRI dhan50 (5.38 t/ha and 150 days).

IIRON, Boro 2022-23

The IIRON (Set#38) trial consisting 35 entries along with the five checks BRRI dhan28, BRRI dhan67, BRRI dhan92, BRRI dhan101, and BRRI dhan35 were grown at BRRI RS, Habiganj farm during Boro 2022-23. None of the genotypes exhibited superior performance in comparison to the standard checks BRRI dhan92. The seven entries SV0202, SV0806, SV0434, SV0436, SV0856, SV0147, and SV0193 (7.33-7.67 t/ha) exhibited a higher grain yield than the check BRRI dhan101 (6.57 t/ha) but produced a similar grain yield with the check BRRI dhan67 (7.12 t/ha). Similarly, the grain yield of 11 entries (6.58-7.01 t/ha) was on par with the check BRRI dhan101 (6.57 t/ha). A total of seven entries were selected for advancement to the yield trial stage.

CROP-SOIL-WATER MANAGEMENT

Effect of planting time on Boro rice varieties at haor region of Bangladesh. Nine BRRI varieties (BRRI dhan28, BRRI dhan29, BRRI dhan67, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96 and Bangabandhu dhan100) were evaluated in natural field condition at BRRI RS farm, Habiganj to identify the suitable planting time and variety for haor areas. There were five sets of seeding starting from 25 October at 10 days interval. Growth duration increased significantly in all the varieties at early planting than the late planting one. Plant height of all the rice variety was reduced significantly in earlier two sets than the other sets of planting. Irrespective of rice variety 4th set (25 November sowing) had longest plant height. Irrespective of rice varieties poor panicle exertion and spikelet degeneration were recorded in first set of planting. BRRI dhan84 had spikelet degeneration

up to 3rd set (sowing on 15 November), while it was up to 2nd set (05 November) for BRRI dhan28, BRRI dhan67, BRRI dhan88, and BRRI dhan96. Irrespective of planting time long duration varieties (BRRI dhan29, BRRI dhan89 and BRRI dhan92) had higher grain yield than the short duration varieties (Table 2). BRRI dhan84 had significantly higher spikelet sterility than BRRI dhan28 in first three sets of planting, which indicating its reproductive stage cold susceptibility. In respect of grain yield and sterility BRRI dhan88 and BRRI dhan96 was more or less similar to BRRI dhan28. BRRI dhan67 and Bangabandhu dhan100 had less spikelet sterility and higher grain yield than BRRI dhan28. Long duration varieties BRRI dhan29 BRRI dhan89 and BRRI dhan92 escaped cold stress at reproductive phase in early planting due to its longer growth duration. However, BRRI dhan89 had slightly higher spikelet sterility in fifth set of planting than the other tested varieties.

Table 2. Grain yield of Boro varieties at different sowing times.

Variety	Sowing time				
	25 Oct	05 Nov	15 Nov	25 Nov	05 Dec
BRRI dhan28	3.99	5.26	6.35	6.58	5.78
BRRI dhan29	7.40	8.08	8.48	7.97	7.84
BRRI dhan67	6.17	8.07	7.08	6.64	6.69
BRRI dhan84	3.62	5.49	5.60	6.09	7.60
BRRI dhan88	3.71	5.55	6.85	6.80	6.00
BRRI dhan89	7.34 9.24 9.09 8.01				8.12
BRRI dhan92	7.95	9.04	8.84	8.16	8.14
BRRI dhan96	3.29	5.98	5.68	6.80	5.74
Bangabondhu dhan100	6.38	7.02	7.50	7.81	7.75
LSD _{5%} Variety	0.29				
LSD _{5%} Planting	0.21				
LSD _{5%} Variety* Planting	0.64				

Influence of nitrogen and potassium rates on performance of modern rice

An experiment was conducted at BRRI RS farm, Habiganj during Boro 2022-23. Five doses of K (0, 50, 100, 150 and 200 kg/ha) in the main plot and four doses of N (0, 100, 120 and 140 kg/ha) in the subplots were tested with BRRI dhan92 in Boro season. In K deficient (0 kg/ha) soil, rice grain yield increased with the application of N100 dose (7.96 t/ha) but it decreased significantly with the further increase of N rates (7.38-7.52 t/ha). Application of N at the rate 140 kg ha⁻¹ with 50 kg K ha⁻¹ produced significantly higher grain yield (8.87 t/ha) than the other combination of N and K fertilization.

Long-term missing element trial for diagnosing yield limiting nutrient in soil of Habiganj

An experiment was initiated in a permanent layout at the BRRI regional station Habiganj farm in Boro 2007-08 season with missing element approach using eight treatments in RCB design with three replications. The treatments were-T₁=NPKS (Complete), T₂=PKS (-N), T₃=NKS (-P), T₄=NPS (-K), T₅=NPK (-S), T₆=KS (-NP), T₇=PS (-NK) and T₈= all missing (-NPKS). BRRI dhan92 was used as a test crop. The balanced fertilizer treatment (NPKSZn) showed significantly higher grain yield. The highest grain yield was obtained in T₁ (8.15 t ha⁻¹) followed by T₅ (7.93 t ha⁻¹). The N and K omission treatment (T₂ and T₄) produced significantly lower yield (6.51-6.75 t ha⁻¹) than the other treatments. Result revealed that N is the most yield limiting nutrient element followed by K in BRRI RS farm, Habiganj.

Screening for preharvest spouting of Boro rice

Yield loss and quality deterioration of rice have been frequently reported due to pre-harvest sprouting (PHS). Seeds become spout in the field if mature panicles of susceptible rice variety get contact with water. An experiment was conducted to evaluate PHS tolerance of 26 BRRI developed modern Boro varieties in the field condition during Boro 2022-23 at BRRI RS farm Habiganj. The plants were tagged at the time of 50% flowering (anthesis). Thirty days after anthesis (DAA), panicles were immersed in a plastic pot filled with water (IL) by bending without

causing much damage to the plant. Germination of the seeds of those panicles were counted seven days after immersed into water. On the basis of germination percentage, BRRI dhan96 was the most susceptible to pre-harvest sprouting, with 76% germinated seed in the panicle at 80% maturity stage. BRRI dhan50 (51%), BRRI dhan86 (36%), BRRI dhan74 (29%), BRRI dhan67 (28%), BRRI dhan84 (25%), BRRI dhan60 (22%), BRRI dhan88 (22%), BRRI dhan59 and BRRI dhan63 (15%) were also identified as susceptible to PHP. BRRI dhan35, BRRI dhan55, BRRI dhan92 and BRRI dhan97 showed tolerance to PHP.

PEST MANAGEMENT

Monitoring of insect pest and natural enemy incidence by using light trap

Rice insect pests and their natural enemies were monitored daily by using light trap during July 2022 to June 2023 at BRRI RS farm, Habiganj. The abundance of green leafhopper (GLH), yellow stem borer (YSB), brown planthopper (BPH), green mirid bug, grasshopper was found in the light trap during the reporting period (Fig.1). Among the insect pests BPH population was found highest followed by GLH, green mirid bug and YSB. The highest peak of BPH, GLH and YSB were recorded in October- November. Green mirid bug population was also increased according to the increase of BPH population.

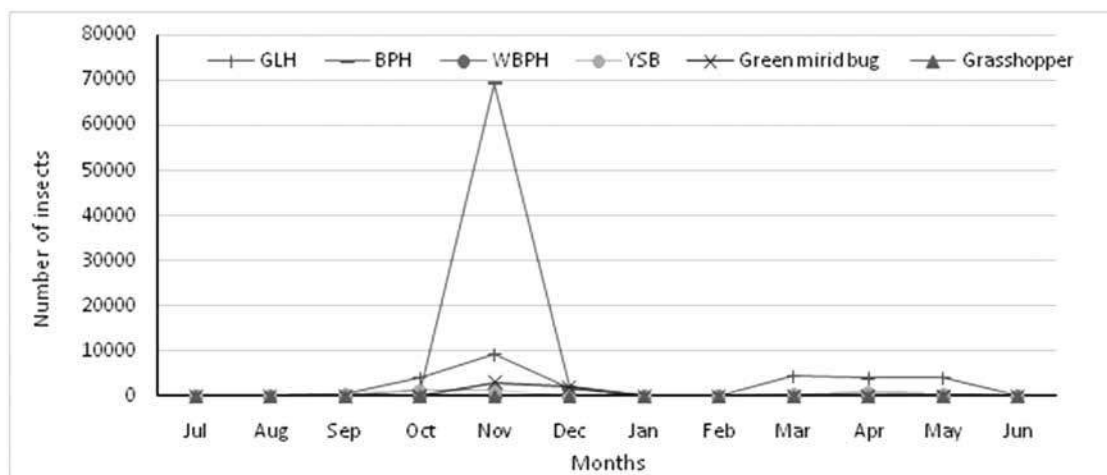


Fig.1. Incidence patterns of major insect pests in light trap. BRRI RS, Habiganj. July 2022-Jun 2023.

TECHNOLOGY TRANSFER

Advanced Line Adaptive Research Trail (ALART)

ALART (PQR), T. Aman 2022

Two premium quality rice lines BR8493-3-5-1-P1 and BR9590-45-1-2-3-P2 along with standard check varieties BRRI dhan34 and BRRI dhan70 were evaluated on farm condition at Bahubol, in Habiganj. The advanced line BR8493-3-5-1-P1 did not germinate. Another genotype BR9590-45-1-2-3-P2 was susceptible to brown spot. It had less tiller number and lower yield than the check varieties. So, the advanced line was not recommended for proposed variety trial (PVT).

ALART (BRR), Boro 2022-23

Four blast resistant lines, namely BR12454-BC2-56-81-27-3-30, BR12454-BC2-69-97-39-5-44, BR12454-BC2-71-91-6-23-26 and BR12454-BC2-75-32-31-39-7 along with two standard check varieties BRRI dhan29 and

BRRI dhan89 were evaluated on farm condition at Baniachong in Habiganj. Tested breeding lines were neck blast resistant but yield was lower than the check varieties. So, none of the advanced lines was recommended for PVT.

Re-ALART (BRR), Boro 2022-23

An experiment was conducted on farm condition at Baniachong in Habiganj. Four blast resistant lines along with two standard check varieties, BRRI dhan28 and BRRI dhan88 were evaluated in this experiment. The breeding line BR(Path)12452-BC6-53-21-11 had the highest grain yield but it showed lodging tendency at maturity stage. Other two breeding lines BR(Path)13784-BC3-63-6-4-HR6 and BR(Path)12452-BC3-42-22-11-4 had statistically similar yield to check variety BRRI dhan88 (Table3). Those three lines were resistant to neck blast. So, the advanced lines BR(Path)13784-BC3-63-6-4-HR6, BR (Path)12452-BC6-53-21-11 and BR (Path)12452-BC3-42-22-11-4 were recommended for PVT.

Table3. Plant height, growth duration and grain yield of different entries under Re-ALART (BRR), Boro 2022-23.

Genotype	PH (cm)	GD	GY (t ha ⁻¹)
V1= BR(Path)12452-BC3-42-22-11-4	114.53	142	7.51
V2= BR(Path)12452-BC6-53-21-11	117.43	142	8.02
V3= BR(Path)13784-BC3-61-1-6-HR3	104.97	140	4.69

Genotype	PH (cm)	GD	GY (t ha ⁻¹)
V4= BR(Path)13784-BC3-63-6-4-HR6	101.20	144	7.70
V5=BRRI dhan28 (ck)	115.07	140	3.32
V6=BRRI dhan88 (ck)	95.20	142	7.95
CV	2.73	6.32	3.65
LSD	5.38	1.62	0.43

ALART (FBR Barishal), Boro 2022-23

An experiment was conducted on farm condition at Baniachong, in Habiganj. Four lines of favourable Boro ecosystem BRBa1-4-9, BRBa14-NGR414-1, BRBa3-1-7, BRBa40-NGR1255-1 along with two standard check varieties, BRRI dhan58 and BRRI dhan89 were evaluated in this experiment. The yield ranges of four lines and two check varieties were 7.85-8.24 t/ha and 7.05-8.43 t/ha, respectively. None of the lines out yielded the check variety BRRI dhan89. The tested genotype BRBa 1-4-9, BRBa14-NGR414-1 and BRBa40-NGR1255-1 was susceptible to leaf blast and BRBa40-NGR1255-1 was susceptible to neck blast. So, the advanced lines were not recommended for PVT.

ALART (FBR MD), Boro 2022-23

An experiment was conducted on farm condition at Baniachong, in Habiganj. Two medium duration lines of favourable Boro ecosystem IR12A173 and IR17A1694 along with two standard check varieties BRRI dhan58 and BRRI dhan96 were evaluated in this experiment. The yield of two lines and two check varieties ranged from 6.82-7.35 t/ha and 6.08-6.93 t/ha, respectively (Table4). The insect and disease incidence were lower in all lines. The tested genotype IR12A173 was attractive to the ALART monitoring team and the farmers due to higher yield and less disease. So, this advanced line was recommended for PVT.

Table 4. Plant height, growth duration and grain yield of different entries under ALART (FBR MD), Boro 2022-23.

Genotype	PH (cm)	GD	GY (tha ⁻¹)
V1= IR12A173	103.9	153	7.35
V2= IR17A1694	95.5	146	6.82

Genotype	PH (cm)	GD	GY (tha ⁻¹)
V3=BRRI dhan58 (ck)	97.9	151	6.08
V4=BRRI dhan96 (ck)	89.6	146	6.93
CV	1.8	4.99	4.75
LSD	3.4	1.48	0.52

ALART (FBR SD), Boro 2022

An experiment was conducted at the farmer's field of Baniachong in Habiganj. Four short duration lines of favourable Boro ecosystem BR11318-5R-63, BR11337-5R-72, SVIN109 and IR17A1723 along with two standard check varieties BRRI dhan81 and BRRI dhan96 were evaluated in this experiment. The yield of breeding lines and check varieties ranged from 6.12-7.31 t/ha and 3.77-6.87 t/ha, respectively (Table5). The line BR11318-5R-63 was susceptible to leaf blast. Other two lines BR11318-5R-63 and IR17A1723 were damaged by rat. The tested genotype BR11337-5R-72 was liked by the farmers due to its higher yield, less disease and insect infestation. So, it was recommended for PVT.

Table 5. Plant height, growth duration and grain yield of different entries under ALART (FBR SD), Boro 2022-23.

Genotype	PH (cm)	GD	GY (tha ⁻¹)
V1=BR11318-5R-63	107.1	146	6.13
V2=BR11337-5R-72	104.2	150	7.31
V3=SVIN109	108.3	148	6.48
V4=IR17A1723	85.6	141	6.12
V5=BRRI dhan81(ck)	86.2	141	3.77
V6=BRRI dhan96(ck)	92.8	142	6.87
CV	1.1	2.39	5.42

ALART (SHR 1), Boro 2022-23

An experiment was conducted on farm condition at Baniachong, in Habiganj. Three SHR-1 lines, namely BRH10-1-14-2-6, BRH13-2-4-7-2B and BRH15-24-7B along with a standard check variety BRRI dhan81 were evaluated in this experiment. The yield of breeding lines and the check variety ranged from 4.79-6.03 t/ha and 1.94 t/ha, respectively. The tested genotype BRH10-1-14-2-6 had lower tiller number per hill, irregular flowering and maturity. The tested genotypes were not chosen by the farmers due to their poor phenotypic acceptance, irregular flowering and maturity. So, none of the advanced lines was recommended for PVT.

ALART (SHR 2), Boro 2022-23

An experiment was conducted at the farmers field of Baniachong, in Habiganj. Three SHR-2 lines, namely BRH11-2-4-7B, BRH13-2-4-2-1B and BRH238-5-1-4-2 along with a standard check variety BRRI dhan88 were evaluated in this experiment. The yield of three lines and the check variety ranged from 4.87-5.72 t/ha and 6.18 t/ha, respectively. The tested genotypes were found with 20% to 50% mixture, lower tiller number per hill, irregular flowering and maturity. The tested genotypes were not attractive to farmers due to their poor phenotypic acceptance, irregular flowering and maturity as well as low yield. So, none of the advanced lines was recommended for PVT.

Demonstration

In Aus 2022, 50 demonstrations of BRRI dhan48, BRRI dhan98 and BRRI hybrid dhan7 were conducted in Sylhet region. Average yield of BRRI dhan48, BRRI dhan98 and BRRI hybrid dhan7 were 4.2 t/ha, 4.45 t/ha and 5.0 t/ha, respectively. Farmers were motivated to cultivate all the three varieties. In T. Aman 2022, 100 demonstrations of BRRI dhan75, BRRI dhan79, BRRI dhan87, BRRI dhan90, BRRI dhan93, BRRI dhan94, BRRI dhan95, BRRI hybrid dhan4 and BRRI hybrid dhan6 were conducted at Sylhet region. Average yield of BRRI dhan75, BRRI dhan79, BRRI dhan87, BRRI dhan90, BRRI dhan93, BRRI dhan94, BRRI dhan95, BRRI hybrid dhan4 and BRRI hybrid dhan6 were 4.5 t/ha, 5.3 t/ha, 4.2 t/

ha, 4.9 t/ha, 5.0 t/ha, 5.0 t/ha, 5.5 t/ha, 5.8 t/ha and 5.9 t/ha, respectively. Most of the farmers were motivated to cultivate BRRI dhan75, BRRI dhan90, BRRI dhan95 BRRI hybrid dhan4 and BRRI hybrid dhan6. BRRI dhan87 performed better in Habiganj and Moulvibazar but affected by tungro disease in Sylhet district. BRRI dhan93 and BRRI dhan94 were lodged in some areas. In Boro 2022-23, 300 demonstrations of BRRI dhan67, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, Bangabandhu dhan100, BRRI hybrid dhan3 and BRRI hybrid dhan5. Average yield of BRRI dhan67, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92, Bangabandhu dhan100, BRRI hybrid dhan3 and BRRI hybrid dhan5 were 6.3 t/ha, 3.3 t/ha, 6.2 t/ha, 6.9 t/ha, 7.0 t/ha, 6.2 t/ha, 6.4 t/ha, 7.5 t/ha, and 7.9 t/ha, respectively. Most of the farmers have chosen BRRI hybrid dhan5, BRRI hybrid dhan3, BRRI dhan92, BRRI dhan89, Bangabandhu dhan100 and BRRI dhan67 for Boro season due to their higher yield and less blast disease. Some farmers preferred BRRI dhan96 and BRRI dhan88 for their short duration. BRRI dhan84 was severely affected by neck blast resulting its poor yield in Haor areas.

Farmer's Training

BRRI RS, Habiganj conducted 10 farmers training programmes at different location of Sylhet region during the reporting period. These training programmes were conducted at Habiganj Sadar, Chunarughat, Baniachong, Madhobpur, Sylhet Sadar, Biswanath, Moulvibazar Sadar, Rajnagar, Goainghat, Shantiganj. In total 300 persons were trained. Awareness for adopting improved rice cultivation technologies and enhancing the dissemination of BRRI varieties was done through those trainings.

Farmers field day

BRRI regional station, Habiganj conducted 10 field day programmes in different locations of Sylhet region during the reporting period (Aus season-01, Aman season-04, Boro season-05). More than 2,000 (average of 200 in each field day) farmers, extension personnel, administrative people, public leaders participated in these field days. Most of the farmers have preferred BRRI dhan98 over BRRI

ghan48 due to its higher yield and slender grain in Aus season. In Aman season, farmers chosen BRRI dhan75 for its short duration and BRRI dhan95 for its non-lodging and higher yield. BRRI dhan89, BRRI dhan92 and Bangabandhu dhan100 have been chosen for Boro season due to their higher yield and less blast disease. Farmers showed their interest to cultivate the demonstrated varieties in the next season.

Seed Production

Breeder seed production

In Boro 2022-23, a total of 25,750 kg (BRRI dhan28 = 6,750 kg, BRRI dhan29 = 2,750 kg, BRRI dhan89 = 8,250 kg, BRRI dhan92 = 5,500 kg and Bangabandhu dhan100 = 2500 kg) breeder seed were produced

TLS seed production

In Aus 2022, a total of 900 kg BRRI dhan98, in T. Aman 2022, a total 6,250 kg (BR22 = 1,150 kg, BRRI dhan49 = 400 kg, BRRI dhan75 = 250 kg, BRRI dhan79 = 650 kg, BRRI dhan87 = 500 kg, BRRI dhan90 = 700kg, BRRI dhan93 = 600kg, BRRI dhan94 = 800 kg, BRRI dhan95 = 1,200 kg) and in Boro 2022-23, a total of 15,730 kg (BRRI dhan28 = 80 kg, BRRI dhan29 = 1000 kg, BRRI dhan67 = 3,600 kg, BRRI dhan84 = 2,600 kg, BRRI dhan88 = 4,700, BRRI dhan89 = 300, BRRI dhan92 = 1,500, BRRI dhan96 = 750 kg, Bangabandhu dhan100 = 1,200 kg) TLS seed were produced. BRRI released varieties would be disseminated quickly to farmers by using these seeds.

BRRI RS, Rajshahi

480	Summary
481	Varietal Development
486	Pest Management
488	Rice Farming Systems
490	Technology Transfer

SUMMARY

In Aus season, four trials were conducted under TRB project. In OYT-T. Aus programme, 15 entries produced significantly higher yield than BRRI dhan48, BRRI dhan82 and BRRI dhan98. Three AYT's consist of 214 breeding lines were evaluated. In AYT#1, the entry BR12087-5R-132-1 produced significantly higher yield than BRRI dhan98. In AYT#2, 3 entries produced significantly higher yield than the checks BRRI dhan48, BRRI dhan82 and BRRI dhan98. In AYT#3, three entries produced significantly higher grain against the checks. In OYT-HTTR, 20 entries produced higher yield and the entry BR10966-B-3R-23 produced the yield of 7.19 t/ha yield. In AYT-HTTR, the entry no. BR12098-4R-202-1 produced high yield of 5.87 t/ha.

In hybridization programme, 947 F_1 seeds were produced from 12 crosses in T. Aman season. Five crosses were selected in T. Aman and confirmed as true F_1 's and 12,446 individual progenies were harvested from rapid generation advanced of segregating populations. Seven regional yield Trial (Rainfed Lowland Rice, zinc enriched rice, premium quality rice and disease resistant rice) were conducted in T. Aman in which a total of 24 breeding lines were evaluated and eight entries were found promising for further advancement. In T. Aman season, under TRB project, two entries produced higher yield than BRRI dhan49, BRRI dhan87 & IRBB60 in OYT-BB. In OYT#1, 45 entries gave significantly higher yield than BRRI dhan56 and BRRI dhan71. Forty-four entries produced higher yield than BRRI dhan49, BRRI dhan56 and BRRI dhan71 in OYT#2. Among the two AYT's, none of the entries performed significantly higher in AYT#1 while in AYT#2, the entry IR100097-B-B-RGA-B-RGA-8 produced significantly higher yield of 4.75 t/ha than BRRI dhan56 and BRRI dhan71. Under the AGGRiNet Trial, IR132084-B-1327-2-1-B-13, IR132084-B-26-1-5-B-2 and IR116709-B-B-2-2-B-B produced significantly higher grain than BRRI dhan87. Under the DSR (stage 2) programme, two entries- IR17D1089 and IR 86612-26-7-1-1-1-1-1-1 produced higher yield than BRRI dhan87. Under the QTL line evaluation programme, two entries- 22QWS-10 and 22QWS-14 produced higher yield than BRRI dhan87.

In Boro season, a total of 555 F_1 seeds were produced from nine crosses. Ten crosses were selected in Boro and confirmed as true F_1 's. In total 9334 individual progenies were harvested from rapid generation advanced of segregating populations of F2-F5 generations. During Boro, 16 YTs (15 RYT & 1 AYT) with 119 breeding lines were evaluated of which 41 lines were found promising for further advancement. Under the TRB project, seven trials were conducted in Boro season. In OYT-BB, 14 entries out of 460 produced higher grain yield against BRRI dhan88, BRRI dhan89, BRRI dhan92 and BRRI dhan101. Three OYT's in PQR were evaluated in Boro season. In OYT#1, 26 lines out of 330 produced higher yield than BRRI dhan50, BRRI dhan63 and BRRI dhan81. In OYT#2, 24 entries out of 171 lines showed significantly higher yield than the checks BRRI dhan50, BRRI dhan63 and BRRI dhan81. Entry no. BR11978-4R-60 produced 8.84 t/ha grain with six days shorter GD compared to BRRI dhan63. OYT#3, six lines out of 104 showed higher yield against BRRI dhan50, BRRI dhan63 and BRRI dhan92. Three AYT's -PQR programme were evaluated and two entries BR11359-4R-250 and BR11359-4R-169 produced significantly higher grain yield than the checks BRRI dhan50, BRRI dhan58 and BRRI dhan63 in AYT#2. Under the AGGRiNet the trial, a total of 200 advanced breeding lines under MD (stage 1) programme were evaluated and the entry no- IR19A9045 produced significantly higher yield than the six checks.

Three different lighting periods were evaluated to identify in insect pest where the highest number of insect pest was captured at late night (11 pm to 6 am) lighting period. Among the captured insect pest and natural enemies, 83% was insect pest and 17% was natural enemies. The highest number of insect pests and natural enemies were found at plant canopy. Among the collected insect pests and natural enemies, 73% was insect pests and 27% was natural enemies.

Out of five, two four-crops cropping patterns viz Potato/pumpkin-T. Aus-T. Aman and Mustard-Onion-T. Aus-T. Aman produced higher system than three crops cropping pattern (Potato-Maize-T. Aman) under crop productivity and soil health

evaluation trial. The gross return as well as gross margin remained higher in strip tillage un-puddled rice followed by strip tillage maize and mungben system. Gross return, gross margin and marginal benefit cost ratio (MBCR) remained remarkably higher in pair row Potato/pair row Maize-T Aus (BRRI dhan82)-T. Aman (BRRI dhan75) than other four crops cropping patterns and thus the pattern could be the transferable technology for Rajshahi region. In another four crops evaluation trial, it was found that the highest rice equivalent yield (26.3 t/ha) was observed in Mustard-Boro-Vegetable-T. Aman followed by Mustard-Boro-Aus-Blackgram cropping pattern (24.5 t/ha).

In stability experiments, BRRI hybrid dhan7 top ranked followed by BRRI dhan98 in Aus season, while BRRI dhan72 produced higher yield followed by BRRI hybrid dhan6 in Aman season. In Boro season, BRRI dhan89 gave higher yield followed by BRRI dhan102.

Under ALART SHR-1 during Aman season, the entry BRH13-1-9-7B produced significantly higher yield than BRRI dhan57 and Jirashail in two locations. In Boro season, one entry viz BRBa14-NGR414-1 produced significantly higher yield than the check varieties in Re-ALART-FBR Barishal. BRH13-2-4-7-2B produced significantly higher yield than BRRI dhan81 in ALART SHR-1 while BRH13-2-4-2-1B produced higher yield than BRRI dhan88 in SHR-2. The tested entries BR11318-5R-63, IR17A1694 and SVIN109 produced significantly higher yield than the check varieties in ALART FBR-SD and all the tested entries produced higher yield than the checks BRRI dhan29 and BRRI dhan89 of ALART BRR in Boro season.

In variety demonstration trials, the highest yield was found in BRRI dhan98 followed by BRRI dhan48 in Aus season while in Aman season; the highest yield was found in BRRI dhan51 followed by BRRI dhan87. In Boro season, the highest yield was found in BRRI dhan89 followed by BRRI dhan102 and BRRI dhan92. In Head to Head Adaptive Trial (HHAT) in Aman season, the grain yield remained higher in BRRI dhan93 followed by BRRI dhn94. In Boro season, the highest grain yield was found in BRRI dhan74 followed by BRRI dhan88 in short duration varieties. In case of long duration

varieties, the grain yield remained higher in BRRI dhan102 followed by BRRI dhn92. BRRI RS, Rajshahi arranged 42 training programmes where one thousand two hundred and sixty participants were participated. Considering three seasons (Aus, T. Aman and Boro), breeder and TLS seed were produced 4, 24 and 15 tons, respectively in BRRI RS, Rajshahi.

VARIETAL DEVELOPMENT

Observation yield trial (OYT#1) under TRB project T. Aus 2022

In total 688 advanced breeding lines were evaluated with three checks BRRI dhan48, BRRI dhan82 and BRRI dhan98. Out of 688, fifteen entries produced higher yield (4.94-5.68 t/ha; GD 99-109 days) compared to the checks (4.30-4.78 t/ha; 104-106 days). The entry no- BR 12426-5 R-51 produced higher yield 5.68 t/ha with more or less similar GD (105 days) than BRRI dhan82 (4.78 t/ha; 104 days).

Observation yield trial (OYT#2) high temperature tolerant (HTTR), T. Aus 2022

In total 124 advanced breeding lines were evaluated with four checks BRRI dhan48, BRRI dhan82, BRRI dhan98 and N22 at BRRI RS, Rajshahi farm. It showed that 20 entries produced higher yield (5.60-7.19 t/ha; GD 99-122 days) compared to the checks (3.54-5.43 t/ha; 100-109 days). The entry no. BR10966-B-3R-23 produced higher yield 7.19 t/ha with five days shorter GD (102 days) compared to BRRI dhan48 (5.43 t/ha; 107 days). Some of the entries became sterile due to heat effect.

Advanced yield trial (ATY#1, AYT#2 and AYT#3) under TRB project, T. Aus 2022

Three AYT_s, consist of 214 genotypes along with standard checks were evaluated at BRRI RS Rajshahi farm where **AYT#1** consists of 93 genotypes along with the checks BRRI dhan48, BRRI dhan82 and BRRI dhan98 (4.14-5.46 t/ha, 103-105 days). Three entries produced more 5 t/ha yield ranging from 5.09-5.67 t/ha with GD 104-106 days. Entry no-BR12087-5R-132-1 (5.67 t/ha; 104 days) produced significantly highest grain with 1 days shorter GD compared to the highest grain producing check BRRI dhan98 (5.46 t/ha, 105 days).

AYT#2 consists of 111 genotypes along with the checks BRRI dhan48, BRRI dhan82 and BRRI

dhan98 (4.41-5.02 t/ha; 105-110 days). It showed that three entries produced significantly higher yield ranging from 5.18-5.31 t/ha followed by GD 112-113 days compared to the checks. BR 11866-5 R-351 produced 5.31 t/ha grain with eight days longer GD as 113 days compared against the check BRRI dhan48 (5.02 t/ha; 105 days).

AYT#3 consists of 10 genotypes along with the checks BRRI dhan48, BRRI dhan82 and BRRI dhan98 (2.19-4.75 t/ha; 110-111 days), among them three entries produced significantly higher grain ranging from 5.30-5.83 t/ha with the GD 112-116 days. Entry no- BR11898-5R-241 produced higher yield 5.83 t/ha with five days longer GD as 115 days against BRRI dhan82 (4.75 t/ha; 110 days). BRRI dhan48 and BRRI dhan98 yielded low because of infestation of stem borer.

Advanced yield trial (AYT#4), high temperature tolerant (HTTR) T. Aus 2022

AYT#4 consists of 44 genotypes along with the checks BRRI dhan48, BRRI dhan82, BRRI dhan98 and N22 (2.79-4.73 t/ha; 99-112 days), among them three entries showed statistically significant grain yield ranging from 5.27-5.87 t/ha with 101-106 days GD. The entry BR12098-4R-202-1 produced higher grain yield 5.87 t/ha with similar GD of 101 days compared against the check BRRI dhan98 (4.73 t/ha; 101 days). Some entries were very late, panicles of some entries became sterile due to heat effect and BRRI dhan82 yielded low because of rat damage.

Hybridization, T. Aman 2022-23

For trait development of high yielding premium quality rice, a total of 947 F_1 seeds were produced from twelve crosses using eleven parents in T. Aman 2022 season.

F_1 Confirmation, T. Aman 2022-23

Out of seven crosses, five crosses were selected and confirmed as true F_1 s comparing with their parents respectively and registered in the BRRaj cross register. Seeds of these selected F_1 plants were selfed to produce F_2 seeds. At maturity, F_2 seeds of all selected plants were harvested individually, dried, cleaned and preserved for further advancement.

Rapid generation advance of segregating nurseries, T. Aman 2022-23

In total 12,446 individual progenies were harvested from rapid generation advanced of segregating populations of different generations (F_2 - F_4). Overall recovery of the lines across the generations was 89%.

Regional yield trial (RYT), T. Aman 2022-23

A total of 24 breeding lines were evaluated in seven different RYT (rainfed lowland rice-RLR, zinc enriched rice-ZER, premium quality rice-PQR and Disease Resistant Rice-DRR) at BRRI RS farm (Rajshahi) against nine different standard checks (BRRI dhan49, BRRI dhan71, BRRI dhan72, BRRI dhan75, BRRI dhan87, BRRI dhan93, BRRI dhan94, IRBB60 and Zirashail).

In RLR, BR10482-1-2-3-1-3 produced significantly higher yield (6.53 t/ha) with 136 days than BRRI dhan49, BRRI dhan71, BRRI dhan87 and BRRI dhan93 (Yield: 5.31-6.24 t/ha). All the tested entries produced the higher yield (6.19-6.57 t/ha) than BRRI dhan72 (5.65 t/ha), only BR10471-1-2-3-15-1 showed similar to BRRI dhan87 in ZER yield trial. In the short-slender rice yield trial, the genotypes BRH17-23-8-2-7B produced higher yield (5.39 t/ha) than the check BRRI dhan49 (5.37 t/ha) with 108 days. Out of four, the genotype BRH9-3-14-2B gave higher yield (4.56 t/ha) than the check Zirashail (4.28 t/ha) with similar GD (114 days) in zira type yield trial. In DRR (Bacterial blight) yield trial, BR11869-5R-72 produced similar yield (5.54 t/ha) to the check BRRI dhan49 (5.65 t/ha).

Observation yield trial (OYT), disease resistance rice (DDR) of T. Aman 2022

In OYT, 42 lines were grown along with the two standard checks dhan49 and BRRI dhan87 and resistant check IRBB60 at BRRI RS Rajshahi farm. Two entries produced significantly higher yield (5.57-6.28 t/ha; GD 106-111 days) than the three checks BRRI dhan49, BRRI dhan87 and IRBB60 (4.16-5.41 t/ha; 111-129 days). Among them, entry no. BR11127-4R-10-1 produced higher yield 6.28 t/ha with 23 days shorter GD (106 days) than BRRI dhan49 (5.41 t/ha; 129 days).

Observation Yield Trial (OYT#1 and OYT#2), Development of Drought Tolerant Rice (DTR) under TRB project, T. Aman 2022

Six hundred twenty genotypes along with the standard checks were evaluated in two OYTs at BRRI RS, Rajshahi. In OYT#1, 245 lines (GD: 100-120 days) conducted with checks BRRI dhan56 and BRRI dhan71, among them 45 entries produced significantly higher yield (4.85-7.46 t/ha; 101-117 days) than the two checks (3.75-4.21 t/ha; 100-107 days). Entry BR13018-4R-116 produced the highest yield 7.46 t/ha with similar GD 107 days compared to BRRI dhan56 (4.21 t/ha; 107 days) and all the entries. BR13017-4R-11 produced 2nd highest yield 7.16 t/ha with similar GD 107 days followed by 1st one.

OYT#2 consists of 375 lines (GD: 121-140 days) along with checks BRRI dhan49, BRRI dhan56 and BRRI dhan71 were tested and 44 entries produced higher yield ranging 4.40 to 7.84 t/ha with GD 107-130 days compared to three checks rang from 3.37 to 4.11 t/ha with GD 106-128 days. Entry BR12307-5R-48 produced higher yield 7.84 t/ha with 13 days longer GD (126 days) than BRRI dhan71 (4.11 t/ha; 113 days).

Advanced yield trial (AYT#1 and AYT#2), development of drought tolerant rice (DTR) under TRB project, T. Aman 2022

Thirty-five genotypes along with standard checks were tested in two AYT#1, 23 lines were tested with two varieties BRRI dhan56 and BRRI dhan71. Here none of entries performed significantly higher in grain production. Beside this, 4 entries gave higher yield (4.19-4.47 t/ha; GD 108-114 days) than the checks (3.78-4.01 t/ha; 107-109 days). Entry no. BR12021-6R-117 produced non-significant higher yield 4.47 t/ha with 1 days shorter GD (108 days) compared to BRRI dhan71 (4.01 t/ha; 109 days).

In AYT#2, 12 lines along with the checks BRRI dhan56 and BRRI dhan71 were tested and the entry IR100097-B-B-RGA-B-RGA-8 produced significantly higher yield 4.75 t/ha with 2 days longer GD of 112 days compared to the checks BRRI dhan56 and BRRI dhan71 (3.66-4.14 t/ha; 107-110 days).

Establishment of AGGRi network trial (DSR stage 1) under IRRI-DSR rice breeding programme. T. Aman 2022

This trial was conducted with 284 breeding lines including 11 local entries, five global checks and four local check varieties-BRRI dhan75, BRRI dhan79, BRRI dhan87 and BRRI dhan95 were evaluated at BRRI RS Rajshahi farm. The tested entries showed a wide range of variations on grain yield starting from 2.60 t/ha to 7.73 t/ha with the average value of 4.86 t/ha. Growth duration also varied among selected lines. The entries varied in growth duration from 111 days to 139 days with average value of 121 days. Wide variations in plant height were also observed among this breeding lines. Among them seven entries produced statistically significantly higher yield ranging from (6.72-7.73 t/ha, 115-127 days) compared to the four check varieties (4.27-6.34 t/ha, 113-132 days). GD was also more or less similar to the checks (Table 1) the entry IR132084-B-1327-2-1-B-13 (7.73 t/ha, 123 days), IR132084-B-26-1-5-B-2 (7.17 t/ha, 124 days) and IR116709-B-B-2-2-B-B (7.16 t/ha and 127 days) performed better on grain production, producing more than 7 t/ha yield with 0-2 to 3 days shorter GD compared to the check BRRI dhan87 (6.34 t/ha, 126 days).

Establishment of AGGRi network trial (DSR stage 2) under IRRI-DSR rice breeding programme, T. Aman 2022

This trial was evaluated under the supervision of BRRI RS, Rajshahi with 60 advanced breeding lines including five local check varieties BRRI dhan54, BRRI dhan62, BRRI dhan87, BINA dhan16 and BINA dhan17 and site-specific entries- BRRI dhan56, BRRI dhan71, BRRI dhan75 and BRRI dhan90. Among all the tested entries as well as site-specific entries and checks, two entries produced significantly higher yield having IR17D1089 (5.60 t/ha, 115 days) and IR 86612-26-7-1-1-1-1-1-1 (5.88 t/ha, 99 days) with GD (ranges from 0-16 days) compared to BRRI dhan71 (5.11 t/ha, 99 days) and 6-22 days shorter GD compared to BRRI dhan87 (5.50 t/ha and 121 days). The checks and site-specific entries yielded 3.56-5.50 t/ha, with GD ranging from 92 to 115 days.

Establishment of AGGRi network trial (medium stage 1) under IRRI- irrigated rice breeding Programme, T. Aman 2022

This trial comprises 200 advanced breeding lines with ten global IRRI 104, IRRI 123, IRRI 154, IRRI 156, IRRI 168, IRRI 174, IR16A3838, IR16A3891, IR16A4085 and IR16A4261 and six local check varieties BRRI dhan49, BRRI dhan75, BRRI dhan87, BINA dha11, BINA dhan17 and Rabi dhan1 were evaluated at BRRI RS, Rajshahi. Thirteen entries produced higher yield (6.51-8.18 t/ha; GD 105-122 days) than the checks (3.05-5.93 t/ha; 112-128 days). Entry IR19A8774 produced higher yield 8.18 t/ha with 20 days shorter GD (105 days) than BRRI dhan87 (5.93 t/ha; 125 days).

Establishment of AGGRi network trial (medium stage 2) under IRRI- irrigated rice breeding programme, T. Aman 2022

This trial is composed with 50 advanced breeding lines developed at BRRI RS Rajshahi farm with six global and four local check varieties BRRI dhan49, BRRI dhan72, BRRI dhan75 and BRRI dhan87. Six entries produced higher yield (6.13-6.77 t/ha; GD 121-123 days) all the three checks (4.44-5.86 t/ha; 126-132 days). Entry IR18A2266 produced higher yield 6.77 t/ha with seven days shorter GD (119 days) than BRRI dhan87 (5.86 t/ha; 126 days).

Assessment of QTL effect on different biotic stresses and agronomic traits, T. Aman 2022

Yield trial of some selected entries under QTL lines evaluation was conducted at BRRI RS, Rajshahi farm with three advanced lines of BRRI-BRRI dhan71, BRRI dhan75 and BRRI dhan87. Among them two entries produced significantly higher yield 22QWS-10 (6.05 t/ha, 123 days) and 22QWS-14 (6.23 t/ha, 123 days) which were with one day earlier GD compared to BRRI dhan87 (5.74 t/ha, 124 days). Fifteen entries produced more than 5 t/ha yield ranging from 5.00 to 6.23 t/ha yield around with 122-125 days GD, which were 7 -10 days shorter compared to BRRI dhan71 (4.53 t/ha, 115 days). Yield and GD of the checks ranged from 3.61-5.74 t/ha, 112-124 days

Hybridization, Boro 2022-23

A total of 555 F1 seeds were produced from nine crosses using seven parents in Boro season.

Rapid generation advance of segregating nurseries, Boro 2022-23

In total 9334 individual progenies from 19 crosses were harvested from F2-F5 generations through FRGA method.

Regional yield trial (RYT), Boro 2022-23

Sixteen RYT were conducted in Boro season 2022-23. In RYT (FBR-SD), BR11894-5R-376, BR11900-5R-24 and BR11903-5R-56 produced significantly higher yield (7.74-8.17 t/ha) than the checks BRRI dhan28 (6.98 t/ha) and BRRI dhan96 (7.08 t/ha) with the same growth duration. With the same growth duration, IR17A1735 (7.17 t/ha) and BR8899-14-4-1-2-2-1 (7.41 t/ha) produced significantly higher yield compared to BRRI dhan81 (6.76 t/ha) and IR18A1398 and BR11342-5R-23 showing similar yield and growth duration to BRRI dhan89 (7.83 t/ha) in RYT (FBR-MD). Three promising lines viz BR11894-5R-260, BR11318-5R-148 and BR11318-5R-84 produced similar yield (8.13-8.44 t/ha) and growth duration (160 days) with BRRI dhan89 (ck) and BRRI dhan92 (ck) in RYT (FBR-LD). RYT in AWD, the BR11206-5B-351 showed same yield (7.66 t/ha) and growth duration (158 days) to the check BRRI dhan58. The genotype BR (Bio)13028-AC24-1-2 produced significantly higher yield (7.54 t/ha) than the checks (BRRI dhan86 and BRRI dhan96) with 154 days growth duration in RYT (FBR-Bio). All the tested entries produced significantly higher yield compared to the check BRRI dhan88 (6.87 t/ha), but NGR 522-2, NGR 270-3, NGR 418-1, NGR 416-1, NGR 994-1 and NGR 710-1 produced similar yield to the check BRRI dhan89 (7.91 t/ha) in RYT (FBR-Barishal). In RYT (FBR-STR), three tested entries viz BR11712-4R-93, BR11727-4R-6 and BR11712-4R-346 produced similar yield (7.76-8.09 t/ha) with growth duration compared to the check BRRI dhan89 (8.00 t/ha). None of the entry produced higher yield than the check BRRI dhan84 (5.83 t/ha) in RYT (Black Rice- SD). In RYT (Black Rice- MD), all the tested entries produced significantly higher yield than the check Indonesian Black Rice (4.79 t/ha), although, BR12839-4R-47-1 (6.64 t/ha) and BR12839-4R-90-1 (6.83 t/ha) produced similar yield to BRRI dhan88 (6.68 t/ha).

ha). The three tested entries (BR9674-1-4-1-3-P1, BR9674-1-4-1-3-P2 and BR9674-7-3-2-1-P2) produced significantly higher yield (7.28-7.68 t/ha) than BRRI dhan74 and BRRI dhan84, although similar yield and growth duration to BRRI dhan29 (7.30 t/ha, 161 days) in RYT (ZER). In RYT# PQR-1, all the tested entries produced significantly higher yield compared to the checks (6.29-6.64 t/ha), except Lomba Zira (5.95 t/ha) in both the locations (BRRI farm & Naogoan, Rajshahi). An average yield of the both locations, the genotype Katari (Shibganj) performed significantly higher yield (7.23 t/ha) than all the tested entries and checks (BRRI dhan50 and BRRI dhan63) in RYT (PQR-2). Among the tested entries, IR18A2102 (7.32 t/ha, 152 days) and BR7528-2R-19-16-RIL-55 (7.26 t/ha, 157 days) produced significantly higher yield than the checks (BRRI dhan50, BRRI dhan63 and BRRI dhan86) in RYT (ELS). Out of 18, three entries viz BR11866-5R-73, BR11866-5R-277 and BR (Path)13800-BC3-8-6 produced significantly higher yield with same growth duration (153 days) than the checks BRRI dhan58 (6.79 t/ha) and BRRI dhan101 (7.37 t/ha). At the same time BR (Path)13800-BC3-8-1 and BR (Path)13800-BC3-8-9 produced similar yield and growth duration as BRRI dhan89 (7.79 t/ha) and BRRI dhan92 (7.92 t/ha) in RYT (DRR-1). Among the tested entries in RYT (DRR-2), only one genotype BR (Path)13800-BC3-134-8 gave higher yield than the checks BRRI dhan89 (7.67 t/ha) and BRRI dhan92 (7.72 t/ha) with same growth duration. Out of 13, four tested entries (IR18A2427, IR19A1473, IR19A1146, IR16A4085) produced same yield (7.74-7.96 t/ha) with BRRI dhan89 (ck) and BRRI dhan92 (ck), but these entries produced significantly higher yield compared to the check BRRI dhan88 (6.57 t/ha) in AYT (AGGRiNet).

Observation yield trial (OYT), development of disease resistance rice (DDR) under TRB project, Boro 2022-23

In total 460 advanced breeding lines were evaluated with three susceptible checks BRRI dhan88, BRRI dhan89 and BRRI dhan92 and one BB resistant check BRRI dhan101 at BRRI RS, Rajshahi farm. It showed that 14 entries produced significantly higher yield ranging 8.40 to 8.94 t/ha; GD 143-157 days compared with all the checks (7.43-8.28 t/ha;

142-158 days). Among them, entry the BR13180-4R-129 produced higher yield 8.94 t/ha with two days longer GD of 156 days becoming the highest yield producing check than BRRI dhan92 (8.28 t/ha; 154 days).

Observation yield trial (OYT#1, OYT#2 and QYT#3), development of premium quality rice (PQR) under TRB project, Boro 2022-23

A total 605 genotypes along with the standard checks were evaluated in three OYTs at BRRI RS, Rajshahi farm. In OYT#1, 330 lines (GD: 138-145 days) were tested with checks BRRI dhan50, BRRI dhan63 and BRRI dhan81. Among them, 26 entries (7.30-8.89 t/ha, GD 139-159 days) produced significantly higher yield than the three checks (6.02-7.17 t/ha, GD 142-150 days). Instead of the entry BR11966-4R-94 showed the highest grain yield 8.89 t/ha with the GD of 144 days compared to all the entries and checks.

In OYT#2, 171 lines (GD: 146-150 days) with the checks BRRI dhan50, BRRI dhan63 and BRRI dhan81 were evaluated. Among them 24 entries (7.32-8.84 t/ha, GD 140-154 days) showed significantly higher yield with mentioned GD compared to all the check varieties (5.86-7.12 t/ha, GD 143-146 days). The entry BR11978-4R-60 produced 8.84 t/ha grain with six days shorter GD (140 days) compared to the check BRRI dhan63 (7.12 t/ha, 146 days).

In OYT#3, 104 fixed lines (GD: 151-157 days) were established at BRRI RS, Rajshahi farm. With the checks BRRI dhan50, BRRI dhan63 and BRRI dhan92. Among them six entries showed more than 8 t/ha yield which were statistically significant (8.04-8.89 t/ha, 144-149 days) and performed better against the three checks (6.12-7.78 t/ha, 143-157 days). The highest grain producing entry was BR11980-4R-605 (8.89 t/ha, 144 days) which produced 11 days shorter GD compared with BRRI dhan92 (7.78 t/ha, 157 days).

Advanced yield trial (AYT#1, AYT#2 and AYT#3), development of premium quality rice (PQR) under TRB project, Boro 2022-23

Yield trial of a total of 63 breeding lines under three AYT in PQR programme were evaluated at

BRRI RS, Rajshahi farm, In AYT#1, 18 lines (GD: 138-145 days) where none of the entries performed significantly higher than the checks. In AYT#2, 15 lines were evaluated and among them two entries BR11359-4R-250 (7.91 t/ha, 156 days) and BR11359-4R-169 (7.81 t/ha, 151 days) produced significantly higher grain yield than the checks BRRI dhan50, BRRI dhan58 and BRRI dhan63 (6.60-7.31 t/ha, 149-155 days).

In AYT#3, 30 lines were tested and found that none of the entries produced higher grain yield than the checks BRRI dhan50, BRRI dhan63 and BRRI dhan92.

Establishment of AGGRi network trial (medium stage 1) under IRRI- dry season rice breeding programme, Boro 2022-23

This trial was conducted with 200 breeding lines including 10 global checks and six national checks- BRRI dhan28, BRRI dhan29, BRRI dhan67, BRRI dhan88, BRRI dhan89 and BRRI dhan92 at BRRI RS, Rajshahi farm. The tested entries showed a wide range of variations on grain yield starting from 4.29 t/ha to 9.71 t/ha with average value of 7.40 t/ha. Growth duration also varied among the selected lines. The entries varied in growth duration from 127 days to 147 days with average value of 137 days. Wide variations in plant height were also observed among these breeding lines. Among all the tested lines one entry- IR19A9045 (9.71 t/ha, 133 days) produced significantly higher yield with 6-20 days shorter GD compared to the six checks (6.67-8.92 t/ha, 139-155). Eleven entries (8.73-9.71 t/ha, 127-143 days) produced significantly higher on grain yield with 9- 25 shorter GD than the second highest producing check BRRI dhan89 (8.61 t/ha, 152 days) but lower on grain production to the 12-28 days lower GD compared to the highest grain producing check BRRI (8.92 t/ha, 155 days).

Establishment of AGGRi network trial (medium stage 2) under IRRI- dry season rice breeding programme, Boro 2022-23

This experiment was set up at BRRI RS, Rajshahi research field selected from previous T. Aman 2022 season in AGGRi MD stage 1 trial on the basis of their performance. Seedling of this trial were

damaged by bird attack and cold damage so we transplanted only seven breeding lines with three global- IRRI104, IRRI123 and IRRI168 and four national checks-BRRI dhan28, BRRI dhan88, BRRI dhan92 and RABI dhan1. We found that, none of entries produced the higher grain yield compared to the checks BRRI dhan92 (8.63 t/ha, 151 days). Two entries IR18A2514 (7.84 t/ha, 143 days) and IR18A2513 (7.92 t/ha, 138 days) performed significantly higher on grain yield compared to BRRI dhan88 (7.34 t/ha, 140 days).

Assessment of QTL effect on different biotic stresses and agronomic traits, Boro 2022-23

Yield trial of selected entries under QTL lines were evaluated at BRRI RS, Rajshahi farm with four advanced lines of BRRI dhan67, BRRI dhan75, BRRI dhan89 and BRRI dhan92. None of entries produced higher grain yield compared to the checks (7.65-7.97 t/ha, 152-157 days).

PEST MANAGEMENT

Impact of lighting period on the trapping of insects

The experiment was conducted in BRRI RS, Rajshahi farm during the T. Aman season 2022. Three different lighting periods were evaluated. These are early night (7 pm to 9 pm), mid night (9 pm to 11 pm) and late night (11 pm to 6 am).

The highest number of insect pest (860.00) was captured at late night lighting period and it was significantly different with the other two lighting periods. In case of natural enemies, the highest number of natural enemies (212.67) was captured at early night lighting period and it was significantly different with the other two lighting periods. Among them insect pest was 83% and natural enemies was 17% (Fig.1)

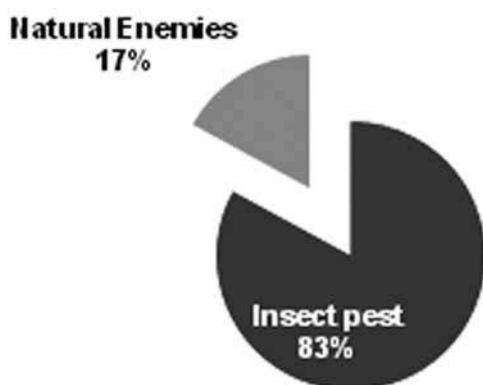


Fig. 1. Percentage of insect pests and natural enemies captured in the light trap during T. Aman 2022

Dominated insect pests on different lighting periods were green leaf hopper (GLH), white leaf hopper (WLH), stem borer (SB), rice leaf folder (RLF), case worm (CW) and rice bug (RB). The number of GLH (96.67) and rice bug (39.67) remained higher at early night lighting period while the highest number of SB (577.00) and RLF (35.33) was found at late night period. The highest number of WLH (144) and CW (72) was found at mid night lighting period where CW (51.67) was found at early night (7 pm to 9 pm) lighting period.

Dominated natural enemies on different lighting period were Carabid beetle (CDB), lady bird beetle (LBB), staphylinid beetle (STPD), damsel fly (Dam. fly) and ear wig (EW). The highest number of CDB (96.67) and EW (70.33) were found at early night. The highest number of LBB (7.33), STPD (27.33) and damsel fly (9.33) were also found at early night.

Effect of the setting heights of solar light trap to maximize the catch of rice insect pests

The experiment was conducted in the rice field of BRRI RS, Rajshahi farm during the T. Aman season 2022. Three different light-setting heights were evaluated. Heights were below the plant canopy (0.5 m from the ground), at the plant canopy (1.0 m from the ground), and above the plant canopy (1.5 m from the plant canopy). A solar light trap was set up for lighting and it was put on from dusk

to dawn, then the next morning, dead/killed insect populations were collected, identified, counted, and recorded.

The highest number of insect pests and natural enemies were found at plant canopy. Among the collected insect pests and natural enemies, 73% was insect pests and 27% was natural enemies (**Fig. 2**).



Fig. 2. Percentage of insect pests and natural enemies captured in the light trap during T. Aman 2022.

Dominated insect pests on different trap setting heights were green leaf hopper (GLH), white leaf hopper (WLH), stem borer (SB), rice leaf folder (RLF), case worm (CW) and Rice bug (RB). The highest number of GLH (594.00) and RB (122.00) were found at plant canopy level. In case of WLH capturing, there was no significantly different among the treatment. The highest number of SB (687.33) was found at above plant canopy level height. The highest number of RLF (24.00) was found at plant canopy. The highest number of CW (64.00) was found at above plant canopy level height and it was not significantly different with plant canopy level height. The lowest number of CW (49.33) was found at below plant canopy (0.5 m high from the ground) level height and it was not significantly different with plant canopy level.

Dominated natural enemies on different trap setting heights were carabid beetle (CDB), lady bird beetle (LBB), staphylinid beetle (STPD), damsel fly (Dam. fly) and ear wig (EW). The highest number

of CDB (542.00) and EW (154.00) were found at above plant canopy while the lowest number of CDB (370.50) and EW (119.00) were found at below plant canopy (0.5 m high from the ground) level height. The highest number of LBB (13.00) and damselfly (22.00) were found at plant canopy (1.0 m high from the ground) level height and they were not significantly different with below plant canopy (0.5 m high from the ground) level height. There was no significant difference among the treatments for STPD capturing.

RICE FARMING SYSTEMS

Evaluation of crop productivity and soil health under four crops cropping patterns in Rajshahi region

The trial was conducted at BRRIRS, Rajshahi during 2022-23 in RCB design with three replications to identify the profitable cropping patterns in Rajshahi region. The cropping patterns were CP₁. Potato/pumpkin (relay)-T Aus-T. Aman (BRRRI dhan75), CP₂. Potato-mungbean-T. Aus-T. Aman (BRRRI dhan75), CP₃. Field Pea-Onion-T. Aus-T. Aman (BRRRI dhan75), CP₄. Mustard-Onion-T. Aus-T. Aman (BRRRI dhan75), CP₅. Mustard-Onion/Maize (relay)-T. Aman (BRRRI dhan75), CP₆. Potato-Maize-T. Aman (BRRRI dhan95). BRRRI and BARI recommended crop and fertilizer management practices were followed for all the treatments.

Among the cropping patterns, the rice equivalent yield (REY), yield of first crop (Rabi season) remained higher (14.60 t/ha) in CP₂ (Potato) followed by CP₂ (13.8 t/ha) (Potato) and CP₆ (13.13 t/ha) (Potato) and that was found lower (5.40 t/ha) in CP₃ (field pea) and thus the result indicated that the potato-based patterns in Rabi season produced higher yields compared to the other crop-based patterns. In the second crop, REY was found higher in CP₃ (Onion, 9.16 t/ha) and that was remained lower (Mungbean, 2.38 t/ha) in CP₂. The REY in the third crop was found higher in CP₆ (Maize, 5.68 t/ha) followed by CP₁ (5.60 t/ha). Transplanted Aman rice (Kharif II season) was the fourth crop in all the cropping patterns and the higher yield in T. Aman season was found in CP₆ (6.13 t/ha) followed by CP₂ (5.60 t/ha). The lower yield in Aman season

was found in CP₅ (5.21 t/ha). Considering system yield, the higher REY (30.12 t/ha) was found in CP₁ followed by CP₂ (27.86 t/ha). The lower system yield was found in CP₄ (25.1 t/ha). Out of five, two four-crops cropping patterns viz Potato/pumpkin-T. Aus-T. Aman and Mustard-Onion-T Aus-T. Aman gave higher rice equivalent yield (REY) than the popular three crops cropping pattern (Potato-Maize-T. Aman).

Evaluation of crop productivity and soil health under strip tillage system in maize-Mungbean-Rice cropping pattern

The trial was conducted at BRRRI RS, Rajshahi in 2022-23 to evaluate the productivity and profitability of strip tillage system. The tillage and crop establishment methods were T₁: Strip tillage dry seeded rice followed by strip tillage maize and mungbean, T₂: Strip tillage un-puddled rice through rice transplanter followed by strip tillage maize and mungbean, T₃: Conventional tillage transplanted rice followed by strip tillage maize and mungbean, T₄: Conventional transplanted rice followed by conventional maize and mungben.

The higher grain yield of Aman rice was found in T₂ (5.70 t/ha) which was statistically similar with all the other treatments except T₁ (5.18 t/ha). The highest grain yield of maize was found in T₂ (11.46 t/ha) followed by T₁ (11.30 t/ha) while the lowest yield was recorded in T₄ (9.80 t/ha). In case of mungbean, there was no statistical difference in yield among the treatment ranging from 0.90 t/ha in T₁ to 1.02 t/ha in T₃. Considering cropping system yield, the rice equivalent yield (REY) remained higher in T₂ (19.33 t/ha) closely followed by T₁ (17.52 t/ha) treatment and that was found lower in T₄ (16.59 t/ha) treatment. The gross return (Tk 5,51,240/ha) as well as gross margin (Tk 2,58,980) remained higher in T₂ while those were remained lower in T₄ treatment (gross return Tk 4,75,520/ha and gross margin Tk (1,48,950/ha)

Evaluation of crop productivity under four crops cropping patterns in Rajshahi region

The trial was conducted at farmer's fields of Puthia and Dhokrakul upazila of Rajshahi district during 2020-23 in RCB design with three replications to

identify the profitable cropping patterns in Rajshahi region. The cropping patterns were CP₁: Pair row Potato/pair row Maize-T. Aus (BRRI dhan82)-T. Aman (BRRI dhan75), CP₂: Potato-pumpkin-T. Aus (BRRI dhan82)-T. Aman (BRRI dhan75), CP₃: Potato-Mungbean-T. Aus (BRRI dhan82)-T. Aman (BRRI dhan75), CP₄: Maize-Mungbean-T. Aman (BRRI dhan75), CP₅: Potato-Maize-T. Aman (BRRI dhan75). BRRI and BARI recommended crop and fertilizer management practices were followed for all the treatments.

Considering system yield of all cropping patterns, the yield was affected significantly (adjusted 3-year pooled mean data) and the higher system yield in terms of rice equivalent yield (REY) was found in

CP₁ (31.54 t/ha) followed by CP₂ (28.27 t/ha) and that was remained lower in CP₄ (18.53 t/ha) (**Table 1**). Among the five cropping patterns, the higher gross return was found in CP₁ followed by CP₂ and CP₃ while the lowest gross return was found in CP₄. Like gross return, the gross margin remained higher in CP₁ followed by CP₃ and CP₂ and that was remained lower in CP₄. Marginal benefit cost ratio (MBCR) remarkably higher in CP₁ compared to the other two four-crop-based patterns indicated that pair row Potato/pair row Maize-T Aus (BRRI dhan82)-T. Aman (BRRI dhan75) could be the transferable technology and this pattern could be disseminated in the farmers' field of Rajshahi region.

Table 1. System yield and economics of (adjusted 3-year pooled mean) of different cropping systems in Rajshahi district of Bangladesh during 2020-23.

Cropping Pattern	System yield (REY) (t/ha)	Gross return (Tk/ha)	Variable cost (Tk /ha)	Gross margin (Tk/ha)	MBCR
CP ₁	31.54	843919	440760	403159	1.63
CP ₂	28.27	755686	438470	317216	0.56
CP ₃	27.79	752147	402370	349777	0.94
CP ₄	18.53	492513	223830	268683	-1.61
CP ₅	26.83	712073	359930	352143	-
LSD (0.05)	2.60	-	-	-	-

Price (at harvest): Rice: Tk 28/kg, Potato Tk 14/kg, Mungbean: Tk 70/kg, Maize: Tk 25/kg, Pumpkin= 28 kg/ha, Rice straw: 1.5 Tk/kg, CP = Cropping pattern

Evaluation of zero tillage mustard based cropping patterns in Rajshahi region.

The trial was conducted at BRRI RS, Rajshahi during 2022-23 in RCB design with three replications to identify the extent of resource conservation and to increase the crop productivity. The cropping patterns were CP₁: Mustard (Conventional tillage BARI Sorisha17)-Boro (Bangobandhu dhan100)-T. Aman (BRRI dhan71), CP₂: Mustard (Zero tillage BARI Sorisha17 Before 7-10 days of harvest of Aman rice) -Boro (Bangobandhu dhan100)-T. Aman (BRRI dhan71), CP₃: Mustard (Zero tillage BARI Sorisha17 After harvesting of Aman rice) -Boro (Bangobandhu dhan100)-T. Aman (BRRI dhan71), CP₄: Boro (BRRI dhan81)-T. Aman (BRRI dhan71). BRRI and BARI recommended crop and

fertilizer management practices were followed for all the treatments.

The yield performance of Mustard in CP₁, CP₂, CP₃ were 1.35, 1.15, 1.25 (t/ha) respectively. The yields of Boro rice (Bangobandhu dhan100) in CP₁, CP₂ and CP₃ were 6.13, 6.15 and 6.02 (t/ha) and CP₄ (BRRI dhan81) 5.89 t/ha, respectively. The yield of T. Aman rice (BRRI dhan71) was recorded 5.94, 5.80, 5.82, 5.89 (t/ha) in CP₁, CP₂, CP₃ and CP₄ respectively.

Evaluation of three and four cropped cropping patterns for Rajshahi region

The trial was conducted at BRRI RS, Rajshahi during 2022-23 in RCB design with three replications to identify the profitable cropping patterns in Rajshahi

region. The cropping patterns were: CP₁: Mustard (BARI Sorisha-14)-Boro (BRRI dhan88)-Aus (BRRI dhan98)-Blackgram (BARI Mas-3); CP₂: Mustard (BARI Sorisha-17)-Boro (BRRI dhan88)-Vegetable (red amaranth, Stem Amaranth)-T. Aman (BRRI dhan 71); CP₃: Mustard (BARI Sorisha-17)-Boro (BRRI dhan92)-T. Aman (BRRI dhan 71); CP₄: Boro (BRRI dhan92)-Fallow -T. Aman (BRRI dhan71). BRRI and BARI recommended crop and fertilizer management practices were followed for all treatments.

Among the tested cropping patterns, the highest rice equivalent yield (26.3 t/ha) was observed in CP₂ (Mustard-Boro-Vegetable-T. Aman) treatment followed by CP₁ (Mustard-Boro-Aus-Blackgram) cropping pattern (24.5 t/ha) and the lowest value (13.4 t/ha) was recorded in CP₄ treatment (13.39 t/ha).

4. SOCIO-ECONOMICS AND POLICY

Stability analysis of BRRI developed Aus varieties

Fourteen rice varieties were evaluated during 2022-23. Among the 17 varieties, BRRI hybrid dhan7 top ranked (5.61 t/ha) followed by BRRI dhan98 (5.01 t/ha) while the grain yield remained lower in BRRI dhan21 (3.12 t/ha).

Stability Analysis of BRRI developed T. Aman rice varieties

Forty-seven Aman rice varieties were evaluated at BRRI RS, Rajshahi farm during 2022-23. BRRI dhan72 produced higher yield (6.17 t/ha) followed by BRRI hybrid dhan6 (5.95 t/ha). Next to BRRI hybrid dhan6, the rice yields in Aman season remained higher in BRRI dhan94 (5.87 t/ha).

Stability Analysis of BRRI developed Boro rice varieties

Forty-nine rice varieties were evaluated at BRRI RS, Rajshahi farm during Boro season of 2022-23. Considering the yield performance, top four rice varieties were BRRI dhan89 (9.36 t/ha), BRRI dhan102 (8.88 t/ha), BRRI hybrid dhan3 (8.58 t/ha) and BRRI dhan92 (8.46 t/ha). BR6 (4.52 t/ha) and BRRI dhan27 (4.03 t/ha) were the low yielding among the Boro varieties.

TECHNOLOGY TRANSFER

ALART for SHR and DTR in Aman season

ALART (SHR-1). The ALART-SHR-1 was conducted in three locations of Rajshahi region with two advanced lines and two standard checks BRRI dhan57 and Zirashail during Aman season of 2022-23. The results showed that the entries BRH13-1-9-7B produced significantly higher yield with similar growth duration to the check varieties in two locations.

ALART (SHR-2). The ALART-SHR-2 was conducted in three locations of Rajshahi with five advanced lines and two standard checks BRRI dhan62 and BRRI dhan75 during Aman season of 2022-23. The results found that none of the entries produced significantly higher yield than the check varieties in all the locations.

ALART-DTR (Mohadebpur). The ALART-DTR experiment was conducted in two locations of Rajshahi district with two advanced lines and two standard checks of BRRI dhan71 and BRRI dhan75 during Aman season 2022. The results found that none of the entries produced significantly higher yield than the check variety BRRI dhan71.

ALART for FBR-Barishal, SHR, FBR-SD, FBR-MD and BRR in Boro season

ALART-FBR-Barishal. The experiment was conducted in Singra upazila of Natore district with four advanced lines and two standard checks of BRRI dhan58 and BRRI dhan89 during Boro season of Boro 2022-23. The results showed that the entry BRBa14-NGR414-1 produced significantly higher yield with similar growth duration than the check varieties.

ALART-SHR-1. The experiment was conducted in Paba upazila of Rajshahi district with the standard checks BRRI dhan81 and Zirashail during Boro season of 2022-23. The results found that the entry BRH13-2-4-7-2B produced significantly higher yield with similar growth duration than the checks.

ALART-SHR-2. The experiment was conducted in Paba upazila of Rajshahi district with three advanced lines and a standard check BRRI dhan88 during Boro season of 2022-23. The results found that

the entry BRH13-2-4-2-1B produced significantly higher yield with six days longer growth duration than the check.

ALART-FBR-SD. The experiment was conducted in Singra upazila of Natore district with four advanced lines and three standard checks BRRI dhan81 and BRRI dhan96 during Boro season 2022-23. The results found that the tested entries BR11318-5R-63, IR17A1694 and SVIN109 produced significantly higher yield with 5-7 days longer growth duration than the check varieties.

ALART-FBR-MD. The experiment was conducted in Singra upazila of Natore district with two advanced lines and two standard checks BRRI dhan58 and BRRI dhan96 during Boro season of

2022-23. The results found that the entries did not produced significantly higher yield than the check varieties.

ALART-BRR. The experiment was conducted in Paba upazila of Rajshahi district with four advanced lines and two standard and susceptible checks BRRI dhan29 and BRRI dhan89 during Boro season of 2022-23. The results found that all the tested entries produced higher yield than the checks (**Table 2**).

RE-ALART-BRR. The RE-ALART-BRR experiment was conducted in Paba upazila of Rajshahi district with four advanced lines and two standard checks BRRI dhan28 and BRRI dhan88. The results found that none of the entry produced higher yield than the checks.

Table 2. Yield and growth duration of ALART-BRR in Boro season, Rajshahi 2022-23.

Genotypes	Grain Yield (t/ha)	Growth duration (day)
V1 = BR12454-BC2-56-81-27-3-30	9.22	167
V2 = BR12454-BC2-69-97-39-5-44	8.70	165
V3 = BR12454-BC2-71-91-6-23-26	9.55	165
V4 = BR12454-BC2-75-32-31-39-7	8.98	165
V5 = BRRI dhan29 (Std. and Sus ck).	7.81	167
V6 = BRRI dhan89 (Std. and Sus ck.)	8.10	164
LSD (0.05)	0.49	-

Demonstration of BRRI released varieties in farmers' fields of Rajshahi region

Field demonstrations were carried out at different locations of Rajshahi region during T. Aus, T. Aman and Boro seasons of 2022-23. Around 100 crop cut was done in Aus season from the demonstration plots and the highest yield (5.71 t/ha) was found in BRRI dhan98 followed by BRRI dhan48 (5.43) while the local Pariza recorded the lowest grain yield of rice (3.50). A total of 850 demonstrations was established in Aman season where the highest yield was found in BRRI dhan51 (6.45 t/ha) followed by BRRI dhan87 (5.80 t/ha) while the lowest grain yield was found in BRRI dhan90 (4.90 t/ha). In Boro season, 425 demonstrations were established in farmers' field where the highest yield was found in BRRI dhan89 (8.53 t/ha) followed by BRRI dhan102 (8.30 t/ha) and BRRI dhan92 (8.10

t/ha) while the lowest grain yield was found in BRRI dhan81 (6.01 t/ha).

Head-to-Head Adaptive Trial (HHAT), Boro 2022-23

HHAT trial with six long duration rice varieties was conducted in Aman season of 2022 in five locations of Rajshahi region. The grain yield remained higher in BRRI dhan93 (6.35 t/ha) followed by BRRI dhn94 (5.93 t/ha) and that was remained lower in Swarna (4.80 t/ha). HHAT was conducted in six locations with five short duration (BRRI dhan28, BRRI dhan74, BRRI dhan88, Bangabandhu dhan100, BINA Dhan—25 and BAU-3) and four long duration varieties (BRRI dhan29, BRRI dhan89, BRRI dhan92, BRRI dhan102 and BINA Dhan-24) during Boro season of 2022-23. In case of short duration varieties, the highest grain yield was found in BRRI dhan74 (8.17 t/ha) followed by

BRRI dhan88 (7.78 t/ha) and Bangabandhu dhan100 (7.52 t/ha) and the lowest yield was recorded in BINA Dhan-25 (7.06 t/ha). In case of long duration varieties, the grain yield remained higher in BRRI dhan102 (8.99 t/ha) followed by BRRI dhn92 (8.59 t/ha) and the grain yield remained lower in BINA Dhan-24 (7.38 t/ha).

Farmers training and seed distribution

Farmers' training is an important tool to train up farmers on updated information for rice cultivation. BRRI RS, Rajshahi arranged 42 training programmes on modern rice cultivation, pest management, farm mechanization, cropping pattern etc at different upazilas of Rajshahj region. One thousand two hundred and sixty participants attended in the training programmes. Seeds of modern rice varieties were distributed to the farmers for variety demonstration.

Truthfully leveled and Breeders Seed production

Nucleus seed stock was collected from GRS Division of BRRI. Single seedling was transplanted

per hill. For breeder seed production, all official formalities with SCA and BRRI authorities were performed maintaining proper channel. Breeder seed was produced in T. Aman and Boro seasons but TLS seed was produced in Aus and T. Aman and Boro seasons. Considering three seasons (Aus, T. Aman and Boro), breeder and TLS seeds were produced 4, 24 and 15 tons, respectively.

Advisory services

Any serious problem related to rice production at farmers' field was addressed duly in co-operation with the Department of Extension (DAE), Bangladesh Agricultural Development Corporation (BADC), Barind Multipurpose Development Authority (BMDA), Seed Certification Agency (SCA) and different NGOs. Field visits were done mainly to address different problems on insect and disease attack.

BRRI RS, Rangpur

494	Summary
494	Varietal Development Programme (Vdp)
496	Development Of Hybrid Rice Parental Lines And Hybrids
504	Crop-Soil-Water Management
508	Socio-Economic
508	Technology Transfer Demonstration

SUMMARY

To develop region specific suitable modern rice varieties for Rangpur-Dinajpur region, ten germplasm were collected from farmers' field for maintenance breeding, ten single crosses were made and 109 progenies were bulked from 4F₅, 2F₆ and 3F₈ generations during 2022-23. In total, 280 individual plants and four fixed genotypes were selected from observational yield trial under the breeding programme for second generation rice. In OYT, BRrang13-RGA-1-1-3 produced 9.48 t/ha which was higher than BRRI dhan88 (7.05 t/ha). Under Basmati rice breeding programme, 270 individual plants and five fixed genotypes were selected from OYT. BRrang55-RGA-3-2 produced the highest yield (7.66 t/ha) over BRRI dhan50 (6.50 t/ha) in OYT. A total of 28 RYT and 19 ALARTs were conducted during this reporting period. Under the development of hybrid rice parental lines and hybrids, in total 295 testcross F₁s were made from source nursery by testcross. Under TRB platform, in T. Aus 2022, in AYT trial, 111 advanced lines with three standard checks BRRI dhan48, BRRI dhan82 and BRRI dhan98 were tested and the highest yield was found in BR 11866-5 R-294 (5.91 t/ha) with 107 days growth duration. In T. Aman season, in different yield trials, 357 genotypes were tested in six locations of northern region of Bangladesh. Among the tested genotypes 194 genotypes were selected based on phenotypic acceptance, growth duration, survivability and higher yield performance. In total 488 genotypes were tested in different yield trials in Boro season and 86 genotypes were selected based on cold tolerant (SES), phenotypic acceptance, growth duration, and yield performance.

In effect of herbicide on weed infestation of rice experiment, Penoxulam controls Azolla at first stage but later stage 2,4- D Amine perform better to control Azolla.

In planting time experiment, appreciable better yield was achieved in T. Aman season when BRRI

dhan87 and BRRI dhan90 transplanted on 20 of August. BRRI dhan93 higher yield on 20 July - 5 August. BRRI dhan75 should preferably be transplanted on 20 July- 20 August. In Boro season, grain yield was higher for BRRI dhan89 and all the varieties produced higher grain yield on 16 January and 1 February planting.

In long-term nutrient omission trial has been running in the BRRI RS farm, Rangpur since 2014-15 in Boro-Fallow-T. Aman cropping pattern. After eighth cropping year, it was observed that the omission of N in T. Aman and omission of N and P in Boro season from complete fertilizer significantly reduced the grain yield of rice at BRRI RS, Rangpur farm.

A total of 2319 varietal demonstrations were conducted in Rangpur-Dinajpur region during this reporting period. Under TRB programmes, twelve head to head adaptive trials were conducted in 2022-23. Fifteen field days were arranged and 20 farmers training were conducted on modern rice production technologies. A total of 1,170 kg, 10,681 kg and 33,599 kg TLS were produced in T. Aus, T. Aman and Boro season, respectively. A total of 4,000 kg breeder seed was produced in T. Aman season and 5,250 kg breeder seed was also produced in Boro season. Moreover, a total of 9,250 kg breeder seed was sent to GRSD, BRRI Gazipur. In this reporting period, 35,421 kg TLS was distributed for dissemination and popularization of latest BRRI varieties in Rangpur-Dinajpur region.

VARIETAL DEVELOPMENT PROGRAMME (VDP)

Development of rice varieties suitable for T. Aman and Boro season in Rangpur region

In total 10 germplasm were collected from farmers' field for maintenance of breeding. Five single crosses were made using six parents (Table 1). In T. Aman, 109 progenies were bulked from 4F₅, 2F₆ and 3F₈ generations (Table 2).

Table 1. List of crosses made, breeding for standard rice varieties for Rangpur region, T. Aman 2022.

Cross combination	F ₁ seed	Characteristic
T. Aman 2022		
BRRI dhan93/BRRI dhan34	52	Premium quality

Cross combination	F ₁ seed	Characteristic
BRRI dhan87/ BRRI dhan34	35	Premium quality
BRRI dhan90/ BRRI dhan34	84	Premium quality
BR8415-5-4-Rang5-8-1-1-1/ BRRI dhan34	32	Premium quality
BRRI dhan90/ Kataribhog (Dinajpur)	29	Premium quality

Table 2. List of selected progenies from F₅-F₈, Breeding for standard rice varieties for Rangpur region, T. Aman 2022.

BR no.	Cross	Selected progenie	Objective
F ₅ Generation			
BRrang34	BR8415-5-4-Rang5-8-1-1-1/Black rice	10	Premium quality
BRrang35	BRRI dhan90/BRRI dhan70	15	Premium quality
BRrang36	BRRI dhan87/Miniket (Dinajpur)	25	Premium quality
BRrang37	BR8412-5-4-Rang5-8-1-1-1/Black rice	20	Premium quality
F ₆ Generation			
BRrang28	BRRI dhan87/Shompa katari	10	Premium quality
BRrang30	BRRI dhan87/Black rice (GRSD)	10	Premium quality
F ₈ Generation			
BRrang13	Nania/Swarna5	19	Earliness, PQR and High yield
BRrang15	Swarna5/Minikit	10	Earliness, PQR and High yield
BRrang21	BRRI dhan75/ Minikit	10	Earliness, PQR and High yield
Total		109	

Breeding of photoperiod-sensitive rice varieties (PSR) for Lowland and Charland ecosystem

Five crosses were made and one cross (BRrang50) was selected from 8 F₁s for advance as F₂ (Table 3).

Table 3. List of crosses made, breeding of Photoperiod-sensitive rice varieties (PSR) for lowland and charland ecosystem, T. Aman 2022.

Cross connibation	F ₁ seed	Characteristic
Swarna5/Malshira	25	Moderate Photoperiod sensitive
Swarna5/ Kalijira (Slender)	30	Moderate Photoperiod sensitive
Swarna5/ Gainja (Red)	38	Moderate Photoperiod sensitive
Swarna5/ Gainja (White)	40	Moderate Photoperiod sensitive
Swarna5/ Kataribhog	48	Moderate Photoperiod sensitive

Breeding for Second Generation Rice (SGR)

In total 280 individual plants were selected based on the better performance in flowering, phenotypic acceptability, insect and disease reaction, earliness and grain yield. Selected plants will be evaluated in next season. Four fixed genotypes were selected (Table 4).

Table 4. Agronomic parameters of the selected materials from observational yield trial (OYT), Boro 2023.

Designation	PHt. (cm)	Mat. (day)	Yield (t/ha)
BRrang13-RGA-1-1-3	100	148	9.48
BRrang13-RGA-1-2-5	102	145	9.22
BRrang13-RGA-2-5-1	100	140	9.03
BRrang13-RGA-3-3-1	105	150	8.88
BRRI dhan88 (ck)	95	145	7.05
BRRI dhan89 (ck)	110	158	8.10

DS: 2 Dec, 2022; DT: 14 Jan 2023 and Spacing: 20 cm x 20 cm

Breeding for Antioxidant Rice

50 individual plants were selected based on the better performance in flowering, phenotypic acceptability, insect and disease reaction, earliness and grain yield. Selected plants will be evaluated in next season.

Breeding for Basmati Rice (God of Grains)

In total 270 individual plants were selected based on the better performance in flowering, phenotypic acceptability, insect and disease reaction, earliness and grain yield. Selected plants will be evaluated in next season. Five fixed genotypes were selected (Table 5).

Table 5. Agronomic parameters of the selected materials from observational yield trial (OYT), Boro 2022-23.

Designation	PHt. (cm)	Mat. (day)	Yield (t/ha)
BRrang55-RGA-1-2	100	145	6.84
BRrang55-RGA-2-1	102	142	6.43

Designation	PHt. (cm)	Mat. (day)	Yield (t/ha)
BRrang55-RGA-3-2	98	140	7.66
BRrang55-RGA-3-4	99	146	6.96
BRrang55-RGA-5-1	95	148	7.19
BRRI dhan50 (Ck)	104	154	6.50
BRRI dhan89 (Ck)	121	162	7.80

DS: 1 Dec 2022; DT: 12 Jan 2023 and Spacing: 20 cm x 20 cm

DEVELOPMENT OF HYBRID RICE PARENTAL LINES AND HYBRIDS

Constituting of Source Nursery (SN), T. Aman 2022

A total two hundred and ten (210) testcross F_1 s were made from source nursery by testcross. The testcross F_1 s along with corresponding male parents and standard checks will be evaluated in testcross nursery during next Boro season 2022-23.

Testcross nursery (SN), T. Aman 2022

Out of 183, two testcross F_1 s were found completely sterile and initiated to backcrossing with corresponding male parents for conversion of prospective maintainers into new CMS lines against bacterial blight. But none of hybrids were found heterotic compared to the standard checks. Mature backcross (BC_1F_1) seeds were properly collected and growing in Boro season 2022-23.

Constituting of Source Nursery (SN), Boro 2022-23

A total of 85 testcross F_1 s were made from source nursery by testcross. The testcross F_1 s along with corresponding male parents and standard checks will be evaluated in testcross nursery during next T. Aman season 2023.

Test cross nursery (TCN), Boro 2022-23

Two hundred and ten (210) test crosses (F_1 s) were evaluated in test cross nursery for their pollen fertility status of which five entries were found heterotic over check varieties. Pollen parents of those combinations were regarded as suspected restorers and selected for fertility restoration ability with other CMS lines in next season.

Back cross nursery (BCN), Boro 2022-23

Two back cross generations (BC₁) were advanced to next generations (BC₂) for conversion of prospective maintainers into new CMS lines against bacterial blight.

Development of disease resistant (Blast) hybrid rice parental lines by molecular approach, Boro 2022-23

Evaluation of parents by molecular marker against blast resistance gene *Pi9*, Boro 2022-23

Before hybridization two bacterial blight resistant restorers, BRRI31R-MAS-P2 and BRRI20R-MASP3 and one maintainer, IR75608B-ASP3 with resistant and susceptible check were used in this experiment for evaluation of blast resistance gene *Pi9* by gene based marker. The transferability and polymorphism of gene-based marker, NSRMPi9 were checked between the recurrent parents, BRRI31R-MAS-P2, BRRI20R-MASP3 and IR75608B-ASP3 and donor parent IRRI154Pi9. All pyramided restorer and maintainer lines BRRI31R-MAS-P2, BRRI20R-MASP3 and IR75608B-MASP3 were showed polymorphic nature with respect to this gene and showed susceptible allele with 230bp, against blast resistance gene (*Pi9*).

Hybridization

After validation hybridization was done between three recipient parents BRRI31R-MAS-P2, BRRI20R-MASP3, IR75608B-MASP3 and one donor parent IRRI154Pi9 carrying blast resistance gene *Pi9*. One hundred and twenty-six F₁ seeds (naked) were found from three cross combinations. The F₁ populations will be grown in next T.Aman season 2023.

Regional yield trial (RYT), T. Aus 2022

One RYT was conducted under T. Aus season. Twelve genotypes were evaluated against two standard checks; BRRI dhan48 and BRRI dhan98. BR11864-5R-31 produced the highest yield (3.50 t/ha) followed by BR118607-4R-6 (3.41 t/ha) over BRRI dhan48 (2.64 t/ha) and BRRI dhan98 (3.42 t/ha).

Regional yield trial (RYT), T. Aman 2022

A total of 7 RYTs were conducted in T. Aman season: one Rainfed Lowland Rice (RLR), one Short and

medium Rice (SD-MD), one zinc enriched rice (ZER) one disease resistant rice (DDR-BB), one short slender, one Swarna and long slender and one Zirashail type against the standard check varieties.

RYT#1 (RLR-1). Four genotypes along with four standard checks; BRRI dhan49, BRRI dhan71, BRRI dhan87 and BRRI dhan93 were evaluated. BR10475-1-2-3-5-5 produced the highest yield (6.48 t/ha) with 117 days among all the tested entries.

RYT# 2 (SD-MD). Three genotypes along with standard checks; BRRI dhan75 and BRRI dhan87 were evaluated. IR19A7068 produced the highest yield (5.39 t/ha) with 116 days among the tested entries.

RYT#3 (ZER). Four genotypes along with two standard checks BRRI dhan72 and BRRI dhan87 were evaluated. BR10470-1-2-3-13-5 produced the highest yield (5.74 t/ha) with 112 days over all the check yield; BRRI dhan72 (4.72 t/ha) and BRRI dhan87 (5.12 t/ha).

RYT#4 (DRR-BB). Three genotypes were tested along with three checks BRRI dhan49, BRRI dhan87 and IRBB60 (Res ck.). None of the tested genotypes were found high yielder over the check varieties.

RYT#5 (Short slender; BRRI Rangpur). Three genotypes along with one standard check; BRRI dhan49 were evaluated. BRH13-2-14-2-1B produced the highest yield (5.93t/ha) over all the tested entries.

RYT#6 (Swarna and long slender). Five genotypes along with two checks BRRI dhan87, BRRI dhan94 were evaluated. BRH11-2-4-7B produced the highest yield (5.37t/ha) over all the tested entries.

RYT#7 (Zirashail type). Three genotypes along with one standard check Zirashail were evaluated. All the tested entries performed better over Zirashail (3.90 t/ha). BRH11-7-17-10B produced the highest yield (4.80 t/ha) followed by BRH13-9-5-3B (4.76 t/ha).

Regional Yield Trial (RYT), Boro 2022-2023

A total of 20 RYTs were conducted during Boro season: one favorable Boro rice (FBR-Barishal),

one favorable boro rice (FBR-SD), one favorable boro rice (FBR-MD), one favorable boro rice (FBR-LD), two disease resistant rice (DRR), one zinc enriched rice (ZER), one salinity tolerant rice (STR), four premium quality rice (PQR), one **balst and bacterial blight** resistant rice, two antioxidant rice, one water savings, one Zira type (Zira), two short slender (SS), one extra long slender (ELS) against standard check varieties.

RYT# 1 (FBR-Barishal). Nine genotypes along with two checks BRRI dhan88 and BRRI dhan89 were evaluated. None of the entries produced higher grain over the standard check varieties.

RYT# 2 (FBR-SD). Nine genotypes along with two checks BRRI dhan28 and BRRI dhan96 were evaluated. BR11900-5R-24 produced the highest grain yield (7.33 t/ha) followed by BR11903-5R-56 (7.09t/ha) and BR12180-5R-29 (6.94 t/ha).

RYT# 3 (FBR-MD). Nine genotypes along with two checks; BRRI dhan81 and BRRI dhan89 were evaluated. None of the entries produced higher grain over the standard check varieties.

RYT# 4 (FBR-LD). Five genotypes along with three checks; BRRI dhan81, BRRI dhan89 and BRRI dhan92 were evaluated. None of the entries produced higher grain over the standard check varieties.

RYT#5 (DRR-1). Eighteen genotypes along with four standard checks BRRI dhan58, BRRI dhan89, BRRI dhan92 and BRRI dhan101 were evaluated. BR11604-4R-24 produced the highest yield (8.33 t/ha) followed by BR (Path)13800-BC3-109-10 (8.27 t/ha), BR11867-5R-140 (8.16 t/ha) and BR11866-5R-73 (8.15 t/ha).

RYT#6 (DRR-2). Ten genotypes along with two standard checks BRRI dhan89 and BRRI dhan92 were evaluated. All the tested entries performed better than both the checks. BR (Path)13800-BC3-224-17 produced the highest yield (8.92 t/ha) followed by BR (Path)13800-BC3-8-5 (8.90 t/ha), BR (Path)13800-BC3-134-25 (8.87 t/ha) and BR (Path)13800-BC3-224-44 (8.83 t/ha).

RYT#7 (ZER). Three genotypes were evaluated along with three checks; BRRI dhan29, BRRI dhan74 and BRRI dhan84. BR9674-1-4-1-3-P1 produced the highest grain yield (8.39 t/ha and 164

days) followed by BRRI dhan29 (8.21 t/ha and 160 days).

RYT# 8 (STR). Seven advanced genotypes along with three standard checks; BRRI dhan67, BRRI dhan89 and BRRI dhan99 were evaluated. BR11712-4R-93 produced the highest grain yield (7.79 t/ha and 159 days) followed by BRRI dhan89 (7.68 t/ha and 159 days).

RYT#9 (PQR-1). Three genotypes were evaluated along with the checks BRRI dhan50 and BRRI dhan63. None of the tested genotypes performed better over the standard checks.

RYT#10 (PQR-2). Nine genotypes were evaluated along with two checks BRRI dhan63 and BRRI dhan81. BR10646-3-2-2-4-3 produced the highest grain yield (6.48 t/ha and 157 days) followed by BR10646-3-2-2-4-4 (7.31 t/ha and 148 days).

RYT#11 (PQR-1, Parbotipur, Dinajpur). Three genotypes were evaluated along with the checks BRRI dhan50 and BRRI dhan63. None of the tested genotypes performed better than the standard checks.

RYT#12 (PQR-2, Parbotipur, Dinajpur). Nine genotypes were evaluated along with two checks; BRRI dhan63 and BRRI dhan81. Lomba Zira produced the highest grain yield (5.92 t/ha and) followed by Koushik Hilli (5.56 t/ha and 152 days).

RYT#13 (Balst and bacterial blight). Ten genotypes were evaluated along with the standard check BRRI dhan28. BR (path)201 produced the highest grain yield (7.17 t/ha the 147 days) followed by BR (path)204 (7.08 t/ha and 146 days).

RYT#14 (Antioxidant-1_Medium Duration). Eight genotypes were evaluated along with two standard checks Indonesian Black Rice and BRRI dhan88. BR12839-4R-157-2 produced the highest grain yield (6.05 t/ha and 155 days) followed by BR12839-4R-47-1 (5.99 t/ha and 155 days).

RYT#15 (Antioxidant-1_Short duration). Three genotypes were evaluated along with standard check; BRRI dhan84. None of the tested genotypes performed better than the standard checks.

RYT#16 (Water Saving). Two genotypes were evaluated along with the standard check BRRI

dhan58. BR11204-5B-224 produced the highest grain yield (9.45 t/ha and 158 days) followed by BRRI dhan58 (9.06 t/ha and 154 days).

RYT#17 (Zira type). Five genotypes were evaluated along with two standard checks BRRI dhan28 and Zirashail. BRH13-7-9-3-2B produced the highest grain yield (6.94 t/ha and 152 days) followed by BRRI dhan28 (6.27 t/ha and 144 days).

RYT#18 (Short slender). Five genotypes were evaluated along with the standard check Katari. BRH18-9-4-2-3B produced the highest grain yield (7.69 t/ha and 150 days) followed by BRH13-5-12-2-2B (6.99/ha and 150 days).

RYT#19 (Short slender, Parbotipur, Dinajpur). Five genotypes were evaluated along with the standard check Katari. BRH13-5-12-2-2B produced the highest grain yield (6.55 t/ha and 146 days) followed by BRH18-9-4-2-3B (6.54/ha and 146 days).

RYT#20 (Extra long slender). Six genotypes were evaluated along with three checks; BRRI dhan28, BRRI dhan63 and BRRI dhan86. BR7528-2R-19-16-RIL-59 produced the highest grain yield (7.17t/ha; 161 days) followed by BR9945-5R-21 (7.01 t/ha; 162 days). On the otherhand, BRRI dhan50 produced grain yield (6.56 t/ha) with 154 days.

Advanced Line Adaptive Research Trial (ALART)

A total of nineteen ALARTs were conducted under T. Aman 2022 and Boro 2022-23 seasons. In T. Aman, nine ALARTs and ten ALARTs in Boro season were performed to develop rice varieties. In T. Aman 2022, BR8493-3-5-1P1 performed better than the standard check (BRRI dhan70) under PQR programme. In short slender programme, BRH13-2-4-7-2B (5.35 t/ha) and BRH10-1-14-6-2B (5.35 t/ha) performed better than the check BRRI dhan57 (4.74 t/ha). One genotype (BRBa3-1-7) from FBR Barishal and one genotype (BRH13-2-4-7-2B) from (SHR-1) performed better than the standard checks during Boro 2022-2023.

Transforming Rice Breeding (TRB) project

T. Aus 2022

Development of short duration T. Aus rice varieties

The main objective of the project is development of shorter growth duration high yielding (5.0-7.0 t/ha) T. Aus rice varieties with better phenotypic acceptance and grain quality.

In OYT, a total of 300 fixed lines with three standard checks BRRI dhan48, BRRI dhan82 and BRRI dhan98 were tested by following non-replicated augmented RCB design. Among the tested genotypes we have selected 69 genotypes based on phenotypic acceptance and grain yield (≥ 4.00 t/ha) for next generation yield trial. Plant height ranged from 88 to 134 cm and growth duration ranged from 88 to 122 days with maximum 82.8% spikelet fertility. The trial heritability for grain yield was 63%, which ensured the precision of the trial. In this trial, the genotype BR 12614-4 R-158 with 108 days growth duration produced the highest grain yield (5.88 t/ha). Whereas the best performing standard check BRRI dhan98 produced 5.85 t/ha grain yield with 103 days growth duration. Among the tested genotypes the yield range of 10 genotypes were 5.52 t/ha to 5.88 t/ha.

In AYT, 111 advanced lines with three were tested standard checks BRRI dhan48, BRRI dhan82 and BRRI dhan98 following row-column design. Among the tested genotypes we have selected 25 genotypes based on phenotypic acceptance and grain yield for next generation yield trial. Plant height ranged from 82 to 129 cm and growth duration ranged from 88 to 137 days. Whereas standard check BRRI dhan98 produced 5.25 t/ha grain yield with 105 days. The highest yield was found in BR 11866-5 R-294 (5.91 t/ha) with 107 days growth duration. We have found 81% acceptable heritability for grain yield which ensure the precision of the trial.

T. Aus (Heat) 2022

Development of short duration heat tolerant rice varieties for late Boro and T. Aus

The main objective of the project is to develop heat tolerant with shorter growth duration and high

yielding (5.5-8.0 t/ha) rice varieties for late Boro and T. Aus season with better phenotypic acceptance and acceptable grain quality.

In OYT, a total of 124 fixed lines with three standard checks BRRI dhan48, BRRI dhan82, BRRI dhan98, one heat tolerant international check N22 were tested by following non-replicated augmented RCB design. Among the tested genotypes we have selected 35 genotypes based on phenotypic acceptance, grain yield (≥ 5.00 t/ha) and more than 60.8% spikelet fertility. In these trial growth duration ranged from 102 to 125 with maximum 79.8% spikelet fertility. The trial heritability for grain yield was 79%, which ensured the precision of the trial. In this trial, the genotype BR12605-4R-173-1 with 117 days growth duration produced highest grain yield (7.52 t/ha). Whereas the best performing standard check BRRI dhan98 produced 6.45 t/ha grain yield with 110 days growth duration.

In AYT, 48 advanced lines with three standard checks BRRI dhan48, BRRI dhan82, BRRI dhan98, one heat tolerant international check N22 were tested by following row-column design. Among the tested genotypes we have selected 15 genotypes based on phenotypic acceptance and grain yield and spikelet fertility. In these trial growth duration ranged from 92 to 117 days. The highest yield was found in BR11845-4R-40-1 (6.06 t/ha) with 104 days growth durations. Standard check BRRI dhan98 produced similar grain yield (6.04 t/ha) with 105 days growth duration. We have found 74% heritability for grain yield which ensured the precision of the trial.

T. Aman 2022

Development of submergence and stagnant flood tolerant rice varieties

General objectives of the study included the following targets:

- Development of high yielding rice varieties with two to three weeks of submergence, stagnant flood and anaerobic germination tolerances with yield target 6.0-6.5 t/ha (under stress 5.0 t/ha).
- Development of multiple stress tolerant rice

varieties like submergence + stagnant flood, submergence + drought, submergence + anaerobic germination, submergence + biotic stress with yield target 6.0-6.5 t/ha (under stress 5.0 t/ha).

- Shorter growth duration.

In different yield trial, 357 genotypes were tested in 6 location of northern region of Bangladesh. Among the tested genotypes 194 genotypes were selected based on phenotypic acceptance, growth duration, survivability and higher yield performance.

In total 176 test entries in OYT (Observational yield trial), 14 test entries in PYT (Preliminary yield trial) and 112 test entries in AYT_Early (Advance yield trial_early) and 35 test entries in AYT_Late (Advanced Yield trial_late), Ten entries in PVS (participatory variety selection) and one entry in PVT (Proposed variety trial) have been evaluated in six locations under rainfed condition (Payrabanda, Rangpur), controlled submergence condition (Submergence tank, BRRI RS, Rangpur) as well as in flood prone farmers' field condition (Bhogdanga, Kurigram; Kodalkhata, Lalmonirhat; Gangachara; Rangpur and Jalalganj, Mithapukur). In the farmers' field of Kurigram, and Gangachara there was a flood for 14 days at early vegetative and PI stage of the crop whereas location of Lalmonirhat was flood free this year. In the submergence tank, artificial flood for 16 days with 90 cm depth of water was created for proper screening and to evaluate the performance of all the trial entries. In a total of 65 lines out of 176 lines from OYT, five lines from 14 lines of PYT, 44 lines out of 112 lines from AYT_Early and 17 entries from 35 entries of AYT_Late and one best performing genotype was selected from PVS (participatory Variety selection) trial to be promoted in ALART (Advanced Line Adaptive Research Trial). The entries were selected based on phenotypic acceptance, higher survivability and yield under rainfed condition, flood prone farmers field as well as under controlled submergence condition.

Moreover, a short duration submergence tolerant advanced breeding line (IR16F1148) was evaluated under PVT for releasing as new variety in six locations which produced significantly higher yield

(17.85%) than the tolerant check variety BINA dhan11. It was recommended to conduct proposed variety trial (PVT) in next season in order to release it as variety.

AGGRI medium duration 2022 wet season trial (submergence)

The main objective of this trial was Selection of best performing parental materials with better phenotypic acceptability and higher survivability under natural submerged condition. In this trial, 160 breeding lines along with 10 global check varieties were evaluated by following Alpha Lattice design with two replications under natural stress condition at Bhogdanga, Kurigram under the supervision of BRRI regional station. Only 10 days natural submergence was occurred in this location due to late transplanting. Best performing 50 genotypes were selected genotypes based on phenotypic acceptance, uniformity, survivability, growth duration and yield for the submergence screening condition. Very little variation was observed among the genotypes. The survivability was ranged from 80 to 97% due to short period of submergence trial. The heritability obtained from days to 80% maturity, days to 50% flowering, phenotypic acceptance (PAcp) and grain yield (t/ha) were 72%, 66%, 45% and 60% respectively, under natural stress condition indicating high level of precision in this experiment.

AGGRI network trial 2022 wet season late maturity- control submergence

The main objective of this programme is to understand and select the best performing breeding lines with highest genetic merits across the northern areas of Bangladesh. Under these late maturity-control submergence tolerance breeding programme, 54 breeding lines along with five global check and five local varieties were evaluated under control submergence stress condition at submergence tank of BRRI RS, Rangpur by following Alpha Lattice design with two replications. Fourteen days control submergence stress with 95 cm water depth was imposed for screening best performing genotypes. A wide range of variation was observed among the genotypes. The survivability was ranged from 0 to 74%. Based on the phenotypic acceptability, higher survivability, uniformity and grain yield,

seven genotypes were selected for yield trials. The heritability obtained from days to 80% maturity, days to 50% flowering, plant height, phenotypic acceptance (PAcp) and grain yield (t/ha) were 76%, 81%, 63%, 69%, 53% and 93% respectively, under control stress condition.

Development of drought tolerant rice varieties

The aim of the project is to develop drought tolerant shorter growth duration high yielding (4.5 – 6.5 t/ha) T. Aman rice varieties for drought prone area of Bangladesh with better phenotypic acceptance and grain quality. A total of 659 fixed lines from previous LST trial with the standard checks BRRI dhan49, BRRI dhan56 BRRI dhan57 and BRRI dhan71 were tested by following non-replicated augmented RCB design in three OYT trial and RCB design for AYT trials in Barabari, Lalmonirhat. During panicle initiation (PI) to hard dough stage there was no rainfall and supplementary irrigation. As a result the underground water table was below 200 cm which is extreme condition for evaluating drought stress tolerant material.

In OYT-1 (Growth duration: 100-120 days) trial, 45 advanced lines were selected among 245 fixed lines based on phenotypic acceptance, plant height, response to drought stress, growth duration and grain yield. Advanced line BR11788-5R-64 produced 6.11 t/ha grain yield with 111 days growth duration whereas BRRI dhan71 produced 5.534 t/ha grain yield.

In OYT-2 (Growth duration: 121-140 days) trial, 38 advanced lines were selected among 375 fixed lines based on phenotypic acceptance, plant height, response to drought stress, growth duration and grain yield. Advanced breeding lines BR11771-5R-42 produced 7.65 t/ha grain yield with 129 days growth duration. Whereas the t performing check BRRI dhan71 produced 6.56 t/ha grain yield with 115 days growth duration.

In AYT-1 (Growth duration: 100-120 days) trial, six advanced lines were selected among 25 fixed lines based on phenotypic acceptance, plant height, response to drought stress, growth duration and grain yield. Advanced line BR11253-6R-34 produced 4.96 t/ha grain yield with 118 days growth

duration whereas BRRI dhan71 produced 4.43 t/ha grain yield with 113 days growth duration.

In AYT-2 (Growth duration: 121-140 days) trial, four advanced lines were selected among 14 fixed lines based on phenotypic acceptance, plant height, response to drought stress, growth duration and grain yield. Advanced line IR17L1314 produced 4.76 t/ha grain yield with 109 days growth duration.

Development of disease resistant (BLB, RTV, NB) rice varieties for T. Aman

A total of 59 fixed lines from previous LST and OYT trial with standard checks BRRI dhan49 and BRRI dhan87 and as well as resistance check IRBB60 were tested by following non-replicated Augmented RCB design for OYT and Row-column design for AYT trial. In total 25 genotypes were selected based on disease infestation, phenotypic acceptance, growth duration and higher yield performance.

In OYT, the yield range was 3.52-7.09 t/ha where, growth duration ranged within 104-123 days. Among 18 selected genotypes, BR11110-3R-61-1 produced 7.09 t/ha grain yield with 117 days growth duration. On the other hand, best performing check variety BRRI dhan87 produced 6.63 t/ha grain yield with 122 days growth duration.

In AYT, the yield ranged from 2.45 to 6.59 t/ha and growth duration ranged from 113 to 137 days. Among seven selected genotypes BR12121-4R-53-1 6.59 t/ha grain yield with 126 days growth durations. Whereas the best performing check variety BRRI dhan87 produced 5.41 t/ha grain yield with 126 days duration.

Development of insect resistance rice (bph) for T. Aman season

A total of 367 fixed lines with four standard checks BRRI dhan33, BRRI dhan49, BRRI dhan52 and BRRI dhan87 were tested by following non-replicated augmented RCB design for OYT and row-column design for PYT and AYT under Hotspot for BPH condition in Payrabanda, Rangpur. In total 77 genotypes were selected based on Insect SES score, phenotypic acceptance, growth duration and higher yield performance.

In OYT trial, 33 genotypes were selected out of 231 based on BPH incidence, phenotypic acceptance and grain yield. Six genotypes scored 1 and 26 genotypes scored 3 against BPH under hotspot condition. The yield range was 0.03-5.51 t/ha whereas 30 genotypes did not give any grain yield and not flowered due to massive BPH attack. 31 genotypes produced 0.03 to < 1.00 t/ha grain yield. Advanced breeding lines BR13097-4 R-105 produced 5.51 t/ha grain yield with 120 days growth duration. On the other hand, susceptible check BRRI dhan33, BRRI dhan49 and BRRI dhan87 did not give any grain yield.

In AYT, five genotypes were selected out of 31 on BPH incidence, phenotypic acceptance and grain yield. Four genotypes scored 3 and 11 genotypes scored 5 against BPH under hotspot condition. The yield range was 0.00-4.76 t/ha whereas 5 genotypes did not give any grain yield and not flowered due to massive BPH attack. Five genotypes produced < 2.00 t/ha grain yield. Advanced breeding lines IRBPHN-SVIN013-18 and BR 11044-4 R -47 produced 4.76 t/ha grain yield with 118 and 116 days growth durations. On the other hand, susceptible check BRRI dhan33, 49 and BRRI dhan87 did not give any grain yield.

In PYT#1 (Early) trial, eight genotypes were selected out of 55 on BPH incidence, phenotypic acceptance and grain yield. Three genotypes scored 3 and 10 genotypes scored 5 against BPH under hotspot condition. The yield range was 0.00-4.69 t/ha whereas seven genotypes did not give any grain yield due to massive BPH attack. Eight genotypes produced 0.26 t/ha to < 1.00 t/ha grain yield. Advanced breeding lines BR 12208-5 R-97 produced 4.69 t/ha grain yield. On the other hand, susceptible check BRRI dhan33, produced 0.96 t/ha grain yield.

In PYT#2 (Late) trial, eight genotypes were selected out of 50 on BPH incidence, phenotypic acceptance and grain yield. Eight genotypes scored 3 and 15 genotypes scored 5 against BPH under hotspot condition. The yield range was 0.97-4.22 t/ha. Eight genotypes produced 0.26 t/ha to < 1.00 t/ha grain yield. Advanced breeding lines BR 12214-5 R-39 produced 4.22 t/ha grain yield with 148 days

growth duration. On the other hand, susceptible check BRRI dhan87, produced 3.0 t/ha grain yield with BPH score 5 (Scape BPH due to moderate growth duration).

Development of rainfed lowland rice (RLR) for T. Aman season

The aim of the trial is to develop favourable rice variety for T. Aman with shorter growth duration (≤ 130 days), high yield potential (≥ 6.5 t/ha), better phenotypic and grain quality. A total of 575 fixed lines from previous LST and OYT trial with six standard checks BRRI dhan49, BRRI dhan57 and BRRI dhan62, BRRI dhan71, BRRI dhan75 and BRRI dhan87 were tested by following non-replicated Augmented RCB design in OYT and RCB design in AYT.

In OYT-1 (GD: 94-120 days) trial, 20 advanced lines were selected among 227 fixed lines based on phenotypic acceptance, plant height, response to drought stress, growth duration and grain yield. The yield and growth duration range of this trial were 0.45-7.63 t/ha and 96-132 days respectively. Advanced line BR12628-5R-184 produced 7.63 t/ha grain yield with 110 days growth duration. Whereas best performing check variety BRRI dhan87 produced 6.09 t/ha grain yield with 122 days growth duration.

In OYT-2 (GD: 121-140 days), 16 advanced lines were selected among 290 fixed lines based on phenotypic acceptance, plant height, response to drought stress, growth duration and grain yield. The yield and growth duration ranges of this trial were 0.818-7.92 t/ha and 99-143 days respectively. Advanced line BR12305-5R-107 7.92 t/ha grain yield with 130 days growth duration. Whereas best performing check variety BRRI dhan71 produced 5.42 t/ha grain yield with 114 days growth durations.

In AYT-1 (GD: 101-120 days) trial, 13 advanced lines were selected among 32 fixed lines based on phenotypic acceptance, plant height, response to drought stress, growth duration and grain yield. The yield range of this trial were 0.45-6.1 t/ha. Advanced line BR12007-6R-61 produced 6.1 t/ha grain yield with 111 days growth duration. Whereas best performing check variety BRRI dhan71 produced 5.31 t/ha grain yield with 114 days growth duration.

AYT-2 (GD: 101-140 days) was a photosensitive trial. Ten advanced lines were selected among 36 lines based on phenotypic acceptance, response to drought stress, photosensitivity and grain yield. The yield range of this trial were 2.84-7.75 t/ha. Advanced line BR11222-6R-92 produced 7.75 t/ha grain yield with 135 days growth duration. Whereas best performing check variety BRRI dhan49 produced 6.59 t/ha grain yield with 130 days growth duration.

BORO, 2022-2023

Development of favorable boro and cold tolerant rice varieties

The project is aimed at developing favourable Boro and seedling and reproductive stage cold tolerant rice varieties for stress prone environment. In different yield trials, 488 genotypes were tested out of which 86 genotypes were selected based on cold tolerant (SES), phenotypic acceptance, growth duration, and yield performance.

From OYT (FBC), 13 genotypes from AYT (ML)-out of 38 and 6 genotypes from AYT (Early) out of 18 were selected.

In OYT (FBC), 67 genotypes were selected out of 432 genotypes. The genotypes BR13136-5R-166 gave highest grain yield (8.96 t/ha) with 156 days growth duration and 3 SES score for spikelet degeneration. Whereas best performing check variety BRRI dhan89 gave 8.09 t/ha grain yield with 163 days growth duration.

In AYT (ML), 13 genotypes were selected out of 38 the genotypes. BR12137-6R-93 gave 8.84 t/ha grain yield with 164 days growth duration and spikelet degeneration during flowering stage. Among the tested genotypes eight genotypes gave yield from 7.00 t/ha to 8.84 t/ha. Whereas best performing check variety BRRI dhan89 gave 8.52 t/ha grain yield with 167 days growth duration.

In AYT (Early), 6 genotypes were selected out of 18 genotypes. BR12554-5R-128 gave 7.27 t/ha grain yield with 158 days growth duration. Whereas best performing check variety BRRI dhan96 gave 5.89 t/ha grain yield with 158 days growth duration.

Development of insect resistance (BPH) rice varieties

In OYT experiment, 360 genotypes with one susceptible check BR3, 2 standard checks (BRRI dhan88 & BRRI dhan89) and one tolerant check T27A were evaluated by following augmented RCB design with 6 block. 83 genotypes were selected among the tested genotypes based on phenotypic acceptance, BPH incidence, growth duration, and yield performance. One genotypes showed BPH score 3, 9 genotypes showed BPH score 5, 8 genotypes showed BPH score 7 and 6 genotypes showed BPH score 9. It also mentioned that about 300 genotypes scape BPH infestation (BPH score 0) due to earliness. The highest grain yield (8.87 t/ha) was found in BR12671-4R-502 with 157 days growth durations Whereas best performing check variety BRRI dhan89 gave 7.52 t/ha grain yield with 167 days growth duration and BPH score 7.

In PYT trial, total 82 genotypes were evaluated with three standard checks BRRI dhan88, BRRI dhan89 and BRRI dhan92 by following row-column design during Boro 2022-2023. 39 genotypes were selected based on phenotypic acceptance, insect resistance score and grain yield. 3 genotypes showed BPH score 3, 3 genotypes showed BPH score 5, 3 genotypes showed BPH score 7, and 3 genotypes showed BPH score 9. It also mentioned that remaining genotypes scape BPH infestation (BPH score 0) due to earliness. Advanced genotypes BR 12671-4 R-95 showed highest grain yield 810.186 t/ha. Whereas best performing check BRRI dhan92 gave 9.65 t/ha grain yield.

In AYT trial, total 30 genotypes were evaluated with standard checks BRRI dhan88, BRRI dhan89 and BRRI dhan92 by following row-column design during Boro 2022-2023. 9 genotypes were selected based on phenotypic acceptance, insect resistance score and grain yield. Advanced genotypes BR 12208-5 R-330 showed highest grain yield 9.59 t/ha with 157 days growth duration. On the other hand best performing check variety BRRI dhan89 gave 9.57 t/ha grain yield with 155 days growth durations. It also mention that no BPH infestation occurred in this trial due to earliness of the trial.

Development of disease resistance (BB, RTV and Blast) rice varieties

The main objective of this programme is to develop short and medium duration disease resistant (BB, Blast and RTV) high yielding (≥ 7.00 t/ha) rice variety for irrigated Boro season. In different yield trials, 527 genotypes were tested out of which 111 genotypes were selected based on disease infestation, phenotypic acceptance at maturity stage, growth duration and yield performance.

From OYT 72 genotypes out of 460, from AYT, 22 genotypes out of 67 were selected for further yield conformation.

In OYT (BB), the genotype BR12116-5R-147 produced the highest yield of 9.26 t/ha with 165 days growth duration. Three genotypes produced more than 8.00 t/ha yield, 13 genotypes produced more than 7.00 t/ha grain yield. Whereas the best performing check variety BRRI dhan58 produced 7.19 t/ha grain yield with 157 days growth duration.

In AYT (BB), the best performing genotype BR11868-5R-124 produced 9.715 t/ha grain yield with 162 days growth duration, having better phenotypic acceptance ($P_{Ac}=3$) and no visible BLB and blast infestation. Among the tested genotypes, 11 genotypes produced grain yield 7.00 t/ha to 8.9 t/ha with no BLB and blast disease symptom. On the other hand best performing standard check variety BRRI dhan88 produced 6.06 t/ha grain yield with 150 days growth duration.

CROP-SOIL-WATER MANAGEMENT

Effect of herbicide on azolla infestation in rice field

The experiment was conducted at the BRRI RS farm, Rangpur, during T. Aman 2022 to find out the effect of herbicide on weed infestation of rice. The treatments were; i) T_1 : Remove water from the plot (Farmers' practice), ii) T_2 : Herbicide (Penoxsulam), iii) T_3 : Herbicide (Bispyribac sodium), iv) T_4 : Herbicide (2,4-D Amine), v) T_5 : Incorporation of Azolla after full mat formation in the field); and T_6 : Control. The treatments were distributed in RCB design with three replications. Twenty-eight-day-old seedlings were transplanted at 20- x 20-cm

spacing. All fertilizers except urea were applied during final land preparation. Irrigation, weeding, disease and insect control were done as and when necessary. Yield data were recorded during harvesting. Statistical analysis was done by using CropStat programme.

Results and Discussion

The highest grain yield 5.39 t/ha was found in T₅ treatment and consequently panicle/m² and grains/panicle also found the highest in this treatment (Table 6). The highest Azolla dry weight was found in control treatment at 7 DAS (Days after spray), 14 DAS and 21 DAS. Penoxulam treated plot showed

that at 7 DAS Azolla was decreased but after 7 DAS it increased gradually. In 2,4-D Amine treated plot it showed that at 7 DAS Azolla was similar to the control plot but after that it gradually decreased. The herbicide 2,4-D Amine is a slow acting product having also slow effect in Azolla. Due to over dose of Bispyribac sodium, phytotoxicity found in the plot and rice plant was destroyed. After 21 DAS Azolla were washed out by heavy rain water. Other weed dry wt found the highest at T₁ and T₆ treatment. Penoxulam control Azolla at first stage but later on 2,4- D Amine perform better to control Azolla.

Table 6. Effect of herbicide on Azolla infestation in rice field during T. Aman, 2022.

Treatment	Panicle number/m ²	Grain/panicle	1000 grain wt (g)	Grain yield (t/ha)	Other weed dry wt. (g)	Azolla dry wt. 7 DAS (g)	Azolla dry wt. 14 DAS (g)	Azolla dry wt. 21 DAS (g)
T ₁	216	103	24.56	5.02	14.66	20.00	1.24	5.93
T ₂	223	101	24.86	5.03	6.70	5.07	7.33	9.13
T ₃	0	0	0	0	10.70	5.86	15.73	25.73
T ₄	238	105	24.66	5.33	5.13	23.96	10.93	2.76
T ₅	240	106	24.97	5.39	6.26	21.20	0.00	0.00
T ₆	198	100	24.16	4.57	13.80	24.13	25.73	20.93
LSD _{0.05}	14.09	16.48	1.79	0.64	5.06	4.29	4.59	3.66
CV (%)	7.1	10.5	4.8	8.4	16.1	14.1	15.4	17.3

T₁: Removal of water from the plot (Farmers' practice), T₂: Herbicide (Penoxsulam), T₃: Herbicide (Bispyribac sodium), T₄: Herbicide (2,4-D Amine), T₅: Incorporation of Azolla after full mat formation in the field); and T₆: Control.

Effect of planting time on newly developed BRRI varieties in different regional stations

The experiments were conducted at the BRRI RS farm, Rangpur both in T. Aman and Boro seasons, 2022-2023 for transplanting newly released varieties under specific agro-climatic conditions.

T. Aman, 2022

The experiment was conducted at BRRI RS farm, Rangpur aimed to identify a suitable planting window of BRRI dhan75, BRRI dhan87, BRRI dhan90 and BRRI dhan93 type cultivars to maximize grain yield. The selected varieties were

planted at five different dates at 15 days interval from 5 July to 5 September. Twenty-five-day-old seedlings were transplanted following split-plot design, placing planting date in the main plots and varieties in the sub-plots with three replications. All the agronomic practices were performed uniformly for all the treatments. Data of agronomic parameters i.e. panicle number m⁻², grains panicle⁻¹ and yield were collected at harvest. Results showed that there was a significant effect of transplanting date on the yield of potential of the tested varieties in T. Aman season (Tables 7 and 8). Early transplanting of BRRI dhan75 (5 July to 20 August) produced

greater number of panicles m⁻², grains/panicle and grain yield than the delayed transplanting. BRRI dhan87 and BRRI dhan90 transplanted on 20 August produced higher grain yield (Table 8). BRRI dhan93 produced higher yield on 20 July to 5

August. In conclusion, to achieve appreciable better yield in the Rangpur region, BRRI dhan75 should preferably be transplanted on 20 July - 20 August, BRRI dhan87 and BRRI dhan90 on 20 of August and BRRI dhan93 on 20 July - 5 August.

Table 7. Effect of planting time on the panicles m⁻² and number of grains panicle⁻¹ of rice in Aman 2022.

Variety	Date of transplanting									
	Panicle m ⁻²					Grains panicle ⁻¹				
	5 Jul	20 Jul	5 Aug	20 Aug	5 Sep	5 Jul	20 Jul	5 Aug	20 Aug	5 Sep
BRRI dhan75	283	257	275	267	175	218	187	176	174	200
BRRI dhan87	250	242	258	233	200	154	171	198	160	163
BRRI dhan90	258	258	242	258	250	322	338	336	386	341
BRRI dhan93	292	267	267	248	258	255	229	210	216	161
CV (%)	12.7					9.0				
CV (%)	10.5					6.7				
LSD	45					25.7				

Table 8. Effect of planting time on the GDD accumulation and yield of rice in T. Aman 2022.

Variety	Date of transplanting									
	GDD					GY				
	05 Jul	20 Jul	05 Aug	20 Aug	5 Sep	05 Jul	20 Jul	5 Aug	20 Aug	5 Sep
BRRI dhan75	1950.7	2011.9	1928.8	1962.5	1941.5	3.01**	5.38	5.37	5.43	4.67
BRRI dhan87	2315.7	2285.3	2294.2	2264.4	2192.5	4.14*	4.06*	4.53*	6.05	4.79
BRRI dhan90	2309.9	2193.5	2125.4	2049.7	1856.8	2.57*	3.60	3.65	4.81	4.13
BRRI dhan93	2441.7	2385.3	2353.3	2299.5	2180.5	2.51*	5.46	5.42	4.83	1.97**
CV (%)	1.2					9.1				
CV (%)	0.9					6.2				
LSD	9.2					1.01				

*Lodging **Bird damage

Boro 2022-23

In Boro season, varieties BRRI dhan88, BRRI dhan89 and BRRI dhan92 were tested to find out the optimum planting date. Forty-five-day-old seedling was transplanted during 16 December to 16 February at 15-days interval. Single seedlings were transplanted at 20 cm x 20 cm spacing. The

treatments were distributed in a split-plot design, placing planting date in the main plots and varieties in the sub-plots with three replications. Results indicated that grain yield of rice was higher for BRRI dhan89 and all the varieties produced higher grain yield on 16 January and 1 February planting (Tables 9 and 10).

Table 9. Effect of planting time on the panicles m⁻² and number of grains panicle⁻¹ of rice in Boro 2022-23.

Variety	Date of transplanting									
	16 December		1 January		16 January		01 February		16 February	
	Panicles m ⁻²	Grains panicle ⁻¹	Panicles m ⁻²	Grains panicle ⁻¹	Panicles m ⁻²	Grains panicle ⁻¹	Panicles m ⁻²	Grains panicle ⁻¹	Panicles m ⁻²	Grains panicle ⁻¹
BRRi dhan88	328	118	297	120	220	177	300	153	402	104
BRRi dhan89	280	167	291	124	248	163	271	155	288	150
BRRi dhan92	287	141	293	121	251	134	325	147	315	126

Table 10. Effect of planting time on the GDD accumulation and yield of rice in Boro 2022-23.

Variety	Date of transplanting									
	16 December		1 January		16 January		1 February		16 February	
	Yield (t/ha)	GDD (°C)	Yield (t/ha)	GDD (°C)	Yield (t/ha)	GDD (°C)	Yield (t/ha)	GDD (°C)	Yield (t/ha)	GDD (°C)
BRRi dhan88	5.4	1700.7	5.2	1674.6	5.2	1631	6.7	1618.5	5.2	1678.5
BRRi dhan89	5.6	2040.9	5.5	1942.1	7.6	1926.7	7.7	1936.6	5.3	1967.3
BRRi dhan92	6.0	2046.7	5.4	1965.1	7.0	1965.6	7.4	1992.3	5.1	2011.5

3. Long-term missing element trial at BRRi RS, Rangpur

Long-term nutrient omission trial is an effective tool for identifying the contribution of nutrients in crop production. In order to find out the role of major macro and micronutrients, a long-term field experiment has been running in the BRRi RS farm, Rangpur since 2014-15 in Rice-Fallow-Rice cropping pattern. The experiment includes seven treatments [T₁=Fertilizer control, T₂= NPKSZn, T₃= PKSZn (-N), T₄= NKSZn (-P), T₅= NPSZn (-K), T₆=NPKZn (-S), T₇=NPKS (-Zn)] which were designed in RCB with three replications. Fertilizer nutrients i.e., N-P-K-S-Zn rate was 95-8-40-12-

1 kg ha⁻¹ and 145-10-60-15-2 kg ha⁻¹ in T. Aman and Boro seasons, respectively. HYV rice has been growing in Boro-Fallow-T. Aman cropping pattern. Omission of major nutrients significantly reduced the grain yield. After eighth cropping year, it was observed that the omission of N in T. Aman and omission of N and P in Boro season from complete fertilizer significantly reduced the grain yield of rice at BRRi RS, Rangpur farm. Among the major nutrient elements, omission of N appeared as the most yield limiting nutrient followed by P and K omission for rice in both seasons. The S and Zn omission have no significant effect on yield reduction at BRRi RS, Rangpur farm yet (Tables 11 and 12).

Table 11. Effect of long-term missing element on the tiller, panicle, grain and straw yield of BRRi dhan87 at BRRi farm, Rangpur in T. Aman 2022.

Treatment	Tiller per m ²	Panicle per m ²	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	(%) Grain yield decreased due to nutrient omission
T ₁	176 b	166 b	3.37 c	3.10 c	-
T ₂	267 a	254 a	5.82 a	6.05 a	-
T ₃	203 b	195 b	3.95 b	4.36 b	32
T ₄	257 a	240 a	5.59 a	5.94 a	4

Treatment	Tiller per m ²	Panicle per m ²	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	(%) Grain yield decreased due to nutrient omission
T ₅	261 a	245 a	5.70 a	5.99 a	2
T ₆	262 a	249 a	5.65 a	6.04 a	3
T ₇	265 a	252 a	5.74 a	6.10 a	1.5
<i>LSD (0.05)</i>	46	44	0.40	0.53	
<i>CV (%)</i>	6.7	6.71	2.72	3.45	

N.B. T₁= Control, T₂= NPKSZn, T₃= PKSZn (-N), T₄= NKSZn (-P), T₅= NPSZn (-K), T₆= NPKZn (-S), T₇=NPKS (-Zn)

Table 12. Effect of long-term missing element on the tiller, panicle, grain and straw yield of BRRI dhan89 at BRRI RS farm, Rangpur in Boro 2022-23.

Treatment	Tiller/m ²	Panicle/m ²	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	(%) Grain yield decreased due to nutrient omission
T ₁	126 b	120 b	3.04 c	2.75 c	-
T ₂	224 a	214 a	6.71 a	6.18 a	-
T ₃	141 b	135 b	3.54 c	3.22 c	47
T ₄	199 a	189 a	5.10 b	4.65 b	24
T ₅	206 a	191 a	6.32 a	5.88 a	6
T ₆	208 a	198 a	6.51 a	6.06 a	3
T ₇	209 a	199 a	6.53 a	6.10 a	2.5
<i>LSD (0.05)</i>	31	30	0.82	0.48	
<i>CV (%)</i>	5.77	5.91	5.3	3.39	

N.B. T₁= Control, T₂= NPKSZn, T₃= PKSZn (-N), T₄= NKSZn (-P), T₅= NPSZn (-K), T₆= NPKZn (-S), T₇=NPKS (-Zn)

SOCIO-ECONOMIC

Stability analysis of BRRI varieties at BRRI RS, Rangpur in T. Aus, T. Aman and Boro season during 2022-2023

In total 109 BRRI developed varieties were evaluated during T. Aus (13), T. Aman (47) and Boro (49) season at the BRRI RS following RCBD with three replications. BRRI dhan98 produced highest yield (4.4 t/ha) followed by BRRI dhan42 (3.60 t/ha) and BRRI dhan48 (3.60 t/ha) during T. Aus season. In T. Aman, BRRI dhan71 (6.28 t/ha) produced the highest yield followed by BRRI dhan73 (5.33 t/ha) and BRRI dhan53 (5.17 t/ha) in short duration; BRRI dhan51 (6.32 t/ha) produced the highest yield followed by BRRI dhan78 (6.04 t/ha) and BRRI dhan79 (5.46 t/ha) in medium

duration. In long duration, BR22 (3.94 t/ha) produced highest yield followed by BRRI dhan46 (3.46 t/ha). During Boro season, BRRI hybrid dhan5 showed the highest yield (9.76 t/ha) followed by BRRI hybrid dhan3 (9.41 t/ha) and BRRI hybrid dhan2 (9.21 t/ha) in short duration group. In long duration group, BR15 produced the highest yield (9.77 t/ha) followed by BRRI dhan89 (9.34 t/ha) and BRRI dhan29 (9.27 t/ha).

TECHNOLOGY TRANSFER DEMONSTRATION

BRRI RS, Rangpur (GOB). A total of 2319 (2319 bighas) varietal demonstrations were conducted at different locations of Rangpur-Dinajpur region. In T. Aus season (111 Bighas), BRRI dhan48, BRRI dhan82, BRRI dhan98, BRRI hybrid dhan7

were used and maximum yield was observed 5.50 t/ha in BRRI dhan82 followed by 5.12 t/ha in BRRI dhan98 at Ranisankail, Thakurgaon and minimum yield was observed 3.29 t/ha in case of BRRI dhan98 at Hatibandha, Lalmonirhat. In T. Aman session (728 bighas), BRRI dhan70, BRRI dhan71, BRRI dhan75, BRRI dhan79, BRRI dhan87, BRRI dhan90, BRRI dhan93, BRRI dhan94, BRRI dhan95, BRRI dhan103, BRRI hybrid dhan4 and BRRI hybrid dhan6 were used. Maximum yield was observed 6.97 t/ha in BRRI dhan75 at Palichora, Sadar, Rangpur followed by 6.62 t/ha in BRRI hybrid dhan6 at Palichora, Sadar, Rangpur and minimum yield was 4.09 in BRRI dhan79 at Gokunda, Sadar, Lalmonirhat. In Boro season (1480 bighas), BRRI dhan74, BRRI dhan89, BRRI dhan92, BRRI dhan96, Bangabandhu dhan100, BRRI dhan102, BRRI hybrid dhan3 as well as BRRI hybrid dhan5 were used. Yield range was 6.0 to 9.0 t/ha. Maximum yield was observed 9.0t/ha in BRRI dhan89 at Atowari, Panchagarh and minimum was 6.0 in

BRRI dhan74 in Sundorganj, Gaibandha.

TRB Project. Twelve Head to Head Adaptive trials were conducted in twelve upazilas under seven districts in Rangpur-Dinajpur region during the reporting period. Nine varieties viz BR11, BRRI dhan52, BRRI dhan72, BRRI dhan87, Katribhog, BRRI dhan34, BRRI dhan70, BRRI dhan80 and BRRI dhan90 were used in T. Aman season. Eleven varieties viz BRRI dhan28, BRRI dhan29, BRRI dhan74, BRRI dhan88, BRRI dhan89, BRRI dhan92, Bangabandhu dhan100, BRRI dhan102, BINA dhan24, BINA dhan25 and BAU dhan3 were used in Boro season. In T. Aman season, BR11, BRRI dhan52, BRRI dhan70, BRRI dhan87 and BRRI dhan90 (Tables 13 and 14); and in Boro season BRRI dhan74, BRRI dhan92, Bangabandhu dhan100, BRRI dhan102, BINA dhan24 and BINA dhan25 were chosen by the farmers due to grain appearance, high yield and less disease incidence (Tables 15 and 16).

Table 13. Grain yield of Head to Head Adaptive trials for medium duration under TRB project in Rangpur region, T. Aman 2022.

Location	Yield (t/ha)			
	BR11	BRRI dhan52	BRRI dhan72	BRRI dhan87
Mithapukur, Rangpur	5.11	5.00	4.33	5.08
Taraganj, Rangpur	5.20	4.83	4.46	5.39
Kawnia, Rangpur	5.37	4.99	4.46	5.56
Sadar, Kurigram	6.55	5.80	5.44	6.16

Table 14. Grain yield of Head to Head Adaptive trials for premium quality rice under TRB project in Rangpur region, T. Aman 2022.

Location	Yield (t/ha)				
	B R R I dhan34	BRRI dhan70	BRRI dhan80	B R R I dhan90	Katiribhog
Parbortipur, Dinajpur	3.60	4.58	4.61	4.48	3.39
Bochaganj, Dinajpur	3.53	4.49	4.70	4.48	3.29
Chiribondor, Dinajpur	3.60	4.40	4.40	4.34	3.01

Table 15. Grain yield of Head to Head Adaptive trials for long duration under TRB project in Rangpur-Dinajpur region, Boro 2022-23.

Location	Yield (t/ha)				
	B R R I dhan29	B R R I BRRi dhan89	B R R I BRRi dhann92	B R R I dhan102	B I N A dhan24
Boda, Panchagarh	8.53	8.04	9.18	7.60	8.47
Parbortipur, Dinajpur	8.26	7.57	8.57	8.01	8.06
Sadar, Rangpur	8.47	8.40	8.92	8.33	8.33

Table 16. Grain yield of Head to Head Adaptive trials for short duration under TRB project in Rangpur-Dinajpur region, Boro 2022-23.

Location	Yield (t/ha)					
	B R R I dhan28	B R R I BRRi dhan74	B R R I dhann88	Bangabandhu dhan100	B I N A dhan25	B A U dhan3
Mithapukur, Rangpur	6.37	7.33	6.69	6.74	6.59	6.53
Sadar, Lalmonirhat	5.94	6.75	6.49	6.52	6.26	6.23

Training and Field Day: Twenty farmers training on modern rice production technology was conducted at different upazilas of Rangpur-Dinajpur region in collaboration with DAE. A total of 600 farmers were trained through this program. A total of 50 womens were present in farmers training program. It was very much helpful to minimize knowledge gap on modern Rice production technologies. Twelve in-house training were arranged at the programs BRRi regional station to improve the capability in office management of the office staff. Fifteen field days were arranged at different demonstration sites in collaboration with DAE during 2022-2023. A total of 1000 farmers, local leaders and DAE personnel attended those field day programs.

Seeds and seedling distribution among the flood affected farmers. BRRi RS, Rangpur arranged special programmes for the flood affected farmers. Different photosensitive varieties viz BR22, BRRi dhan34, Nizarsail and Gainja were distributed among the flood affected farmers in Sadar-Gaibandha, Rajarhat-Kurigram, Kawnia-Sadar-Rangpur, Sadar-Lalmonirhat, Payrabandh-Mithapukur-Rangpur and Dharmadas- Metro-Rangpur.

Promotional activities for the former enclave's farmer. BRRi RS, Rangpur conducted 20 demonstration programmes for the dissemination of BRRi developed latest varieties in Dashiarchora, Fulbari, Kurigram (Former enclave).

Seed production and dissemination in July 2022-June 2023

A total of 1,170 kg, 10,681 kg and 33,599 kg TLS were produced in T. Aus, T. Aman and Boro season respectively. A total of 4,000 kg breeder seed (BRRi dhan93 and BRRi dhan95) was produced in T. Aman season and 5,250 kg breeder seed (BRRi dhan74 and BRRi dhan89) was also produced in Boro season. Moreover, 9,250 kg breeder seed was sent to the GRS Division, BRRi HQ, Gazipur. In three seasons, 3,5421 kg TLS was distributed among the farmers for dissemination in Rangpur-Dinajpur region (Table 17).

Table 17. Variety-wise seed production and distribution during T. Aus, 2022, T. Aman 2022 and Boro 2022-23.

Variety	Amount (kg)		Send to GRS (Breeder-kg)	Sold (TLS-kg)	Distribution of TLS (kg)
	TLS	Breeder seed			
T. Aus, 2022					
BRRI dhan48	283	-	-	123	160
BRRI dhan82	140	-	-	40	100
BRRI dhan98	747	-	-	197	550
BRRI hybrid dhan7	-	-	-	-	500
Total	1170	-	-	360	1310
T. Aman 2022					
BR22	470	-	-	70	400
BRRI dhan34	621	-	-	500	121
BRRI dhan49	100	-	-	100	-
BRRI dhan51	60	-	-	60	-
BRRI dhan52	284	-	-	204	80
BRRI dhan70	226	-	-	176	50
BRRI dhan71	368	-	-	268	100
BRRI dhan75	2076	-	-	1076	1040
BRRI dhan79	405	-	-	205	200
BRRI dhan80	203	-	-	83	120
BRRI dhan87	1141	-	-	241	900
BRRI dhan93	2967	2000	2000	367	2600
BRRI dhan95	1357	2000	2000	357	1000
BRRI dhan103	178	-	-	78	100
Naizarsail	73	-	-	73	-
Gainja	152	-	-	152	-
BRRI hybrid dhan4	-	-	-	-	500
BRRI hybrid dhan6	-	-	-	-	500
Total	10681	4000	4000	3970	7711
Boro 2022-2023					
BR16	47	-	-	47	-
BRRI dhan28	66	-	-	66	-
BRRI dhan29	81	-	-	81	-
BRRI dhan50	200	-	-	-	200
BRRI dhan58	213	-	-	213	-

Variety	Amount (kg)		Send to GRS (Breeder-kg)	Sold (TLS-kg)	Distribution of TLS (kg)
	TLS	Breeder seed			
BRRI dhan67	114	-	-	14	100
BRRI dhan74	6149	2500	2500	1049	5100
BRRI dhan81	529	-	-	29	500
BRRI dhan84	675	-	-	175	500
BRRI dhan86	66	-	-	66	-
BRRI dhan88	581	-	-	281	300
BRRI dhan89	5076	2750	2750	1576	3500
BRRI dhan92	15497	-	-	1497	14000
BRRI dhan96	302			102	200
Bangabandhu dhan100	4003			503	3500
BRRI hybrid dhan3	-	-	-	-	500
BRRI hybrid dhan5	-	-	-	-	500
Total	33599	5250	5250	5699	28900
Grand Total	45450	9250	9250	10029	35421

BRRI RS, SATKHIRA

514 Summary

517 Varietal Development, Trb

517 Aggri Network Trials In Bangladesh For Salt-Stress Prone Environment

521 Crop-Soil-Water Management

522 Socio-Economic And Policy

522 Technology Transfer

SUMMARY

In T. Aman season, 29 crosses were made, 39 F_1 s were confirmed and 41,192 segregating progenies derived from 110 crosses. Yield trials were carried out in Gazipur, Debhata, Kaliganj and BRRI farm, Satkhira in T. Aman season. In LST, out of 5085 breeding lines of 30 crosses, 452 lines were selected. Out of 772 genotypes, 237 genotypes were selected from OYT. Four PYTs (PYT-1 to PYT-4) were conducted using 179 breeding lines. Forty-five genotypes, out of 105 genotypes were selected from AYT-1 and AYT-2. In RYT-1 and RYT-2, total sixteen genotypes were evaluated in ten locations and no genotypes were selected. In ALART, three genotypes were evaluated and one genotype (BR11716-4R-102) was recommended for PVT.

A total of 32 F_1 s were confirmed. In total 49,590 segregating progenies from 114 crosses (F_2 - F_5 generation) were harvested and grown. In LST trial, 956 lines out of 6277 lines were selected. A total of 146 genotypes were selected out of 312. Out of 159 genotypes, 45 genotypes were selected from four PYTs. Thirty-one genotypes were selected from three AYT's. Thirty-one genotypes were evaluated from four RYT's and two BR11712-4R-93 and BR11717-4R-12 entries were selected RYT-1 to conduct ALART.

Two hundred breeding lines from IRRI along with six international check varieties and four national check varieties were evaluated at two locations viz., Shyamnagar and Kaliganj upazilas of Satkhira during Boro 2022. Among 200 entries, only 13 genotypes from were selected based on salinity tolerance at hotspot condition.

AFACI materials in Stage-1 trial was conducted in two locations viz Kaliganj and Debhata in the coastal area. Out of 104 tested entries only seven entries survived in Kaliganj whereas, the other entries did not survive due to severe salinity in Debhata.

Three entries were evaluated in RYT (SD/MD) for high yielding rice comparing with BRRI dhan75 and BRRI dhan87. IR19A1788 performed better over the highest yielder check, BRRI dhan87.

None of the tested entries performed better over the check, BRRI dhan87.

Four entries were evaluated with two check varieties, BRRI dhan72 and BRRI dhan87 for RYT-ZER. The entry, BR10490-1-2-3-8-7 produced statistically higher yield over BRRI dhan72.

Four entries were evaluated in RYT-RLR for high-yielding rice compared with BRRI dhan49, BRRI dhan71, BRRI dhan87 and BRRI dhan93. None of the tested entries performed better over the check, BRRI dhan71.

Five entries along with two checks BRRI dhan94 and BRRI dhan87 were evaluated for Swarna and long slender type. The entry BR9396-6-2-2B and BR10238-5-1-4-2 performed better than the two checks. In RYT-SS, three entries were evaluated with one check variety. The entry BRH13-2-14-2-1B produced statistically higher yield over the check, BRRI dhan49.

RYT for Zirashail Type Grain, three entries were evaluated with one check variety, Zirashail.

In RYT-Zirashail type grain, no entry performed statistically better over the local check. RYT for ZER, 3 entries were evaluated with three check varieties, BRRI dhan29, BRRI dhan74 and BRRI dhan84 during boro 2022-23. The entry, BR9674-1-4-1-3-P1 produced statistically higher yield over BRRI dhan74, BRRI dhan84 and BRRI dhan29.

RYT for favourable Boro rice was evaluated consisting of nine entries comparing with two check varieties, BRRI dhan88 and BRRI dhan89. The entry NGR 522-2 performed better statistically higher yields over BRRI dhan88 and BRRI dhan89. Nine entries were evaluated with two check varieties, BRRI dhan28 and BRRI dhan96 for RYT-SD. The entry, BR12180-5R-17 and BR11900-5R-56 produced statistically higher yield over the two checks.

In RYT-Extralong slender, 09 entries comparing with three check varieties, BRRI dhan50, BRRI dhan63 and BRRI dhan86 were evaluated and no entry performed better over the three checks.

In RYT-Medium Duration, 11 entries comparing with two check varieties, BRRI dhan81 and BRRI

ghan89 were evaluated at BRRi farm Satkhira during Boro 2022-23. The entry BR8899-14-4-1-2-2-1 performed better over the checks.

RYT for Late Transplanting rice was evaluated consisting of three entries comparing with one check varieties, BRRi dhan28 at BRRi farm Satkhira during Boro 2022-23. The BRH17-23-8-2-7B entry performed better over the checks, BRRi dhan28 and others genotypes.

RYT for Zira type rice was evaluated consisting of seven entries comparing with two check varieties, BRRi dhan28 and Zirashail. The BRH17-23-8-2-7B entry performed better over the checks, BRRi dhan28 and Zirashail.

RYT for premium quality rice was evaluated where nine test materials were evaluated against two check varieties of BRRi dhan63 and BRRi dhan81. The experiment was conducted at BRRi RS farm, Satkhira. In RYT (PQR-1), the genotypes, Zira, Nachol and Miniket, Ballobpur performed better in terms of grain yield over the check varieties of BRRi dhan63 and BRRi dhan81.

RYT-PQR-2 for premium quality rice was evaluated where three test materials were evaluated against two check varieties of BRRi dhan50 and BRRi dhan63. In RYT (PQR-2). No genotype performed better in terms of grain yield over the checks, BRRi dhan50 and BRRi dhan63.

RYT-SS was evaluated where five test materials were evaluated against one check variety of Katari. The genotypes BRH18-9-4-2-3B, BRH13-5-12-2-2B, BRH14-2-1-7B and BR9392-1-7-5B performed better in terms of grain yield over three check variety of Katari.

In RYT (FBR-Bio), no genotype performed better in terms of grain yield over three check varieties of BRRi dhan86 and BRRi dhan96.

A GXE trial for premium quality rice was evaluated where 20 test materials were evaluated against six check varieties of BRRi dhan50, BRRi dhan63, BRRi dhan81, BRRi dhan104, Tepi Boro and Rata Boro. In GXE (PQR), no genotype performed better in terms of grain yield over check variety of BRRi dhan104.

In ALART-PQR, two genotype was tested against the checks BRRi dhan34 and BRRi dhan70 at Dokkhin Sonabariya, Kalaroya under Satkhira district. The tested genotype BR8493-3-5-1-P1 showed statistically higher yield advantage over the check varieties but this tested genotype was higher growth duration than that of the check variety BRRi dhan70.

Five genotypes were tested against the check varieties Zirashail and BRRi dhan57 at Haroddoha, Satkhira Sadar under Satkhira district. In ALART-SHR-1, the tested entry BRH13-2-4-7-2B and BRH10-1-14-6-2B showed statistically better yield compared to their respective check varieties.

An ALART was conducted for superior high yielding (SHR-2) extra-long and long slender type at Rajpur, Kalaroya under Satkhira district. Five genotypes were tested against the check varieties BRRi dhan62 and BRRi dhan75. The tested entry BR9392-1-9-7-5B showed statistically better yield over the check variety, BRRi dhan62. BR10247-14-18-4 was also good.

In Boro 22-23, ALART was conducted for superior high yielding (SHR-2) at Jugorazpur, Satkhira Sadar, during Boro 202-23. Three genotypes were tested against the check variety BRRi dhan88. In ALART-SHR-2, all the tested entries showed statistically better yield over the check variety, BRRi dhan88.

In Boro 22-23, ALART was conducted for blast resistant rice ((BRR) (Re-ALART)) at Gourighona, Keshabpur, Jashore during boro 202-23. Four genotypes were tested against the check varieties BRRi dhan28 and BRRi dhan88. The tested entries BR (Path)12452-BC and BR(Path)13784-BC showed statistically better yield over the check variety BRRi dhan28 but these two tested entries were statistically similar to BRRi dhan88.

ALART for SHR-1 was evaluated consisting of four entries comparing with the check varieties of BRRi dhan81. The experiment was conducted at farmers' field at Jugrajpur, Satkhira Sadar, Satkhira during Boro 2022-23 season. Among the three tested genotypes of ALART for SHR-1, BRH13-2-4-7-2B performed higher yield than the check variety

of BRRI dhan81 and BRH10-1-14-2-6 produce also better than the check BRRI dhan81.

In Boro 2022-23, ALART for blast resistant rice (BRR) was conducted at farmer's field at Gourighona, Keshobpur, Jashore during Boro 2022-23 season. About four genotypes were tested against the 2 checks of BRRI dhan29 and BRRI dhan89. In ALART (BRR), all the tested genotypes of BR12454-BC2-56-81-27-3-30, BR12454-BC2-69-97-39-5-44, BR12454-BC2-71-91-6-23-26 and BR12454-BC2-75-32-31-39-7 performed better in terms of grain yield than the check varieties of BRRI dhan29 and BRRI dhan89.

Missing element trial was carried out at BRRI RS farm, Satkhira using BRRI dhan87 and BRRI dhan67 during T. Aman 2021 and Boro 2022-23, respectively. Control plot (without fertilization) reduced the highest yield level of 35% followed by N omitted plot (30%), where other nutrient omitted plots reduced the yield level of 9-21% compared to complete fertilizer dose. In Boro season, application of N, P, K, S and Zn significantly increased rice yield compared to control and N omitted plot. Omission of N, P, K, S and Zn (control plot) significantly reduced rice yield over the missing of P, K, S and Zn plot. Control plot (without fertilization) reduced the highest yield level of 64% followed by N omitted plot (52%), where other nutrient omitted plots reduced the yield level of 7-21% compared to complete fertilizer dose.

Bio-coated urea was formulated to improve rice yield in saline soil and tested for its efficacy in field condition. Study was conducted at BRRI R/S Satkhira in AEZ13 (Saline soil) where EC was 12-14ds/m during crop vegetative stage. BRRI dhan67 was grown as test crop. Application of bio-coated urea (BCU) improved grain yield 27-39% in saline soil (12-14 ds/m) compared to prilled urea (PU). Significantly the highest grain yield obtained in the BCU applied treatments compared to PU application. From the study report we may have hypothesized that bio-coated zeolite based urea granule may reduce reactive N loss, improve N fertilizer use efficiency along with crop productivity for sustainable rice production in saline soil.

During Aus 2022, among the 13 varieties, BRRI

dhan98 showed the highest yield followed by BRRI hybrid dhan7 but they were statistically similar to each other. During T. Aman 2022, among short-duration varieties, BRRI dhan87 had the best performance based on yield compared to others. In medium-duration Aman varieties (21) based on yield, BRRI dhan72 produced the highest grain yield, which was identical to BRRI dhan80. The growth duration of those varieties ranged from 126-127 days. In long-duration T. Aman varieties (11), BR23 produced the highest yield, which was identical to BRRI dhan10.

During Boro 2022-23, among the short-duration varieties (23), particularly among hybrid varieties, BRRI hybrid dhan5 produced the highest yield compared to BRRI hybrid dhan2. And particularly among inbred varieties, BRRI dhan101 showed better performance considering yield compared to the others. Among the long-duration varieties (26), BRRI dhan102 produced the highest yield followed by BRRI dhan97 but they were identical to each other. The growth duration of those varieties ranged from 144-146 days. The growth duration of those varieties ranged from 140-144 days. Among the long-duration varieties, BRRI dhan97 gave higher yield followed by BRRI dhan99.

Head-to-head adaptive trial was non-replicated in a location in Boro 2022-23. Irrespective of location, in the SD trial Bangabandhu dhan100 yielded the highest followed by BRRI dhan88. However, BRRI dhan28 produced the lowest yield among the tested varieties in those location. In the Saline trial BRRI dhan97 yielded the highest followed by BRRI dhan99. BRRI dhan99 and Bangabandhu dhan100 might be suitable for southern Bangladesh and can be recommended for this area, but more trial should be needed for a concrete recommendation.

A total of 30.49 tons of breeder seed of different Aman and Boro rice varieties were produced and sent to GRS Division. In addition, 30.32 tons of truthfully labelled seeds of different Aman and Boro rice varieties were produced, stored, sold, and distributed to the farmers, NGOs and DAE.

Seven farmer's trainings on rice production technology, quality seed production and preservation were conducted to train 210 farmers

of Satkhira, Khulna and Jashore districts. A total of 11 days were arranged during the reporting period. BRRI, Satkhira participated in various workshops, seminars, regional and district agricultural coordination committee meetings, district coordination committee meetings, discussion meetings, and farmers' field visits with advisory activities on field level and online basis.

VARIETAL DEVELOPMENT, TRB

Development of salt tolerant rice (STR). The objective of this project is to develop high yielding salt tolerant rice cultivars based on product profile for southern coastal zone of Bangladesh. Salinity is one of the major constraints for the rainfed lowland and Boro rice ecosystem in the southern coastal zone of Bangladesh.

In T. Aman season, 29 crosses were made using 40 well characterized elite parents with higher genetic merit/breeding values and various alleles of interest. A total of 39 F_1 s were confirmed as true hybrids through hybridity test via F_1 verification by quality check (QC) genotyping with purity SNP panel during T. Aman season. In T. Aman season, 41,192 segregating progenies derived from 110 crosses were advanced in F_2 - F_5 generations using FRGA technique. Yield trials were carried out in Gazipur, Debhata, Kaliganj and BRRI farm, Satkhira in T. Aman season. In LST, out of 5,085 breeding lines of 30 crosses, 452 lines were selected on the basis of strong culm with good plant ideotype, acceptable grain type and uniformity at heading in field condition (Fig. 1)

Out of 772 genotypes, 237 genotypes were selected from OYT. Four PYTs (PYT-1 to PYT-4) were conducted using 179 breeding lines following alpha lattice design. One hundred seven genotypes were selected from these trials depending on grain yield, salinity tolerance and phenotypic acceptability. Forty-five genotypes, out of 105, genotypes were selected from AYT-1 and AYT-2 (Fig. 2). In RYT-1 and RYT-2, sixteen genotypes were evaluated in ten locations and no genotypes were selected.

In ALART, three genotypes were evaluated and one genotype (BR11716-4R-102) was recommended for PVT. The mean grain yield of selected line

(BR11716-4R-102) ranged from 3.30 t/ha 6.52 t/ha in ten locations which were significantly higher than the check varieties (Table 1).

In Boro Season, 35 crosses were made using 64 detailed characterized elite parents with higher breeding values. A total of 32 F_1 s were confirmed as true hybrids through F_1 verification by quality check (QC) genotyping with purity SNP panel. In total 49,590 segregating progenies from 114 crosses (F_2 - F_5 generation) were harvested from FRGA nursery and grown in the subsequent generation. In LST trial, 956 lines out of 6277 lines were selected on the basis of desirable plant type, grain quality and uniformity at flowering under field condition (Figs. 4, 5 and 6). A total of 146 genotypes were selected out of 312 from OYT based on growth duration, grain yield, and homogeneity in different morpho-agronomic traits. Out of 159 genotypes, 45 genotypes were selected from four PYTs. Thirty-one genotypes were selected from three AYT.

Thirty-one genotypes were evaluated four RYT and two BR11712-4R-93 and BR11717-4R-12 selected from RYT-1 to conduct ALART. These two lines produced higher yield than the check variety BRRI dhan89 and BRRI dhan99 at six locations and showed high tolerance to salt stress during Boro season 2022-23.

AGGRi NETWORK TRIALS IN BANGLADESH FOR SALT-STRESS PRONE ENVIRONMENT

Two hundred breeding lines from IRRI along with six international check varieties and four national check varieties were evaluated at two locations viz, Shyamnagar and Kaliganj upazilas of Satkhira during Boro 2022 to select superior genotypes aiming to include directly in the variety release system or use as parents in the breeding programme.

In Shyamnagar, grain yield ranged from 0.34 tha^{-1} (IR21LT1560) to 2.02 tha^{-1} (A69-1, IR21LT1564) and growth duration 120 days (IR21LT1081) to 147 days (IR21LT1239), respectively. Among 200 entries, only 13 genotypes were selected based on salinity tolerance at hotspot condition (Fig.7a and 7b), grain type and grain yield. Only one genotype IR21LT1564 produced better yield (2.02 tha^{-1})

than BRRI dhan99 (1.49 tha^{-1}) and BINA dhan-10 (1.69 tha^{-1}) and similar yield with A69-1. This one genotype may be considered as potential to evaluate in the advanced yield trial in the next season as stage-2 and also recycle as a parent in the breeding programme. On the contrary, none of the genotypes including checks were survived in Kaliganj, Satkhira.

It is important to note that when the trial plot was salinized using irrigation water with high salinity (EC ~ 7.0 dS/m), the irrigation water enters into the trial plot from one side and then this salt water ran off towards the other end of trial plot and salt accumulated in the distal (other part) part of the trial field. The salinity gradient in two opposite directions of the trial site was not equal. Thus, the genotypes of the distal part of the trial did not survive due to excessive accumulation of salt consequently the salt stress was higher as well. Although we were unable to collect data from both the replications in these unavoidable circumstances, however, we had selected 13 genotypes based on phenotypic acceptability, yield under salt stress in hotspot salinity condition.

AFACI Trial

Evaluation of AFACI materials in Stage-1 trial

The experiment was conducted in two locations viz Kaliganj and Debhata in the coastal area. Out of 104 tested entries only seven entries survived in Kaliganj whereas, no other entries survived due to severe salinity in Debhata. Table 2 shows the survived genotypes and their performance. Those genotypes showed poor yield performance which were existed due to the high level of salinity (5.35-26.3 dS/m) in Kaliganj. Almost all the entries were damaged and yield of seven entries were very low, for instance, the highest yield was 0.22 tha^{-1} for IR18T1137.

Both the checks BRRI dhan89 and BRRI dhan67 completely damaged. The salinity graph of Kaliganj revealed that the genotypes faced the gradual increase of salinity stress from transplanting to maturity with its severity during the sensitive reproductive phase (Fig. 8). Selected genotypes identified as potential sources of salinity tolerance

and may be included in the variety release system and also can be utilized as donors in forward breeding of STR breeding programme.

Regional Yield Trial During T. Aman 2022

(RYT for Short/Medium Duration Rice (SD/MD) (RYT- SD/MD))

Three entries were evaluated in RYT (SD/MD) for high yielding rice comparing with BRRI dhan75 and BRRI dhan87. IR19A1788 performed better than the highest yielder check BRRI dhan87 but they are identical to each other, specifically grain yield in RYT (SD/MD) (Table 3). None of the tested entries performed better over the check, BRRI dhan87.

RYT for Zinc Enriched Rice (RYT-ZER)

Four entries were evaluated with two check varieties, BRRI dhan72 and BRRI dhan87. The entry, BR10490-1-2-3-8-7 produced statistically higher yield over BRRI dhan72 (Table 4).

RYT for Rainfed Lowland Rice (RYT-RLR)

Four entries were evaluated in RYT-RLR for high-yielding rice compared with BRRI dhan49, BRRI dhan71, BRRI dhan87 and BRRI dhan93. None of the tested entries performed better over the check, BRRI dhan71 (Table 5). But the entry, BR10475-1-2-3-5-5 was statistically similar to all the checks except BRRI dhan71 for grain yield.

RYT for Swarna and Long Slender Type

Five entries along with two checks BRRI dhan94 and BRRI dhan87 were evaluated. The entry BR9396-6-2-2B and BR10238-5-1-4-2 performed better over the two checks but they are the statistically similar to each other for the grain yield (Table 6).

RYT for Short Slender Grain Type (RYT-SS)

Three entries were evaluated with one check variety, BRRI dhan49. The entry BRH13-2-14-2-1B produced statistically higher yield over the check, BRRI dhan49 (Table 7).

RYT for Development of Zirashail Type Grain

Three entries were evaluated with one check variety, Zirashail. In RYT-Zirashail type grain, no entry performed statistically better over the local check (Table 8).

RYT in Boro 2022-23

Development of Zinc Enriched Rice (RYT-ZER)

Three entries were evaluated with three check varieties, BRRI dhan29, BRRI dhan74 and BRRI dhan84. The entry, BR9674-1-4-1-3-P1 produced statistically higher yield over BRRI dhan74, BRRI dhan84 and BRRI dhan29 (Table 9).

RYT (Barishal) for Favourable Boro Rice (RYT-FBR#Bari)

A regional yield trial for favourable Boro rice was evaluated consisting of nine entries comparing with two check varieties, BRRI dhan88 and BRRI dhan89. The entry NGR 522-2 performed better statistically providing higher yields over BRRI dhan88 and BRRI dhan89 (Table 10).

RYT for Short Duration (RYT-SD)

Nine entries were evaluated with two check varieties, BRRI dhan28 and BRRI dhan96. The entry, BR12180-5R-17 and BR11900-5R-56 produced statistically higher yield over the two checks (Table 11).

RYT in Boro 2022-23

RYT-Extra-long slender

A regional yield trial for extra-long slender rice was evaluated consisting of nine entries comparing with three check varieties, BRRI dhan50, BRRI dhan63 and BRRI dhan86. The experiment was conducted at BRRI RS farm, Satkhira during Boro 2022-23. Forty-five-day-old seedlings were transplanted in 5.4 m × 10 rows plot following RCB design with three replications using 2-3 seedlings per hill maintaining the spacing of 20 cm × 20 cm. In RYT-Extra-long slender, the no entry performed better over the three checks, BRRI dhan50, BRRI dhan63 and BRRI dhan86. Moreover, genotype BR9945-5R-21 produce 6.8 t/ha yield which is better than other genotypes (Table 12). This genotype can be used for further varietal development.

RYT-Medium Duration

A regional yield trial for medium duration rice was evaluated consisting of 11 entries comparing with two check varieties, BRRI dhan81 and BRRI dhan89. The experiment was conducted at BRRI RS

farm, Satkhira during Boro 2022-23. Forty-five-day-old seedlings were transplanted in 5.4 m × 10 rows plot following RCB design with three replications using 2-3 seedlings per hill maintaining the spacing of 20 cm × 20 cm. In RYT- medium duration, the BR8899-14-4-1-2-2-1 entry performed better over the checks, BRRI dhan81 and BRRI dhan89 (Table 13). This genotype can be used for further varietal development.

RYT-Late Transplanting

A regional yield trial for late transplanting rice was evaluated consisting of three entries comparing with one check variety, BRRI dhan28. The experiment was conducted at BRRI RS farm, Satkhira during Boro 2022-23. Forty-five day-old seedlings were transplanted in 5.4 m × 10 rows plot following RCB design with three replications using 2-3 seedlings per hill maintaining the spacing of 25 cm × 15 cm. In RYT- late transplanting, the BRH17-23-8-2-7B entry performed better over the checks BRRI dhan28 and other genotypes (Table 14). This genotype can be used for further varietal development.

RYT-Zira type

A regional yield trial for Zira type rice was evaluated consisting of seven entries comparing with two check varieties, BRRI dhan28 and Zirashail. The experiment was conducted at BRRI RS farm, Satkhira during Boro 2022-23. Forty-five-day-old seedlings were transplanted in 5.4 m × 10 rows plot following RCB design with three replications using 2-3 seedlings per hill maintaining the spacing of 25 cm × 15 cm. In RYT- Zira type, the BRH17-23-8-2-7B entry performed better over the checks, BRRI dhan28 and Zirashail (Table 15). This genotype can be used for further varietal development.

RYT for Premium Quality Rice-1 (RYT-PQR-1)

A regional yield trial for premium quality rice was evaluated where nine test materials were evaluated against two check varieties of BRRI dhan63 and BRRI dhan81. The experiment was conducted at BRRI RS farm, Satkhira. In RYT (PQR-1), the genotypes, Zira, Nachol and Miniket, Ballobpur performed better in terms of grain yield over the check varieties of BRRI dhan63 and BRRI dhan81 (Table 16).

RYT for Premium Quality Rice-2 (RYT-PQR-2)

A regional yield trial for premium quality rice was evaluated where three test materials were evaluated against two check varieties of BRRI dhan50 and BRRI dhan63. In RYT (PQR-2), no genotype performed better in terms of grain yield over three checks, BRRI dhan50 and BRRI dhan63 (Table 17).

RYT for Short Slender Rice (RYT-SS)

A regional yield trial for short slender rice was evaluated where five test materials were evaluated against one check variety of Katari. In RYT-SS, the genotypes BRH18-9-4-2-3B, BRH13-5-12-2-2B, BRH14-2-1-7B and BR9392-1-7-5B performed better in terms of grain yield over three check variety of Katari (Table 18).

RYT for Favourable Boro Rice (RYT-FBR-Bio)

A regional yield trial for short slender rice was evaluated where five test materials were evaluated against two check varieties of BRRI dhan86 and BRRI dhan96. The experiment was conducted at BRRI RS farm, Satkhira. In RYT (FBR-Bio), no genotype performed better in terms of grain yield over three check varieties of BRRI dhan86 and BRRI dhan96 (Table 19).

GXE Interaction Trial During Boro 2022-2023

GXE Interaction of Basmati Rice on Physio-chemical and cooking properties for development of Premium Quality Rice (PQR)

A GXE trial for premium quality rice was evaluated where 20 test materials were evaluated against six check varieties of BRRI dhan50, BRRI dhan63, BRRI dhan81, BRRI dhan104, Tepi Boro and Rata Boro. In GXE (PQR), no genotype performed better in terms of grain yield over the check variety of BRRI dhan104 (Table 20).

Advanced Line Adaptive Research Trial (ALART) during T. Aman 2022

ALART for Premium Quality Rice (PQR)

In ALART-PQR, two genotype was tested against the checks BRRI dhan34 and BRRI dhan70 at Dokkhin Sonabariya, Kalaroya under Satkhira district. The tested genotype BR8493-3-5-1-P1 showed statistically higher yield advantage over the

check varieties but this tested genotype was higher growth duration than that of the check variety BRRI dhan70 (Table 21).

ALART for Superior High Yielding (SHR-1) Zirashail Type

Five genotypes were tested against the check varieties Zirashail and BRRI dhan57 at Haroddoha, Satkhira Sadar under Satkhira district. In ALART-SHR-1, the tested entry BRH13-2-4-7-2B and BRH10-1-14-6-2B showed statistically better yield compared to their respective check varieties. There was a little variation regarding growth duration among entries (Table 22).

ALART for Superior High Yielding Rice (SHR-2) Extra-long and long slender

ALART was conducted for superior high yielding (SHR-2) extra-long and long slender type at Rajpur, Kalaroya under Satkhira district. Five genotypes were tested against the check varieties BRRI dhan62 and BRRI dhan75. In ALART-SHR-2, the tested entry BR9392-1-9-7-5B showed statistically better yield over the check variety BRRI dhan62. BR10247-14-18-4 was also good. It may also be alternative to BRRI dhan62 although they are similar to each other (Table 23).

ALART during Boro 2022-23

ALART for Superior High Yielding Rice (SHR-2)

In Boro 22-23, ALART was conducted for superior high yielding rice (SHR-2) at Jugorazpur, Satkhira Sadar, during Boro 2022-23. Three genotypes were tested against the check variety BRRI dhan88. In ALART-SHR-2, all the tested entries showed statistically better yield over the check variety, BRRI dhan88. There was a little variation regarding growth duration among the entries (Table 24).

ALART for Blast Resistant Rice (BRR) (Re-ALART)

In Boro 22-23, ALART was conducted for blast resistant rice ((BRR) (Re-ALART)) at Gourighona, Keshabpur, Jashore during Boro 2022-23. Four genotypes were tested against the check varieties BRRI dhan28 and BRRI dhan88. The tested entries

BR (Path)12452-BC and BR (Path)13784-BC showed statistically better yield over the check variety, BRRI dhan28 but these two tested entries were statistically similar to BRRI dhan88. plant height of BR (Path)12452-BC was comparatively taller than BRRI dhan28. There was a little variation regarding growth duration among entries (Table 25).

ALART for superior high yielding rice (SHR-1)

ALART for superior high yielding rice (SHR-1) was evaluated consisting of four entries comparing with the check varieties of BRRI dhan81. The experiment was conducted at farmer's field at Jugraipur, Satkhira Sadar, during Boro 2022-23 season. Forty-one-day old seedlings were transplanted in 5.0 m × 5.0 m plot following RCB design with three replications using 2-3 seedlings per hill maintaining spacing of 25 cm × 15 cm. Among the three tested genotypes of ALART for SHR-1, BRH13-2-4-7-2B performed higher yield (7.77 t ha⁻¹ in 138 days) than the check variety of BRRI dhan81 (6.56 t ha⁻¹ in 134 days) and BRH10-1-14-2-6 produce 7.63 t/ha also better than the check BRRI dhan81 (Table 26).

ALART for Blast Resistant Rice (BRR)

In Boro 2022-23, ALART for blast resistant rice (BRR) was conducted at farmer's field at Gourighona, Keshobpur, Jashore during Boro 2022-23 season. In this experiment, four genotypes were tested against the two checks of BRRI dhan29 and BRRI dhan89. In ALART (BRR), all the tested genotypes of BR12454-BC2-56-81-27-3-30, BR12454-BC2-69-97-39-5-44, BR12454-BC2-71-91-6-23-26 & BR12454-BC2-75-32-31-39-7 performed better in terms of grain yield than the check varieties of BRRI dhan29 and BRRI dhan89 (Table 27).

CROP-SOIL-WATER MANAGEMENT

Missing element trial

The experiment was carried out at BRRI RS farm, Satkhira using BRRI dhan87 and BRRI dhan67 during T. Aman 2021 and Boro 2022-23, respectively. Missing element trial was done using seven treatments in RCB design with three replications. NPKSZn was applied at the rate of 100:15:60:10:1 kg ha⁻¹ in T. Aman and

120:18:75:20:3 kg ha⁻¹ in Boro season. In T. Aman 2022, nutrient controlled plot and N omitted plot produced the lowest yield compared to the other fertilizer treatments (Table 28). Control plot (without fertilization) reduced the highest yield level of 35% followed by N omitted plot (30%), where other nutrient omitted plots reduced the yield level of 9-21% compared to complete fertilizer dose. In Boro season, application of N, P, K, S and Zn significantly increased rice yield compared to the control and N omitted plot (Table 27). Omission of N, P, K, S and Zn (control plot) significantly reduced rice yield over the missing of P, K, S and Zn plot. However, insignificant variation in rice yield was observed between the missing of N solely and control treatment (Table 27). Control plot (without fertilization) reduced the highest yield level of 64% followed by N omitted plot (52%), where other nutrient omitted plots reduced the yield level of 7-21% compared to complete fertilizer dose.

Effects of bio-coated urea on rice yield in Boro season in the south-western coastal ecosystem.

Bio-coated urea was formulated using exopolysaccharide producing bacteria to improve rice yield in saline soil and tested for its efficacy in field condition. The study was conducted BRRI RS Satkhira in AEZ13 (Saline soil) where EC was 12-14 ds/m during crop vegetative stage. BRRI dhan67 was grown as test crop. Five treatments as T1 = Control, T2= N(PU)PKSZn (kg/ha) @ 120-20-50-20-1, T3= N(PU)PKSZn (kg/ha) @ 120-20-120-20-1, T4= N(BCU)PKSZn (kg/ha) @ 120-20-50-20-1, T5= N(BCU)PKSZn (kg/ha) @ 120-20-120-20-1 were assigned randomly in randomized complete block design with three replications. Application of bio-coated urea (BCU) improved grain yield 27-39% in saline soil (12-14 ds/m) compared to prilled urea (PU). Significantly the highest grain yield obtained in the BCU applied treatments (T4 and T5) compared to PU application (T2 and T3) (Table 29). From the study report we may have hypothesized that bio-coated zeolite based urea granule may reduce reactive N loss, improve N fertilizer use efficiency along with crop productivity for sustainable rice production in saline soil.

SOCIO-ECONOMIC AND POLICY

Stability analysis of BRRI varieties at Satkhira during 2022-23

During Aus 2022, among the 13 varieties, BRRI dhan98 showed the highest yield (4.44 t ha⁻¹) followed by BRRI hybrid dhan7 (4.20 t ha⁻¹) but they were statistically similar to each other (Table 30). The growth duration of these varieties were 146 days.

During T. Aman 2022, among short-duration varieties, BRRI dhan87 (6.11 t ha⁻¹) had the best performance based on yield compared to others (Table 31). In medium-duration Aman varieties (21) based on yield, BRRI dhan72 produced the highest grain yield (5.71 t ha⁻¹), which was identical to BRRI dhan80 (5.41 t ha⁻¹) (Table 32). The growth duration of those varieties ranged from 126-127 days. In long-duration T. Aman varieties (11), BR23 (4.79 t ha⁻¹) produced the highest yield, which was identical to BRRI dhan10 (4.66 t ha⁻¹) (Table 33).

During Boro 2022-23, among the short-duration varieties (23), particularly among hybrid varieties, BRRI hybrid dhan5 produced the highest yield (7.71 t ha⁻¹) compared to BRRI hybrid dhan2 (7.53 t ha⁻¹). And particularly among inbred varieties, BRRI dhan101 showed better performance considering yield compared to the others (Table 34). Among the long-duration varieties (26), BRRI dhan102 produced the highest yield (7.57 t ha⁻¹) followed by BRRI dhan97 (7.38 t ha⁻¹) but they were identical to each other (Table 35). The growth duration of those varieties ranged from 144-146 days. The growth duration of those varieties ranged from 140-144 days. Among the long-duration varieties, BRRI dhan97 produced higher yield followed by BRRI dhan99 (Table 36).

TECHNOLOGY TRANSFER

Head-to-head adaptive trial (HHAT) of modern rice varieties

The trial was non-replicated in a location in Boro 2022-23. Thirty-day-old seedlings of five varieties

were transplanted side by side in around one bigha of land (33 decimal) using 2-3 seedling hill⁻¹ at a spacing of around 20 cm × 20 cm. Fertilizer and cultural practices were followed as per BRRI recommendations. Irrespective of the location, in the SD trial Bangabandhu dhan100 yielded the highest (8.48 tha⁻¹) followed by BRRI dhan88 (7.67 tha⁻¹) (Table 37). However, BRRI dhan28 produced the lowest yield among the tested varieties in those locations. In the saline trial BRRI dhan97 yielded the highest followed by BRRI dhan99 (Table 38). BRRI dhan99 and Bangabandhu dhan100 might be suitable for southern Bangladesh and can be recommended for this area, but more trial should be needed for a concrete recommendation.

Seed production and dissemination

A total of 30.49 tons of breeder seed of different Aman and Boro rice varieties were produced and sent to GRS Division. In addition, 30.32 tons of truthfully labelled seeds of different Aman and Boro rice varieties were produced, stored, sold, and distributed to the farmers, NGOs and DAE.

Training, field day and workshop

Seven farmer's trainings on rice production technology, quality seed production and preservation were conducted to train 210 farmers of Satkhira, Khulna and Jashore districts. A total of field eleven days were arranged during the reporting period. BRRI, Satkhira participated in various workshops, seminars, regional and district agricultural coordination committee meetings, district coordination committee meetings, discussion meetings, and farmers' field visits with advisory activities on field level and online basis.

Table 1. Performance of genotypes in ALART, STR, Salinity Breeding, T. Aman 2022-23.

Genotype	Growth duration (days)	Grain yield (t/ha)								Mean
		Westbyde BRR1 Gaz	Kaliganj (Satk)	Debhata (Satk)	Sadar (Gopalganj)	Sadar (Bagerhat)	Feni (Sonagazi)	Companiganj (Noakhali)	Kolapara (Patua)	
BR11712-4R-218	121	4.05	4.34	4.47	4.57	4.57	6.03	4.91	2.89	4.48
BR11716-4R-102	121	4.29	4.42	4.27	4.90	4.90	6.52	5.30	3.30	4.74
BR11723-4R-172	122	3.64	4.34	4.37	4.47	4.47	5.86	5.11	2.43	4.34
BRR1 dhan73 (ck)	122	1.51	4.08	3.93	4.00	4.00	4.82	4.44	2.81	3.70
BRR1 dhan87 (S. ck)	127	4.17	4.08	4.00	4.43	4.43	5.44	5.00	2.58	4.27
% Yield increase over BRR1 dhan87		2.89	8.33	6.65	10.61	10.61	20.0	6.0	27.91	11.0
LSD <0.05						0.323				
CV (%)						7.74				

Table 2. The performance of selected genotypes from AFACI Stage-1, Salinity Tolerant Rice (STR) Breeding in Kaliganj, Satkhira during Boro 2022-23.

Entry no.	Designation	GD	PH	ET	Grain yield (tha ⁻¹)
25	IR15T1319	126	89	61	0.15
42	IR18T1137	126	87	65	0.22
60	IR16F1148	126	91	71	0.20
98	IR129420-B-30-B-2-1	127	78	77	0.05
102	IRRI 104	127	83	79	0.18
104	IRRI 154	127	82	79	0.13
106	IRRI 230	130	83	81	0.18

GD= Growth duration in days, PH= plant height in cm, ET= Effective tiller number

Table 3. Performance of different entries under RYT (SD/MD) at BRR1, Satkhira during T. Aman 2022.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR10490-1-2-3-8-7	101	115	4.63
BR10470-1-2-3-13-5	124	117	4.40

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR10471-1-2-3-15-1	125	119	4.30
BR9674-1-1-5-2-P4-HR1	113	117	4.12
BRRI dhan72(ck)	122	123	4.15
BRRI dhan87(ck)	120	122	4.80
LSD (0.05)	1.33	0.57	0.25
CV (%)	1.39	0.59	7.04
DS= 9 Jul 2022		DT= 5 Aug 2022	

Table 4. Performance of different entries under RYT (ZER) at BRRI, Satkhira during T. Aman 2022.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR10490-1-2-3-8-7	101	115	4.63
BR10470-1-2-3-13-5	124	117	4.40
BR10471-1-2-3-15-1	125	119	4.30
BR9674-1-1-5-2-P4-HR1	113	117	4.12
BRRI dhan72(ck)	122	123	4.15
BRRI dhan87(ck)	120	122	4.80
LSD (0.05)	1.33	0.57	0.25
CV (%)	1.39	0.59	7.04
DS= 9 Jul 2022		DT= 5 Aug 2022	

Table 5. Performance of different entries under RYT (RLR) at BRRI, Satkhira during T. Aman 2022.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR10458-20-2-3-1-3	122	139	3.82
BR10490-1-2-3-11-3	121	114	4.24
BR10475-1-2-3-5-5	131	117	4.44
BR10482-1-2-3-1-3	140	134	3.86
BRRI dhan49(ck)	103	132	4.34
BRRI dhan71(ck)	99	115	5.66
BRRI dhan87(ck)	124	123	4.96
BRRI dhan93(ck)	119	134	4.24
	1.23	0.57	0.30

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
	1.26	0.56	8.28
DS= 27 Jun 2022		DT= 27 Feb 2022	

Table 6. Performance of different entries under RYT (Swarna and Long Slender Type) at BRRI, Satkhira during T. Aman 2022.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BRH9392-6-2-1-3-4	131	131	5.73
BR9396-6-2-2B	119	132	6.33
BR10238-5-1-4-2	127	131	5.88
BR9392-10-20-1B	116	117	4.76
BRH11-2-4-7B	112	115	4.56
BRRI dhan94(ck)	118	134	4.76
BRRI dhan87(ck)	125	124	5.76
LSD (0.05)	1.37	0.36	0.76
CV (%)	1.39	0.35	17.35
DS= 27 Jun 2022		DT= 26 Jul 2022	

Table 7. Performance of different entries under RYT (SS) at BRRI, Satkhira during T. Aman 2022.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BRH13-2-14-2-1B	125	128	5.62
BRH17-23-8-2-7B	108	111	4.18
BRH13-7-9-3-2B		Seedling short	
BRRI dhan49(ck)	104	133	4.59
LSD (0.05)	2.38	-	0.14
CV (%)	2.60	-	3.45
DS= 27 Jun 2022		DT= 26 Jul 2022	

Table 8. Performance of different entries under RYT (Zirashail Type) at BRRI, Satkhira during T. Aman 2022.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BRH11-7-17-10B	119	122	5.23
BRH13-9-5-3B	119	122	5.14
BRH9-3-14-2B	120	122	5.32

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
Zirashail	120	111	5.25
LSD (0.05)	1.03	-	0.17
CV (%)	1.05	-	4.07
DS= 27 Jun 2022		DT= 26 Jul 2022	

Table 9. Performance of different entries under RYT (ZER) at BRRI, Satkhira during Boro 22-23.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
V1=BR9674-1-4-1-3-P1	108.33	142.00	7.82
V2= BR9674-1-4-1-3-P2	109.33	142.00	6.97
V3= BR9674-7-3-2-1-P2	97.67	140.67	6.93
V4= BRRI dhan29 (CK)	98.00	138.67	6.68
V5= BRRI dhan74 (ck)	96.33	133.33	7.30
V6= BRRI dhan84 (ck)	104.67	131.67	6.78
LSD (0.05)	0.69	0.44	0.17
CV (%)	0.83	0.39	2.90
DS= 3 Dec 2022		DT= 11 Jan 2023	

Table 10. Performance of different entries under RYT (FBR-Barishal) at BRRI, Satkhira during Boro 2022-23.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
V1=NGR 522-2	97	136	6.51
V2=NGR 270-3	96	140	5.81
V3= NGR 418-1	92	139	5.48
V4=NGR 416-1	96	134	6.31
V5= NGR 968-1	102	136	6.46
V6= NGR 994-1	98	141	6.43
V7= NGR 745-2	93	141	6.41
V8= NGR 590-2	94	135	5.45
V9= NGR 710-1	97	140	5.79
V10= BRRI dhan88 (ck)	83	134	5.93
V11= BRRI dhan89 (ck)	105	144	5.62
LSD (0.05)	0.60	0.51	0.27
CV (%)	0.77	0.45	5.42
DS= 4 Dec 2022		DT= 10 Jan 2023	

Table 11. Performance of different entries under RYT (FBR-SD) at BRRI, Satkhira during Boro 2022-23.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
V1= BR11637-5R-140	116	140	6.47
V2=BR11894-5R-376	113	143	5.94
V3=BR11900-5R-24	100	142	6.47
V4=BR11900-5R-56	100	139	6.76
V5=BR12180-5R-17	108	146	7.00
V6=BR12180-5R-29	106	146	4.96
V7=BR12208-5R-274	123	139	5.88
V8= BR12208-5R-394	89	137	6.06
V9=BR12208-5R-402	95	137	5.02
V10=BRRI dhan28 (ck)	102	137	5.39
V11= BRRI dhan96 (ck)	84	136	4.68
LSD (0.05)	1.28	0.43	0.25
CV (%)	1.52	0.37	5.16

DS= 27 Nov 2022 DT= 9 Jan 2023

Table 12. Grain yield, plant height and growth duration of RYT-Extra-long slender entries during Boro 2022-23.

Entry/Variety	PH (cm)	GD (day)	Yield (t/ha)
BR9945-5R-21	96.33	143	6.8
BR10604-5R-58	97	143	5.73
IR18A2102	92.33	143	5.85
BR7528-2R-19-16-RIL-52	109	143	5.83
BR7528-2R-19-16-RIL-55	102	143	5.92
BR7528-2R-19-16-RIL-59	102.33	143	5.93
BRRI dhan50 (ck)	81	148	5.76
BRRI dhan63 (ck)	82.6	146	7.17
BRRI dhan86 (ck)	91.67	142	6.98
LSD _{0.05}	4.9	2.3	0.5
CV (%)	2.8	0.9	5.1

DS= 27 Nov 2022 DT= 8 Jan 2023

Table 13. Grain yield, plant height and growth duration of RYT-MD entries during Boro 2022-23.

Entry/Variety	PH (cm)	GD (day)	Yield (t/ha)
IR17A1275	96.33	143	5.78
IR17A1694	97	143	5.15
IR17A1735	92.33	143	4.81
IR18A1398	109	143	6.10
IR18A1907	102	143	5.72
IR18A2119	102.33	143	5.71
BR8899-14-4-1-2-2-1	81	140	6.16
BR11342-5R-23	82.6	142	5.19
BR12177-5R-43	91.67	142	5.85
BRRI dhan81 (ck)	93.97	143	5.2
BRRI dhan89 (ck)	105.93	142	6.14
LSD _{0.05}	5.9	2.3	0.9
CV (%)	2.8	0.8	5.6
DS=27Nov 2022		DT= 7 Jan 2023	

Table 14. Grain yield, plant height and growth duration of RYT- Late transplanting entries during Boro 2022-23.

Entry/Variety	PH (cm)	GD (day)	Yield(t/ha)
BRH13-2-4-6-4B	97.86	142	3.79
BRH11-7-17-10B	97.90	138	4.81
BRH17-23-8-2-7B	97.76	142	5.43
BRRI dhan28 (ck)	99.9	143	3.56
LSD _{0.05}	5.9	2.3	0.5
CV (%)	2.7	0.8	5.7
DS=03 Jan 23		DT=13 Feb 2023	

Table 15. Grain yield, plant height and growth duration of RYT- Zira type entries during Boro 2022-23

Entry/Variety	PH (cm)	GD (day)	Yield(t/ha)
V1=BRH13-9-5-3B	95.67	136	6.49
V2= BRH12-1-7B-P1	97.87	138	7.14
V3= BRH9-3-14-2B	103.53	142	5.48

Entry/Variety	PH (cm)	GD (day)	Yield(t/ha)
V4= BR10247-4-7-4B	113.13	136	5.91
V5= BRH13-7-9-3-2B	101.4	136	5.32
V6= BBI dhan28	100.27	136	6.86
V7=Zirashail	104.7	136	6.19
LSD0.05	5.9	2.3	0.9
CV (%)	2.7	0.8	6.85
DS=27 Nov 2022	DT=11 Jan 2023		

Table 16. Performance of tested genotypes under RYT (PQR-1) at BRRI farm, Satkhira during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
Lamba Zira, Tanor	93	132	6.72
BR10645-6-4-8-1-2	97	142	6.43
Zira, Nachol	100	131	6.92
Miniket, Ballobpur	100	134	6.96
BR10646-3-2-2-4-3	109	142	4.70
BR10646-3-2-2-4-4	105	142	6.86
BR10646-3-3-3-1-4	111	140	5.39
BR10648-12-1-3-4-1	113	135	6.83
Koushik-Hili	110	141	6.77
BRRI dhan63 (Ck)	91	137	6.87
BRRI dhan81 (Ck)	102	134	6.84
LSD (0.05)	0.71	1.11	0.76
CV (%)	0.41	0.48	6.92
DS= 3 Dec 2022	DT= 10 Jan 2023		

Table 17. Performance of tested genotypes under RYT (PQR-2) at BRRI farm, Satkhira during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR10642-4-5-1-2-1	114	147	5.19
Katari, Shibganj	106	143	6.70
Shiva (TH)	89	152	5.60
BRRI dhan50 (Ck)	90	143	6.94
RRI dhan63 (Ck)	93	138	7.02

Genotype	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
LSD (0.05)	1.77	0.69	1.29
CV (%)	0.96	0.25	10.90
DS= 3 Dec 2022		DT= 10 Jan 2023	

Table 18. Performance of tested genotypes under RYT (SS) at BRRI farm, Satkhira during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BRH18-9-4-2-3B	98.93	140	6.55
BRH13-5-12-2-2B	99.67	141	6.50
BRH14-2-1-7B	97.53	141	6.63
BRH9-3-2B	103.43	141	5.81
BR9392-1-7-5B	86.33	141	6.68
Katari (ck)	106.70	148	5.86
LSD (0.05)	1.02	0.92	NS
CV (%)	0.57	0.36	13.50
DS= 4 Dec 2022		DT= 12 Jan 2023	

Table 19. Performance of tested genotypes under RYT (FBR-Bio) at BRRI farm, Satkhira during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR(Bio)13028-AC24-1-2	115	137	5.14
BR(Bio)13028-AC24-2-3	107	137	5.30
BR(Bio)13028-AC24-2-4	110	137	4.84
BR(Bio)13028-AC24-3-3	112	137	5.23
BR(Bio)13028-AC24-3-1	106	137	5.81
BRRI dhan86 (ck)	102	137	6.91
BRRI dhan96 (ck)	102	137	6.94
LSD (0.05)	4.70	0	0.62
CV (%)	2.45	-	6.06
DS= 4 Dec 2022		DT= 12 Jan 2023	

Table 20. Performance of tested genotypes under GXE interaction (PQR) at BRRI farm, Satkhira during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
Basmati (1230)	*	*	*
Basmati (D) (3928)	120	138	6.33
Basmati (4488)	136	145	6.78
Basmati 370 (4489)	137	144	5.85
Basmati 37 (4491)	137	146	6.29
Basmati (N13) (4493)	132	148	4.99
Basmati 370 (4494)	142	147	6.20
Basmati 107 (4501)	150	150	5.44
Basmati 377 (4507)	*	*	*
Basmati 406 (4508)	136	149	6.28
Basmati (4754)	123	150	7.51
Basmati (6614)	107	141	7.18
Super Basmati	102	139	5.55
Basmati Sufaid 187	148	140	6.41
Indian Basmati	100	152	7.57
Basmati TAP L-90 (2517)	122	141	6.89
Basmati Nanot 439 (4496)	146	141	5.98
Basmati Pardnr 442 (4497)	99	140	5.11
Basmati 433 (4509)	134	141	6.65
Pusha Basmati	113	154	5.72
BRRI dhan50 (ck)	82	149	7.30
BRRI dhan63 (ck)	87	148	7.14
BRRI dhan81 (ck)	93	143	6.36
BRRI dhan104 (ck)	101	153	7.69
Tepi Boro (ck)	137	140	6.03
Rata Boro (ck)	151	140	5.57
LSD (0.05)	4.50	1.70	1.49
CV (%)	1.93	0.62	12.33

DS= 30 Nov 2022

DT= 8 Jan 2023

* Did not flower

Table 21. Performance of different genotypes under ALART-PQR during T. Aman 2022

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
V1=BR8493-3-5-1-P1	126	132	4.38
V2=BR9590-45-1-3-2-P2	114	146	2.68
V3=BRRI dhan34 (ck)	141	149	2.24
V4=BRRI dhan70 (ck)	135	127	4.37
LSD (0.05)	2.32	-	0.13
CV (%)	2.2	-	4.79
DS: 2 Feb 2022	DT: 4 Aug 2022		

Table 22. Performance of different genotypes under ALART-SHR-1 (Zirashail Type) during T. Aman 2022.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
V1=BRH15-24-7B	103	108	5.27
V2=BRH13-1-9-7B	108	108	4.71
V3=BRH13-2-4-7-2B	109	108	5.84
V4=BRH10-1-14-6-2B	111	108	5.66
V5=BR10247-4-7-4B	106	107	4.03
V6=Zirashail (ck)	116	103	3.84
V7=BRRI dhan57(ck)	111	103	4.40
LSD (0.05)	1.03	0.18	0.19
CV (%)	1.15	0.20	4.93
DS: 6 Jul 2022	DT: 3 Aug 2022		

Table 23. Performance of different genotypes under ALART-SHR-2 (Extra-long and long slender Type) during T. Aman 2022

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
V1=BR9392-1-9-7-5B	108	110	4.70
V2=BR10247-14-18-4	100	98	4.47
V3=BR9392-40-50-1B	106	105	4.02
V4=IR12A-177	104	108	4.20
V5=BR10238-5-1-4-2	106	107	4.49
V6=BRRI dhan62 (ck)	99	100	4.35
V7=BRRI dhan75(ck)	100	105	5.44

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
LSD (0.05)	1.96	0.18	0.12
CV (%)	2.32	0.21	3.33
DS: 2 Jul 2022	DT: 27 Jul 2022		

Table 24. Performance of different genotypes under ALART-SHR-2 during Boro 2022-23.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
V1=BRH11-2-4-7B	87	134	6.91
V2=BRH13-2-4-2-1B	88	134	6.40
V3=BRH238-5-1-4-2	86	137	6.90
V4=BRRI dhan88 (ck)	91	134	5.42
LSD (0.05)	1.33	0.24	0.25
CV (%)	1.84	0.21	4.82
DS: 1 Dec 2022	DT: 8 Jan 2023		

Table 25. Performance of different genotypes under ALART-(BRR) (Re-ALART) during boro 2022-23.

Entry/Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
V1=BR(Path)12452-BC3	111	132	7.16
V2= BR(Path)12452-BC	114	133	7.51
V3= BR(Path)13784-BC	102	130	6.23
V4= BR(Path)13784-BC	99	129	7.29
V5= BRRI dhan28 (ck)	109	130	5.03
V6= BRRI dhan88 (ck)	91	132	6.98
LSD (0.05)	0.79	0.46	0.46
CV (%)	0.93	0.43	8.32
DS: 30 Nov 2022	DT: 7 Jan 2023		

Table 26. Performance of different genotypes under ALART for SHR-1 during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BRH10-1-14-2-6	101.63	134	7.63
BRH13-2-4-7-2B	111.43	138	7.77
BRH15-24-7B	103.74	145	6.78
BRRI dhan81 (ck)	93.83	134	6.56

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
CV (%)	2.11	0.39	4.06
LSD _{0.05}	5.59	1.31	0.44
DS: 1 Dec 2013	DT: 8 Jan 2023		

Table 27. Performance of tested genotypes under ALART (BRR) at Keshobpur, Jashore during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR12454-BC2-56-81-27-3-30	125	154	8.33
BR12454-BC2-69-97-39-5-44	108	154	8.09
BR12454-BC2-71-91-6-23-26	118	154	8.08
BR12454-BC2-75-32-31-39-7	123	153	8.04
BRRI dhan29 (Std. & Sus. ck)	104	155	7.20
BRRI dhan89 (Std. & Sus. ck)	109	154	6.77
LSD (0.05)	1.29	0.98	0.58
CV (%)	0.62	0.35	4.11
DS= 21 Nov 2022	DT= 2 Jan 2023		

Table 28. Effect of missing element on grain yield and panicle number of BRRI dhan87 during T. Aman 2022 and BRRI dhan67 in Boro 2022-23.

Treatment	T. Aman 2022			Boro 2022-23		
	Straw yield (5m ²)	Grain yield (t ha ⁻¹)	Yield decrease (%) due to missing nutrient	Straw yield (5m ²)	Grain yield (t ha ⁻¹)	Yield decrease (%) due to missing nutrient
PKSZn (-N)	2.32	3.60	30	1.69	2.97	52
NKSZn (-P)	3.64	4.48	21	4.03	4.92	21
NPSZn (-K)	3.25	4.88	13	3.71	5.69	7
NPKZn (-S)	3.10	4.45	20	3.54	5.38	12
NPkS (-Zn)	3.38	5.01	11	4.03	5.48	10
NPkSZn	3.33	5.61	-	4.18	6.09	-
Control	2.45	3.92	35	1.53	2.22	64
LSD (0.05)	0.37	0.51		5.78	0.21	
CV (%)	14.21	13.64		8.50	5.25	

Table 29. Effects of Bio-coated urea on rice yield of BRRI dhan67 in Boro 2022-23.

Treatment	Boro 2022-23	
	Plant height (cm)	Grain yield (t/ha)
T1	105.8	4.25
T2	112.23	5.15
T3	109.13	5.00
T4	114.43	6.56
T5	112.97	6.96
LSD (0.05)	0.37	0.51
CV (%)	6.21	4.34

Table 30. Performance of different BRRI varieties under stability analysis during Aus 2022.

Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR21	121	144	2.92
BR24	123	167	3.75
BR26	118	145	3.19
BRRI dhan27	123	146	3.04
BRRI dhan42	131	147	3.78
BRRI dhan43	91	146	3.60
BRRI dhan48	120	145	3.36
BRRI dhan65	99	146	3.32
BRRI dhan82	91	165	3.46
BRRI dhan83	152	144	3.72
BRRI dhan85	115	145	3.66
BRRI dhan98	114	146	4.44
BRRI hybrid dhan7	99	146	4.20
LSD (0.05)	3.14	0.45	0.29
CV (%)	3.34	0.37	10.03

DS: 1 May 2022

DT: 23 May 22

Table 31. Performance of different short duration BRRI varieties under stability analysis during Aman 2022.

Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BRRI dhan33	101	110	4.40
BRRI dhan39	105	112	4.03
BRRI dhan53	103	117	4.06
BRRI dhan56	108	105	4.05
BRRI dhan57	111	100	3.38
BRRI dhan62	93	100	3.15
BRRI dhan66	114	109	3.76
BRRI dhan71	104	111	4.12
BRRI dhan73	114	117	3.73
BRRI dhan75	104	105	4.91
BRRI dhan87	118	120	6.11
BRRI dhan90	102	115	3.55
BRRI dhan95	119	119	4.22
BRRI Hybrid dhan4			NG
BRRI Hybrid dhan6			NG
LSD (0.05)	1.28	0.75	0.15
CV (%)	1.47	0.83	4.35
DS= 31 Jul 2022		NG=not germinated	

Table 32. Performance of different medium duration BRRI varieties under stability analysis during Aman 2022.

Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR3	81	130	3.21
BR4	99	137	4.85
BR11	86	138	4.10
BR25	111	132	3.88
BRRI dhan30	95	140	4.87
BRRI dhan31	101	135	4.22
BRRI dhan32	101	122	4.70
BRRI dhan40	102	137	4.09
BRRI dhan44	101	137	4.18

Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BRRI dhan49	73	128	4.82
BRRI dhan51	66	134	4.52
BRRI dhan52	97	135	3.68
BRRI dhan54	83	130	4.88
BRRI dhan70	97	125	4.17
BRRI dhan72	87	126	5.71
BRRI dhan77	122	137	4.84
BRRI dhan78	94	130	5.18
BRRI dhan79	80	127	4.82
BRRI dhan80	91	127	5.41
BRRI dhan93	81	130	4.20
BRRI dhan94	83	134	4.14
LSD (0.05)	1.91	0.45	0.18
CV (%)	2.55	0.42	4.91

Table 33. Performance of different long duration BRRI varieties under stability analysis during Aman 2022.

Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR5	104	140	3.26
BR10	87	141	4.66
BR22	93	142	4.11
BR23	98	141	4.79
BRRI dhan34*	115	130	3.37
BRRI dhan37*	101	135	3.21
BRRI dhan38*	99	135	3.86
BRRI dhan41	98	143	4.13
BRRI dhan46	89	145	3.76
BRRI dhan76	117	147	3.45
BRRI dhan91	119	150	4.39
LSD (0.05)	1.67	0.28	0.22
CV (%)	2.02	0.25	6.78

Table 34. Performance of different short duration BRRI varieties under stability analysis during Boro 2022-23.

Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR1	85	147	5.57
BR6	97	136	5.36
BRRI dhan26	109	135	5.18
BRRI dhan27	143	109	2.56
BRRI dhan28	88	135	6.21
BRRI dhan36	90	136	5.12
BRRI dhan45	100	136	5.80
BRRI dhan55	99	139	5.76
BRRI dhan61	87	139	5.27
BRRI dhan63	86	139	5.97
BRRI dhan67	98	136	5.94
BRRI dhan68	95	136	5.67
BRRI dhan74	94	139	4.63
BRRI dhan81	95	136	4.62
BRRI dhan84	91	136	5.53
BRRI dhan86	88	135	4.93
BRRI dhan88	88	136	5.46
BRRI dhan96	85	139	5.14
Bangabandhu dhan100	98	139	6.47
BRRI dhan101	109	139	7.03
BRRI Hybrid dhan2	99	141	7.53
BRRI Hybrid dhan3	105	138	6.70
BRRI Hybrid dhan5	107	140	7.71
LSD (0.05)	1.01	0.40	0.19
CV (%)	1.28	0.36	4.08

Table 35. Performance of different long duration BRRI varieties under stability analysis during Boro 2022-23.

Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR2	121	144	5.69
BR3	111	167	5.69

Variety	Plant height (cm)	Growth duration (day)	Grain yield (t/ha)
BR7	121	145	5.75
BR8	121	146	6.21
BR9	127	147	5.07
BR12	98	146	6.15
BR14	119	145	6.51
BR15	99	146	5.09
BR16	91	165	7.17
BR17	133	144	3.97
BR18	116	145	5.76
BR19	113	146	5.52
BRRI dhan29	101	146	6.96
BRRI dhan35	114	146	5.51
BRRI dhan47	102	139	5.88
BRRI dhan50	90	144	5.78
BRRI dhan58	103	144	4.45
BRRI dhan59	88	144	4.55
BRRI dhan60	90	139	6.12
BRRI dhan64	102	144	4.59
BRRI dhan69	107	144	6.40
BRRI dhan89	112	144	5.52
BRRI dhan92	110	146	5.11
BRRI dhan97	116	144	7.38
BRRI dhan99	115	146	6.75
BRRI dhan102	100	146	7.57
LSD (0.05)	1.43	0.34	0.18
CV (%)	1.62	0.28	3.77

Table 37. Yield (t/ha) and growth duration (day) of head-to-head adaptive trial (HHAT- SD) entries during Boro 2022-23.

Location/ Variety	Keshobpur		Kaliganj	
	Yield	GD	Yield	GD
BRRI dhan28	6.30	142	4.21	145
BRRI dhan74	6.88	145	4.46	147
BRRI dhan88	7.67	146	4.99	145

BAU dhan3	7.45	147	5.08	148
Bangabandhu dhan100	8.48	148	5.03	145
BINA dhan25	6.71	142	4.58	143

Table 38. Yield (t/ha) and growth duration (day) of head-to-head adaptive trial (HHAT- Saline) entries during Boro 2022-23.

Location/ Variety	Kaliganj		Jugrajpur		Keshobpur	
	GD	Yield	GD	Yield	GD	Yield
BRRI dhan28	145	4.51	142	6.78	142	6.78
BRRI dhan67	143	5.42	141	7.59	141	7.59
BRRI dhan97	153	6.38	152	8.87	152	8.87
BRRI dhan99	144	6.07	143	8.50	143	8.50

Figure

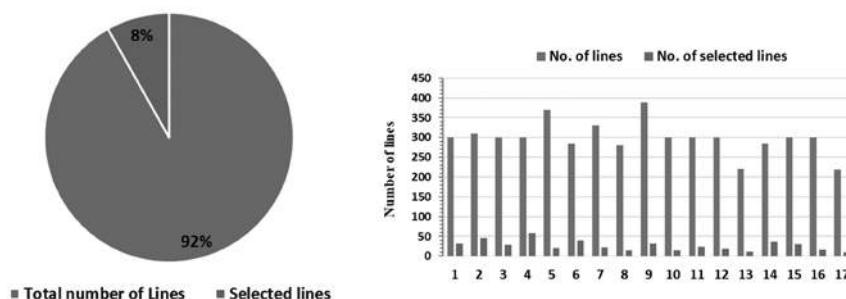


Fig. 1. Number of lines of LST population, T. Aman2022-23.

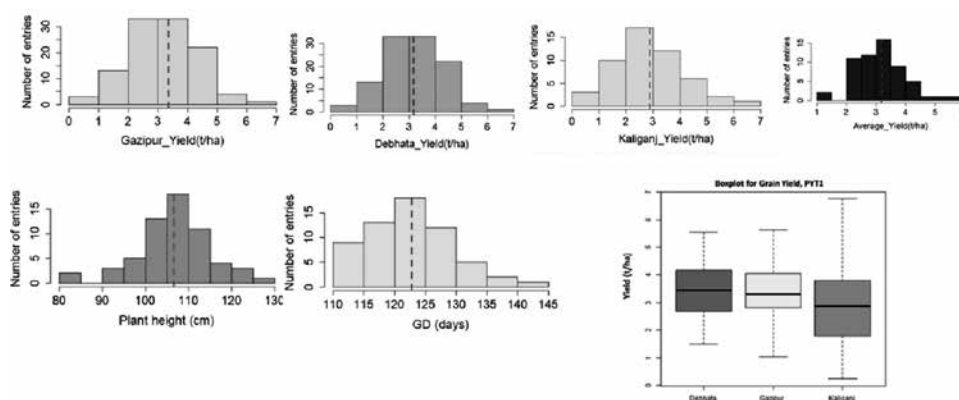


Fig. 2. Graphical illustrations show the frequency distribution (number of entries) for yield, growth duration and plant height traits of PYT-1 trial at three locations T. Aman 2022-23.



Fig. 3. Field view of OYT lines, Experimental plot, Satkhira, T. Aman, 2022-23.

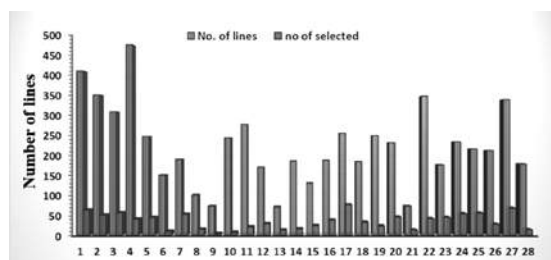


Fig. 4 Frequency distribution of LST lines in Boro 2022-23.

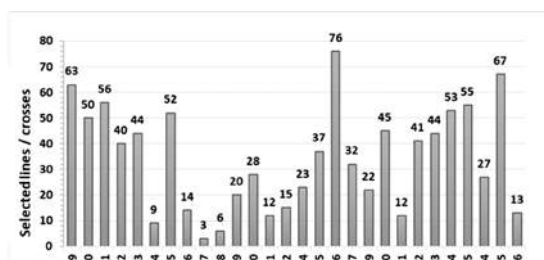


Fig. 5. Number of selected lines from LST population, Boro 2022-23.

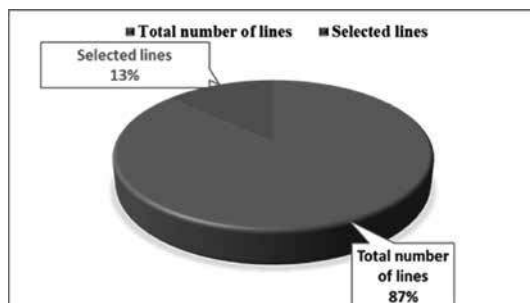


Fig. 6. The selection pressure imposed during identification of desirable LST lines in Boro 2022-23.

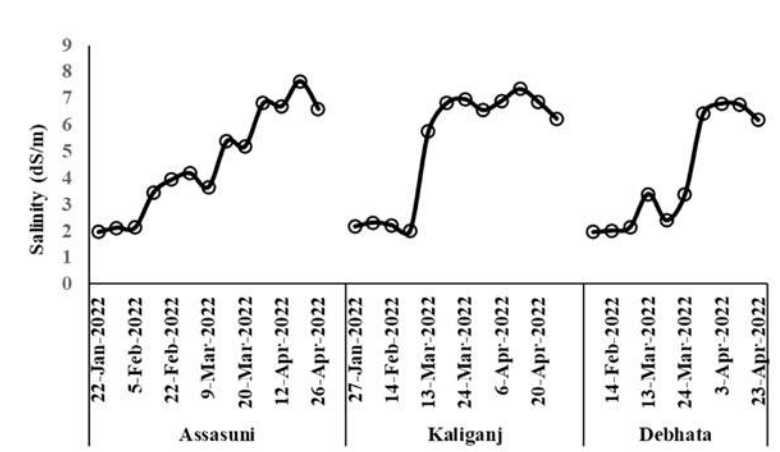


Fig. 7a. Soil water salinity of the experimental plots at Assasuni, Kaliganj and Debhata, Satkhira during Boro 2021-22,

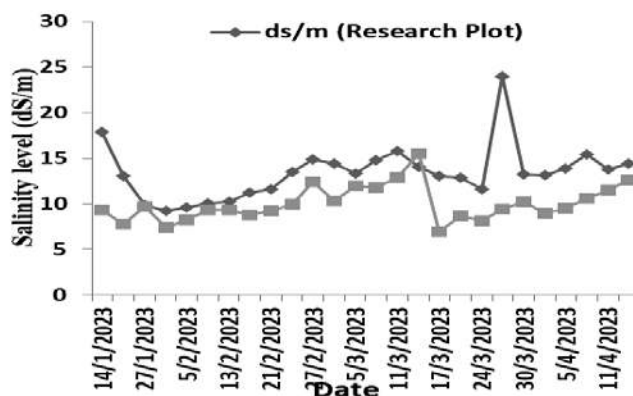


Fig. 8. Field view of AFACI-1 trial during irrigated season (Boro) 2022-23.



Fig. 7b. Salinity level (electrical conductivity: EC expressed in dS/m) at trial plots Shyamnagar during Boro season 2022-23.

BRRI RS, SONAGAZI

544	Summary
548	Variety Development
555	Pest Management
556	Crop-Soil Water Management
559	Socio-Economic And Policy
559	Technology Transfer
562	Enrichment Of Seed Stock

SUMMARY

Altogether 79 crosses were made during T. Aman and Boro at BRRI Regional Station, Sonagazi. For pure line selection of Ranguin (one of the best local Aus varieties in hilly areas), five plants were selected on the basis of uniformity, good plant type, disease and insect free during T. Aus.

Regional Yield Trials (RYT)

A total of 191 breeding lines were tested under RYT trials during the reporting period from which 34 lines were found better than the checks regarding grain yield and yield contributing characters. Breeding lines were supplied from Plant Breeding and Biotechnology Divisions.

RYT Aus 2022. Seventeen lines along with standard checks BRRI dhan27, BRRI dhan48 and BRRI dhan98 were tested under 2 RYT (Favourable condition and non-saline tidal condition) during T. Aus 2022 from which, three lines from RYT-Favorable condition (BR11863-5R-256, BR11607-4R-72 and FBR-416; two lines from RYT- non-saline tidal condition (BR9829-78-1-2-1 and BR11868-5R-2) were selected for advancing trial under on-station condition which were supplied from Plant Breeding Division of BRRI HQ.

RYT Aman 2022. Fifty-seven lines along with standard checks BRRI dhan49, BRRI dhan71, BRRI dhan72, BRRI dhan73, BRRI dhan87, BRRI dhan91, BRRI dhan93, BRRI dhan94 and IRBB60 were tested under 10 RYT (BB, RLR, Tidal, ZER, LS, SS, STR1, STR2, STR1- Farmers' Field, STR2-Farmers' Field) during T. Aman 2022 from which, two lines from RYT# BB (BR11869-5R-47, BR11874-5R-109), one line from RYT-Tidal (BR10238-5-1-9-3B), one line from RYT-ZER (BR9674-1-1-5-2-P4-HR1) were selected for advancing trial.

RYT Boro 2023. One-hundred eighteen lines along with standard checks BRRI dhan28, BRRI dhan29, BRRI dhan50, BRRI dhan58, BRRI dhan63, BRRI dhan67, BRRI dhan74, BRRI dhan81, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, BRRI dhan97, Indonesian Black Rice and local checks (Zirashail, Tepi Boro

and Rata Boro) were tested under 14 RYT (BB-Blast, BB, ZER, FBR-Barishal, FBR-SD, FBR-MD, FBR-LD, FBR-ELS, FBR-Biotechnology, PQR-Basmati, STR, Zira type, Antioxidant-Black rice-SD, Antioxidant-Black rice-MD) during Boro 2022-23. Three lines from FBR-SD (BR11637-5R-140, BR11903-5R-56, BR12208-5R-402), two lines from FBR-MD (IR18A1398, IR18A1907), two lines from FBR-LD (BR11894-5R-260, BR11318-5R-84), three lines from FBR-ELS (BR9945-5R-21, IR18A2102, BR7528-2R-19-16-R1L-59), four lines from FBR-Barishal (NGR 418-1, NGR 968-1, NGR 994-1, NGR 745-2), three lines from STR (BR11712-4R-44, BR11712-4R-93, BR11712-4R-12, BR11712-4R-346), two lines from BB (BR(Path)13800-BC3-8-1, BR(Path)13800-BC3-109-10), five lines from BB-Blast (BR(Path)13800-BC3-8-5, BR(Path)13800-BC3-134-8, BR(Path)13800-BC3-8-11, BR(Path)-13800-BC3-12-13, BR(Path)13800-BC3-134-25) were selected for advanced trial.

AGGRi network trials (ANT) for salt-stress prone environment in Boro 2023. The tested entries showed a wide range of variations in grain yield started from 0.56 to 4.23 t ha⁻¹ with a mean value of 1.98 t ha⁻¹ in 1st replication and 0.58 to 3.68 t ha⁻¹ with mean value of 2.26 t ha⁻¹ in 2nd replication. The overall performance across the site of the tested lines varied from 0.62 to 3.40 t ha⁻¹ with mean value of 2.12 t ha⁻¹. Flowering (50%) and growth duration also varied significantly within the sites. The entries varied in flowering from 103-126 days and growth duration from 129 to 152 days. Wider variations in plant height were also observed within location. Plant height of the entries varied from 63 to 118 cm. During the experimental period, significant salinity level observed. Mean Salinity levels were 3.0, 19.69 and 5.15 dS/m at vegetative, flowering and maturity stages, respectively. A total of five rice genotypes entry no. 37 (IR21LT1293), 39 (IR21LT1605), 119 (IR21LT1157), 131 (IR21LT1048), and 148 (IR21LT1679) performed better than the check varieties. Those five genotypes were selected based on yield performance (3.13 to 3.40 t ha⁻¹), growth duration (131-142 days), Plant height (82-91 cm) and salinity score (3-5) under salinity stress for further investigation.

Advanced Line Adaptive Research Trial (ALART). A total of 18 advanced breeding lines were evaluated during the reporting period.

Survey of pest incidence: Survey was carried out at farmers' fields of Feni, Noakhali, Laxmipur, Cox's bazar, Chattogram and Khagrachari districts both in Aman 2022 and Boro 2022-23. Sites were selected with the suggestion and collaboration of upazila Agriculture Officer (UAO) of the Department of Agricultural Extension (DAE). Sub Assistance Agricultural Officer (SAAO) of concerned block helped in site selection who were the front-line workers and very much familiar to the farmers as well as their fields.

Bacterial leaf blight (BLB), bacterial leaf streak (BLS), sheath rot, false smut and sheath blight infestation were observed in different scores during Aman season. BRRI dhan49 in different locations and other breeding materials of BRRI RS, Sonagazi research field were affected by false smut disease in different locations due to fluctuation of environmental conditions during Aman season. BRRI dhan28, BRRI dhan29, BRRI dhan67, BRRI dhan89, BRRI 92 and BRRI dhan84 were affected moderately to high by neck blast during Boro season. The farmers were suggested for taking preventive measures using fungicide.

Rice insect pests and their natural enemies were monitored throughout the reporting period by Pennsylvanian light traps from July 2022 to June 2023 at the experimental field of BRRI RS, Sonagazi, Feni. The abundance of leaf roller, stem borer, rice bug, green leafhopper, grasshopper, mole cricket, field cricket, and stink bug were found in the light trap during the reporting period. Some beneficial insects like lady bird beetle, spider, damselfly, carabid beetle, staphylinid beetle were also found.

Reduction of insecticide use in rice production. BRRI dhan97 and Bangabandhu dhan100 produced significantly higher yield in T2 (Prophylactic insecticide use) treatment as compared to T1 (Refrained from insecticide) treatment. BRRI dhan96 produced similar yield in both the treatments. Significantly higher number of white head (caused by yellow stem borer attack) and ETL

percentage was found in all three varieties using T1 as compared to T2. Nevertheless, Bangabandhu dhan100 produced the highest yield (6.59 t/ha^{-1}) using T2 treatment as compared to all treatment-variety combinations. Besides, BRRI dhan97 showed the highest number of white head (139) and ETL percentage (4.38) using T1 as compared to all the treatment-variety combinations. All treatment-variety combinations showed below 5% ETL.

Activities of BRRI RS, Sonagazi Development Karmasuchi

Yield maximization, Aman 2022. The results showed that the highest grain yield was found in T4= STB + Cow dung (2 t/ha) for BRRI dhan87 (5.93 t/ha), BRRI dhan94 (4.86 t/ha) and BRRI dhan95 (5.50 t/ha) but in STB BRRI dhan95 (5.56 t/ha) was insignificant. In consideration of variety, the treatments effect was significant for BRRI dhan87, but BRRI dhan94 and BRRI dhan95 were insignificant. For BRRI dhan87 and BRRI dhan94 the treatment STB + Cow dung (2 t/ha) produced the highest grain yield which was statistically significant from other treatments. The results also indicates that STB + Cow dung (2 t/ha) treatment was enough for the maximum yield of tested varieties BRRI dhan87, BRRI dhan94 and BRRI dhan95.

Effect of planting time, Boro 2023. The highest grain yield (8.63 t/ha) was found in BRRI dhan92 followed by BRRI dhan89 (8.34 t/ha) in 1st planting on 5 December 2022 (seeded on 1st November 2022) than the delayed plantings. The lowest grain yield of tested varieties was found on the delayed plantings (25 January 2023).

Yield maximization, Boro 2023. The results showed that the highest grain yield was found in T1=STB for BRRI dhan92 (9.31 t/ha) followed by BRRI dhan89 (7.66 t/ha) and BRRI dhan96 (7.14 t/ha) for T3=STB + 20% more N. In consideration of variety the treatments' effect was significant for BRRI dhan89, BRRI dhan92 and BRRI dhan96. For BRRI dhan96 the treatment T3=STB + 20% more N produced the highest grain yield which was statistically significant from compared to the other treatments. The results also indicated that T1=STB dose treatment is enough for the maximum yield of

tested varieties BRRI dhan89 and BRRI dhan92 but BRRI dhan96 required 20% more N than STB dose.

Optimizing planting geometry, Boro 2023. The closest spacing (20 cm × 15 cm) produced the highest grain yield (7.49 t/ha) of Bangabandhu dhan100 which was statistically similar with the spacing 25 cm×15 cm (7.37 t ha⁻¹). The yield was gradually decreased with increasing spacing and it was the lowest (6.04 t/ha) in the wider spacing (30 cm × 30 cm).

Nitrogen use efficiency (NUE), Boro 2023. T₆ produced the highest yield 8.12 t/ha whereas the lowest yield was 3.39 t/ha at T₈. Finally, higher grain yield and straw yield was observed by the application of increased N rates than the recommended N rate.

Multi-location trials (MLT) of promising hybrid, Aman 2022. On the basis of yield, growth duration, plant height and other agronomic characters hybrid BRRI97A/BRRI53R, BRRI97A/BRRI42R, BRRI99A/BRRI42R and BRRI97A/BRRI43R were selected from MLT-1 and hybrid IR78369A/BRRI42R, IR58025A/BRRI46R, IR102758A/BRRI42R, IR58025A/BRRI43R, IR105688A/BRRI43R and IR78369A/BRRI53R were selected from MLT-2 for advanced trials. During Boro 2022-23, three hybrids BRRI97A/BRRI42R, BRRI125A/EL86R and BRRI97A/BRRI38R were selected based on stable yield performance and yield advantage over the checks.

Stability analysis, Aus 2022. Among the varieties, BRRI dhan98 ranked the top in terms of yield (6.36 t ha⁻¹) followed by BRRI hybrid dhan7 (5.88 t/ha). The variety BR21, BRRI dhan65, and BRRI dhan27 were found low yielding varieties having grain yield 3.300, 3.36 and 3.72 t ha⁻¹, respectively.

Stability analysis, Aman 2022. Among the varieties, BRRI dhan103 ranked the top in terms of mean yield (5.70 t ha⁻¹) followed by BRRI dhan52 (5.58 t/ha). The variety BR5, BRRI dhan62, and BRRI dhan91 were found low yielding varieties having grain yield 2.5, 3.15 and 3.20 t ha⁻¹, respectively.

Stability analysis, Boro 2023. Among the varieties, BRRI dhan89 ranked the top in terms of

yield (8.56 t ha⁻¹) followed by BRRI dhan92 (8.48 t/ha). The variety BR7, BR17 and BR8 were found low yielding varieties having grain yield 4.21, 4.82 and 5.04 t ha⁻¹, respectively.

Head-to-Head Adaptive Trial (HHAT) Aman 2022 under TRB Project. Ten HHATs (Costal Ecosystem-5, Short duration-2 and Flash flood system-3) were conducted at Sonagazi and Fulgazi of Feni; Mirsarai of Chattogram, Chakaria and Sadar of Cox's bazar districts during Aman 2022. BRRI dhan79 produced the highest mean grain yield (5.22 t ha⁻¹) for coastal ecosystem, BRRI dhan75 yielded the highest (5.46 t ha⁻¹) for short duration, BRRI dhan52 produced the highest mean grain yield (4.98 t ha⁻¹) for flash flood ecosystem.

HHAT Boro 2023 under TRB Project. Fifteen HHATs (Short duration-3, long duration-3, Salinity-3 and hill-6) were conducted at Sonagazi, Feni Sadar, Chagalnaya, Mirsarai, Companiganj, Cox's bazar Sadar, Khagrachari Sadar, Mahalchari, Manikchari, Guimara, Ramgarh upazila of different districts during Boro 2022-23. BRRI dhan74 yielded the highest in average of the locations (7.05 tha⁻¹) for short duration, BRRI dhan102 yielded the highest on average of the locations (8.14 tha⁻¹) for long duration, BRRI dhan99 yielded highest on average of the locations (6.17 t ha⁻¹) for salinity ecosystem and Bangabandhu dhan100 yielded the highest on average of the locations (7.11 tha⁻¹) for hilly areas.

Demonstration of modern rice varieties. A total 1,572 demonstration modern rice varieties were executed in 1,572 bigha land during the reporting period under GOB and different projects.

GOB Fund. A total of 630 demonstrations were executed in 630 bigha land at farmer's field at Chattogram and Rangamati regions during 2022-2023 funded by GOB.

Karmasuchi Fund. A total of 462 demonstrations were executed in 462 bigha land at farmer's field during the reporting period under BRRI RS, Sonagazi Research and Development Karmasuchi.

Hybrid Project Fund. A total of 240 demonstrations were executed in 240 bigha land at farmer's field during 2022-23 financial year (Boro 2022-23) funded by BRRI Hybrid project.

TRB Project Fund. One-hundred-twenty demonstrations were executed in 120 bigha land at farmers' field during 2022-23 funded by TRB project.

PQR Project Fund. A total of 120 Pilot production (PP) of PQR varieties were conducted in 4 upazilas of two districts (Sirajganj and Bogura) under PQR project during Aman 2022 and Boro 2023.

Activities of Premium quality rice (PQR) project during 2022-23

Adaptive trial (AT) of PQR varieties. A total of 24 adaptive trials (AT) were conducted in four upazilas of two districts during Aman 2022 and Boro 2023 under PQR project funded by KGF. Four upazila are Royganj and Tarash of Sirajganj while Sherpur and Dhunat of Bogura district. Seven PQR varieties like BRRI dhan34, BRRI dhan70, BRRI dhan75, BRRI dhan80, BRRI dhan90, BRRI dhan103 and Binadhan-13 included in Aman 2022 while five rice varieties BRRI dhan63, BRRI dhan81, Bangabandhu dhan100, BRRI dhan102 and Binadhan-25 were compared used in the ATs. Standard management practices were followed in the trials.

AT Aman 2022. Irrespective of variety and location, the highest mean grain yield (5.13 t ha^{-1}) was found in BRRI dhan75 followed by BRRI dhan90 (4.91 t ha^{-1}). The lowest grain yield (3.01 t ha^{-1}) was obtained in Binadhan-13 followed by BRRI dhan34 (3.43 t ha^{-1}). Across the locations, BRRI dhan75 produced the highest grain yield (6.32 t ha^{-1}) that was at par with BRRI dhan90 (6.02 t ha^{-1}), while Binadhan-13 produced the lowest yield (3.60 t ha^{-1}) followed by BRRI dhan34 (4.02 t ha^{-1}).

AT Boro 2023. Grain yield and growth of the varieties were significantly affected by genotypes and environments and their interaction ($G \times E$). Irrespective of variety and location, the highest mean grain yield (8.02 t ha^{-1}) was found in BRRI dhan102 followed by Bangabandhu dhan100 (6.91 t ha^{-1}). The lowest grain yield (5.14 t ha^{-1}) was obtained in Binadhan-25 followed by BRRI dhan81 (5.32 t ha^{-1}) and local variety Katari (5.54 t ha^{-1}). Across the locations, BRRI dhan102 produced the highest grain yield (8.77 t ha^{-1}) at Sherpur, Bogura and the yield (4.26 t ha^{-1}) was found in Binadhan-25 at Tarash,

Sirajganj that was at par with BRRI dhan81 (4.55 t ha^{-1}) at Dhunat, Bogura.

Pilot production (PP) of PQR varieties

A total of 120 Pilot Production (PP) trials of PQR varieties were conducted in four upazilas of two districts (Sirajganj and Bogura) under PQR project during Aman 2022 and Boro 2023. Four PQR varieties BRRI dhan34, BRRI dhan75, BRRI dhan80, and BRRI dhan90 were used in Aman 2022, while five rice varieties BRRI dhan50, BRRI dhan63, BRRI dhan81, Bangabandhu dhan100 and BRRI dhan102 were used in Boro 2023. The programme was executed through public and private partnership (PPP).

PP Aman 2022. Across the locations, BRRI dhan75 produced the highest grain yield (6.03 t ha^{-1}) at Royganj, Sirajganj followed by BRRI dhan90 (5.71 t ha^{-1}) at Royganj, Sirajganj; while the lowest yield (2.81 t ha^{-1}) was obtained in BRRI dhan34 at Royganj, Sirajganj. Total production of all the varieties was 34.55 tons of which 3,640 kg retained as seeds (11% of total production) by the farmers for next season cultivation. About 1,793 farmers gained awareness and knowledge about the varieties and 329 farmers (18%) were motivated to cultivate the varieties.

PP Aman 2022. Irrespective of variety and locations, BRRI dhan102 produced the highest grain yield (8.46 t ha^{-1}) at Royganj, Sirajganj followed by Bangabandhu dhan100 (7.83 t ha^{-1}) at Sherpur, Bogura; while the lowest grain yield (4.73 t ha^{-1}) obtained in BRRI dhan81 at Sherpur, Bogura followed by BRRI dhan50 (5.43 t ha^{-1}) at Tarash, Sirajganj. Total area and total production of all the varieties were 60 bigha and 52.74 tons from which 2,750 kg was retained as seeds (5% of total production) by the farmers for next season cultivation. About 2,500 farmers gained awareness and knowledge about the varieties and 348 farmers (14% of total farmers) were motivated to cultivate the varieties.

Farmers' training under PQR project. A total of eight farmers' training on premium quality rice (PQR) technologies was executed in Sirajganj and Bogura districts. About 240 farmers, extension

personnel, and NGO personnel participated as trainee.

Field Day under PQR project

Twelve field days were conducted during the reporting period in Sirajganj and Bogura districts. Around 1,500 participants attended the field days and gathered knowledge about rice technologies.

Farmers Training on Rice production Technology 2022-23

GOB fund. A total of 40 farmers' trainings on rice production technologies were executed and the farmers were trained up among the 1,200 participants 925 were male and 275 were female farmers.

Karmasuchi Fund. A total of 64 farmers trainings on rice production technologies were conducted and the farmer were trained among 1,920 participants 1,472 were male and 448 were female farmers.

Field day 2022-23

GOB fund. Fourteen field days were conducted in selected demonstration sites at maturity stage during 2022-2023 financial year. Nearly 1,500 progressive farmers, local leaders, extension personnel (DAE and NGO personnel) and public representatives participated in those occasions.

Karmasuchi fund. A total of 26 field days were organized in selected demonstration sites at maturity stage during 2022-23 funded by BRRI RS, Sonagazi research and development Karmasuchi. Almost 2600 progressive farmers, local leaders, extension personnel and public representatives were participated in the occasions.

Hybrid project fund. Two field days were conducted under Hybrid rice project. About 210 progressive farmers, local leaders, extension personnel (DAE and NGO personnel) and public representatives participated in those occasions.

Breeder Seed Production

GOB fund. A total of 30.25 tons of breeder seeds were produced under GOB fund during the reporting period. All the breeder seeds of different varieties were sent to Genetic Resources and Seed Division, BRRI HQ, Gazipur.

Karmasuchi fund. A total of 35.6 ton breeder seeds were produced under Karmasuchi fund during the reporting period. All the breeder seeds of different varieties were sent to Genetic Resources and Seed Division, BRRI HQ, Gazipur.

Quality Seed (TLS) Production

GOB fund. Twenty-five tons of truthfully Labeled seeds (TLS) of modern rice varieties were produced by BRRI RS, Sonagazi during the reporting period.

Karmasuchi fund. A total of 43.73 ton of TLS of modern rice varieties were produced by BRRI RS, Sonagazi during the reporting period.

- ❖ VARIETY DEVELOPMENT
- ❖ PEST MANAGEMENT
- ❖ CROP-SOIL-WATER MANAGEMENT
- ❖ SOCIO-ECONOMIC AND POLICY
- ❖ TECHNOLOGY TRANSFER
- ❖ ENRICHMENT OF SEED STOCK

VARIETY DEVELOPMENT

Germplasm collection for pure line selection. Ranguin is a one of the best and popular local Aus variety in hilly areas. Ranguin was collected from Khagrachari during T. Aus 2022.

Investigators: M Adil, S Tamanna, B Karmakar

Regional Yield Trials (RYT), T. Aus 2022

Seventeen lines along with standard checks BRRI dhan27, BRRI dhan48 and BRRI dhan98 were tested under 2 RYT (Favourable condition and non-saline tidal condition) in BRRI RS, Sonagazi, Feni to test the yield performance and to evaluate the yield potential and adaptability.

Investigators: M Adil, S Tamanna, B Karmakar

RYT-Favourable condition, T. Aus 2022

Twelve advanced breeding lines along with two standard checks BRRI dhan48 and BRRI dhan98 were evaluated at BRRI RS, Sonagazi, Feni during T. Aus 2022. The advanced breeding lines BR11863-5R-256, BR11607-4R-72 and 7 FBR-416 produced higher yield than the checks. Therefore, BR11863-5R-256, BR11607-4R-72 and 7 FBR-416 were selected for further varietal development activities.

RYT-Non-saline-tidal during T. Aus 2022

Five advanced breeding lines along with two standard checks BRRi dhan27, BRRi dhan48 and BRRi dhan98 were evaluated at BRRi, Sonagazi, Feni during T. Aus 2022. The advanced breeding lines BR9829-78-1-2-1 and BR11868-5R-2 produced higher yield than checks. Therefore, BR9829-78-1-2-1 and BR11868-5R-2 were selected for further variety development activities.

Hybridization, T. Aman 2022

In this hybridization programme, local popular varieties Rajashail, Kajalshail and Kalobajal were used as female and 36 BRRi varieties were used as male parents, expected to introgress genes from diverse genetic background for the improvement of local popular photosensitive variety with higher yield (7.0 t/ha), slender grain, lodging tolerance. Crossing was done among the desirable parents. Usual method of emasculation and pollination was followed for crossing.

Table 1. List of Rajashail crosses made during T. Aman, 2022-23, BRRi RS, Sonagazi.

Parentage	No. of emasculated panicle	No. of F1 seeds	Date of pollination
Rajashail/BR11	3	56	15 Oct 2022
Rajashail/BR3	2	52	10 Oct 2022
Rajashail/BRRi dhan103	6	71	12 Oct 2022
Rajashail/BRRi dhan49	4	120	9 & 11 Oct 2022
Rajashail/BRRi dhan52	5	88	8 & 11 Oct 2022
Rajashail/BRRi dhan54	4	27	12 Oct 2022
Rajashail/BRRi dhan70	3	24	14 Oct 2022
Rajashail/BRRi dhan71	3	71	15 Oct 2022
Rajashail/BRRi dhan72	2	15	13 Oct 2022
Rajashail/BRRi dhan75	5	102	9 & 13 Oct 2022
Rajashail/BRRi dhan76	2	32	15 Oct 2022
Rajashail/BRRi dhan77	3	88	15 Oct 2022
Rajashail/BRRi dhan78	2	18	13 Oct 2022
Rajashail/BRRi dhan79	4	93	11 & 12 Oct 2022
Rajashail/BRRi dhan80	2	15	12 Oct 2022
Rajashail/BRRi dhan87	4	89	7 & 8 Oct 2022
Rajashail/BRRi dhan90	2	33	14 Oct 2022
Rajashail/BRRi dhan94	3	15	10 Oct 2022

Table 2. List of Kajalshail crosses made during T. Aman, 2022-23, BRRi R/S, Sonagazi.

Parentage	No. of emasculated panicle	No. of F1 seeds	Date of pollination
Kajolshail/BR10	3	108	3 Nov 2022
Kajolshail/BR11	2	136	3 Nov 2022
Kajolshail/BR22	2	37	2 Nov 2022
Kajolshail/BR22	2	85	2 Nov 2022
Kajolshail/BR22	1	35	3 Nov 2022

Parentage	No. of emasculated panicle	No. of F1 seeds	Date of pollination
Kajolshail/BR23	3	142	3 Nov 2022
Kajolshail/BRRI dhan103	2	120	1 Nov 2022
Kajolshail/BRRI dhan34	4	147	1 Nov 2022
Kajolshail/BRRI dhan46	3	173	2 Nov 2022
Kajolshail/BRRI dhan49	4	70	31 Oct 2022
Kajolshail/BRRI dhan51	2	121	3 Nov 2022
Kajolshail/BRRI dhan52	2	53	2 Nov 2022
Kajolshail/BRRI dhan54	5	149	31 Oct 2022
Kajolshail/BRRI dhan87	4	103	31 Oct 2022
Kajolshail/BRRI dhan75	4	218	1 Nov 2022

Table 3. List of Kalobajal crosses made during T. Aman 2022-23, BRRI RS, Sonagazi.

Parentage	No. of emasculated panicle	No. of F1 seeds	Date of pollination
Kalobajal/BR22	4	56	12 Nov 2022
Kalobajal/BR23	5	70	11 & 13 Nov 2022
Kalobajal/BRRI dhan52	1	11	12 Nov 2022
Kalobajal/BRRI dhan87	2	34	12 Nov 2022
Kalobajal/BRRI dhan93	1	14	12 Nov 2022

Table 4. List of Ratoon crosses made during T. Aman 2022-23, BRRI RS, Sonagazi.

Parentage	No. of emasculated panicle	No. of F1 seeds	Date of pollination
Rajashail/BR22	8	77	08, 11, 13 Nov 2022
Rajashail/BR23	5	55	9, 12, 13 Nov 2022
Rajashail/BRRI dhan93	4	83	15 Nov 2022

Table 5. List of BR22 & BR23 crosses made during T. Aman 2022-23, BRRI RS, Sonagazi.

Parentage	No. of F1 seeds	No. of emasculated panicle	Date of pollination
BR22/BR23	1	17	1 -Nov 2022
BR23/BR22	2	16	17 Nov 2022

Results: Forty-three crosses were made using 30 parents (Table 6).

Investigators: M Adil, S Tamanna, B karmakar
Regional Yield Trials (RYT), T. Aman 2022

Fifty-seven lines along with standard checks BRRI dhan49, BRRI dhan71, BRRI dhan72, BRRI dhan73, BRRI dhan87, BRRI dhan91, BRRI dhan93, BRRI dhan94 and IRBB60 were tested under 10 RYT (BB, RLR, Tidal, ZER, LS, SS, STR1, STR2,

STR1- Farmers' Field, STR2-Farmers' Field) in BRRI, Sonagazi, Feni to test the yield performance and to evaluate the yield potential and adaptability.

Investigators: M Adil, S Tamanna, B Karmakar
RYT bacterial blight (BB) during T. Aman 2022

Four advanced breeding lines along with three standard checks BRRI dhan87 and IRBB60 were

evaluated at BRRI RS, Sonagazi, Feni during Aman 2022. The advanced breeding lines BR11869-5R-47 and BR11874-5R-109 produced higher yield than checks. So, BR11869-5R-47 and BR11874-5R-109 selected for further varietal development activities.

RYT zinc enriched rice (ZER) during T. Aman 2022

Four advanced breeding lines along with two standard checks BRRI dhan72 and BRRI dhan87 were evaluated at BRRI, Sonagazi, Feni during Aman 2022. The advanced breeding line BR9674-1-1-5-2-P4-HR1 produced higher yield than the checks. So, BR9674-1-1-5-2-P4-HR1 was selected for further variety development activities.

RYT (Tidal) during T. Aman 2022

Four advanced breeding lines along with one standard check BRRI dhan91 were evaluated at BRRI, Sonagazi, Feni during Aman 2022. The advanced breeding line BR10238-5-1-9-3B produced higher yield than the check. So, BR10238-5-1-9-3B was selected for further variety development activities.

Advanced line adaptive research trial (ALART)

Four ALARTs were conducted at experimental field of BRRI RS, Sonagazi, Feni to test the yield performance and to evaluate the yield potential and adaptability of superior breeding lines,

ALART STR Aman 2022

In Aman 2022 two STR trials were conducted, one in Sonagazi, Feni and the other in Companiganj, Noakhali. Three advanced breeding lines were tested with two local check BRRI dhan73 and BRRI dhan87. Lines BR11712-4R-218 and BR11716-4R-102 showed better yield performance than the check varieties in Sonagazi, Feni (Table 1). In Companiganj lines BR11712-4R-218 and BR11716-4R-102 showed better yield performance than BRRI dhan73 but statistically similar with BRRI dhan87.

ALART for premium quality rice (PQR), T. Aman 2022

Two lines BR8493-3-5-1-P1 and BR9590-45-1-3-2-P2 were evaluated against two standard checks in ALART (PQR). Two genotypes produced lower yield (2.90 and 2.82 t ha⁻¹) compared to two check varieties (2.69 and 3.23 t ha⁻¹). BR8493-3-5-1-P1 genotype showed the highest yield (2.90 t ha⁻¹) with

the lowest growth duration (127 days) the compared to other genotypes.

Re-ALART for submergence tolerance rice; long duration (SubTR-LD), Aman 2022

Two lines BR9158-19-9-6-50-2-HR1 and IR13F441 were evaluated against two standard checks in ALART (SubTR-LD). The average grain yield of all advanced lines (5.58 - 5.03 t ha⁻¹) was higher than the check variety BRRI dhan44 and BRRI dhan52 (5.10 t ha⁻¹, 5.25 t ha⁻¹ respectively). BR9158-19-9-6-50-2-HR1 genotype showed the yield (2.90 t ha⁻¹) with the lowest growth duration (136 days) than the other genotypes but IR13F441 genotype showed the highest yield (5.58 t ha⁻¹) with lowest growth duration (137 days) than the two standard checks.

Re-ALART for submergence tolerance rice; long duration (SubTR-LD), Aman 2022

Among the advanced line and check varieties, the advanced line IR13F441 produced the highest yield (5.51 t ha⁻¹) followed by the 2nd highest average yield (5.1 t ha⁻¹) by the standard check BRRI dhan52. On an average, all the entries matured within 135-143 days. The variety BRRI dhan44 produced the highest growth duration (GD) of 143 days whereas IR13F441 line had the lowest GD of 135 days. The mean plant height of BRRI dhan44 was higher 131cm than the others. All the data represented here were mean data from replicated entries.

Hybridization, Boro 2022-23

In this hybridization programme, popular varieties BRRI dhan67, BRRI dhan74, BRRI dhan97 and BRRI dhan99 were used as female and 22 BRRI varieties/Breeding lines were used as male parents, expected to introgress genes from diverse genetic background for the improvement of popular variety BRRI dhan67, BRRI dhan74, BRRI dhan97 and BRRI dhan99 with higher yield (8.5. t/ha), slender grain, lodging tolerance, salt tolerant and disease resistant. Crossing was done among the desirable parents. Usual method of emasculation and pollination was followed for crossing.

Results: Forty-three crosses were made using parents (Table 6).

Investigators: M Adil, S Tamanna, B Karmakar

Table 6. List of BRRI dhan67 crosses made during T. Aman 2022-23, BRRI Sonagazi.

Parentage	No. of emasculated panicle	No. of F ₁ seed
BRRI dhan67/BR11607-4R-72	4	26
BRRI dhan67/BR11712-4R-44	5	99
BRRI dhan67/BR11712-4R-93	1	4
BRRI dhan67/BR12180-5R-7	5	85
BRRI dhan67/BR11723-4R-12	1	18
BRRI dhan67/BR12177-5R-1	2	10
BRRI dhan67/BR11712-4R-79	3	47
BRRI dhan67/BR11716-4R-105	2	17
BRRI dhan67/BR11712-4R-1	2	15

Table 7. List of BRRI dhan74 crosses made during T. Aman 2022-23, BRRI RS, Sonagazi.

Parentage	No. of emasculated panicle	No. of F ₁ seed
BRRI dhan74/IRRI 154 (Pi9)	3	52
BRRI dhan74/BR11607-4R-72	5	64
BRRI dhan74/BR11712-4R-44	6	84
BRRI dhan74/BR11712-4R-93	2	29
BRRI dhan74/BR12180-5R-7	2	20
BRRI dhan74/BR11723-4R-12	2	61
BRRI dhan74/BR11716-4R-105	3	43
BRRI dhan74/BR11712-4R-1	4	76
BRRI dhan74/BPH resistant line	5	88

Table 8. List of BRRI dhan97 crosses made during T. Aman 2022-23, BRRI RS, Sonagazi.

Parentage	No. of emasculated panicle	No. of F ₁ seed
BRRI dhan97/BR11607-4R-72	3	38
BRRI dhan97/BR11712-4R-44	2	14
BRRI dhan97/BR11723-4R-38	3	26
BRRI dhan97/BR11723-4R-12	5	79
BRRI dhan97/BR11716-4R-64	2	9
BRRI dhan97/BR11712-4R-79	2	18
BRRI dhan97/BR11716-4R-105	5	90
BRRI dhan97/BR11712-4R-1	3	49

Table 9. List of BRRI dhan99 crosses made during T. Aman 2022-23, BRRI RS, Sonagazi.

Parentage	No. of emasculated panicle	No. of F ₁ seed
BRRI dhan99/BR11712-4R-93	3	172
BRRI dhan99/BR12180-5R-7	2	85
BRRI dhan99/BR12177-5R-1	5	83
BRRI dhan99/BR11712-4R-227	2	14
BRRI dhan99/BR11715-4R-16	3	58
BRRI dhan99/BR11712-4R-79	4	104
BRRI dhan99/BR11716-4R-105	2	25
BRRI dhan99/BR11712-4R-1	3	84

Results: Forty-three crosses were made using 26 parents (Table 6).

Investigators: M Adil, S Tamanna, B karmakar

Regional yield trials (RYT), Boro 2022-23

One hundred eighteen lines along with standard checks BRRI dhan28, BRRI dhan29, BRRI dhan50, BRRI dhan58, BRRI dhan63, BRRI dhan67, BRRI dhan74, BRRI dhan81, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan96, BRRI dhan97, Indonesian black rice and Local checks (Zirashail, Tepi Boro and Rata Boro) were tested under 14 RYT (BB-Blast, BB, ZER, FBR-Barishal, FBR-SD, FBR-MD, FBR-LD, FBR-ELS, FBR-Biotechnology, PQR-Basmati, STR, Zira type, Antioxidant-Black rice-SD, Antioxidant-Black rice-MD) in BRRI, Sonagazi, Feni to test the yield performance and to evaluate the yield potential and adaptability.

RYT favourable Boro rice short duration (FBR SD), Boro 2022- 23

Nine advanced breeding lines along with two standard checks BRRI dhan28 and BRRI dhan96 were evaluated at BRRI RS, Sonagazi, Feni during Boro 2022-23. The advanced breeding lines BR11637-5R-140, BR11903-5R-56 and BR12208-5R-402 produced higher yield than the checks. So, BR11637-5R-140, BR11903-5R-56 and BR12208-5R-402 were selected for further varietal development activities.

RYT favorable Boro rice medium suration, Boro 2022-23

Nine advanced breeding lines along with two standard checks BRRI dhan81 and BRRI dhan89

were evaluated at BRRI RS, Sonagazi, Feni during Boro 2022-23. The advanced breeding lines IR18A1398 and IR18A1907 produced higher yield than the checks (Table 7). So, IR18A1398 and IR18A1907 were selected for further variety development activities.

RYT favorable Boro rice long duration Boro 2022-23

Five advanced breeding lines along with three standard checks BRRI dhan81, BRRI dhan89 and BRRI dhan92 were evaluated at BRRI RS, Sonagazi, Feni during Boro 2022-23. The advanced breeding lines BR11894-5R-260 and BR11318-5R-84 produced higher yield than the checks. Therefore, BR11894-5R-260 and BR11318-5R-84 were selected for further variety development activities.

RYT favorable Boro rice extra-long-slender, Boro 2022-23

Six advanced breeding lines along with three standard checks BRRI dhan50, BRRI dhan63 and BRRI dhan86 were evaluated at BRRI, Sonagazi, Feni during Boro 2022-23. The advanced breeding lines BR9945-5R-21, IR18A2102 and BR7528-2R-19-16-R1L-59 produced higher yield than the checks). Therefore, BR9945-5R-21, IR18A2102 and BR7528-2R-19-16-R1L-59 were selected for further varietal development activities.

RYT favorable Boro rice Barishal Boro 2023

Nine advanced breeding lines along with two standard checks BRRI dhan88 and BRRI dhan89 were evaluated at BRRI RS, Sonagazi, Feni during

Boro 2022-23. The advanced breeding lines NGR 418-1, NGR 968-1, NGR 994-1 and NGR 745-2 produced higher yield than the checks. So, NGR 418-1, NGR 968-1, NGR 994-1 and NGR 745-2 were selected for further varietal development activities.

RYT salt tolerant rice (STR) Boro 2022-23

Seven advanced breeding lines along with three standard checks BRRi dhan97, BRRi dhan89 and BRRi dhan99 were evaluated at BRRi RS, Sonagazi, Feni during Boro 2022-23. The advanced breeding lines BR11712-4R-44 and BR11712-4R-93 produced higher yield than the all checks. But BR11712-4R-12 and BR11712-4R-346 produced higher yield than BRRi dhan97. So, BR11712-4R-44, BR11712-4R-93, BR11712-4R-12 and BR11712-4R-346 were selected for further varietal development activities.

RYT Bacterial Blight (BB) Boro 2022-23

Eighteen advanced breeding lines along with three standard checks BRRi dhan58, BRRi dhan89 and BRRi dhan92 and one resistant check BRRi dhan101 were evaluated at BRRi RS, Sonagazi, Feni during Boro 2022-23. The advanced breeding lines (BR(Path)13800-BC3-8-1 and BR(Path)13800-BC3-109-10 produced higher yield than the checks and showed better performance against BB and blast. Therefore, (BR(Path)13800-BC3-8-1 and BR(Path)13800-BC3-109-10 were selected for further varietal development activities.

RYT blast-bacterial blight (Blast-BB) Boro 2022-23

Ten advanced breeding lines along with three standard checks BRRi dhan89 and BRRi dhan92 were evaluated at BRRi RS, Sonagazi, Feni during Boro 2022-23. The advanced breeding lines BR (Path)13800-BC3-8-5, BR (Path)13800-BC3-134-8, BR (Path)13800-BC3-8-11, BR (Path) -13800-BC3-12-13 and BR (Path)13800-BC3-134-25 produced higher yield than checks and showed better performance against blast and BB. Therefore, (BR (Path)13800-BC3-8-5, BR(Path)13800-BC3-134-8, BR(Path)13800-BC3-8-11, BR (Path)13800-BC3-12-13 and BR (Path) 13800 -BC3-134-25 were selected for further variety development activities.

AGGRi network trials (ANT) for salt-stress prone environment in Boro 2023

A total of 190 RGA (rapid generation advance) derived IRRI breeding lines along with six global and four national check varieties were evaluated at coastal saline environment like Companiganj of Noakhali district under BRRi RS, Sonagazi, Feni during dry season (DS) Boro 2023 to understand salinity resistant and to select superior lines for direct use in variety release or as parents in the breeding programme. The trials were designed in Alpha lattice design with two replications. Unit plot size was 3.12 m² (27 hills × 5 rows). Two to three seedlings per hill were transplanted following 20 cm × 20 cm spacing in the trial. Forty-seven-day-old seedlings were transplanted on 3-4 February 2023 at Companiganj, Noakhali. Applied fertilizers N, P, K, S and Zn @ 120, 22, 75, 20 and 2.7 kg ha⁻¹ as urea, TSP, MOP, gypsum and zinc sulfate in the experimental field. All amount of P, K, S and Zn was applied at the time of final land preparation and nitrogen (urea) were applied in three equal splits at 10, 25 and 45 days after transplanting (DAT). Saline water was imposed in experimental field to increasing salinity stress for the crop.

Results and discussion. Grain yield of the genotypes tested under AGGRi Network Trial (ANT) under salinity stress varied significantly within the two replications. The entries showed a wide range of variations in grain yield started from 0.56 to 4.23 t ha⁻¹ with a mean value of 1.98 t ha⁻¹ in first replication and 0.58 to 3.68 t ha⁻¹ with mean value of 2.26 t ha⁻¹ in second replication. The overall performance across the site of the tested lines varied from 0.62 to 3.40 t ha⁻¹ with mean value of 2.12 t ha⁻¹. Flowering (50%) and Growth duration also varied significantly within the sites. The entries varied in flowering from 103-126 days and growth duration from 129 to 152 days. Wider variations in plant height were also observed within location. Plant height of the entries varied from 63 to 118 cm. During the experimental period, significant salinity level observed. Mean was salinity levels were 3.0, 19.69 and 5.15 dS/m at vegetative, flowering and maturity stages, respectively. A total of five rice genotypes entry no. 37 (IR21LT1293), 39 (IR21LT1605), 119 (IR21LT1157), 131

(IR21LT1048), and 148 (IR21LT1679) performed better than the check varieties. Those five genotypes were selected based on yield performance (3.13 to 3.40 t ha⁻¹), growth duration (131-142 days), plant height (82-91 cm) and salinity score (3-5) under salinity stress for further investigation.

Head-to-head adaptive trial under TRB Project during Aman 2022

Ten HHAT (Costal Ecosystem-5, Short duration-2 and Flash flood system-3) were conducted at Sonagazi, Fulgazi, Mirsarai, Chakaria, Cox's bazar Sadar upazilas of different districts during Aman 2022. For Costal ecosystem five varieties viz BINA dhan10, BINA dhan23, BRRI dhan73, BRRI dhan78 and BRRI dhan79 were used, for six short duration varieties viz BRRI dhan71, BRRI dhan75, Binadhan-7, 6, 17 and 22 were used, for Flash flood system viz Binadhan-11, BR11, BRRI dhan51, BRRI dhan52, BRRI dhan79 and Lal Guti Swarna were used in those adaptive trial. In case of costal ecosystem BRRI dhan79 yielded the highest in average of the locations (5.22 t ha⁻¹), In case of short duration, BRRI dhan75 yielded the highest on average of the locations (5.46 t ha⁻¹), In cases of flash flood system BRRI dhan52 yielded the highest average of the locations (4.98 t ha⁻¹).

Head-to-head adaptive trial under TRB project during Boro 2022-23

Fifteen HHAT (Short duration-3, long duration-3, Salinity-3 and hill-6) were conducted at Sonagazi, Feni Sadar, Chagolnaiya, Mirsarai, Companiganj, Cox's bazar Sadar, Khagrachari Sadar, Mahalchari, Manikchari, Guimara, Ramgarh upazilas of different districts during Boro 2022-23. For short duration, six varieties viz BRRI dhan28, BRRI dhan97, BRRI dhan88, Bangabandhu dhan100, BAU dhan3 and Binadhan-25 were used; for long duration five varieties viz BRRI dhan29, BRRI dhan89, BRRI dhan92, BRRI dhan102 and Binadhan-24 were used, for salinity four rice varieties viz BRRI dhan28, BRRI dhan67, BRRI dhan97 and BRRI dhan99 were used, for hill five varieties viz BRRI dhan28, BRRI dhan97, BRRI dhan84, BRRI dhan88 and Bangabandhu dhan100 were used in those adaptive trials. In case of short duration BRRI dhan97 yielded the highest on

average of the locations (7.05 t ha⁻¹). In case of long duration BRRI dhan102 yielded the highest on average of the locations (8.14 t ha⁻¹). In case of salinity BRRI dhan99 yielded the highest on average of the locations (6.17 t ha⁻¹). In case of hill Bangabandhu dhan100 yielded the highest on average of the locations (7.11 t ha⁻¹).

PEST MANAGEMENT

Survey and monitoring of rice diseases

Survey was carried out at farmers' fields of Feni, Noakhali, Laxmipur, Cox'sbazar, Chattogram and Khagrachari districts both in T. Aman 2022 and Boro 2022-23. Sites were selected with the suggestion and in collaboration with upazila Agricultural Officer (UAO) of the Department of Agricultural Extension (DAE). Sub Assistance Agricultural Officer (SAAO) of the concerned block helped in site selection who were the front-line workers and very much familiar to the farmers as well as their fields. Bacterial Leaf Blight (BLB), bacterial leaf streak (BLS), sheath rot, false smut and sheath blight infestation were observed in different scores during T. Aman season. BRRI dhan49 in different locations and other breeding materials of BRRI RS, Sonagazi research field were affected by false smut disease in different locations due to fluctuation of environmental conditions during Aman season. BRRI dhan28, BRRI dhan29, BRRI dhan97, BRRI dhan89, BRRI 92 and BRRI dhan84 were affected moderately to high by neck blast during Boro season. The farmers were suggested for taking preventive measures using fungicide.

Monitoring of insect pests and natural enemies by using light trap

Rice insect pests and their natural enemies were monitored throughout the reporting period by Pennsylvanian light traps from July 2022 to June 2023 at the experimental field of BRRI RS, Sonagazi, Feni. The abundance of leaf roller, Stem borer, rice bug, green leafhopper, grasshopper, mole cricket, field cricket, and stink bug were found in the light trap during the reporting period. Some beneficial insects like lady bird beetle, spider, damselfly, carabid beetle, staphylinid beetle were also found.

Reduction of insecticide use in rice production to ensure safe food production

The experiment was conducted at the experimental field of BRRI, RS, Sonagazi during Boro 2022-23 designed to manage insect pests with less or no use of insecticide and to compare insect pests and natural enemy status in insecticide free and insecticide spray field. Three BRRI varieties i.e., V1=BRRI dhan96, V2=BRRI dhan97 and V3=Bangabandhu dhan100 were transplanted separately in a one bighas of field. Each field was divided into two for two treatments i.e., T₁=Refrained from insecticide use up to 40 days (to increase natural enemies) and T₂= Prophylactic insecticide use@15 days interval (3 times). This experiment was laid out in a CRD with three replications. Forty-day-old seedlings of each variety were transplanted in one bighas of land using 2-3 seedlings with a spacing of 20 cm x 20 cm. BRRI recommended fertilizer doses was used in all the plots. All the intercultural operations were done when required except insecticide use. Insect pests and natural enemies in the rice field was monitored fortnightly by sweeping and visual counting of randomly selected 20 hills. Perching @100/ha were also used in T₁ and insecticide used ETL based or not. In T₂, granular insecticide was used during 1st top dressing of urea as a farmers practice without considering insect infestation. Another two times insecticide were also used at 15 days interval in T₂. Bangabandhu dhan100 and BRRI dhan97 produced significantly higher yield in T2 (Prophylactic insecticide use) treatment as compared to T1 (Refrained from insecticide) treatment. BRRI dhan96 produced significantly similar yield in both treatments. Significantly higher number of white head (caused by yellow stem borer attack) and ETL percentage was found in all three varieties using T1 treatment as compared to T2 treatment. Nevertheless, BRRI dhan100 produced the highest yield (6.59 tha⁻¹) using T2 treatment as compared to all treatment-variety combinations. Besides, BRRI dhan97 showed the highest number of white head (139) and ETL percentage (4.38) using T1 treatment as compared to all treatment-variety combinations. All treatment-variety combinations showed below 5% ETL.

CROP-SOIL WATER MANAGEMENT

Effect of planting date on the performance of modern rice varieties at southeast of Bangladesh, Boro 22-23

During Boro 2022-23 season this experiment was conducted at BRRI RS, Sonagazi farm, aimed to identify a suitable planting window of Boro rice cultivars to maximize grain yield. From 5 December 2022 – 25 January 2023 the selected varieties were transplanted. Thirty-five-day-old seedlings were used for transplanting. The spacing was 20 cm x 20 cm. Each plot size was 2.6m x 3.80 m. Total number of plots was 72 and area for each set was 9.88 m x 12 = 118.56m². This experiment was laid out in a split plot design with three replications. Fertilizer doses were applied as per requirements. Urea top dressing was done at 20, 35 and 50 days after transplanting. BRRI dhan92 produced higher grain yield (8.63 t/ha) followed by BRRI dhan89 (8.34 t/ha) than the delayed transplanting and the seeding date was 1st November 2022 which was transplanted at 5 December 2022. The lowest grain yield of the tested varieties was found on 20 December 2022 seeding date and 25 January 2023 transplanting date (Table 15).

Optimizing planting geometry of Bangabandhu dhan100, Boro 202-23

The experiment was conducted at the experimental field of BRRI RS, Sonagazi during Boro 2022-23 aimed to investigate the responses of Bangabandhu dhan100 to varying plant spacings and to determine the optimum spacing for better performance of Bangabandhu dhan100. Forty-two-day-old seedlings were transplanted in 3m x 4m (12m²) unit plot by using 2-3 seedlings/hill with six different spacings (20 cm x 15 cm, 20 cm x 20 cm, 25 cm x 15 cm, 30 cm x 15 cm, 25 cm x 25 cm and 30 cm x 30 cm). The experiment was laid out following randomized complete block design (RCBD) with three replications. BRRI recommended fertilizer dose: N, P, K, S and Zn @ 124, 22, 75, 20 and 4 kg ha⁻¹ (270, 112, 150, 112 and 11 kg ha⁻¹) was used.

Result and discussions.

In this experiment six different spacing were used as treatment. The closest spacing (20 cm x 15 cm)

produced the highest grain yield (7.49 t/ha), which was gradually decreased with increasing spacing. In case of spacing (30 cm × 30 cm) the yield was reduced due to lodging loss whether it provided the lowest yield was 6.04 t/ha (Table 1). T₆ (30 cm × 30 cm) provided the highest number (216) of tiller, highest number of panicle (206) per 12 hills respectively. There was significant difference in plant height between the spacing such as 30 cm × 30 cm) and 20 cm × 15 cm. Among the spacings 20cm×15cm produced the highest grain yield (7.49 t/ha) which was statistically similar with the spacing 25 cm×15 cm (7.37 t ha⁻¹) (Table 24). This Table shows information about the biological yield and harvest index is significantly similar between T₁=20 cm × 15cm and T₃=25 cm × 15cm treatments. So, to get the highest grain yield from Bangabandhu dhan100, it is recommended to use closer spacing in coastal region, but if we want the highest tiller and panicle number, we can use wider spacing (Fig. 1 and Table 16).

Nitrogen Use Efficiency on Modern Rice Variety for Boro Season

The experiment was conducted at the experimental field of BRRI RS, Sonagazi during Boro 2022-23 aimed to evaluate the responses of Bangabandhu dhan100 under a range of nitrogen supplies, to investigate the nitrogen use efficiency and to find out optimum nitrogen requirement for maximum yield of Bangabandhu dhan100 and to determine the optimum spacing for better performance of Bangabandhu dhan100. The variety was used as planting material. Forty-three-day-old seedlings were transplanted in 3m x 4m (12m²) unit plot using 2-3 seedlings with 20 cm × 20 cm spacing. The experiment was laid out following randomized complete block design (RCBD) with 3 replications. Seven levels of nitrogen were used as treatments and applied in the experiment as T₁= BRRI recommended dose: N, P, K, S and Zn @ 124, 22, 75, 20 and 4 kg ha⁻¹ (270, 112, 150, 112 and 11 kg ha⁻¹), T₂ = T₁ - N, T₃ = T₁ but 50 kg N ha⁻¹, T₄ = T₁ but 100 kg N ha⁻¹, T₅ = T₁ but 150 kg N ha⁻¹, T₆ = T₁ but 200 kg N ha⁻¹, T₇ = Soil test based (STB) nutrient rates (N, P, K, S and Zn @ 88, 15, 54, 6 and 1 kg ha⁻¹); Recorded in 2021, Soil Science Lab, BRRI, Gazipur. T₈ = Control/Native Nutrient

Result and discussions. In this experiment, eight different treatments were used. There was a positive effect of different N fertilizer doses on growth and yield components of Bangabandhu dhan100. The maximum plant height was recorded 114.9 cm under the treatment T₆ (T₁ but 200 kg N ha⁻¹) and the lowest plant height was 89.37cm under the treatment T₂ (T₁ - N). T₆ shows the highest number (157) of tiller/12 hill and the lowest number (98) of tiller/12hill was observed in T₈. Average highest panicle number/12 hill (144) was obtained in T₆ treatment and the lowest panicle number/12 hill (82) was obtained in treatment T₈. Nutrient controlled plot gave the lowest yield compared to other fertilizers treatment (Table 23). T₆ which produced the highest yield 8.12 t/ha whether the lowest yield was 3.39 t/ha at T₈. Finally, higher grain yield and straw yield was observed by the application of increased N rates than the recommended N rate.

Multi-location Yield Trials (MLT) of promising Hybrid T. Aman 2022

The experiments conducted at BRRI RS, Sonagazi, during T. Aman 2022, were pointed to assess the yield of promising rice hybrids at different locations for their adaptability. Eleven and ten hybrids with three checks were used as planting materials in Set-1 and Set-2, respectively. Twenty-one-day-old seedlings were transplanted with a spacing of 20 × 15 cm² using one seedling/hill. Fertilizers were applied @ with 150:100:70:60:10 kg/ha urea, TSP, MP, gypsum and ZnSO₄ respectively. Intercultural and agronomic practices were made when necessary.

Results and discussions. In MLT Set-1, entry AZ 7006 (ck-2) produced the highest yield (6.42 t/ha) compared to the other entries (5.77-4.33 t/ha) and showed 120 cm plant height with 118 days growth duration. On the other hand, entry BRRI97A/BRRI53R, BRRI97A/BRRI42R, BRRI99A/BRRI42R, BRRI97A/BRRI43R and Dhanny Gold (ck-3) produced satisfactory higher yield (5.77-5.63 t/ha) than rest of the entries (5.39-4.33 t/ha) and exhibited 105-117 cm plant height with 109-120 days growth duration. So, on the basis of yield, growth duration, plant height and other agronomic characters, the entries BRRI97A/BRRI53R,

BRR197A/BRR142R, BRR199A/BRR142R and BRR197A/BRR143R were selected for advanced trials (Table 17).

In MLT Set-2, entry IR78369A/BRR142R produced the highest yield (7.01 t/ha) compared to the other entries (6.93-5.72 t/ha) and showed 109 cm plant height and 119 days growth duration. On the other hand, the entries IR58025A/BRR146R, IR102758A/BRR142R, IR58025A/BRR143R, IR105688A/BRR143R and IR78369A/BRR153R produced satisfactory higher yield (6.93- 6.38 t/ha) than the rest of the entries (5.72-6.29 t/ha) and exhibited 109-115 cm plant height with 108-112 days growth duration. So, on the basis of yield, growth duration, plant height and other agronomic character, entry IR78369A/BRR142R, IR58025A/BRR146R, IR102758A/BRR142R, IR58025A/BRR143R, IR105688A/BRR143R and IR78369A/BRR153R were selected for advanced trials (Table 18).

Multi-location Yield Trials (MLT) of promising hybrids Boro 2022-23

The experiments conducted at BRR1 RS, Sonagazi, during Boro 2022-23, were pointed to find out suitable promising hybrids for Boro season. Fourteen hybrids with four checks were used as planting materials. Thirty-Five-day-old seedlings were transplanted with a spacing of 20 × 15 cm² using one seedling/hill. Fertilizers were applied @ with 280:150:150:75:12 kg/ha urea, TSP, MP, gypsum and ZnSO₄ respectively. Intercultural and agronomic practices were made when necessary. Among fourteen hybrids, entry BRR197A/BRR142R showed yield advantage ranging from 0.43-53% over all the checks. Entry BRR1125A/EL86R and BRR197A/BRR138R produced yield advantage ranging from 2-9% over SL8H (ck-2), 6-15% over Heera-2 and 34-45% over Tej Gold. Therefore, three hybrids BRR197A/BRR142R, BRR1125A/EL86R and BRR197A/BRR138R were selected based on stable yield performance and yield advantage over the checks.

Soil management to maximize the yield of newly released rice varieties

This experiment was conducted in BRR1 RS, Sonagazi farm during Aman 2022 and Boro 2022-23, designed to know the fertilizers combination

for maximum rice yield and to know the effect of more nitrogen and potassium on rice yield to the farmers of char land. This experiment was done in split plot design with three replications and three rice varieties in each season. In Aman (BRR1 dhan87, BRR1 dhan95 and BRR1 dhan94) and in Boro (BRR1 dhan89, BRR1 dhan92 and BRR1 dhan96) were used. From this experiment rice grain yield, tiller/m², panicle/m², grain/panicle, 1000 grain weight, plant height and unfilled grain percent data was collected. Soil test based nutrient recommendation in Sonagazi was 88:15:54:6 kg/ha for T. Aman season and 178:24:82:10:1.7 kg/ha for Boro season. Different levels of fertilizer dose were used as treatments T1= soil test based fertilizer application, T2= soil test based fertilizer plus 20% more nitrogen, T3= soil test based fertilizer plus 20% more potassium and T4= soil test based fertilizer with available organic matter (2 t/ha).

Results and discussion. Aman 2022: The results showed that the highest grain yield was found in T4= STB+cow dung (2 t/ha) for BRR1 dhan87 (5.93 t/ha), BRR1 dhan94 (4.86 t/ha) and BRR1 dhan95 (5.50 t/ha) but in STB BRR1 dhan95 (5.56 t/ha) which is insignificant. In consideration of variety, the treatments effect was significant for BRR1 dhan87, but BRR1 dhan94 and BRR1 dhan95 is insignificant. For BRR1 dhan87 and BRR1 dhan94 the treatment STB + Cow dung (2 t/ha) gave highest grain yield which was statistically significant from other treatments. The results also indicated that STB + cow dung (2 t/ha) treatment is enough for the maximum yield of the tested varieties BRR1 dhan87, BRR1 dhan94 and BRR1 dhan95.

Boro 2022-23. The results showed that the highest grain yield was found in STB for BRR1 dhan92 (9.31 t/ha), BRR1 dhan89 (7.66 t/ha) and BRR1 dhan96 (7.14 t/ha) for STB + 20% more N. In consideration of variety the treatments effect was significant for BRR1 dhan89, BRR1 dhan92 and BRR1 dhan96. For BRR1 dhan96 the treatment STB + 20% more N gave highest grain yield which was statistically significant from other treatments. The results also indicate that STB dose treatment is enough for the maximum yield of tested varieties BRR1 dhan89 and BRR1 dhan92 but BRR1 dhan96 required 20% more N than STB dose.

SOCIO-ECONOMIC AND POLICY

Stability analysis of BRRI developed rice varieties

Three experiments on stability analysis of BRRI developed rice varieties were conducted in Aus 2022, Aman 2022 and Boro 2023 seasons. The experiments were laid out in RCBD with three replications. Standard management practices were followed for all the experiments in all the seasons.

Stability analysis Aus 2022. Among the varieties, BRRI dhan98 ranked the top in terms of yield (6.36 t ha⁻¹) followed by BRRI hybrid dhan7 (5.875 t/ha). The varieties BR21, BRRI dhan65, and BRRI dhan27 were found low yielding having grain yield 3.300, 3.356 and 3.713 t ha⁻¹ respectively.

Stability analysis Aman 2022. Among the varieties, BRRI dhan103 ranked the top in terms of yield (5.704 t ha⁻¹) followed by BRRI dhan52 (5.582 t/ha). The variety BR5, BRRI dhan62, and BRRI dhan91 were found low yielding having grain yield 2.512, 3.153 and 3.202 t ha⁻¹ respectively.

Stability analysis Boro 2023. Among the varieties, BRRI dhan89 ranked the top in terms of yield (8.557 t ha⁻¹) followed by BRRI dhan92 (8.481 t/ha). The variety BR7, BR17 and BR8 were found low yielding having grain yield 4.213, 4.817 and 5.039 t ha⁻¹ respectively (Fig. 5).

TECHNOLOGY TRANSFER

Demonstration of modern rice varieties

Demonstration in Aus 2022 under Karmasuchi. A total of 162 SPDPs were executed in 162 bigha land under 18 upazilas of Chattogram and Rangamati regions in collaboration with DAE during Aus 2022 funded by Karmasuchi. BRRI dhan48, BRRI dhan82, BRRI dhan83, BRRI dhan85 and BRRI dhan98 were used in the SPDPs. Area of each SPDP was 1 bigha. BRRI dhan98 produced the highest mean grain yield (6.21 t ha⁻¹) followed by BRRI dhan48 (5.60 t ha⁻¹) and the lowest grain yield was found in BRRI dhan82 (4.21 t ha⁻¹). Total production of all the varieties was 1,29,439 kg from which 13,324 kg was retained as seeds (6% of total production) by the farmers for next season cultivation. About 14,159 farmers gained

awareness and knowledge about the varieties and 2,586 farmers (9%) were motivated to cultivate the varieties in next season.

Demonstration, Aman 2022 under GOB. A total of 300 SPDPs were executed in 360 bigha land in Chattogram and Rangamati regions during Aman 2022 in collaboration with DAE. BRRI dhan34, BRRI dhan49, BRRI dhan52, BRRI dhan70, BRRI dhan71, BRRI dhan75, BRRI dhan78 BRRI dhan79, BRRI dhan80, BRRI dhan87, BRRI dhan90, BRRI dhan91, BRRI dhan93, BRRI dhan94 and BRRI dhan95 were used in the SPDPs. Area of each SPDP was one bigha. BRRI provided input support like quality seeds, fertilizer and signboard while crop managements were done by the farmers under the supervision of DAE. BRRI dhan94 produced the highest mean grain yield (5.37 t ha⁻¹) followed by BRRI dhan87 (5.28 t ha⁻¹) and the lowest grain yield was found in BRRI dhan34 (3.38 t ha⁻¹). Total production of all the varieties was 2,41,526 kg from which 15,110 kg was retained as seeds (6% of total production) by the farmers for next season cultivation. About 21,526 farmers gained awareness and knowledge about the varieties and 3,004 farmers (17% of total farmers) were motivated to cultivate the varieties.

Demonstration during Aman 2022 under Karmasuchi

A total of 90 SPDPs were conducted during Aman 2022 at 13 upazilas of eight districts of Chattogram and Rangamati regions under Sonagazi development Karmasuchi. Eight modern rice varieties BRRI dhan71, BRRI dhan75, BRRI dhan78, BRRI dhan79, BRRI dhan80, and BRRI dhan87, BRRI dhan93 and BRRI dhan94 were demonstrated in the SPDPs. Area of each SPDP was one bigha and total area of SPDP was 90 bigha. Across the locations, BRRI dhan94 produced the highest grain yield (6.84 t ha⁻¹) at Fotikchari, Chattogram followed by BRRI dhan87 (6.62 t ha⁻¹) at Rangamati Sadar, Rangamati. The lowest yield (4.23 t ha⁻¹) was obtained in BRRI dhan78 at Kamalnagar, Laxmipur. Total production of all the varieties was 73,185 kg from which 6,657 kg was retained as seeds (10% of total production) by the farmers for next season cultivation. About, 4,475

farmers gained awareness and knowledge about the varieties and 780 farmers (17%) were motivated to cultivate the varieties. Farmers preferences based on overall performances and product profile of the tested varieties were BRRI dhan94> BRRI dhan87> BRRI dhan93> BRRI dhan79> BRRI dhan71> BRRI dhan75> BRRI dhan80> BRRI dhan78.

Demonstration in Boro 2022-23 under GOB

A total of 330 SPDPs were executed in 330 bigha land under 16 upazilas of eight districts Feni, Noakhali, Laxmipur Chattogram, Cox's bazar, Bandarban, Rangamati and Khagrachari during Boro 2022-23 in collaboration with the Department of Agricultural Extension (DAE). Eleven new Boro varieties like BRRI dhan97, BRRI dhan97, BRRI dhan84, BRRI dhan88, BRRI dhan89, BRRI dhan92, BRRI dhan97, BRRI dhan99, Bangabandhu dhan100 (BRRI dhan100), BRRI dhan101 and BRRI dhan102 were used in the SPDPs. Area of each SPDP was one bigha. BRRI provided input support like quality seeds, fertilizer and signboard while crop management activities were done by the farmers under the supervision of DAE. BRRI. BRRI dhan102 produced the highest mean grain yield (7.57 tha^{-1}) followed by BRRI dhan89 (7.51 tha^{-1}) and the lowest grain yield was found in BRRI dhan97 (5.54 tha^{-1}). BRRI dhan97 showed moderately to highly susceptible to neck blast disease. Total production of all the varieties was 3,05,112 kg from which 30,759 kg was retained as seeds (10%) by the farmers for next season cultivation. About 25,570 farmers gained awareness and knowledge about the varieties and 5,978 farmers (24%) were motivated to cultivate the varieties.

Demonstration in Boro 2022-23 under Karmasuchi

A total of 120 SPDPs were conducted in 15 upazilas of Chattogram and Rangamati regions under Sonagazi development Karmasuchi during Boro 2023. Nine modern rice varieties such as BRRI dhan97, BRRI dhan84, BRRI dhan89, BRRI dhan92, BRRI dhan97, BRRI dhan99, Bangabandhu dhan100, BRRI dhan101 and BRRI dhan102 were demonstrated in the SPDPs. Area of each SPDP was one bigha and total area of

SPDP was 120 bigha. Irrespective of varieties and locations, BRRI dhan102 produced the highest mean grain yield (7.83 tha^{-1}) followed by BRRI dhan101 (7.70 t ha^{-1}) and the lowest grain yield was found in BRRI dhan99 (5.74 t ha^{-1}). Across the locations, BRRI dhan102 produced the highest grain yield (8.92 t ha^{-1}) at Sonagazi, Feni followed by BRRI dhan101 (8.13 t ha^{-1}) at Sadar, Feni. The lowest yield (5.05 t ha^{-1}) obtained in BRRI dhan97 at Banskhali, Chattogram. Total production of all the varieties was 1,63,027 kg from which 9,790 kg was retained as seeds (7% of total production) by the farmers for next season cultivation. About 2,530 farmers gained awareness and knowledge about the varieties and 216 farmers (9%) were motivated to cultivate the varieties. Mean growth duration of BRRI dhan97, BRRI dhan84, BRRI dhan89, BRRI dhan92, BRRI dhan97, BRRI dhan99, Bangabandhu dhan100, BRRI dhan101 and BRRI dhan102 were 145, 140, 153, 158, 148, 149, 143, 150 and 149 days respectively. Farmers preferences based on overall performances and product profile of the tested varieties were BRRI dhan102> BRRI dhan101> BRRI dhan92> BRRI dhan89> Bangabandhu dhan100> BRRI dhan97> BRRI dhan84> BRRI dhan97> BRRI dhan99.

Demonstration in Aus 2022 under Hybrid project

A total of 114 demonstrations of modern rice varieties were conducted during May to September 2022 under hybrid rice project (Table 1). BRRI hybrid dhan7 rice variety demonstrated at farmers' field in the demonstrations. Area of each Demonstration was 1 to 3 bigha and total area of demonstrations was 15.4 ha. Total production was 97.53 ton. A total of 4,041 farmers acquired knowledge about the varieties from which farmers were motivated to cultivate the modern varieties.

Demonstration in Aman 2022 under Hybrid rice project. A total of 60 demonstrations of modern rice varieties were conducted during June to December 2022 under hybrid rice project. BRRI hybrid dhan6 rice variety was shown at farmers' field in the demonstrations. Area of each demonstration was 1 to 3 bigha and total area of demonstrations was 8.03 ha. Total production was 37.99 ton. A total of 3,306

farmers acquired knowledge about the varieties from which farmers were motivated to cultivate the modern varieties.

Demonstration of Hybrid rice in Boro 2023 under Hybrid rice project. A total of 66 demonstrations of modern rice varieties were conducted during December to May 2023 in Chattogram and Rangamati region under hybrid rice project. BRRI hybrid dhan3 and BRRI hybrid dhan5 rice were shown at farmers' field in the demonstrations. Area of each demonstration was 1 to 3 bigha and total area of demonstrations was 8.9 ha. Total production of BRRI hybrid dhan3 was 31.04 ton and BRRI hybrid dhan5 was 37.76 ton. A total of 3,555 farmers acquired knowledge about the varieties from which farmers are motivated to cultivate the modern varieties.

Demonstration in Aman 2022 Funded by TRB Project

A total of 60 SPDPs were conducted in 10 upazilas of eight districts (Feni, Noakhali, Laxmipur, Chattogram, Cox'sbazar, Khagrachari, Rangamati and Bandarban) under TRB during Aman 2022. Five modern rice varieties BRRI dhan78, BRRI dhan79, BRRI dhan87, BRRI dhan93 and BRRI dhan94 were demonstrated in the SPDPs. Area of each SPDP was one bigha and total area of SPDP was 60 bigha. Irrespective of variety and location, BRRI dhan87 produced the highest mean grain yield (6.29 t ha^{-1}) followed by BRRI dhan94 (5.57 t ha^{-1}) and the lowest grain yield was found in BRRI dhan78 (4.94 t ha^{-1}). Across the locations, BRRI dhan87 produced the highest grain yield (6.39 t ha^{-1}) at Bandarban Sadar, Bandarban followed by BRRI dhan78 (6.21 t ha^{-1}) at Kabirhat, Noakhali. The lowest yield (4.18 t ha^{-1}) was obtained in BRRI dhan78 at Raipur, Laxmipur. Total production of all the varieties was 43,178 kg from which 2,875 kg was retained as seeds (6% of total production) by the farmers for next season cultivation. About, 3,325 farmers gained awareness and knowledge about the varieties and 423 farmers (12% of total farmers) were motivated to cultivate the varieties. Farmers preferences based on overall performances and product profile of the tested varieties were BRRI dhan94> BRRI dhan87> BRRI dhan93> BRRI dhan79> BRRI dhan78.

Demonstration in Boro 2023 under TRB project.

A total of 60 demonstrations were conducted in 60 bigha land during Boro 2023 at farmers field of 20 upazilas of eight districts in Chattogram and Rangamati regions under TRB project. Five modern rice varieties BRRI dhan84, BRRI dhan92, and BRRI dhan97, BRRI dhan99 and Bangabandhu dhan100 were demonstrated in the SPDPs. Across the locations, BRRI dhan92 produced the highest grain yield (8.37 t ha^{-1}) at Raipur, Laxmipur followed by BRRI dhan102 (8.65 t ha^{-1}) at Feni Sadar, while the lowest yield (5.87 t ha^{-1}) obtained in BRRI dhan99 at Raipur Laxmipur. Total production of all the varieties was 60,536 kg from which 5,740 kg was retained as seeds (9.48% of total production) by the farmers for next season cultivation. About 5,219 farmers gained awareness and knowledge about the varieties and 942 farmers (18% of total farmers) were motivated to cultivate the varieties.

Farmers Training

A total of 104 farmers trainings on Modern Rice production technology were conducted in eight different districts during the reporting period. Out of 104 farmers' training 40 were funded by GoB and 64 were funded by BRRI RS, Sonagazi development programme. In farmers' training 2,397 male and 723 female farmers participated in which they were trained up with rice production technology in different ecosystems especially on tidal submergence, salinity and favorable environment. A total of 3,000 farmers and DAE staffs were trained during the reporting period.

Field Day

A total of 42 field days were arranged during Aus, T. Aman and Boro season. Out of 42 field days, 14 were funded by GOB, 26 by Karmasuchi and 2 by Hybrid rice project. Nearly 4,200 progressive farmers, local leaders, DAE field staff, public representatives and NGO workers participated in those occasions.

Activities of Premium Quality Rice (PQR) Project during 2022-23

Adaptive trial (AT) of PQR varieties. A total of 24 adaptive trials (AT) were conducted in four upazilas of two districts during Aman 2022 and

Boro 2023 under PQR project funded by KGF. Four upazilas are Royganj and Tarash of Sirajganj while Sherpur and Dhunat of Bogura district. Seven PQR varieties like BRRI dhan34, BRRI dhan70, BRRI dhan75, BRRI dhan80, BRRI dhan90, BRRI dhan103 and Binadhan-13 included in Aman 2022 while five rice varieties BRRI dhan63, BRRI dhan81, Bangabandhu dhan100, BRRI dhan102 and Binadhan-25 were used in the ATs. Standard management practices were followed in the trials.

AT Aman 2022. Irrespective of varieties and locations, the highest mean grain yield (5.13 t ha^{-1}) was found in BRRI dhan75 followed by BRRI dhan90 (4.91 t ha^{-1}). The lowest grain yield (3.01 t ha^{-1}) was obtained in Binadhan-13 followed by BRRI dhan34 (3.43 t ha^{-1}). Across the locations, BRRI dhan75 produced the highest grain yield (6.32 t ha^{-1}) that was at par with BRRI dhan90 (6.02 t ha^{-1}), while Binadhan-13 produced lowest yield 3.60 t ha^{-1} followed by BRRI dhan34 (4.02 t ha^{-1}).

AT Boro 2023. Grain yield and growth of the varieties significantly affected by genotypes and environments and their interaction ($G \times E$). Irrespective of variety and location, the highest mean grain yield (8.02 t ha^{-1}) was found in BRRI dhan102 followed by Bangabandhu dhan100 (6.91 t ha^{-1}). The lowest grain yield (5.14 t ha^{-1}) was obtained in Binadhan-25 followed by BRRI dhan81 (5.32 t ha^{-1}) and local variety Katari (5.54 t ha^{-1}). Across the locations, BRRI dhan102 produced the highest grain yield (8.77 t ha^{-1}) at Sherpur, Bogura and the lowest yield (4.26 t ha^{-1}) was found in Binadhan-25 at Tarash Sirajganj that was at par with BRRI dhan81 (4.55 t ha^{-1}) at Dhunat, Bogura.

Pilot production (PP) of PQR varieties

A total of 120 pilot production (PP) of PQR varieties were conducted in four upazilas of two districts (Sirajganj and Bogura) under PQR project during Aman 2022 and Boro 2023. Four PQR varieties BRRI dhan34, BRRI dhan75, BRRI dhan80, and BRRI dhan90 were used in Aman 2022, while five rice varieties BRRI dhan50, BRRI dhan63, BRRI dhan81, Bangabandhu dhan100 and BRRI dhan102 were used in Boro 2023. The programme was executed through public and private partnership (PPP).

PP Aman 2022. Across the locations, BRRI dhan75 produced the highest grain yield (6.03 t ha^{-1}) at Royganj, Sirajganj followed by BRRI dhan90 (5.71 t ha^{-1}) at Royganj, Sirajganj; while the lowest yield (2.81 t ha^{-1}) obtained in BRRI dhan34 at Royganj, Sirajganj. Total production of all the varieties was 34.55 ton of which 3,640 kg retained as seeds (11% of total production) by the farmers for next season cultivation. About 1,793 farmers gained awareness and knowledge about the varieties and 329 farmers (18%) were motivated to cultivate the varieties.

PP Aman 2022: Irrespective of varieties and locations, BRRI dhan102 produced the highest grain yield (8.46 t ha^{-1}) at Royganj, Sirajganj followed by Bangabandhu dhan100 (7.83 t ha^{-1}) at Sherpur, Bogura; while the lowest grain yield (4.73 t ha^{-1}) was obtained in BRRI dhan81 at Sherpur, Bogura followed by BRRI dhan50 (5.43 t ha^{-1}) at Tarash, Sirajganj. Total area and total production of all the varieties were 60 bigha and 52.74 t from which 2,750 kg was retained as seeds (5% of total production) by the farmers for next season cultivation. About 2,500 farmers gained awareness and knowledge about the varieties and 348 farmers (14% of total farmers) were motivated to cultivate the varieties.

Farmers' training under PQR project. Eight Farmers' training on premium quality rice (PQR) technologies was executed in Sirajganj and Bogura districts. About 240 farmers, extension personnel, and NGO personnel participated in these training programmes as trainee.

Field Day under PQR project

Twelve field days were conducted during the reporting period in Sirajganj and Bogura districts. Around 1,500 participants attended the field days and gathered knowledge about rice technologies.

ENRICHMENT OF SEED STOCK

F1 seed production of BRRI hybrid dhan5

In Boro2022-23 season, F1 seed production of BRRI hybrid dhan5 was conducted at the field of BRRI RS, Sonagazi. A total of 200 kg grain yield (0.17 t/ha) from BRRI hybrid dhan5 was obtained (Table 10).

Table 10: F1 seed production of BRRI hybrid dhan5 during Boro 2022-23.

Combination	Plant height(cm)		50% flowering date		PER (%)	OCR (%)	Yield	
	A line	R line	A line	R line			kg/8 bigha	t/ha
BRRI7A/BRRI31R	89	99	124	139	79	31	200	0.18

Date of Seeding: R1= 10 Dec 2022; R2= 17 Dec 2022; A= 4 Jan 2023

Date of Transplanting: R= 20 Jan 2023; A= 1 Feb 2023

PER (%) = Panicle exertion rate; OCR (%) = Out crossing rate

Breeder Seed Production

GOB Fund. A total of 30.25 ton breeder seeds were produced under GOB fund during the reporting period. All the Breeder seeds of different varieties were sent to Genetic Resource and Seed Division, BRRI, Gazipur.

Karmasuchi Fund A total of 35.6 ton breeder seeds were produced under Karmasuchi fund during the reporting period. All the Breeder seeds of different varieties were sent to Genetic Resources and Seed Division, BRRI, Gazipur.

Quality Seed (TLS) Production

GOB Fund. Twenty-five tons Truthfully labeled seeds (TLS) of modern rice varieties were produced by BRRI Sonagazi during the reporting period.

Karmasuchi Fund: A total of 43.73 ton TLS of modern rice varieties were produced by BRRI RS, Sonagazi during the reporting period.

BRRI RS KUSHTIA

566	Summary
567	Varietal Development
581	Rice Farming Systems
584	Crop-Soil-Water Management
587	Socio-Economics And Policy
592	Technology Transfer
593	Enrichment Of Seed Stock

SUMMARY

Fifty experiments or programmes were conducted from Aus 2022 to Boro 2022-23 under the programme area of Varietal Development, Rice Farming Systems, Crop-Soil-Water Management and Socio-Economics and Policy. Under the Varietal Development Programme Area, 41 trials (RYT, AYT, ALART, G×E interaction) were conducted, of which one trial was during Aus season, seven were in T. Aman and 33 were in Boro season. In addition, four trials of farming systems, two experiments of Crop-Soil-Water management and three stability analysis experiment under the socio-economic and policy programme were executed.

During Aus 2022, only one regional yield trial (RYT#1), favourable condition, T. Aus 2022 was performed. The advanced line, BR11864-5R-31 (6.14 t/ha) produced statistically higher yield over the check varieties, BRRI dhan48 (5.53 t/ha) and BRRI dhan98 (4.85 t/ha).

Seven RYT's were carried out in T. Aman 2022. Three of the tested materials grain under RYT-SS was short and slender. Among them BRH13-2-14-2-1B yielded the highest (6.33 t/ha). Five advanced lines under RYT Swarna type long slender were evaluated against the checks BRRI dhan94 and BRRI dhan87. Only BR9396-6-2-2B significantly out yielded (7.56 t/ha) over BRRI dhan87. Some promising lines were reported with very short duration (<115 days) under ZER RYT in Aman 2022. BR10471-1-2-3-15-1 showed very identical yield (6.29 t/ha) to BRRI dhan72 (6.25 t/ha). In RYT-Zirashail type only one advanced line BRH11-7-17-10B (4.78 t/ha) performed better than the other lines and check variety Zirashail (2.48 t/ha).

Nineteen RYT's were carried out in Boro 2022-23. In the RYT for short duration, BR11903-5R-56 achieved the highest yield at 6.58 t/ha, significantly higher than BRRI dhan28 (5.17 t/ha) and BRRI dhan96 (5.41 t/ha). BR10604-5R-58 achieved a remarkable yield of 6.4 t/ha, significantly higher than the check varieties BRRI dhan50 (5.64 t/ha), BRRI dhan63 (5.63 t/ha), and BRRI dhan86 (5.55 t/ha) in RYT (Extra-long slender grain). BRH18-9-4-2-3B achieved the highest 5.92 t/ha yield followed by BRH13-5-12-2-2B (5.83 t/ha) and BRH9-3-2B

(5.5 t/ha) statistically superior to Katari (4.61 t/ha) in RYT for short slender. The entry BR12839-4R-138-4 (6.58 t/ha) yielded significantly more than Indonesian Black Rice (5.46 t/ha) and BRRI dhan88 (5.93 t/ha) in RYT for anti-oxidant enriched rice. In the yield comparison, BR11991-6R-58-1 (6.2 t/ha) and BR12605-4R-275-1 (5.56 t/ha) showed significant superiority over BRRI dhan28 (4.96 t/ha), Bina dhan14 (4.36 t/ha), and N22 (3.41 t/ha). However, both BR11991-6R-58-1 and BR12605-4R-275-1 yielded similarly to dhan98 (5.52 t/ha) in AYT (Heat-tolerant rice). Basmati-433 (4509) (5.66 t/ha) and Basmati (4754) (5.55 t/ha) showed significantly higher yields than Rata Boro (4.7 t/ha) in G×E interaction of Basmati rice.

The general and specific adaptability of some potential advanced breeding lines were tested in farmers' field collaborating with DAE and feedback information was collected from the farmers as well as extension people. Lines were supplied from Adaptive Research Division (ARD) of BRRI HQ. Eight categories of ALARTs were conducted during T. Aman 2022 and Boro 2022-23. The trials were conducted at Kushtia Sadar, Gangni and Mujibnagar upazila, Meherpur. In ALART PQR, yield performance of advanced line BR8493-3-5-1-P1 (4.68 t/ha) was better among all the advanced lines and check varieties. The advanced lines BRH13-1-9-7B (5.13 t/ha) and BRH10-1-14-6-2B (5.13 t/ha) statistically superior to check variety BRRI dhan57 and the local check Zirashail in ALART SHR-1.

During Boro 2022-23, ALART SHR-1 showed that the advanced lines BRH 10-1-14-2-6B (6.38 t/ha) and BRH13-2-4-7-2B (6.34 t/ha) achieved statistically equal grain yield which was higher than other advanced line and check variety BRRI dhan81 but irregularity at flowering and maturity period was noticed. In ALART SHR-2, although the grain yield of the advanced line BR13-2-4-2-1B (6.25 t/ha) and check variety BRRI dhan88 was significant but growth duration of that line was 10 days longer. Re-ALART FBR-Barishal showed that advanced line BRBa 3-1-7 achieved the highest yield (7.17 t/ha) with good phenotypic appearance and grain quality.

Four programmes were conducted under Rice Farming Systems. The highest rice equivalent yield (REY) along with significant interaction effect of N and K was observed with Urea@STB+ 20% and

MoP@STB+ 20% additional treatment on BRRI dhan63 and BRRI dhan87 in yield response of rice to different rates of Nitrogen and Potassium fertilizer in Boro-Fallow -T. Aman cropping pattern in Kushtia.

For Increasing the system productivity of the dominant cropping pattern in Kushtia region (Boro-Fallow-T. Aman)BARI Sorisha-14 (Relay)-BRRI dhan63- Fallow-BRRI dhan87 cropping pattern proved most profitable with significantly the highest rice equivalent yield (16.09 t/ha), gross return (1,32,730 Tk/ha), and benefit cost ratio of 1.42 to increase the total productivity.

In case of performance of different cropping patterns for year-round vegetable production under agro-forestry systems with exotic date palm (*Phoenix dactylifera*) experiment Carrot – Mukhikachu produced the highest gross margin of 513.22 thousand taka (Table) which was followed by Fallow – Mukhikachu cropping pattern (454.4 thousand taka). The lowest gross margin was observed from Onion/Garlic – Okra cropping pattern (73.37 thousand taka).

Cropping pattern DS Aman (BRRI dhan71) – Lentil produced the highest gross margin of 174.44 thousand taka which was followed by DS Aman (BRRI dhan71) – Grass pea cropping pattern (57.82 thousand taka). The lowest gross margin was observed from DS Aman (BRRI dhan71)– Mustard cropping pattern (32.97 thousand taka) under Evaluation of different rice-based cropping patterns under agro-forestry systems with exotic date palm (*Phoenix dactylifera*) experiment.

In ‘Determination of optimum time of planting and seedling age for yield maximization of BRRI dhan87 at Kushtia region’ experiment, the highest average yield was observed at the time of transplanting on 15 August, which was statistically similar with transplanting on 15 July and 30 July. The highest growth duration was found at the 1st transplanting on 15 July 2021 and 4th transplanting on 30 August.

In ‘Evaluation of drought tolerance ability of newly released BRRI variety in drought prone area’ experiment, BRRI dhan71 and BRRI dhan87 both the varieties suffer drought, transplanted at 30 August and drought can be minimized by

supplemental irrigation. Both varieties produced satisfactory yield and sustain water stress up to 35 cm below soil surface. BRRI dhan71 produced satisfactory yield even it was transplanted late at 30 August. BRRI dhan71 can be a better option for late transplanting and drought tolerant rice variety.

Stability analysis of BRRI varieties were conducted to observe their performance under Genotype Environment interaction. In T. Aus, the highest yielder was BRRI dhan48 (5.4 t/ha) and the lowest was BRRI dhan65 (3.5 t/ha). Several varieties lodged due to severe storm in T. Aus. In T. Aman, the highest yielder was BRRI dhan87 (6.2 t/ha) and the lowest was BRRI dhan91 (3.4 t/ha). In Boro season, the highest yielder was BRRI dhan89 (7.34 t/ha) and the lowest was BR17 (3.75 t/ha).

In total 461 demonstrations (Aus, Aman and Boro) were conducted during 2022-2023 under GoB to disseminate different latest variety. Five and seven adaptive trials under TRB project were performed In Aman 2022 and Boro 2022-23 season, respectively. Ten batches on farmers training consisting of 300 farmers were conducted in five different districts during the reporting period. Ten field days with more than 1000 farmers participants were organised. During the reporting period, BRRI RS, Kushtia produced 1,070, 1430 and 1,367 kg TLS during Aus, Aman and Boro season, respectively. Total production of breeder seed was 3,175 kg and 3,500 kg during Aman and Boro season, respectively.

VARIETAL DEVELOPMENT

Regional yield trial (RYTs), Aus 2022

RYT# Favourable condition, T. Aus, 2022

To select the best-performing advanced breeding lines with higher grain yield over the existing HYVs across multiple experimental sites twelve advanced breeding lines and two standard checks BRRI dhan48 and BRRI dhan98 were tested under this experiment. The advanced line, BR11864-5R-31 (6.14 t/ha) produced the highest yield over all the other advanced lines and check varieties BRRI dhan48 (5.53 t/ha) and BRRI dhan98 (4.85 t/ha) with similar growth duration (Table 1).

Table 1. Performance of RYT#1(Favourable condition) lines in RYT, Aus 2022-2023.

	Designation	Growth duration (day)	Panicle/m ²	Plant height (cm)	Grain/panicle	1000 grain wt. (g)	Yield (t/ha)
	BR1186-5R-82	115	300	104	102	22.18	5.82
	BR11863-5R-256	114	289	106	93	22.43	5.97
	BR11864-5R-31	116	294	102	91	21.21	6.14
	BR11864-5R-38	118	294	106	109	21.46	5.33
	BR11864-5R-75	115	304	102	90	21.47	5.23
	BR11869-5R-98	117	310	108	86	24.14	4.85
	BR11604-4R-133	126	292	112	91	24.02	3.99
	BR11607-4R-6	126	284	106	92	24.98	4.34
	BR11607-4R-72	117	289	110	97	18.88	4.68
	BR9651-15-2-1-3	118	288	103	86	21.88	4.75
	7FBR-400	123	278	106	88	24.79	5.03
	7FBR-416	119	286	103	101	21.90	4.80
	BRR1 dhan48 (ck)	116	287	107	105	20.74	5.53
	BRR1 dhan98 (ck)	116	301	103	106	21.46	5.66
CV (%)		1.85	7.08	6.12	11.29	10.59	11.52
LSD _(0.05)		1.78	16.91	5.27	8.80	1.92	0.48

DS: 22 Apr 2022

DT: 15 May 2022

Regional yield trial (RYTs), T. Aman 2022**RYT#short slender (SS) lines, T. Aman 2022**

To evaluate specific and general adaptability of the advanced breeding lines as compared to the standard checks in on-station condition, three genotypes and

one check variety (BRR1 dhan49) were evaluated in this experiment. Findings stated that BRH13-2-14-2-1B was the highest yielder (6.33 t/ha) among the tested breeding lines (Table 2). Yield of mentioned line was significantly higher than the check variety but growth duration was six days more.

Table 2. Performance of short slender (SS) lines in RYT, T. Aman 2022.

	Designation	GD (day)	Plant height (cm)	Panicle/ m ²	Grain/panicle	Yield (t/ha)
	BRH13-2-14-2-1B	137	114	216	120	6.33
	BRH17-23-8-2-7B	111	98	260	101	4.67
	BRH13-7-9-3-2B	122	111	202	172	5.58
	BRRi dhan49 (ck)	131	92	261	126	5.36
	LSD _(0.05)	4.23	3.57	NS	37.04	0.81
	CV(%)	1.69	1.72	10.32	14.25	7.43
DS: 8 July 2022			DT: 8 Aug 2022			

RYT#Swarnatype long slender (SLS) lines, T.Aman 2022

Five genotypes and two check varieties (BRRi dhan94 and BRRi dhan87) were evaluated under this experiment to evaluate specific and general adaptability of the advanced breeding lines as compared with standard checks in on-station

condition. One of the tested genotypes BR9396-6-2-2B significantly performed better (7.56 t/ha) than the check variety BRRi dhan94 where it was identical to another check BRRi dhan87 (6.94 t/ha) (Table 3). Growth duration of V1, V2 and V3 genotypes was alike of both the checks. But another two lines reported as short duration with lower yield potentiality.

Table 3. Performance of swarnatype long slender (SLS) lines in RYT, T. Aman 2022.

Designation	GD (day)	Plant height (cm)	Panicle/ m ²	Grain/panicle	Yield (t/ha)
BRH9392-6-2-1-3-4	130	116	288	128	6.44
BR9396-6-2-2B	131	118	316	113	7.56
BR10238-5-1-4-2	130	121	314	131	6.05
BR9392-10-20-1B	116	112	279	90	5.90
BRH11-2-4-7B	114	115	319	105	5.49
BRRi dhan94 (ck)	133	114	321	145	6.55
BRRi dhan87 (ck)	127	122	281	120	6.94
LSD _(0.05)	1.16	NS	NS	28.76	0.70
CV(%)	0.52	4.62	11.92	13.59	6.10
D/S: 17 July 2022				D/T: 8 Aug 2022	

RYT#Zinc enriched rice (ZER), T. Aman 2022.

To evaluate specific and general adaptability of the advanced breeding lines as compared to the standard checks in on-station condition, four genotypes and two standard checks BRRI dhan72 and BRRI dhan87 were tested under this experiment. All the

tested breeding lines were found very short duration (<115 days) type. Among them yield of BR10471-1-2-3-15-1 was the highest (6.29 t/ha) (Table 4). Due to stagnant water after a heavy rainfall, lodging occurred causing lower yield of BRRI dhan87.

Table 4. Performance of zinc enriched rice (ZER) lines in RYT, T. Aman 2022.

Designation	GD (day)	Plant height (cm)	Panicle/ m ²	Grain/panicle	Yield (t/ha)
BR1049-1-2-3-8-7	111	111	272	133	4.32
BR147-1-2-3-13-5	111	133	237	119	5.08
BR10471-1-2-3-15-1	109	129	250	151	6.29
BR9674-1-1-5-2-P4-HR1	110	118	218	166	5.40
BRRI dhan72 (ck)	127	128	246	115	6.25
BRRI dhan87 (ck)	128	134	286	118	5.30
HSD _(0.05)	1.34	8.05	NS	NS	NS
CV(%)	0.41	2.26	11.06	19.50	13.24
DS: 8 July 2022			DT: 1 Aug 2022		

RYT#zirashail type, T. Aman 2022.

Three advanced breeding lines and one standard check Zirashail were tested under this experiment to evaluate specific and general adaptability of the advanced breeding lines as compared with

the standard checks in on-station condition. The advanced line BRH11-7-17-10B (4.78 t/ha) performed significantly better than the other lines and check variety Zirashail (2.48 t/ha) (Table 5).

Table 5. Performance of regional yield trial (RYT-zirashail type) lines, T. Aman 2022-2023.

Designation	GD (day)	Plant height (cm)	Panicle/m ²	Grain/panicle	Yield (t/ha)
BRH11-7-17-10B	110	106	251	126	4.78
BRH13-9-5-3B	111	107	254	128	4.50
BRH9-3-14-2B	110	106	232	135	4.52
Zirashail	107	115	306	91	2.48
LSD _{0.05}	1.05	2.36	22.12	NS	0.36
CV(%)	1.17	2.66	10.39	24.3	10.81

DS: 8 July 2022

DT: 1 Aug 2022

Regional yield trial (RYTs), Boro 2022-23**RYT#short duration (SD), Boro 2022-23**

To evaluate the specific and general adaptability of the advanced breeding lines as compared with standard checks in on-station condition nine genotypes and two standard checks BRRI dhan28 and BRRI dhan96 were tested in this experiment.

Among the tested lines, the yield of BR11903-5R-56 was the highest (6.58 t/ha) (Table 6) which was statistically higher than the check varieties, BRRI dhan28 (5.17 t/ha) and BRRI dhan96 (5.41 t/ha).

Here it is also noteworthy that the vegetative stage experienced lower temperatures, while the reproductive stage was marked by higher temperatures.

Table 6. Performance of advanced breeding lines in RYT#SD, Boro 2022-23.

Designation	BLUE_PH (cm)	BLUE_GD (day)	BLUE_Y (t/ha)	Remarks/ Grainshattered
BR11637-5R-140	114	148	4.84	3.5%
BR11894-5R-376	110	151	5.16	2%
BR11900-5R-24	96	153	5.56	3%
BR11903-5R-56	95	143	6.58	1%
BR12180-5R-17	111	155	4.76	2.5%
BR12180-5R-29	101	154	5.96	2.5%
BR12208-5R-274	120	146	5.71	
BR12208-5R-394	90	148	6.12	1.5%
BR12208-5R-402	92	150	5.96	2%
BRRI dhan28	96	143	5.17	
BRRI dhan96	91	144	5.41	
LSD _(0.05)	7.00	1.65	0.78	
Heritability	0.95	0.98	0.78	

DS: 11/27/22

DT: 1 Jun 2023

RYT#extra longslender rice (ELS), Boro 2022-23.

To evaluate the specific and general adaptability of the advanced breeding lines as compared to the standard checks in on-station condition six genotypes and three standard checks BRRI dhan50, BRRI dhan63 and BRRI dhan86 were tested in this experiment. Among the tested lines, the yield of

BR10604-5R-58 was the highest (6.4 t/ha) (Table 7) which was statistically higher than the check varieties BRRI dhan50 (5.64 t/ha), BRRI dhan63 (5.63 t/ha) and BRRI dhan86 (5.55 t/ha).

Here it is also noteworthy that the vegetative stage experienced lower temperatures, while the reproductive stage was marked by higher temperatures.

Table 7. Performance of advanced breeding lines in RYT#ELS, Boro 2022-23.

Designation	BLUE_PH (cm)	BLUE_GD (days)	BLUE_Y (t/ha)	Remark/ Grain shattered
BR9945-5R-21	98	150	5.73	2%
BR10604-5R-58	99	149	6.40	1%
IR18A2102	92	145	5.87	
BR7528-2R-19-16-RIL-52	99	153	4.47	4.5%
BR7528-2R-19-16-RIL-55	101	151	5.05	4%
BR7528-2R-19-16-RIL-59	99	150	5.08	2%
BRRI dhan50	82	156	5.64	6%
BRRI dhan63	87	147	5.63	7%
BRRI dhan86	90	143	5.55	
LSD _(0.05)	2.99	1.51	0.68	
Heritability	0.98	0.98	0.84	

DS :11/27/22

DT: 1 Jun 23

RYT#Short slenderrice (SS),Boro 2022-23

Five genotypes and one standard check, Katari were tested in this experiment to evaluate the specific and general adaptability of the advanced breeding lines as compared to the standard checks in on-station condition. Among the lines tested, BRH18-9-4-2-3B had the highest yield (5.92 t/ha), followed by

BRH13-5-12-2-2B (5.83 t/ha) and BRH9-3-2B (5.5 t/ha) (Table 8). These yields were statistically superior to the yield of the check variety, Katari (4.61 t/ha).

Note- The vegetative stage experienced lower temperatures, while the reproductive stage was marked by higher temperatures.

Table 8. Performance of advanced breeding lines in RYT#SS, Boro 2022-23.

Designation	BLUE_PH (cm)	BLUE_GD (day)	BLUE_Y (t/ha)	Remark/ Grains shattered
BRH18-9-4-2-3B	90	146	5.92	3%
BRH13-5-12-2-2B	86	147	5.83	4%
BRH14-2-1-7B	82	150	5.46	7%
BRH9-3-2B	87	147	5.50	2.5%
BR9392-1-7-5B	79	150	5.14	4%

Designation	BLUE_PH (cm)	BLUE_GD (day)	BLUE_Y (t/ha)	Remark/ Grainshattered
Katari (CK)	92	154	4.61	2.5%
LSD _(0.05)	4.52	1.45	0.78	
Heritability	0.90	0.98	0.74	

DS: 12 Jan 2022

DT: 1 Nov 2023

RYT#zira type rice (Zira-type), Boro 2022-23.

To evaluate the specific and general adaptability of the advanced breeding lines as compared with standard checks in on-station condition five genotypes and two standard checks, BRRI dhan28 and Zirashail were tested in this experiment. Among the tested lines, BRH13-9-5-3B had the highest yield (6.03 t/ha), followed closely by BRH12-1-

7B-P1 (5.99 t/ha) (Table 9) which were statistically significant over the check variety Zirashail (5.05 t/ha). However, the yield of BRH13-9-5-3B and BRH12-1-7B-P1 were statistically similar to BRRI dhan28 (5.7 t/ha).

Note- Here it is also noteworthy that the vegetative stage experienced lower temperatures, while the reproductive stage was marked by higher temperatures.

Table 9. Performance of advanced breeding lines in RYT#Zira-type, Boro 2022-23.

Designation	BLUE_PH (cm)	BLUE_GD (day)	BLUE_Y (t/ha)	Remark/ grainshattered
BRH13-9-5-3B	88	145	6.03	2.5%
BRH12-1-7B-P1	88	145	5.99	3%
BRH9-3-14-2B	94	146	4.64	7.5%
BR10247-4-7-4B	101	148	5.22	3.5%
BRH13-7-9-3-2B	89	148	3.71	6%
BRRI dhan28	88	142	5.70	2%
Zirashail	94	145	5.05	2%
LSD _(0.05)	5.96	3.66	0.74	
Heritability	0.85	0.43	0.91	

DS: 12 Jan 2022

DT: 1 Nov 2023

RYT#anti-oxidant enrichedrice (AER-1), Boro, 2022-23.

To evaluate the specific and general adaptability of the advanced breeding lines as compared with standard checks in on-station condition eight genotypes and two standard checks, Indonesian Black Rice and BRRi dhan88 were tested in this

experiment. The entry, BR12839-4R-138-4 (6.58 t/ha) yielded significantly more than Indonesian Black Rice (5.46 t/ha) and BRRi dhan88 (5.93 t/ha) (Table 10).

Note- The vegetative stage experienced lower temperatures, while the reproductive stage was marked by higher temperatures.

Table 10. Performance of advanced breeding lines in RYT#AER-1, Boro 2022-23.

Designation	BLUE_PH (cm)	BLUE_GD (day)	BLUE_Y (t/ha)	Remark/ grainshattered
BR12839-4R-157-2	98	155	6.01	2.5%
BR12839-4R-5-2	99	155	6.27	2%
BR12839-4R-93	93	152	6.37	1%
BR12839-4R-47-1	94	155	6.52	1.5%
BR12839-4R-90-1	95	155	5.87	8%
BR12839-4R-138-4	103	157	6.58	2.5%
BR12839-4R-78-1	95	158	6.16	2.5%
BR12839-4R-21	102	158	6.47	2%
Indonesian Black Rice	100	155	5.46	4%
BRRi dhan88	91	145	5.93	
LSD _(0.05)	4.92	1.96	0.65	
Heritability	0.81	0.97	0.61	

DS: 11/27/2022

DT: 1 May 2023

AYT#heat tolerant rice (HTR-1), Boro 2022-23.

Thirty-two genotypes and four checks, BRRi dhan28, BRRi dhan98, Bina dhan14 & N22 were tested in this experiment to evaluate the specific and general adaptability of the advanced breeding lines as compared with standard checks in on-station condition. The entries, BR11991-6R-58-1 (6.2 t/ha) and BR12605-4R-275-1 (5.56 t/ha) exhibited statistically significant higher yield compared to

BRRi dhan28 (4.96 t/ha), Bina dhan14 (4.36 t/ha), and N22 (3.41 t/ha) (Table 11). However, these two breeding lines, BR11991-6R-58-1 and BR12605-4R-275-1, yielded statistically similarly to BRRi dhan98 (5.52 t/ha).

Note- The vegetative stage experienced lower temperatures, while the reproductive stage was marked by higher temperatures.

Table 11. Performance of advanced breeding lines in AYT#HTR-1, Boro 2022-23.

Designation	BLUE_PH (cm)	BLUE_GD (day)	BLUE_Y (t/ha)	Remark
BR11845-4R-178-1	103	103	5.39	
BR12432-5R-9-1	110	120	4.66	DHB-3%
BR11845-4R-1-1	104	103	4.94	
BR11845-4R-130-1	94	105	5.28	
BR12605-4R-397-1	90	110	4.23	DHB-4.5%
BR12605-4R-298-1	114	103	5.05	
BR12605-4R-109-1	102	106	5.05	
BR12605-4R-362-1	100	106	4.87	
BR12605-4R-240-1	109	105	5.41	
BR12605-4R-275-1	108	107	5.56	
BR12432-5R-4-1	119	116	5.26	DHB-3.5%
BR11845-4R-69-1	94	108	4.97	
BR11991-6R-58-1	115	107	6.20	
BR12605-4R-121-1	101	108	5.11	
BR11845-4R-50-1	105	109	5.10	
BR11847-4R-104-1	127	99	4.49	DHB-4%
BR11845-4R-90-1	95	103	5.21	
BR11845-4R-120-1	97	104	5.41	
BR11845-4R-73-1	104	104	4.71	
BR10966-B-3R-32	93	105	5.13	
BR11847-4R-172-1	85	108	4.14	DHB-5%
BR12605-4R-297-1	102	107	4.79	
BR12432-5R-227-1	113	120	4.43	DHB-5.5%
BR12605-4R-315-1	91	109	4.50	DHB-2%
BR12605-4R-371-1	99	109	5.16	
BR12432-5R-36-1	110	116	4.38	DHB-3.5%
BR12605-4R-215-1	96	106	4.81	
BR10966-B-3R-57-1	102	104	4.58	
BR11845-4R-40-1	99	106	4.77	
BR12098-4R-199-1	99	111	4.56	
BR12098-4R-202-1	112	117	3.72	DHB-2.5%
BR12098-4R-217-1	117	108	4.28	
BRRI dhan28 (Ck)	106	105	4.96	
Bina dhan14 (Ck)	94	100	4.36	
BRRI dhan98 (Ck)	102	111	5.52	

Designation	BLUE_PH (cm)	BLUE_GD (day)	BLUE_Y (t/ha)	Remark
N22 (Tol. Ck)	109	90	3.41	
LSD _(0.05)	8.25	2.65	0.55	
Heritability	0.90	0.97	0.88	

DS:02/16/23

DT:3/16/23

G×E interaction of Basmati rice trial, premium quality rice (PQR-3)

To evaluate the specific and general adaptability of the advanced breeding lines as compared with standard checks in on-station condition twenty genotypes and three standard checks, BRRI dhan50, BRRI dhan63, BRRI dhan81, proposed BRRI dhan104, TepiBoro and Rata Boro were tested

in this experiment. None of the entries performed better than BRRI dhan63 in terms of yield (Table 12). However, Basmati-433(4509) (5.66 t/ha) and Basmati(4754) (5.55 t/ha) showed significantly higher yields than Rata Boro (4.7 t/ha).

Note- The vegetative stage experienced lower temperatures, while the reproductive stage was marked by higher temperatures.

Table 12. Performance of advanced breeding lines in G×E interaction of Basmati Rice #PQR-3, Boro 2022-23.

Designation	BLUE_PH (cm)	BLUE_GD (day)	BLUE_Y (t/ha)	Remark
Basmati(1230)	149	139	5.00	Lodged-20%
Basmati(D)(3928)	138	114	4.30	
Basmati(4488)	150	143	4.84	Lodged-20%
Basmati370 (4489)	137	125	4.45	
Basmati37(4491)	138	117	4.86	
Basmati(N13)(4493)	161	77	4.68	
Basmati370(4494)	139	114	4.62	
Basmati107(4501)	144	120	3.74	SB-7%
Basmati377(4507)	140	130	4.75	
Basmati406(4508)	140	121	4.58	
Basmati(4754)	137	116	5.55	
Basmati(6614)	144	97	4.52	
Super Basmati	145	97	3.42	SB-5%
Basmati Sufaid187	138	128	4.95	
Indian Basmati	150	101	4.95	
Basmati TAPL-90(2517)	150	143	4.88	Lodged-25%
Basmati Nanot 439(4496)	137	125	4.72	
Basmati Pardnr442(4497)	141	96	5.41	
Basmati-433(4509)	140	119	5.66	
Pusha Basmati	151	105	3.82	SB-5%
BRRI dhan50 (ck)	151	86	5.37	
BRRI dhan63 (ck)	146	86	5.69	

Designation	BLUE_PH (cm)	BLUE_GD (day)	BLUE_Y (t/ha)	Remark
BRR1 dhan81 (ck)	143	93	5.30	
Proposed BRR1 dhan104 (ck)	147	101	5.49	
TepiBoro (ck)	143	145	5.16	Lodged-30%
Rata Boro (ck)	141	148	4.70	Lodged-40%
LSD _(0.05)	2.74	6.34	0.80	
Heritability	0.97	0.99	0.77	

DS:12 Jun 2022

DT: 1/16/23

Advanced line adaptive research trial (ALART) during T. Aman 2022

ALART for premium quality rice (PQR), T. Aman 2022.

Two advanced lines along with two standard checks BRR1 dhan34 and BRR1 dhan70 were evaluated under this trial to evaluate the yield

potential and adaptability of the advanced lines at farmers field in different agro-ecological zones. AdvancedlineBR8493-3-5-1-P1 produced statistically higher yield (4.68t/ha) than the other advanced line and check varieties. But its growth duration is higher than the check variety BRR1 dhan70 (Table 13).

Table 13. Performance of advanced breeding lines in ALART#PQR, T. Aman 2022

	Designation	GD (day)	Panicles/m ²	Plant height (cm)	Grain/ panicle	1000 grain wt. (g)	Yield (t/ ha)
	BR8493-3-5-1-P1	135	229	117	150	12.88	4.68
	BR9590-45-1-3-2-P2	137	172	117	166	16.15	3.66
	BRR1 dhan34(ck)	155	217	140	180	9.76	3.77
	BRR1 dhan70(ck)	126	246	135	124	16.27	4.24
	CV (%)	1.09	7.05	1.83	11.12	3.39	5.94
	LSD _(0.05)	1.22	12.44	1.91	14.09	0.38	0.20

DS-7 July 2022

DT-2 Aug 2022

ALART for SHR-1 (Zirashail type), T. Aman 2022

Five advanced lines along with one standard check BRR1 dhan57 and one local check Zirashail were evaluated under this trial to evaluate the yield potential and adaptability of the advanced lines at farmers field in different agro-ecological zones.

The advanced lines BRH13-1-9-7B (5.13t/ha) and BRH10-1-14-6-2B (5.13t/ha) produced statistically similar grain yield and their yield performance was better than the other advanced lines-check variety BRR1 dhan57 and the local check Zirashail. Their growth duration was similar to the check varieties (Table 14).

Table 14. Performance of advanced breeding lines in ALART#SHR-1, T. Aman 2022

	Designation	GD (day)	Panicles/ m ²	Plant height (cm)	Grain/ panicle	1000 grain wt. (g)	Yield (t/ha)
	BRH15-24-7B	111	214	97	140	16.92	5.11
	BRH13-1-9-7B	110	224	101	128	16.24	5.13
	BRH13-2-4-7-2B	115	225	98	132	15.75	4.81
	BRH10-1-14-6-2B	112	213	102	144	16.58	5.13
	BR10247-4-7-4B	115	227	96	89	16.78	3.70
	Zirashail (ck)	112	238	102	91	18.47	3.65
	BRR1 dhan57 (ck)	107	235	97	110	16.10	3.79
CV (%)		0.78	6.19	3.52	11.53	3.96	7.68
LSD _(0.05)		0.71	11.37	2.85	11.23	0.54	0.28

DS- 7 July 2022

DT-2 Aug 2022

ALART for SHR-1 (Zirashail type), T. Aman 2022.

To evaluate the yield potential and adaptability of the advanced lines at farmer's field in different agro-ecological zones five advanced lines along with one standard check BRR1 dhan57 and one local check Zirashail were evaluated under this

trial. The grain yield of advanced lines BRH15-24-7B, BRH13-1-9-7B and BRH13-2-4-7-2B were significantly similar and their yield performance was better than both of the standard check and local check. Among them the advanced line BRH15-24-7B (5.65 t/ha) produced highest yield with good phenotypic appearance (Table 15).

Table 15. Performance of advanced breeding lines in ALART#SHR-1, T. Aman 2022.

	Designation	GD (day)	Panicles/m ²	Plant height (cm)	Grain/ panicle	1000 grain wt. (g)	Yield (t/ ha)
	BRH15-24-7B	108	221	104	167	15.93	5.65
	BRH13-1-9-7B	107	228	108	161	16.64	5.28
	BRH13-2-4-7-2B	104	230	108	178	15.41	5.37
	BRH10-1-14-6-2B	103	191	106	182	16.52	4.90
	BR10247-4-7-4B	108	230	105	124	18.62	4.58
	Zirashail (ck)	103	226	115	135	18.38	4.22
	BRR1 dhan57 (ck)	103	252	111	138	18.27	5.09
CV (%)		0.78	8.35	1.31	6.72	2.51	6.94
LSD _(0.05)		0.67	15.35	1.15	8.50	0.35	0.28

DS- 7 Jul 2022

DT-31 Jul 2022

Advanced line adaptive research trial (ALART) during Boro 2022-23

ALART for favourable Bororice (FBR-Barishal) (Re-ALART), Boro 2022-23

To evaluate the yield potential and adaptability of the advanced lines at farmers field in different agro-ecological zones four advanced lines along with two

standard checks BRRI dhan58 and BRRI dhan89 were evaluated under this trial. The advanced line BRBa 3-1-7 produced the highest yield (7.17t/ha) over all the other advanced lines and check varieties with shortest growth duration (Table 16). Phenotypic appearance of this line was also good with good grain quality.

Table 16. Performance of advanced breeding lines in ALART#FBR-Barishal, Boro 2022-23.

	Designation	GD (day)	Panicles/ m ²	Plant height (cm)	Grain/ panicle	1000 grain wt. (g)	Yield (t/ha)
	BRBa 1-4-9	150	244	122	124	21.49	6.84
	BRBa 14-NGR414-1	147	236	107	122	18.64	6.54
	BRBa 3-1-7	143	264	100	116	21.03	7.17
	BRBa40-NGR1255-1	149	229	120	115	20.83	6.80
	BRRI dhan58 (Ck)	145	241	102	116	23.56	6.83
	BRRI dhan89 (Ck)	151	203	117	123	23.68	6.97
	CV (%)	0.38	5.92	1.75	10.88	0.68	3.91
	LSD _(0.05)	0.46	11.42	2.02	10.60	0.31	0.22

DS-31 Dec 2022

DT-23 Feb2023

ALART for superior high yielding rice (SHR-1), Boro 2022-23

Three advanced lines along with one standard check BRRI dhan81 were evaluated under this trial to evaluate the yield potential and adaptability of the advanced lines at farmers field in different

agro-ecological zones. The grain yield of advanced lines BRH 10-1-14-2-6B and BRH13-2-4-7-2B was significantly equal which is higher than the yield of advanced line BRH15-24-7B and check variety BRRI dhan81 (Table 17). But both of them were found with irregular flowering and maturity problem.

Table 17. Performance of advanced breeding lines in ALART#SHR-1, Boro 2022-23.

	Designation	GD (day)	Panicles/ m ²	Plant height (cm)	Grain/ panicle	1000 grain wt. (g)	Yield (t/ha)
	BRH 10-1-14-2-6B	142	209	86	167	17.48	6.57
	BRH13-2-4-7-2B	139	260	83	159	16.58	6.56
	BRH15-24-7B	143	275	81	121	17.06	5.89
	BRRI dhan81(Ck)	138	235	88	110	20.88	4.23
	CV (%)	0.68	7.39	2.37	9.20	2.70	4.24
	LSD _(0.05)	0.78	14.77	1.63	10.46	0.40	0.20

DS-27 Dec 2022

DT-23 Feb 2023

ALART for superior high yielding rice (SHR-2), Boro 2022-23

To evaluate the yield potential and adaptability of the advanced lines at farmers field in different agro-ecological zones three advanced lines along with one standard check BRRI dhan88 were evaluated

under this trial. Although the highest grain yield was found by the advanced line BR13-2-4-2-1B (6.25 t/ha) but its growth duration was much higher than the check variety and other advanced lines. The advanced line BR238-5-1-4-2 also produced higher yield than the check variety BRRI dhan88 with almost similar growth duration (Table 18).

Table 18. Performance of advanced breeding lines in ALART#SHR-2, Boro 2022-23.

	Designation	GD (day)	Panicles/m ²	Plant height (cm)	Grain/panicle	1000 grain wt. (g)	Yield (t/ha)
	BRH11-2-4-7B	140	224	106	135	21.37	5.48
	BR13-2-4-2-1B	151	255	124	115	20.88	6.25
	BR238-5-1-4-2	140	257	105	91	24.03	5.76
	BRRI dhan88(Ck)	137	282	93	99	21.58	5.54
CV (%)		0.63	6.83	2.72	12.14	2.41	3.19
LSD _(0.05)		0.73	14.20	2.37	10.91	0.43	0.15

DS-27 Dec 2022

DT-23 Feb 2023

ALART for superior high yielding rice (SHR-1), Boro 2022-23

Three advanced lines along with one standard check BRRI dhan81 were evaluated under this trial to evaluate the yield potential and adaptability of the advanced lines at farmers field in different

agro-ecological zones. The grain yield of advanced lines BRH 10-1-14-2-6B and BRH13-2-4-7-2B was significantly equal which is higher than the yield of advanced line BRH15-24-7B and check variety BRRI dhan81. But at the period of flowering and maturity they both showed irregular characteristics (Table 19).

Table 19. Performance of advanced breeding lines in ALART#SHR-1, Boro 2022-23.

	Designation	GD (day)	Panicles/m ²	Plant height (cm)	Grain/panicle	1000 grain wt. (g)	Yield (t/ha)
	BRH 10-1-14-2-6B	145	311	83	142	17.11	6.38
	BRH13-2-4-7-2B	146	240	83	130	16.99	6.34
	BRH15-24-7B	147	332	81	101	17.54	5.55
	BRRI dhan81(ck)	145	283	88	101	22.25	5.67
CV (%)		0.73	8.25	3.73	9.31	3.80	2.24
LSD _(0.05)		0.87	19.65	2.55	9.02	0.57	0.11

DS-19 Dec 2022

DT-5 Feb 2023

RICE FARMING SYSTEMS

Yield response of rice to different rates of Nitrogen and Potassium fertilizer in Boro-Fallow -T. Aman cropping pattern in Kushtia

Popular varieties of T. Aman and Boro season of Kushtia region were tested in this trial. BRRI dhan87 and BRRI dhan63 were used respectively in T. Aman and Boro season to observe the interaction

effect of different doses of nitrogen and potassium fertilizer. Initial soil status was examined by SRDI regional laboratory, Kushtia. A very clear interaction effect of N and K on BRRI dhan63 and BRRI dhan87 was reported from this experiment (Table 20). The highest REY (14.68 t/ha) was recorded from the plot which was treated with Urea@STB+20% and MoP@STB+30% additional among 16 combinations.

Table 20. Yield response of BRRI dhan63 and BRRI dhan87 to different combinational rates of nitrogen and potassium fertilizer in Boro 2022-23 and T. Aman 2022.

Treatment combination		Yield (t/ha)			REY (t/ha)
Urea	MoP	Boro**	Fallow	T. Aman	
STB	STB	6.24	-	7.70	13.94
STB	STB + 30% additional	6.01	-	7.50	13.51
STB	STB + 60% additional	6.43	-	7.09	13.52
STB	BRRI recomm.	6.16	-	7.15	13.31
STB+20% additional	STB	7.31	-	6.88	14.19
STB+20% additional	STB + 30% additional	7.43	-	6.68	14.11
STB+20% additional	STB + 60% additional	7.16	-	7.52	<u>14.68</u>
STB+20% additional	BRRI recomm.	7.11	-	7.05	14.16
STB-20% less	STB	6.48	-	7.28	13.76
STB-20% less	STB + 30% additional	6.72	-	6.90	13.62
STB-20% less	STB + 60% additional	6.21	-	6.91	13.12
STB-20% less	BRRI recomm.	6.49	-	7.17	13.66
BRRI Recomm.	STB	6.81	-	7.48	14.29
BRRI Recomm.	STB + 30% additional	6.81	-	7.21	14.02
BRRI Recomm.	STB + 60% additional	6.61	-	6.68	13.29
BRRI Recomm.	BRRI recomm.	6.8	-	7.25	14.05
CV _%	Factor A	9.04		6.20	5.59
	Factor B	9.21		6.60	4.37

Increasing the system productivity of the dominant cropping pattern in Kushtia region (Boro-Fallow-T.Aman)

This experiment was conducted to increase the whole systems productivity through inclusion of modern varieties and advanced agronomic management practices and to increase farmers' income through adding high value oil seed crops (mustard) in the existing pattern. Two suitable Boro-Fallow-T. Aman dominated block in Kushtia Sadar upazila (Vill.: Alampur) and Mujibnagar upazila of Meherpur district (Vill.: Mohajanpur) were selected for this on-farm trial. Each of the pattern replicated in separate three farmers' fields in the same block. Fifteen farmers were engaged in this programme. In every season a single variety was cultivated in a minimum one bigha of land for each replication.

Sample crop cut was done for every variety at 80% maturity. Maximum REY yield (16.09 t/ha) was recorded from CP 2 where fallow period was managed with BARI Sorisha-14 and check Aman variety was replaced by a promising HYV, BRRI dhan87 (Table 21). From the economic point of view, CP 2 showed its superiority over the other performed cropping patterns. The highest gross margin (1,32,730 Tk/ha) was obtained from CP 2 followed by CP 4 (1,14,810 Tk/ha) (Table 21). Considering rice-equivalent yield, gross return and gross margin of the CP 2 cropping pattern consisting of BARI Sorisha-14 (Relay) -BRRI dhan63 -Fallow-BRRI dhan87 was found most profitable to increase the total productivity of unit area per year by increasing cropping intensity. This study is being continued year-round to find out the most sustainable cropping pattern.

Table 21. Economics of performed cropping patterns.

Cropping pattern			Season wise grain yield (t/ha)	REY (t/ha)	TVC (·000 Tk/ha)	Gross return (·000 Tk/ha)	Gross margin (·000 Tk/ha)
CP 1	:	BRRI dhan63-Fallow -BRRI dhan87	6.07 – F – 6.39	12.46	260.05	348.88	88.83
CP 2	:	BARI Sorisha-14 (Relay) -BRRI dhan63 -Fallow-BRRI dhan87	1.24 – 6.10 – 6.45	<u>16.09</u>	317.79	450.52	132.73
CP 3	:	BARI Sorisha-14 (Relay)-BRRI dhan63-Fallow-BRRI dhan71	1.41 – 6.17 – 5.07	15.27	317.79	427.56	109.77
CP 4	:	BARI Sorisha-14 (Relay)-BRRI dhan63-Fallow-BRRI dhan75	1.43 – 6.29 – 5.08	15.45	317.79	432.60	114.81
ECP (ck.)	:	BRRI dhan28-Fallow-BRRI dhan49	5.01 – F – 5.18	10.19	260.05	285.32	25.27

*ECP = Existing cropping pattern ** Price: Mustard –80 Tk/kg and Paddy – 28 Tk/kg

Performance of different cropping patterns for year-round vegetable production under agro-forestry systems with exotic date palm (*Phoenix dactylifera*)

This experiment was conducted to ensure year-round vegetable supply for farm family and to increase whole farm productivity with four cropping pattern T_1 (Carrot – Okra), T_2 (Carrot – Mukhikachu), T_3

(Onion/Garlic – Okra), T_4 (Fallow – Mukhikachu) along with control plot. Among the four cropping pattern Carrot – Mukhikachu produced the highest gross margin of 513.22 thousand taka (Table 22) which was followed by Fallow – Mukhikachu cropping pattern (454.4 thousand taka). The lowest gross margin was observed from Onion/Garlic – Okra cropping pattern (73.37 thousand taka).

Table 22. Productivity and economics of year-round vegetable growing cropping patterns under date palm agro-forestry systems, 2022-23.

Cropping pattern (Inter-cropping with date palm)	Yields of crop (t/ha)		Rice equivalent yield (t/ha)		Total (t/ha)	TVC ('000Tk/ha)	Gross return ('000Tk/ha)	Gross margin ('000Tk/ha)
	1st	2nd	1st	2nd				
T_1 = Carrot – Okra	16.78	8.93	11.98	7.98	19.96	197.37	438.1	240.73
T_2 = Carrot – Mukhikachu	23.11	9.33	16.51	11.67	28.18	225.43	738.65	513.22
T_3 = Onion/Garlic – Okra	3.40	9.62	3.64	8.59	12.23	250.58	323.95	73.37
T_4 = Fallow – Mukhikachu	-	13.89	-	17.36	17.36	153.20	607.6	454.4
T_5 = Sole (no crop with date palm)	-	-	-	-	-	-	-	-

**Price: Carrot-20 Tk/kg, Okra-25 Tk/kg, Mukhikachu-35 Tk/kg, Garlic-30 Tk/kg, Rice-28 Tk/kg

Evaluation of different rice-based cropping patterns under agro-forestry systems with exotic date palm (*Phoenix dactylifera*)

This experiment was conducted to ensure food sufficiency for farm family and to increase whole farm productivity with five rice-based cropping patterns T_1 = DS Aman (BRRI dhan71) – Chilli, T_2 = DS Aman (BRRI dhan71) – Mustard, T_3 = DS Aman (BRRI dhan71) – Garden Pea, T_4 = DS

Aman (BRRI dhan71) – Grass pea, T_5 = DS Aman (BRRI dhan71) – Lentil along with one control plot. Among the five cropping patterns DS Aman (BRRI dhan71) – Lentil produced the highest gross margin of 174.44 thousand taka (Table 23) which was followed by DS Aman (BRRI dhan71) – Grass pea cropping pattern (57.82 thousand taka). The lowest gross margin was observed from DS Aman (BRRI dhan71) – Mustard cropping pattern (32.97 thousand taka).

Table 23. Productivity and economics of rice-based cropping patterns under date palm agro-forestry systems, 2022-23.

Cropping pattern (Inter-cropping with date palm)	Yields of crop (t/ha)		Rice equivalent yield (t/ha)		Total (t/ha)	TVC ('000Tk/ha)	Gross return ('000Tk/ha)	Gross margin ('000Tk/ha)
	1st	2nd	1st	2nd				
T ₁ = DS Aman (BRRI dhan71) – Chilli	3.42	Fail	3.42	-	3.42	59.99	95.76	35.77
T ₂ = DS Aman (BRRI dhan71) – Mustard	3.40	0.42	3.40	1.05	4.45	135.73	168.7	32.97
T ₃ = DS Aman (BRRI dhan71) – Garden Pea	3.41	Fail	3.41	-	3.41	59.99	95.48	35.49
T ₄ = DS Aman (BRRI dhan71) – Grass pea	3.44	1.44	3.44	1.81	5.25	102.45	160.27	57.82
T ₅ = DS Aman (BRRI dhan71) – Lentil	3.48	1.00	3.48	2.68	6.16	124	298.44	174.44
T ₆ = Sole (no crop with date palm)	-	-	-	-	-	-	-	-

**Price: Rice-28 Tk/kg, Mustard-70 Tk/kg, Grass pea-35 Tk/kg, Lentil-75 Tk/kg

The experimental plot of chilli was damaged due to high temperature and garden pea plot was damaged by bird

CROP-SOIL-WATER MANAGEMENT

Determination of optimum time of planting and seedling age for yield maximization of BRRI dhan87 at Kushtia region

The experiment was established at BRRI RS farm during Aman season 2022 under three seedling ages (S1=20 days, S2= 25 days and S3= 30 days) and four transplanting dates (T1= 15 July, T2= 30 July, T3= 15 August and T4= 30 August) to find out the optimum planting time and seedling age

for BRRI dhan87. In case of transplanting time, the highest average yield (6.00 t/ha) was observed at the 3rd transplanting time of 15 August 2021 (T3) which was statistically similar to the 1st and 2nd transplanting times of 15 July and 30 July (T1 and T2). On the other hand, in the case of seedling age, there is no significant yield difference among the treatments. The highest growth duration was found at the 1st transplanting on 15 July 2021 and 4th transplanting on 30 August (Table 24).

Table 24. Yield Maximization of BRRI dhan87 during T, Aman 2023 at RS, Kushtia.

Treatment		GD (day)	Plant height (cm)	Panicle/m ²	Grain/panicle	1000 grain wt. (g)	Yield (t/ha)	Ave. Yield (t/ha)
T1	S1	134	126	213	128	23.7	5.6	5.64
	S2	130	123	216	127	24.2	5.3	
	S3	129	126	238	119	23.9	6.0	
T2	S1	129	123	235	115	24.0	5.8	5.76
	S2	126	125	225	130	23.5	5.8	
	S3	124	124	241	123	24.1	5.4	
T3	S1	126	118	226	120	24.5	5.9	6.00
	S2	123	114	218	135	25.2	5.9	
	S3	122	117	235	120	24.7	6.2	
T4	S1	132	105	196	117	24.9	5.2	5.30
	S2	131	106	211	117	24.5	5.4	
	S3	128	108	220	107	24.3	5.3	
HSD _{0.05}		0.0	6.22	30.16	14.4	1.17	0.68	
CV(%)		0.0	3.1	8.1	7.0	2.9	7.1	

T1= 15 Jul, T2= 30 Jul, T3= 15 Aug and T4= 30 Aug

S1= 20 days, S2= 25 days and S3= 30 days

Evaluation of drought tolerance ability of newly released BRRI variety in drought prone area

Drought is a natural hazard that is a normal part of climate for all regions, but it should not be viewed as merely a physical phenomenon. This experiment has been conducted at BRRI RS, Kushtia in T. Aman 2022 to evaluate drought response under different water stress conditions, to figure out the effect of supplemental irrigation on yield and yield contributing parameters, and to identify the suitability of newly released BRRI variety in drought prone areas. Three treatments, rainfed (I_0), supplemental irrigation when perched water table is 25 cm below the soil surface (I_2) and supplemental

irrigation when perched water table is 35 cm below the soil surface (I_3) were used to mitigate drought. Two varieties BRRI dhan87 and BRRI dhan71 were sown at two different dates 26 July and 10 August 2021 respectively. From our experiment we can conclude that both the varieties suffer drought transplanted at 30 August and drought can be minimized by supplemental irrigation. Both the varieties produced satisfactory yield and sustained water stress up to 35 cm below soil surface (Table 25.1 and 25.2) BRRI dhan71 produced satisfactory yield even if transplanted late at 30 August (Fig. 1). BRRI dhan71 can be a better option for late transplanting and drought tolerant rice variety.

Table 25.1.Effect of irrigation treatments and transplanting dates on BRRI dhan71.

Irrigation treatment	15 August transplanting		30 August transplanting	
	Rainfall (mm)	No. of Irrigation	Rainfall (mm)	No. of Irrigation
Rainfed	512	0	394	0
SI at -25 cm water depth		0		1
SI at -35 cm water depth		0		1

Table 25.2.Effect of irrigation treatments and transplanting dates on BRRI dhan87.

Irrigation Treatment	15 August transplanting		30 August transplanting	
	Rainfall (mm)	No. of Irrigation	Rainfall (mm)	No. of Irrigation
Rainfed	512	0	394	0
SI at -25 cm water depth		1		1
SI at -35 cm water depth		1		1

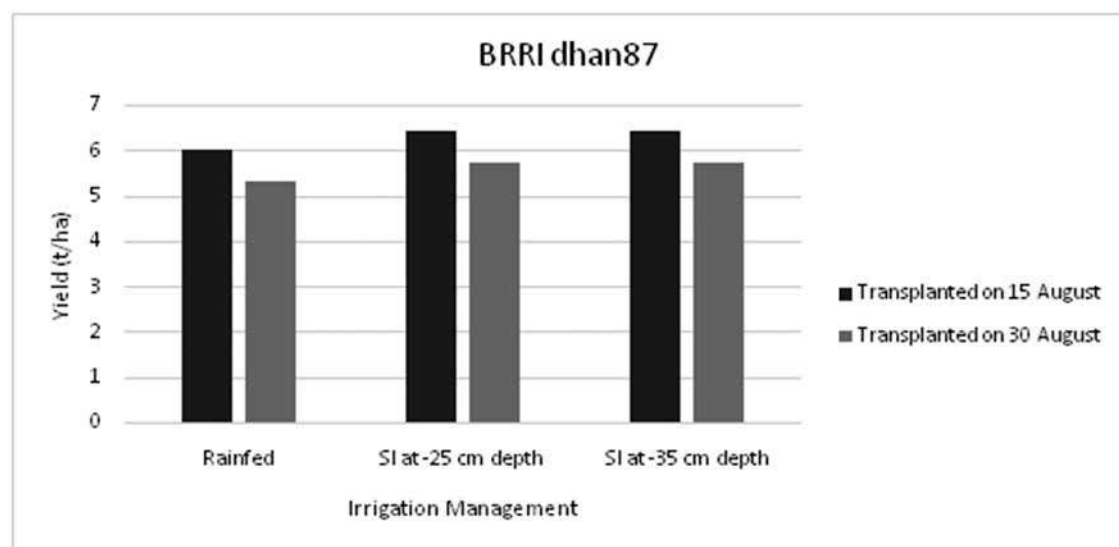


Fig 1.Yield performance of BRRI dhan87 under different irrigation treatments and transplanting dates during T.Aman, 2022 in BRRI RS farm, Kushtia.

BRRi dhan71

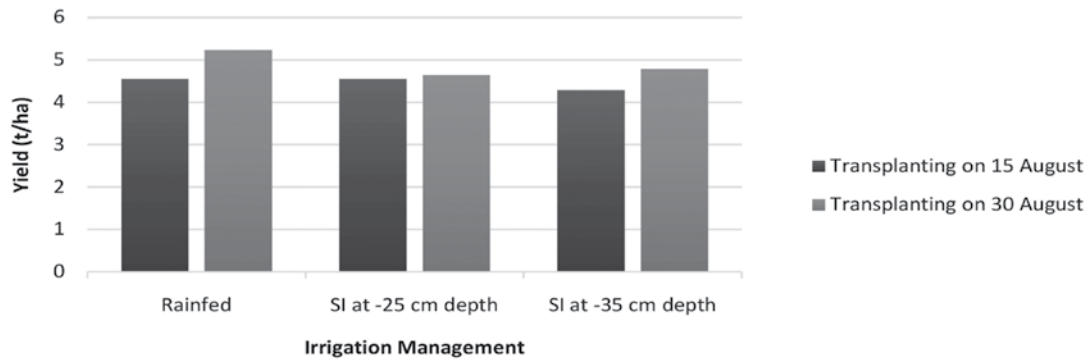


Fig 2. Yield performance of BRRi dhan71 under different irrigation treatments and transplanting dates during T. Aman 2022 in BRRi RS farm, Kushtia.

SOCIO-ECONOMICS AND POLICY

Stability analysis of BRRi developed rice varieties in T. Aus 2022

In T. Aus 2022, thirteen varieties were used in this trial to maintain season, year and location

wise database on the yield performance of BRRi varieties. Among the 13 varieties, the highest yield was obtained by BRRi dhan48 (5.4 t/ha) and the lowest by BRRi dhan65 (3.5 t/ha) (Table 26).

Table 26. Stability analysis of BRRi varieties, T. Aus 2022.

Variety	GD (day)	Yield (t/ha)	Rank
BR21	119	4.4	5
BR24	112	4.0	7
BR26	119	3.7	11
BRRi dhan27	122	3.6	12
BRRi dhan42	112	3.8	10
BRRi dhan43	118	3.9	8
BRRi dhan48	119	5.4	1
BRRi dhan65	114	3.5	13
BRRi dhan82	111	3.8	9
BRRi dhan83	124	5.0	3
BRRi dhan85	117	4.1	6
BRRi dhan98	118	5.2	2
BRRi Hybrid dhan7	125	4.9	4
LSD _{0.05}	1.5648	0.4584	
CV (%)	1.64	13.24	

DS- 22 Apr 2022

DT- 16 may 2022

Stability analysis of BRRI developed rice varieties in T. Aman 2022.

In T. Aman 2022, forty-seven varieties were used in this trial to maintain season, year and location wise database on the yield performance of BRRI varieties. Among the short duration varieties, the highest yielder was BRRI dhan87 (6.2 t/ha) and

the lowest was BRRI dhan56 (4.0 t/ha) (Table 27). Among medium duration varieties, the highest yielder was BRRI dhan72 (5.9/ t/ha) and the lowest was BR3 (3.7 t/ha) in (Table 28) and among long duration varieties, the highest yielder was BR10 (5.6 t/ha) and the lowest was BRRI dhan91 (3.4 t/ha) (Table 29).

Table 27. Short duration stability analysis of BRRI varieties, T. Aman 2022.

Variety	GD (day)	Yield (t/ha)	Rank
BRRI dhan33	122	4.4	12
BRRI dhan39	123	5.2	6
BRRI dhan53	130	5.2	7
BRRI dhan56	118	4	15
BRRI dhan57	117	4.1	14
BRRI dhan62	121	4.2	13
BRRI dhan66	119	4.8	9
BRRI dhan71	121	5.3	4
BRRI dhan73	123	5.4	3
BRRI dhan75	120	5.1	8
BRRI dhan87	131	6.2	1
BRRI dhan90	122	4.5	11
BRRI dhan95	123	5.3	5
BRRI Hybrid dhan4	125	4.6	10
BRRI Hybrid dhan6	117	5.6	2
LSD _{0.05}	0.9079	0.3032	
CV (%)	0.91	7.53	

DS-21 Jul 2022

DT-19 Aug 2022

Table 28. Stability analysis of BRRI varieties (MD), T. Aman 2022.

Variety	GD (day)	Yield (t/ha)	Rank
BR3	131	3.7	21
BR4	142	4.8	16
BR11	142	4.7	17
BR25	139	5.1	11
BRRI dhan30	139	5.3	5
BRRI dhan31	136	5	12
BRRI dhan32	129	4.5	18
BRRI dhan40	141	5.2	8
BRRI dhan44	142	5.1	10
BRRI dhan49	133	4.9	15
BRRI dhan51	139	4.2	20
BRRI dhan52	133	5	13
BRRI dhan54	130	5.4	4
BRRI dhan70	132	5.3	6
BRRI dhan72	127	5.9	1
BRRI dhan77	150	4.9	14
BRRI dhan78	137	5.5	2
BRRI dhan79	133	5.4	3
BRRI dhan80	134	4.5	19
BRRI dhan93	134	5.3	7
BRRI dhan94	134	5.2	9
LSD _{0.05}	0.9108	0.2922	
CV (%)	0.82	7.15	

DS-21 Jul 2022

DT-19 Aug 2022

Table 29. Long duration Stability Analysis of BRRI varieties, T. Aman 2022.

Variety		GD (day)	Yield (t/ha)	Rank
BR5		146	4.1	8
	BR10	147	5.6	1
	BR22	145	5.5	3
	BR23	147	5.4	4
	BRRI dhan34	139	3.7	10
	BRRI dhan37	136	4	9
	BRRI dhan38	138	5	5
	BRRI dhan41	144	5.6	2
	BRRI dhan46	145	4.3	7
	BRRI dhan76	154	4.6	6
	BRRI dhan91	151	3.4	11
LSD _{0.05}		1.0425	0.4181	
CV (%)		0.88	11.03	

DS-21 Jul 2022

DT-19 Aug 2022

Stability analysis of BRRI developed rice varieties in Boro 2022-2023

In Boro/2022-23, forty-nine varieties were used in this trial to maintain season, year and location wise database on the yield performance of BRRI varieties. Among the 23 short duration varieties, the highest yield was obtained by BRRI hybrid

dhan3 (6.28 t/ha) and the lowest by BRRI dhan81 (3.85 t/ha). None of the varieties showed lodging during Boro season (Table 30). Among 26 long duration varieties, the highest yield was obtained by BRRI dhan89 (7.34 t/ha) and the lowest by BR17 (3.75 t/ha). None of the varieties showed lodging during Boro season (Table 31).

**Table 30.Stability analysis of BRRI varieties
(Short duration) Boro 2022-23.**

Designation	GD (day)	Yield (t/ha)	Rank
BR1	147	5.60	3
BR6	141	4.70	16
BR26	135	5.03	6
BRRI dhan27	148	4.53	19
BRRI dhan28	135	4.85	13
BRRI dhan36	140	4.96	10
BRRI dhan45	137	4.62	17
BRRI dhan55	143	5.02	7
BRRI dhan61	144	4.94	11
BRRI dhan63	141	4.88	12
BRRI dhan67	138	4.13	22
BRRI dhan68	144	5.02	8
BRRI dhan74	146	4.98	9
BRRI dhan81	135	3.85	23
BRRI dhan84	138	4.38	20
BRRI dhan86	136	4.82	14
BRRI dhan88	134	4.75	15
BRRI dhan96	140	4.17	21
BRRI dhan100	139	4.57	18
BRRI dhan101	148	5.76	2
BRRI hybrid dhan2	149	5.59	4
BRRI hybrid dhan3	147	6.28	1
BRRI hybrid dhan5	148	5.50	5
LSD _(0.05)	0.6262	0.3273	
CV (%)	0.54	8.16	

DS: 17 Dec 2022

DT: 27 Jan 2023

**Table 31.Stability analysis of BRRI varieties
(Long duration)Boro 2022-23.**

Designation	GD (day)	Yield (t/ ha)	Rank
BR2	149	5.02	20
BR3	158	5.76	14
BR7	159	6.17	10
BR8	158	5.77	13
BR9	155	6.24	8
BR12	156	5.82	12
BR14	149	4.60	22
BR15	157	6.56	6
BR16	156	6.17	9
BR17	145	3.75	26
BR18	160	5.72	15
BR19	156	6.32	7
BRRI dhan29	156	6.74	3
BRRI dhan35	156	5.40	17
BRRI dhan47	146	4.48	24
BRRI dhan50	146	4.85	21
BRRI dhan58	149	6.66	4
BRRI dhan59	148	5.27	18
BRRI dhan60	139	4.59	23
BRRI dhan64	147	4.01	25
BRRI dhan69	149	5.42	16
BRRI dhan89	155	7.34	1
BRRI dhan92	161	6.63	5
BRRI dhan97	149	5.07	19
BRRI dhan99	156	6.92	2
BRRI dhan102	158	6.02	11
LSD	0.6516	0.3117	
CV	0.52	6.74	

DS: 17 Dec 2022

DT:27 Jan 2023

TECHNOLOGY TRANSFER

Varietal Demonstration

Varietal demonstration under GoB

BRRi RS, Kushtia also worked for expansion of newly released BRRi high yielding and hybrid varieties in Aus, Aman and Boro season. In the last reporting year 2022-23 a total of 461 demonstrations were executed at 23 upazilas of five districts. Where 100 demonstrations were in Aus 2022 season, 161 and 200 in Aman and Boro season respectively. BRRi hybrid dhan7 reported as highest yielder (6.03 t/ha) among demonstrated Aus varieties. Among 161 demonstration BRRi dhan87 ranked first with average yield 6.01 t/ha. BRRi dhan90 got very much popularity because

of its growth duration and high market price. Nine varieties were demonstrated during Boro 2022-23 in the farmers' field. BRRi hybrid dhan8 was the highest yielder (8.85 t/ha) on that season.

Head-to-head adaptive trial under TRB project

In five different farmers' field adaptability trial was conducted during T. Aman, 2022 season. Average yield of performed varieties is accumulated (Table 32) where it showed BRRi dhan75 along with BRRi dhan22 were the top most yielders (5.92 t/ha). A total of seven trials where four sets of short duration and three sets of long duration were executed during Boro, 2022-23 season. BRRi dhan74 in short duration group and BRRi dhan92 for long duration group reported as the highest yielders (Table 33).

Table 32. Varietal performance of head-to-head adaptive trial during Aman 2022.

Variety	Lowest yield (t/ha)	Highest yield (t/ha)	Average yield (t/ha)	Rank
BRRi dhan33	4.66	6.25	5.45	2
BRRi dhan39	5.13	5.35	5.24	5
BRRi dhan71	4.8	5.69	5.36	4
BRRi dhan75	4.97	6.84	5.92	1
BINA dhan7	4.05	4.93	4.49	7
BINA dhan16	3.59	5.86	4.99	6
BINA dhan17	4.16	6.32	5.44	3
BINA dhan22	5.18	6.44	5.92	1

Table 33. Varietal performance of head-to-head adaptive trial during Boro 2022-23.

Variety	Lowest yield (t/ha)	Highest yield (t/ha)	Average yield (t/ha)	Rank
Short Duration Group				
BRRi dhan28	4.61	4.91	4.74	6
BRRi dhan74	5.76	6.75	6.38	1
BRRi dhan88	4.26	5.72	5.24	5
Bangabandhu dhan100	5.89	6.24	6.10	3
BINA dhan25	6.12	6.46	6.25	2
BAU dhan3	4.97	7.31	6.09	4

Variety	Lowest yield (t/ha)	Highest yield (t/ha)	Average yield (t/ha)	Rank
Long duration group				
BRRI dhan29	6.77	9.31	7.79	3
BRRI dhan89	7.55	10.03	8.57	2
BRRI dhan92	8.59	10.21	9.26	1
BINA dhan24	6.13	9.61	7.55	4

Farmers' Training and Field Day

In the reporting year, 10 batches of farmers' training were organized in which 300 farmers participated. Modern rice varieties and relevant technologies were disseminated through field demonstrations and 10 field days in which more than 1,000 farmers participated.

ENRICHMENT OF SEED STOCK

Production of truthfully labeled seed (TLS)

Truthfully labeled seed (TLS) production activities were conducted at BRRI RS, Kushtia research field during Aus, Aman and Boro seasons 2022--23. This seed production category was easy without supervision of SCA but quality was maintained providing our own facilities and declared truthfully. BRRI dhan48, BRRI dhan85 and BRRI dhan98 during Aus 2022 whereas BRRI dhan71, BRRI

dhan87 and BRRI dhan90 during Aman 2022 and for Boro 2023 season BRRI dhan63, BRRI dhan89, BRRI dhan92 and BRRI dhan96 were cultivated for TLS seed production. Total production of TLS during Aus, Aman and Boro were 1,070, 1,430 and 1,367 kg, respectively.

Production of breeder seed

Nucleus seeds were supplied from Genetic Resources and Seed (GRS) Division for breeder seed production during Aman and Boro Season. During Aman 2022 season BRRI dhan63, BRRI dhan83 and BRRI dhan87 whereas BRRI dhan63 during Boro 2023 season were cultivated for breeder seed production. Total production of breeder seed during Aman and Boro season was 3,175 kg and 3,500 kg, respectively.

BRRI RS, SIRAJGANJ

596	Summary
596	Varietal Development Programme
608	Pest Management Programme
609	Technology Transfer

SUMMARY

Tested entry BRH13-9-5-3B produced the highest yield which is 1.36 ton higher than the check variety Zirashail in T. Aman 2022. Tested entries BR10471-1-2-3-15-1 and BR9674-1-1-5-2-P4-HR1 produced higher yield (0.33 t/ha and 0.39 t/ha) over the check variety BRRI dhan72 with shorter growth duration in T. Aman 2022. Advanced lines BRH13-2-14-2-1B and BRH13-7-9-3-2B produced 0.82 and 0.57 t/ha higher yield than the check variety BRRI dhan49 in T. Aman 2022. In fungicide spraying trial, genotype HAH 210 and HGB 21 produced significantly higher yield over all the check varieties. In without spraying trial, HAH 210, HGG 205 and HGP 197 produced significantly higher yield over the check variety IR64 Pi9 L in Boro 2022-23. Genotype BR (Path)13800-BC3-8-9 and BR (Path)13800-BC3-109-10 produced significantly higher yield over the check varieties, BRRI dhan58, BRRI dhan89 and BRRI dhan92 in Boro 2022-23. Test entries, BR (Path)13800-BC3-8-5 and BR (Path)13800-BC3-134-25 produced significantly higher yield over the check variety BRRI dhan89 with similar duration in Boro 2022-23. In early warning for rice blast disease, all entries produced higher yield at 26 January planting and among them BRRI dhan74 produced higher yield at all planting dates in Boro 2022-23. The antioxidant tested genotypes BR12839-4R-5-2 and BR12839-4R-157-2 produced significantly higher yield over the check variety BRRI dhan88 but statistically similar with the check variety, Indonesian black rice in Boro 2022-23. For development of short slender Katari rice, BRH13-5-12-2-2B produced 0.13 ton higher yield over the check variety, Katari with shorter duration (11 days) in Boro 2022-23. For development of fine grain ziratype rice, BRH 13-9-5-3B produced significantly higher yield over the check variety, Zirashail with similar growth duration in Boro 2022-23. In ALART, for development of B. Aman (deep areas), BR10230-7-19-2B produced significantly higher yield over the check variety Fulkori with similar duration in Aman 2022. In ALART for SHR-2 (Extra long and long slender), IR12A-177 produced statistically higher yield over the check varieties BRRI dhan62, BRRI dhan75 in

T. Aman 2022. In ALART, for SHR-1 (Zirashail type), BRH13-1-9-7B, BRH15-24-7B and BRH13-2-4-7-2B produced significantly higher yield over the check varieties, Zirashail, BRRI dhan57 in T. Aman 2022. In ALART, for PQR, entries BR8493-3-5-1-P1 and BR9590-45-1-3-2-P2 produced significantly higher yield over the check varieties BRRI dhan34 and BRRI dhan70 in Boro 2022-23. In Re-ALART, for blast resistance rice (BRR), BR (Path)12452-BC6-53-21-11, BR (Path)13784-BC3-61--1-6-HR3 and BR (Path)13784-BC3-63-6-4-HR6 gave statistically higher yield over the check varieties BRRI dhan28 and BRRI dhan88 in Boro 2022-23. In ALART for superior high yielding Rice (SHR-1), BRH13-2-4-7-7B and BRH15-24-7B produced significantly higher yield over the check variety, BRRI dhan81 in Boro 2022-23. In ALART for superior high yielding Rice (SHR-2), BRH238-5-1-4-2 produced significantly higher yield over the check variety, BRRI dhan88 with similar duration in Boro 2022-23. In ALART, for short duration favourable Boro rice (FBR-SD), SVIN109 produced statistically higher yield over the check variety BRRI dhan81 in Boro 2022-23. In Boro 2022-23 season, application of biochar @ 4 t/ha with recommended fertilizer resulted in the higher yield of BRRI dhan89 than the other treatments. In case of BRRI dhan71, number of panicle/hill and higher yield was observed when transplanted on 16 August irrespective of plant spacing in T. Aman 2022.

A total of 8.66 and 9.27 tons of breeder and TLS seed respectively were produced during 2022-23 season.

VARIETAL DEVELOPMENT PROGRAMME

Regional yield trial (RYT), T. Aman 2022 and Boro 2022-23

Development of Zirashail type rice, T. Aman 2022

Three genotypes were evaluated along with Zirashail as standard check at the research field of BRRI Sirajganj. All the tested entries produced significantly higher yield over the check variety. Among the entries, BRH13-9-5-3B produced the highest yield which is 1.36 ton higher than the check variety (Table 1).

Table 1. Effect of Zirashail genotype on growth duration, plant height, panicle m⁻² and yield of rice during T. Aman 2022.

Genotype	Growth duration (day)	Plant height (cm)	Panicle m ⁻²	Grain yield (t ha ⁻¹)
BRH11-7-17-10B	116	109.8	410	5.10±0.25
BRH13-9-5-3B	117	108.9	333	5.41±0.08
BRH9-3-14-2B	118	109.9	333	5.15±0.35
Zirashail (ck)	114	116.0	427	4.05±0.40*
Lsd _(0.05)	-	6.6	23	0.62
CV (%)	-	3.0	3.06	6.3

DS: 6 Jul 2022 DTP: 2 Aug 2022 *Lodging

Development of zinc enriched rice (ZER), T. Aman 2022

Four genotypes were evaluated along with two standard check varieties BRRI dhan72 and BRRI dhan87 at BRRI RS, Sirajganj. The tested genotypes BR10471-1-2-3-15-1 and BR9674-1-1-5-2-P4-HR1 produced higher yield (0.33 t/ha and 0.39 t/ha) over the check variety BRRI dhan72 with shorter growth duration (8 days) (Table 2).

Table 2. Effect of Zinc Enriched Rice genotype on growth duration, plant height, panicle m⁻² and yield of rice during T. Aman 2022.

Genotype	Growth duration (day)	Plant height (cm)	Panicle m ⁻²	Grain yield (t ha ⁻¹)
BR10490-1-2-3-8-7	117	115.2	350	1.45±0.24*
BR10470-1-2-3-13-5	117	126.4	311	3.89±0.05*
BR10471-1-2-3-15-1	121	122.1	211	5.45±0.23
BR9674-1-1-5-2-P4-HR1	121	124.3	235	5.60±0.20
BRRI dhan72 (ck)	129	125.8	294	5.12±0.13
BRRI dhan87 (ck)	129	126.9	307	4.31±0.17**
Lsd _(0.05)	-	8.6	22	0.61
CV (%)	-	3.84	4.29	7.81

DS: 24 Jun 2022 DTP: 20 Jul 2022

* Lodged at flowering

**Lodged before maturity due to heavy storm.

Development of short slender rice (SSR), T. Aman 2022

Three genotypes were grown along with check variety BRRI dhan49 at BRRI RS, Sirajganj. Advanced lines BRH13-2-14-2-1B and BRH13-7-9-3-2B produced 0.82 and 0.57 t/ha higher yield than check variety, BRRI dhan49 (Table 3).

Table 3. Effect of Short slender genotype on growth duration, plant height, panicle m⁻² and yield of rice during T. Aman 2022.

Genotype	Growth duration (day)	Plant height (cm)	Panicle m ⁻²	Grain yield (t ha ⁻¹)
BRH13-2-14-2-1B	137	119.6	350	5.32±0.15
BRH17-23-8-2-7B	117	106.1	311	4.33±0.16
BRH13-7-9-3-2B	121	122.0	211	5.07±0.03
BRRI dhan49	129	102.1	235	4.50±0.07
Lsd _(0.05)	-	4.6	27	0.35
CV (%)	-	2.06	4.41	3.71

DS: 22 Jul 2022

DTP: 19 Aug 2022

Development of Swarna and long slender type rice, T. Aman 2022

Five genotypes were grown along with the check varieties BRRI dhan87 and BRRI dhan94 at BRRI RS, Sirajganj. No tested genotype produced significantly higher yield over the standard checks.

Multi location trial for blast resistant materials, Boro 2022-23

Two sets of experiment of multilocation trial (MLT) for blast resistant materials was conducted

at BRRI RS, Sirajganj. Ten genotypes were grown along with the check varieties BRRI dhan28, BRRI dhan29, BRRI dhan63, BRRI dhan64 and IR64 Pi9 with spraying fungicide and without spraying. No blast infestation was observed in these trials. In spraying trial, genotype HAH 210 and HGB 21 produced significantly higher yield over all the check varieties. In without spraying trial, genotype HAH 210, HGG 205 and HGP 197 produced significantly higher yield over the check variety IR64 Pi9 L (Table 4).

Table 4. Performance of different entries under MLT (With spraying fungicide) during Boro 2022-23.

Desig.	Plant height (cm)		Panicle /hill		Yield (tha ⁻¹)	
	With spraying	Without spraying	With spraying	Without spraying	With spraying	Without spraying
AD 181	113.7	121.2	14	14	6.48±0.30	6.54±0.40
HAH 210	106.2	114.0	14	14	9.37±0.21	8.43±0.30
HAI 84	124.3	125.6	14	13	7.23±0.15	5.28±0.43
AL 73	112.2	116.2	11	13	6.54±0.10	7.42±0.44
HAN 165	90.7	89.9	12	13	8.57±0.30	7.64±0.35
HCP 245	110.7	113.0	11	13	6.72±0.16	6.74±0.15
HGB 21	122.8	120.5	13	14	8.65±0.50	7.52±0.36
HGG 205	98.7	105.7	13	14	5.78±0.21	8.47±0.28
HGK 236	115.3	120.9	9	13	7.49±0.33	8.07±0.24
HGP 197	100.8	101.2	13	12	7.24±0.34	8.57±0.31
BRRI dhan28 (ck)	104.6	104.4	12	14	7.84±0.16	7.67±0.45
BRRI dhan29 (ck)	104.2	105.2	14	13	6.34±0.21	7.76±0.17
BRRI dhan63 (ck)	93.4	94.5	13	15	7.16±0.36	7.40±0.17
BRRI dhan64 (ck)	115.5	114.8	11	11	6.86±0.24	7.59±0.30
IR64 Pi9 L (ck)	95.4	95.0	16	14	6.08±0.10	7.31±0.41
Lsd _(0.05)	2.82	2.37	1.79	1.85	0.79	0.92
CV (%)	1.57	1.30	8.47	8.29	6.59	7.36

DS: 7 Dec 2022

DTP: 23 Jan 2023

Development of disease resistant rice (DRR) for BB (RYT#1) Boro 2022-23

One set of experiment of DRR trial for BB resistant materials was conducted at BRRI RS, Sirajganj. Eighteen genotypes were grown along with the

check varieties BRRI dhan28, BRRI dhan58, BRRI dhan89, BRRI dhan92 and BRRI dhan101. No major BB infestation was observed in this trial. Genotype BR (Path)13800-BC3-8-9 and BR (Path)13800-BC3-109-10 produced significantly higher yield over the check varieties (Table 5).

Table 5. Performance of different entries under RYT DRR BB during Boro 2022-23.

Designation	Plant height (cm)	GD (day)	Panicle /hill	Yield (tha ⁻¹)
BR11604-4R-24	108.6	150	12	7.76±0.21
BR11607-4R-2	101.3	158	15	6.89±0.27
BR11607-4R-258	97.4	148	12	6.59±0.29
BR11866-5R-73	87.4	155	15	7.08±0.41
BR11866-5R-136	98.4	155	13	6.24±0.37
BR11866-5R-223	104.8	160	13	8.87±0.30
BR11866-5R-277	99.4	158	15	8.19±0.31
BR11867-5R-117	92.7	155	14	7.15±0.17
BR11867-5R-140	94.9	155	15	8.08±0.23
BR11867-5R-154	93.6	151	15	7.63±0.22
BR11867-5R-347	98.7	145	9	6.73±0.42
BR11868-5R-9	111.4	146	12	5.20±0.15
BR(Path)13800-BC3-8-1	106.9	155	13	9.19±0.24
BR(Path)13800-BC3-8-6	101.9	155	12	8.29±0.34
BR(Path)13800-BC3-109-10	105.7	151	12	9.30±0.14
BR(Path)13800-BC3-8-7	99.0	155	14	6.84±0.40
BR(Path)13800-BC3-8-9	107.8	150	13	9.47±0.17
BR(Path)13800-BC3-224-28	105.8	151	12	8.35±0.03
BRRI dhan58 (ck)	101.9	150	11	6.14±0.45
BRRI dhan89 (ck)	107.9	155	13	6.20±0.28
BRRI dhan92 (ck)	115.9	158	13	8.34±0.18
BRRI dhan101 (ck)	115.4	150	13	7.21±0.43
Lsd _(0.05)	5.4		3.0	0.90
CV (%)	2.5		10.3	5.8

DS: 8 Dec 2022

DTP: 21 Jan 2023

Development of disease resistant rice (DRR) for blast and BB (RYT#1) Boro 2022-23

One set of experiment of DRR trial for blast and BB was evaluated at BRRI Sirajganj. Twelve genotypes were grown along with the check varieties BRRI dhan89 and BRRI dhan92. No major blast and BB infestation was observed in this trial. None

of the entry produced statistically higher yield over the standard check variety, BRRI dhan92. But test entries, BR(Path)13800-BC3-8-5 and BR (Path)13800-BC3-134-25 produced significantly higher yield over the check variety, BRRI dhan89 with similar duration (Table 6).

Table 6. Performance of entries under RYT DRR Blast and BB during Boro 2022-23.

Designation	GD (day)	Plant ht. (cm)	Panicle /hill	Yield (t ha ⁻¹)
BR(Path)13800-BC3-8-5	156	106.5	13	9.52±0.36
BR(Path)13800-BC3-134-8	153	105.9	13	9.29±0.30
BR(Path)13800-BC3-8-11	159	104.9	14	9.20±0.24
BR(Path)13800-BC3-110-19	159	107.2	14	9.03±0.38
BR(Path)13800-BC3-12-13	157	105.2	12	8.77±0.15
BR(Path)13800-BC3-224-17	156	107.6	13	9.33±0.18
BR(Path)13800-BC3-134-25	152	106.2	12	9.78±0.21
BR(Path)13800-BC3-8-37	157	104.5	13	9.36±0.12
BR(Path)13800-BC3-110-4	159	104.1	13	8.41±0.35
BR(Path)13800-BC3-224-44	157	112.7	14	9.25±0.24
BRRI dhan89 (ck)	156	114.9	14	8.62±0.27
BRRI dhan92 (ck)	159	124.4	15	9.22±0.31
Lsd _(0.05)		1.97	1.68	0.81
CV (%)		1.07	7.49	5.26

DS: 9 Dec 2022

DTP: 25 Jan 2023

1.8 Development of early warning for rice blast disease in Bangladesh Boro 2022-23

Four rice genotypes (BRRI dhan28, BRRI dhan63, BRRI dhan81, BRRI dhan74) were grown in BRRI RS farm, Sirajganj to generate information for

early warning for blast disease. No blast and BB infestation was observed in this trial. All the entries produced higher yield at 26 January planting and among the entries, BRRI dhan74 produced higher yield at all planting dates (Table 7).

Table 7. Performance of different entries under RYT Blast model during Boro 2022-23.

Desig.	Pl. height (cm)			Panicle/hill			Yield (t ha ⁻¹)		
	19 Jan	26 Jan	06 Feb	19 Jan	26 Jan	06 Feb	19 Jan	26 Jan	06 Feb
BRRI dhan28	102.1	98.29	95.4	14	15	13	6.64±0.41	8.11±0.23	5.41±0.29
BRRI dhan63	84.2	87.14	85.1	14	14	14	6.99±0.12	8.08±0.37	5.75±0.26
BRRI dhan81	95.0	95.3	92.2	11	11	12	6.96±0.05	7.31±0.12	4.72±0.18
BRRI dhan74	93.4	96.2	93.6	11	13	14	7.63±0.15	8.40±0.46	6.20±0.22
Lsd _{0.05}	8.72	4.81	6.05	2.51	2.42	2.44	0.82	1.18	0.78
CV (%)	4.66	2.56	3.31	10.22	9.09	9.20	5.84	7.42	7.05

DS: 4 Dec 2022

DTP: 19 Jan 2023

1.9 Development of antioxidant enriched rice, Boro 2022-23

Eight genotypes were grown along with the check varieties BRRI dhan88 and Indonesian black rice at BRRI RS, Sirajganj. The tested genotypes

BR12839-4R-5-2 and BR12839-4R-157-2 produced significantly higher yield over the check variety, BRRI dhan88 but statistically similar with check variety, Indonesian black rice (Table 8).

Table 8. Performance of different entries under RYT medium duration black rice during Boro 2022-23.

Designation	GD (day)	Plant height (cm)	Panicle /hill	Yield (tha ⁻¹)
BR12839-4R-157-2	146	114.7	10	7.29±0.10
BR12839-4R-5-2	145	113.0	9	7.34±0.16
BR12839-4R-93	145	107.1	10	6.40±0.12
BR12839-4R-47-1	147	114.3	9	7.06±0.10
BR12839-4R-90-1	151	113.4	9	6.89±0.22
BR12839-4R-138-4	145	109.9	10	6.53±0.30
BR12839-4R-78-1	146	117.2	10	7.10±0.14
BR12839-4R-21	146	119.5	9	6.47±0.24
Indonesian Black Rice (ck)	145	113.8	13	7.17±0.30
BRRI dhan88 (ck)	145	92.6	11	6.57±0.26
Lsd _(0.05)	-	2.43	1.71	0.65
CV (%)	-	1.27	9.92	5.49

DS: 12 Dec 2022

DTP: 31 Jan 2023

Development of short duration black rice, Boro 2022-23

Three genotypes were grown along with the check variety BRRI dhan84 at BRRI RS, Sirajganj. None of the tested entry produced significantly higher yield over check variety.

Development of water saving rice, Boro 2022-23.

Two genotypes and one check variety BRRI dhan58 were tested in RCB design with three replications. The genotype BR11206-5B-351 produced similar yield with the check variety (Table 9).

Table 9. Performance of water saving rice entries under RYT during Boro 2022-23.

Designation	GD (day)	Plant height (cm)	Panicle /hill	Yield (t ha ⁻¹)
BR11206-5B-351	155	99.54	14	6.69±0.24
BR11204-5B-224	145	101.0	14	6.10±0.16
BRR1 dhan58	152	102.0	13	6.24±0.27
Lsd _(0.05)	-	2.1	1.3	1.06
CV (%)	-	0.94	4.20	7.38

DS: 10 Dec 2022

DTP: 31 Jan 2023

Development of favourable Boro rice (Barishal), Boro 2022-23

Nine genotypes with two check varieties BRR1 dhan88 and BRR1 dhan89 were tested in RCB

design with three replications. None of the tested entry produced significantly higher yield over the check variety BRR1 dhan89 but all tested entries were produced statistically similar yield with the check variety, BRR1 dhan88 (Table 10).

Table 10. Performance of different entries under RYT FBR-Barishal during Boro 2022-23.

Designation	GD (day)	Plant height (cm)	Panicle /hill	Yield (tha ⁻¹)
NGR 522-2	150	97.6	14	7.23±0.08
NGR 270-3	150	97.9	15	7.32±0.02
NGR 418-1	146	96.7	12	7.36±0.12
NGR 416-1	146	97.3	15	7.21±0.13
NGR 968-1	146	96.2	14	7.32±0.27
NGR 994-1	150	99.8	15	7.22±0.12
NGR 745-2	150	98.1	14	7.23±0.22
NGR 590-2	147	94.6	14	7.34±0.09
NGR 710-1	145	92.8	14	7.37±0.17
BRR1 dhan88 (ck)	142	90.4	13	6.91±0.42
BRR1 dhan89 (ck)	158	104.8	14	8.34±0.17
Lsd _(0.05)	-	4.5	1.7	0.56
CV (%)	-	2.7	6.9	4.5

DS: 11 Dec 2022

DTP: 1 Feb 2023

Development of late transplanting Boro rice, boro 2022-23

Three genotypes with two check varieties BRR1 dhan28 was tested in RCB design with three

replications. All the tested entries produced similar grain yield to the check variety. Entry BRH17-23-8-2-7B produced more than 0.4 ton yield than the check variety but duration was longer (10 days) (Table 11).

Table 11. Performance of late transplanting entries under RYT during Boro 2022-23.

Designation	GD (day)	Plant height (cm)	Panicle /hill	Yield (t ha ⁻¹)
BRH13-2-4-6-4B	126	99.4	14	5.74±0.23
BRH11-7-17-10B	124	105.8	15	6.11±0.06
BRH17-23-8-2-7B	132	99.1	15	6.36±0.07
BRR1 dhan28	122	109.5	15	5.94±0.08
Lsd _(0.05)	-	2.98	1.2	0.46
CV (%)	-	1.44	4.14	3.82

DS: 16 Jan 2023

DTP: 20 Feb 2023

Development of short slender Katari rice, Boro 2022-23

Five genotypes with the check variety, Katari were tested in RCB design with three replications.

None of the test entry produced significantly higher yield over check variety but the entry BRH13-5-12-2-2B produced 0.13 ton higher yield over the check variety with shorter duration (11 days) (Table 12).

Table 12. Performance of different entries under RYT short slender Katari during Boro 2022-23.

Designation	GD (day)	Plant height (cm)	Panicle /hill	Yield (t ha ⁻¹)
BRH18-9-4-2-3B	145	91.3	14	6.71±0.18
BRH13-5-12-2-2B	144	90.8	14	6.91±0.13
BRH14-2-1-7B	145	83.2	15	6.04±0.15
BRH9-3-2B	143	92.5	13	6.44±0.19
BR9392-1-7-5B	143	86.6	16	6.27±0.15
Katari (ck)	155	99.1	16	6.78±0.14
Lsd _(0.05)	-	3.0	2.2	0.52
CV (%)	-	1.8	8.2	4.4

DS: 4 Dec 2022

DTP: 13 Jan 2023

Development of fine grain ziratype rice, Boro 2022-23

Five genotypes with two check varieties, BRRI dhan28 and Zirashail were tested in RCB design

with three replications. The genotype BRH 13-9-5-3B produced significantly higher yield over the check variety with similar growth duration (Table 13).

Table 13. Performance of different fine grain ziratype entries during Boro 2022-23.

Designation	GD (day)	Plant height (cm)	Panicle /hill	Yield (t ha ⁻¹)
BRH 13-9-5-3B	146	96.0	12	6.17±0.22
BRH 12-1-7B-P1	145	106.6	11	5.49±0.20
BRH 9-3-14-2B	145	99.9	13	5.67±0.26
BR 10247-4-7-4B	147	104.3	14	5.84±0.69
BRH13-7-9-3-2B	151	112.1	12	5.67±0.22
BRRI dhan28	145	99.4	12	5.23±0.36
Zirashail (ck)	146	91.2	18	5.38±0.24
Lsd _(0.05)	-	7.9	3.07	0.77
CV (%)	-	4.4	12.9	11.3

DS: 4 Dec 2022

DTP: 10 Jan 2023

1.16 Development of favorable boro rice, Boro 2022-23

Five genotypes with two check varieties BRRI dhan86 and BRRI dhan96 were tested in RCB design with three replications. None of the tested entry produced significantly higher yield over the check varieties.

Advanced line adaptive research trial (ALART), T. Aman 2022 and Boro 2022-23**Direct seeded B. Aman, deep areas (100-150 cm water depth), 2022**

The experiment was conducted at the farmers' field of Char situlia, Shahjadpur, Sirajganj. Seven genotypes including one check (Fulkori) was evaluated. Genotypes BR10230-7-19-2B produced significantly higher yield over the the check variety with similar duration (Table 14).

Table 14. Performance of B. Aman entries under ALART 2022 at Shahjampur, Sirajganj.

Genotype	GD (day)	Plant height (cm)	Panicle m ⁻²	Yield (t ha ⁻¹)
BR10230-7-19-2B	164	213.6	158	2.06±0.05
BR9892-6-2-2B	160	191.7	175	1.18±0.07
BR9376-6-2-2B	162	159.4	132	1.09±0.05
BR9392-6-2-1B	163	188.3	125	1.67±0.06
BR-KM (Mun)-pl-5-7-3-B	160	222.2	145	1.57±0.12
BR-DL(Hbj)-PL-12-4-7-B	160	247.8	168	1.52±0.14
Fulkori (ck.)	161	209.2	141	1.74±0.27
Lsd _(0.05)		16.9	9.2	0.31
CV (%)		4.7	3.5	13.5

DS: 08.06.

2.2 Drought Tolerant Rice (DTR), ALART, T. Aman 2022

The experiment was conducted at the farmers' field of Bogura Sadar upazila of Bogura District. Two genotypes including two checks (BRRI dhan71 and BRRI dhan75) was evaluated. None of the tested entry produced significantly higher yield over the check varieties.

2.3 Premium Quality Rice (PQR), ALART, T. Aman 2022.

The experiment was conducted at the farmers, field of Bogura Sadar upazila of Bogura District. Two genotypes including two checks (BRRI dhan34 and BRRI dhan70) was evaluated. Tested entries, BR8493-3-5-1-P1 and BR9590-45-1-3-2-P2 produced significantly higher yield over the check varieties. (Table 15).

Table 15. Performance of different entries under ALART PQR at Bogura Sadar, Bogura during T. Aman 22.

Genotype	GD (day)	Plant height (cm)	Panicle m ⁻²	Yield (t ha ⁻¹)
BR8493-3-5-1-P1	134	125.7	205	5.37±0.23
BR9590-45-1-3-2-P2	156	126.2	182	5.12±0.52
BRRI dhan34 (ck)	152	154.7	262	1.97±0.37
BRRI dhan70 (ck)	134	135.9	207	4.42±0.22
Lsd _(0.05)		12.5	22.6	0.64
CV (%)		4.6	5.3	15.5

DS: 2 Jul 2022

DTP: 30 Jul 2022

2.4 SHR-1 (Zirashail type), ALART, T. Aman 2022.

The experiment was conducted at the farmer's field of Bogura Sadar upazila of Bogura District.

Five genotypes including two checks (Zirashail and BRRI dhan57) were evaluated. Test entries, BRH13-1-9-7B, BRH15-24-7B and BRH13-2-4-7-2B produced significantly higher yield over the check varieties (Table 16).

Table 16. Performance of different entries under ALART SHR-1 at Bogura Sadar, Bogura during T. Aman 22.

Genotype	GD (Day)	Plant height (cm)	Panicle m-2	Yield (t ha ⁻¹)
BRH15-24-7B	109	107.3	231	5.94±0.39
BRH13-1-9-7B	120	106.6	244	6.05±0.10
BRH13-2-4-7-2B	109	109.1	269	5.85±0.17
BRH10-1-14-6-2B	120	108.0	233	4.99±0.08
BR10247-4-7-4B	120	108.6	249	3.46±0.18
Zirashail (ck.)	107	114.9	249	3.85±0.08
BRR1 dhan57(ck.)	107	109.1	332	5.07±0.22
Lsd _(0.05)		3.7	56.4	0.65
CV (%)		1.9	12.2	7.3

DS: 2 Jul 2022

DTP: 30 Jul 2022

2.5 SHR-2 (Extra long and long slender), ALART, T. Aman 2022

The experiment was conducted at the farmers' field of Bogura Sadar upazila of Bogura District. Five

genotypes including two checks (BRR1 dhan62 and BRR1 dhan75) was evaluated. Entry IR12A-177 produced statistically higher yield over the check varieties (Table 17).

Table 17. Performance of SHR-2 entries under ALART at Bogura Sadar in T. Aman 2022.

Genotype	GD (day)	Plant height (cm)	Panicle m-2	Yield (t ha ⁻¹)
VBR9392-1-9-7-5B	118	132.5	271	4.22
BR10247-14-18-4	107	114.6	261	3.79
BR9392-40-50-1B	112	130.7	304	3.38
IR12A-177	115	126.5	273	5.04
BR10238-5-1-4-2	115	128.0	274	4.68
BRR1 dhan62 (ck)	106	105.2	350	4.48
BRR1 dhan75 (ck)	111	116.7	284	4.44
Lsd _(0.05)		3.7	56.8	0.55
CV (%)		1.9	12.2	7.3

DS: 2 Jul 2022

DTP: 30 Jul 2022

Blast resistance rice (BRR), ALART, Boro 2022-23

The experiment was conducted at the farmers' field of Bogura Sadar upazila of Bogura District. Four genotypes including two checks (BRR1 dhan29, BRR1 dhan89) was evaluated. None of the tested entry produced significantly higher yield over check varieties.

Blast resistance rice (BRR), Re- ALART, Boro 2022-23

The experiment was conducted at the farmers' field of Bogura Sadar upazila of Bogura District. Four

genotypes including two checks (BRR1 dhan28, BRR1 dhan88) were evaluated. Tested entries BR(Path)12452-BC6-53-21-11, BR(Path)13784-BC3-61--1-6-HR3 and BR(Path)13784-BC3-63-6-4-HR6 produced statistically higher yield over the check varieties. Among the tested entries, BR(Path)13784-BC3-63-6-4-HR6 produced 0.8 ton yield than BRR1 dhan88 with similar duration (Table 18).

Table 18: Performance of different entries under ALART BRR Re-ALART at Bogura Sadar, Bogura during Boro 2022-23.

Genotype	GD (day)	Plant ht. (cm)	Panicle (m ²)	Yield (t ha ⁻¹)
BR(Path)12452-BC3-42-22-11-4	147	118.2	285	5.69±0.06
BR(Path)12452-BC6-53-21-11	145	109.5	305	6.92±0.28
BR(Path)13784-BC3-61--1-6-HR3	147	103.6	301	6.93±0.07
BR(Path)13784-BC3-63-6-4-HR6	145	104.4	259	7.11±0.02
BRR1 dhan28 (ck)	144	108.5	263	6.03±0.16
BRR1 dhan88 (ck)	144	94.4	314	6.28±0.21
Lsd _(0.05)		4.9	45.2	0.52
CV (%)		2.5	8.6	4.4

DS: 5 Dec 2022

DTP:18 Jan 2023

Superior high yielding rice (SHR-1), ALART, Boro 2022-23

The experiment was conducted at the farmers' field of Bogura Sadar upazila of Bogura District. Three

genotypes including one check (BRR1 dhan81) was evaluated. Among three genotypes, BRH13-2-4-7-7B and BRH15-24-7B produced significantly higher yield over the check variety (Table 19).

Table 19. Performance of different entries under ALART SHR-1 at Bogura Sadar, Bogura during Boro 2022-23.

Genotype	Duration (day)	Plant height (cm)	Panicle (m ²)	Yield (tha ⁻¹)
BRH10-1-14-2-6	152	96.3	282	5.40±0.05
BRH13-2-4-7-7B	150	99.0	307	5.72±0.04
BRH15-24-7B	155	94.1	267	5.63±0.04
BRR1 dhan81 (ck)	148	116.1	276	5.24±0.14
Lsd _(0.05)		7.7	8.9	0.30
CV (%)		3.8	1.6	2.8

DS: 12 Dec 2022

DTP:23 Jan 2023

Superior high yielding rice (SHR-2), ALART, Boro 2022-23

The experiment was conducted at the farmers' field of Bogura Sadar upazila of Bogura District. Three

genotypes including one check (BRR1 dhan88) was evaluated. Among the three genotypes, BRH238-5-1-4-2 produced significantly higher yield over the check variety with similar duration (Table 20).

Table 20. Performance of different entries under ALART SHR-2 at Bogura Sadar, Bogura during Boro 2022-23.

Genotype	Duration (day)	Plant height (cm)	Panicle (m ²)	Yield (t ha ⁻¹)
BRH11-2-4-7B	149	107.6	294	6.57±0.06
BRH13-2-4-2-1B	153	122.1	310	5.65±0.06
BRH238-5-1-4-2	147	105.0	361	7.52±0.12
BRR1 dhan88 (ck)	145	96.8	294	6.28±0.22
Lsd _(0.05)		7.9	21.7	0.35
CV (%)		3.7	3.5	2.7

DS: 12 Dec 2022

DTP:23 Jan 2023

Favourable Boro rice (FBR-Barishal), Re-ALART Boro 2022-23

The experiment was conducted at the farmers' field of Dobila, Tarash, Sirajganj. Six genotypes including two checks (BRRI dhan58 and BRRI dhan89) were evaluated. None of the entry produced higher yield over the check variety.

2.11 Short Duration Favorable Boro Rice (FBR-SD), ALART, Boro 2022-23.

The experiment was conducted at the farmers' field of Dobila, Tarash, Sirajganj. Six genotypes including two checks (BRRI dhan81 and BRRI dhan96) were evaluated. None of the entry produced higher yield over the check variety, BRRI dhan96. But SVIN109 produced statistically higher yield over BRRI dhan81 (Table 21).

Table 21. Performance of different entries under ALART FBR-SD at Dobila, Tarash, Sirajganj during Boro 2022-23

Genotype	Duration (day)	Plant height (cm)	Panicle (m ²)	Yield (t ha ⁻¹)
BR11318-5R-63	146	117.0	392	8.35
BR11337-5R-72	147	109.8	424	8.39
SVIN109	146	105.2	372	8.64
IR17A1723	139	122.0	336	7.61
BRRI dhan81 (ck)	140	112.1	338	7.42
BRRI dhan96 (ck)	145	117.5	375	8.86
Lsd _(0.05)		2.8	16.6	0.95
CV (%)		1.4	2.5	6.33

DS: 14 Dec 2022

DTP:19 Jan 2023

Medium Duration favourable Boro rice (FBR-MD), ALART, Boro 2022-23.

The experiment was conducted at the farmers' field of Dobila, Tarash, Sirajganj. Four genotypes including two checks (BRRI dhan58 and BRRI dhan96) were evaluated. None of the entry produced higher yield over the check varieties.

Crop-Soil-Water Management Programme

Effect of Biochar on rice yield and soil health on problem soils

The study was conducted at BRRI RS, Sirajganj to determine the effect of biochar on rice growth and

yield and soil health. The experiment was initiated in Boro 2019-20. Biochar was applied only in Boro season. In T. Aman season, 30 % fertilizer was reduced from recommended dose in the biochar treated plots. In T. Aman 2022, reduction of 30% fertilizer from the recommended dose in the biochar treated plots produced grain yields similar to full dose of recommended fertilizer. In Boro 2022-23 season, application of biochar @ 4 t/ha with recommended fertilizer resulted in the highest yield of BRRI dhan89 among the other treatments (Table 22).

Table 22. Effect of biochar on the yield of rice crop during 2022-23 season at BRRI RS farm, Sirajganj.

Treatment	Grain yield t ha ⁻¹	
	T. Aman 2022 (BRRI dhan87)	Boro 2022-23 (BRRI dhan89)
Control	3.68 b	2.85 c
Rec. fertilizer	5.65 a	4.74 b
Rec. fertilizer + BC @ 2 t ha ⁻¹ *	5.56 a	5.32 b
Rec. fertilizer + BC @ 4 t ha ⁻¹ *	5.59 a	6.77 a
CV (%)	5.77	7.61

Effect of transplanting date and spacing on the yield of BRRI dhan71 at variable time of planting

The experiment was conducted at BRRI RS, Sirajganj during T. Aman 2022 season to find out the suitable transplanting date and spacing in terms of maximum benefit. The experiment was laid out in a split plot design with three replications.

Thirty-day-old seedlings of BRRI dhan71 was transplanted. Growth duration was the higher at 17 July and 1 September planting irrespective of spacing. Number of panicle/hill was highest when transplanted on 16 August irrespective of spacing. Higher yield was observed at 16 August planting irrespective of spacing (Table 23).

Table 23. Effect of transplanting date and spacing on BRRI dhan71 during T. Aman 2022 at BRRI RS, Sirajganj.

Treatment	GD (day)	Plant height (cm)	Panicle hill ⁻¹	Yield (t ha ⁻¹)
17 July x S ₁	122	118.4	8	5.23±0.25
17 July x S ₂	122	119.5	8	5.91±0.21
17 July x S ₃	122	121.4	8	5.72±0.10
01 August x S ₁	118	114.4	8	5.61±0.22
01 August x S ₂	118	117.7	8	6.35±0.25
01 August x S ₃	118	116.3	9	5.97±0.16
16 August x S ₁	114	119.3	9	6.39±0.33
16 August x S ₂	114	120.8	9	6.58±0.20
16 August x S ₃	114	119.3	9	6.42±0.27
01 September x S ₁	121	121.7	7	5.05±0.12
01 September x S ₂	121	118.2	7	5.44±0.26
01 September x S ₃	121	120.0	8	5.22±0.27
Lsd _(0.05)	-	3.17	0.78	0.56
CV (%)	-	2.06	6.46	5.88

Here, Spacing: S₁= 15 cm x 15 cm, S₂= 20 cm x 15 cm and S₃= 25 cm x 15 cm

Response of latest BRRI varieties and management practices in char land areas

The experiment was conducted at farmer's field of Gandhail, Kazipur, Sirajganj during T. Aman, 2022 and Boro 2022-23 seasons to popularize BRRI varieties and management practices in char land areas. The experiment was laid out in RCB design with three replications. In both the seasons,

recommended practices produced statistically higher yield over the farmers' practices but panicle no. hill⁻¹ was higher in farmers' practices during Boro season. In T. Aman, the highest yield was obtained from BRRI dhan52 followed by BRRI dhan51 and for Boro season, BRRI dhan89 followed by BRRI dhan92 in both management practices (Tables 24 and 25).

Table 24. Effect of different management practices on the yield of BRRI varieties during T. Aman 2022.

Treatment	GD (day)	Plant height (cm)	Panicle hill ⁻¹	Yield (t ha ⁻¹)
T1V1	141	99.3	9	4.87±0.11
T1V2	140	119.1	9	5.24±0.27
T1V3	137	107.3	9	4.45±0.22
T2V1	144	98.2	9	4.34±0.15
T2V2	142	120.3	9	4.47±0.10
T2V3	140	110.2	8	3.86±0.09
Lsd _(0.05)	-	2.2	0.72	0.54
CV (%)	-	1.11	4.70	6.53

Here, **T1**= BRRI Recommended Practices (20cm x 20cm, line sowing, 2seedling/hill; Fertilizers @26-8-14-9 Kg Urea-TSP-MoP-Gypsum/Bigha; Urea: three equal splits 1/3 at 15 DAT, 1/3 at 30 DAT and 1/3 at 5-7 days before PI); **T2**= Farmer's Practices (No spacing, no line, 3-4 seedling/hill; Fertilizer

Management: Fertilizers @30-10-15-10 Kg Urea-TSP-MoP-Gypsum/Bigha; Urea: 5kg urea/bigha with herbicide at 5DAT+15kg urea/bigha at 20-25 DAT+10kg urea at before PI)

V1= BRRI dhan51, **V2**= BRRI dhan52, **V3**= BRRI dhan79

Table 25. Effect of different management practices on the yield of BRRI varieties during Boro 2022-23.

Treatment	GD (day)	Plant height (cm)	Panicle hill ⁻¹	Yield (t ha ⁻¹)
T1V1	162	106.8	12	7.49±0.19
T1V2	158	110.8	12	8.22±0.04
T1V3	162	113.4	13	8.12±0.15
T2V1	164	108.1	13	6.51±0.19
T2V2	160	114.6	14	7.69±0.14
T2V3	164	115.2	15	7.55±0.10
Lsd _{0.05}	-	2.5	1.5	0.40
CV (%)	-	1.23	6.2	2.90

V1= BRRI dhan58,

V2= BRRI dhan89,

V3= BRRI dhan92

Determination of optimum dose of nitrogen on growth and yield of BRRI dhan87 in charland area

The experiment was conducted at BRRI RS, Sirajganj in Aman 2022 season to determine the optimum dose of nitrogen on growth and yield of BRRI dhan87. The experiment was laid out in a RCB design with three replications. The treatments were: T₁= Control; T₂= 30kg N/ha; T₃= 60kg N/

ha; T₄= 90kg N/ha and T₅= 120kg N/ha. Fertilizers @ 100, 120, 110 and 101 kg TSP, MoP, Gypsum, ZnSO₄/ ha were applied in the trial during final land preparation. Urea was applied at three equal splits: 1/3 at 15 DAT, 1/3 at 30 DAT and 1/3 at 5-7 days before PI stage. Thirty-day-old seedling of BRRI dhan87 was transplanted. Panicle number and grain yield didn't vary significantly from T₂ to T₅ (Table 26).

Table 26. Determination of optimum dose of nitrogen on growth and yield of BRRI dhan87 in charland area.

Treatment	Plant height (cm)	Panicle /m ²	Yield (t ha ⁻¹)
T (N ₀)	108	153	4.24±0.20
T ¹ (N ₃₀)	111	191	5.61±0.20
T ² (N ₆₀)	116	197	5.72±0.55
T ³ (N ₉₀)	117	206	5.98±0.32
T ⁴ (N ₁₂₀)	117	210	5.80±0.34
Lsd _(0.05)	5.0	22.7	0.65
CV (%)	2.3	6.3	10.7

PEST MANAGEMENT PROGRAMME

Effect of different trap designs for the management of rats in the rice field

The experiment was conducted in the rice field of BRRI RS, Sirajganj farm during the Boro season 2022-23 to find out the effectiveness of different

trap designs on rat catch. Three different types of traps such as Bamboo made trap, Snap trap and Box type live trap were used. The highest number of rats (14 rats /trap) was captured by Bamboo made trap and it differs significantly from the other traps. The lowest number of rat (1 rat/trap) was captured by Snap trap (Table 27).

Table 27. Effect of different traps design for the management of rat during Boro season, 2022-23.

Treatment	Observation day	Total trapped rat	Trapped rat/trap (no.)
Bamboo made trap	45	93	14a
Box type live trap			3b
Snap trap			1b
Lsd _(0.05)			2.9
CV (%)			31.7

TECHNOLOGY TRANSFER

Head to head adaptive trial (HHAT) of recent modern rice varieties at farmers' field

Ten HHATs were conducted during T. Aman 2022 and Boro 2022-23 seasons at ten farmers' field in Sirajganj district (Kamarkhanda) under the supervision of BRRI RS, Sirajganj. The objective of this trial was to investigate the performance of promising varieties compared to popular mega variety. All the experiments were laid out in a RCB design where one farmer was treated as

one replication. In T. Aman 2022, BRRI dhan87 produced the highest yield over the other varieties in all the locations except Khamar Bordhul followed by BRRI dhan93 and BRRI dhan94 (Table 28). During Boro for long duration (LD) group BRRI dhan92 produced the highest yield over the other varieties in all the places with higher growth duration followed by BRRI dhan89 and BRRI dhan102. On the other hand, for short duration (SD) group Bangabandhu dhan100 produced the highest yield over the other varieties in both the locations, followed by BRRI dhan74 and Binadhan-25 (Tables 29-30).

Table 28. Grain yield of modern rice varieties under head to head adaptive trials during T. Aman 2022 in Sirajganj.

Variety	Konabari		Khamar Bordhul		Dhopakandi		Bagbari		Raidaulatpur	
	GD (day)	Yield (t ha ⁻¹)	GD (day)	Yield (t ha ⁻¹)	GD (day)	Yield (t ha ⁻¹)	GD (day)	Yield (t ha ⁻¹)	GD (day)	Yield (t ha ⁻¹)
BRRI dhan51	140	4.85	140	4.08	142	5.25	141	5.23	137	5.61
BRRI dhan87	127	6.32	129	3.78*	125	6.66	123	6.64	123	6.62
BRRI dhan93	130	5.58	132	4.71	131	6.50	130	6.40	128	6.46
BRRI dhan94	130	5.29	132	4.20	125	6.08	130	6.19	128	6.09
BRRI dhan 95	127	5.07	129	4.39	131	5.54	123	5.99	123	5.80
Guti Shorna	145	4.92	146	4.66	147	5.71	145	5.82	138	6.28

* 75 % lodging at maturity stage

Table 29. Grain yield of modern varieties (Long Duration-LD) under head to head adaptive trials during Boro 2022-23 in Sirajganj.

Variety	Khamar Bordhul		Joyen, Bordhul		Dhopakandi	
	GD (days)	Yield (tha ⁻¹)	GD (days)	Yield (tha ⁻¹)	GD (days)	Yield (t ha ⁻¹)
BRRI dhan29	163	5.65	159	5.75	161	6.27
BRRI dhan89	158	7.07	156	7.20	158	7.58
BRRI dhan92	161	7.19	158	7.40	161	7.90
BRRI dhan102	148	6.88	146	6.98	147	7.46
Binadhan-24	146	6.12	144	6.17	145	6.61

Table 30. Grain yield of modern varieties (Short Duration-SD) under head to head adaptive trials during Boro 2022-23 in Sirajganj.

Variety	Dhopakandi		Khamar Bordhul,	
	GD (day)	Yield (t ha ⁻¹)	GD (day)	Yield (t ha ⁻¹)
BRRI dhan28	144	5.96	146	5.63
BRRI dhan74	148	6.74	149	6.57
BRRI dhan88	141	6.41	144	6.20
Bangabandhu dhan100	148	7.24	148	7.08
Binadhan-25	149	6.62	148	6.49
BAU dhan3	143	6.25	143	6.15

Training and field day. Fourteen farmers' training on modern rice production technology was conducted at different upazilas of Bogura region in collaboration with DAE. A total of 420 farmers were trained through this programme. Among the participants, 55 and 365 were female and male, respectively. Training was very much helpful to minimize knowledge gap on modern rice production technologies. A total of twelve in-house trainings were arranged at BRRI regional station to improve the capability of office staffs for office management. Moreover, BRRI RS, Sirajganj also conducted 10 field days at different upazilas of Bogura region for the dissemination of newly released BRRI varieties.

Breeder and truthfully leveled seed production

Nucleus seed stock was collected from GRS Division of BRRI. Single seedling was transplanted per hill. For breeder seed production, all official formalities with SCA and BRRI authority were maintained through proper channel. Breeder seed was produced in T. Aman and Boro seasons, side by side, TLS seed was produced in Aus, T. Aman and Boro seasons. Considering three seasons (Aus, T. Aman and Boro), breeder and TLS seeds were produced. 8.66 and 9.27 tons respectively (Table 31).

Table 31. Breeder seed and TLS production at BRRI RS, Sirajganj during Aus, Aman, Boro 2021-22.

Variety	Season	Breeder seed (kg)	TLS (kg)
BRRI dhan48	T. Aus 2021	-	515
BRRI dhan82		-	1000
BRRI dhan83		-	310
BRRI dhan98		-	2400
BRRI dhan51	T. Aman 2021	2620	400
BRRI dhan70		-	40
BRRI dhan71		-	400
BRRI dhan75		-	500
BRRI dhan80		-	60
BRRI dhan87		-	1600
BRRI dhan90		900	400
BRRI dhan93		-	145
BRRI dhan88		-	200
BRRI dhan89		2900	500
BRRI dhan92	Boro 2021-22	-	700
Bangabandhu dhan100		2240	100
Total		8,660 kg	9,270 kg

Advisory and Clinical service

Any serious problem related to rice production at farmers' field was addressed duly in co-operation with the Department of Extension (DAE), Bangladesh Agricultural Development Corporation (BADC and Seed Certification Agency (SCA). Field visit to address seed sterility at flowering, blast and rice plant hopper incidence after flowering during T. Aman, Boro season, different information, support in training etc. were the main aspects. Clinical services were also provided to the farmers and extension workers as well.

BRRI RS, GOPALGANJ

612	Summary
618	Rice Germplasm Collection And Characterization
619	Technology Transfer

SUMMARY

In the proposed variety trial (PVT), one set in T. Aman 2022 of inbred trial was evaluated at BRRIRS, Gopalganj. BRRIRS, Gopalganj conducted seven advanced lines adaptive research trials (ALART) in the Gopalganj and Bagerhat districts during the reporting year 2022–2023. In ALART (STR-1) T. Aman 2022, two advanced lines BR11712-4R-218 and BR11716-4R-102 produced a higher yield (4.6–4.9 t ha⁻¹) than the standard check varieties BRRI dhan73 (4.0 t ha⁻¹) and BRRI dhan87 (4.4 t ha⁻¹). In case of ALART (DWR) Aman, three advanced lines BR10230-7-19-2B, BR9376-6-2-2B and BR9392-6-2-1B produced a greater yield (3.1–3.5 t ha⁻¹) than the standard checks Fulkori (2.7 t ha⁻¹). For ALART (SubTR-LD), Aman, one advanced line namely BR9158-19-9-6-50-2-HR1 produced higher yield (5.4 t ha⁻¹) than the standard checks BRRI dhan44 (3.7 t ha⁻¹) and BRRI dhan52 (4.6 t ha⁻¹). In ALART for (FBR-Barishal), Boro, two advanced lines BRBa1-4-9 and BRBa 3-1-7 produced higher yield (7.89–8.06 t ha⁻¹) than the standard checks BRRI dhan58 (6.90 t ha⁻¹) and BRRI dhan89 (7.69 t ha⁻¹). One advanced line, IR12A173, produced a greater yield (7.90 t ha⁻¹) at ALART (FBR- MD), Boro, than the standard checks, BRRI dhan58 (7.64 t ha⁻¹) and BRRI dhan96 (6.88 t ha⁻¹). Again, ALART (FBR-SD), Boro, three advanced lines BR11318-5R-63, BR11337-5R-72 and SVIN109 produced higher yield (7.64–8.16 t ha⁻¹) than the standard checks BRRI dhan81 (7.05 t ha⁻¹) and BRRI dhan96 (7.15 t ha⁻¹) with similar growth duration.

Four RYT, namely RYT (Swarna and long slender type), RYT (Short slender), RYT (Tall breeding materials) and RYT (DWR-Hbg) were conducted during T. Aman 2022. Six RYT such as RYT (FBR-Barishal), RYT (STR), RYT (Zira type), RYT (Tall), RYT (FBR-Boro) and RYT (PQR) were conducted at BRRIRS, Gopalganj during Boro 2022-23.

From the Faridpur and Khulna regions, 216 Aman rice germplasm samples were grown. This rice germplasm was rejuvenated to produce more seed for evaluation and use in the future. The Rice Germplasm Descriptors and Evaluation Form, GRSD, BRRIRS was used in an experiment to characterize 50 T. Aman germplasm using 51 agromorphological characteristics (20 quantitative and 31 qualitative characters).

Under the TRB-BRRIRS project, eleven varietal replacements through Head to Head (HTH) demonstrations were carried out throughout the reporting year, five in the Aman season of 2022 and six in the Boro season of 2022–2023 on each of one bigha (33 decimal) land.

In addition, three block demonstrations were held: one for Aus 2022 season (100 bigha, BRRIRS hybrid dhan7) at Shoronkhola, Bagerhat and two for Boro 2022-23 (200 Bigha, BRRIRS hybrid dhan5) at Kotalipara, Gopalganj and (150 Bigha, BRRIRS Hybrid dhan3) at Tungipara, Gopalganj.

A total number of 500 (30 in Aus, 220 in T. Aman and 250 in Boro) field demonstrations (about one bigha each) of newly released BRRIRS modern rice varieties were conducted in different farmer's field in Gopalganj, Bagerhat and Narail districts. On the other hand, seven farmers' trainings and 17 field days in different locations of BRRIRS, Gopalganj recommended areas were organized. Also, Gopalganj attended a Krishi mela (Agricultural exhibition).

In the reporting year, 4.94 tons of breeder seeds of different BRRIRS varieties were produced and delivered to the GRS Division, BRRIRS, Gazipur. Additionally, 11.66 tons of TLS of BRRIRS rice varieties were produced by BRRIRS, Gopalganj.

VARIETAL DEVELOPMENT

PVT (Inbred trial) T. Aman. One set of inbred trial (Aman, 2022) was evaluated under PVT at BRRIRS, Gopalganj. In proposed variety trial, two advanced breeding lines I-044, I045 and check (I-046) was tested. Two advanced lines produced higher yield (5.17–6.47 t ha⁻¹) than the line coded as 1-064 (2.97 t ha⁻¹) with 20–21 days longer growth durations (Table 1).

Investigators: M Z Islam and S C Das

ALART (STR), T. Aman. Same sets of Advanced Line Adaptive Research Trial (ALART) for salt tolerant rice (STR-1 and STR-2) were conducted at farmers' fields of Kashimpur, Sadar, Bagerhat (STR-1) and Maderdia, Sannashi bazar Rampal, Bagerhat (STR-2) during T. Aman 2022. Three advanced lines BR11712-4R-218, BR11716-4R-102 and BR11723-4R-172 along with BRRIRS dhan73 and BRRIRS dhan87 as checks were tested at farmer's field in two locations (Table 2). In STR-1, both the

advanced lines BR11712-4R-218 and BR11716-4R-102 produced higher yield (4.6-4.9 t ha⁻¹) than the standard check varieties BRRI dhan73 (4.0 t ha⁻¹) and BRRI dhan87 (4.4 t ha⁻¹) with 4-6 days shorter growth durations. In case of STR-2, the trial was damaged due to heavy rainfall.

Investigators: M Z Islam and S C Das

ALART (DWR), Aman. Six advanced lines along with Fulkori check were grown at Neemtala, Haridaspur, Gopalganj sadar during Aman 2022. Three advanced lines BR10230-7-19-2B, BR9376-6-2-2B and BR9392-6-2-1B produced a higher yield (3.1-3.5 t ha⁻¹) than the standard checks Fulkori (2.7 t ha⁻¹) with 11-12 days longer growth durations (Table 3).

Investigators: M Z Islam and S C Das

ALART (SubTR-LD), Aman. Two advanced lines BR9158-19-9-6-50-2-HR1, IR13F441 along with BRRI dhan44 (Sus. ck) and BRRI dhan52 (Tol. ck) as checks were grown at South Gobra, Gopalganj Sadar during T. Aman 2022. One advanced line namely BR9158-19-9-6-50-2-HR1 produced higher yield (5.4 t ha⁻¹) than the standard checks BRRI dhan44 (3.7 t ha⁻¹) and BRRI dhan52 (4.6 t ha⁻¹) with similar growth durations (Table 4).

Investigators: M Z Islam and S C Das

ALART (FBR-Barishal), Boro. Four advanced lines along with BRRI dhan58 and BRRI dhan89 as checks were tested at farmer's field in Charboira, Gobra, Sadar Gopalganj during Boro 2022-23 (Table 5). Two advanced lines BRBa1-4-9 and BRBa 3-1-7 produced higher yield (7.89-8.06 t ha⁻¹) than the standard checks BRRI dhan58 (6.90 t ha⁻¹) and BRRI dhan89 (7.69 t ha⁻¹) with similar growth duration. Due to rat damage and pest infestation (stem borer), yield of BRBa1-4-9, BRBa 3-1-7 and BRRI dhan89 was reduced.

Investigators: M Z Islam, S C Das and MKH Tarek

ALART (FBR, MD), Boro. Two advanced lines IR12A173 and IR17A1694 with BRRI dhan58 and BRRI dhan96 as checks were grown at Charboira, Gobra, Gopalganj sadar during Boro 2022-23. One advanced line IR12A173 produced higher yield (7.90 t ha⁻¹) than the standard checks BRRI dhan58 (7.64 t ha⁻¹) and BRRI dhan96 (6.88 t ha⁻¹). Mean growth duration of all the advanced lines (140 days)

were similar to check variety BRRI dhan58 and with six days longer growth duration than the other check BRRI dhan96 (Table 6).

Investigators: M Z Islam, S C Das and MKH Tarek

ALART (FBR, SD), Boro. During the Boro 2022–2023, four advanced lines with BRRI dhan81 and BRRI dhan96 as checks were tested at a farmer's field in Charboira, Gobra, and Sadar, Gopalganj. Three advanced lines BR11318-5R-63, BR11337-5R-72 and SVIN109 produced higher yield (7.64-8.16 t ha⁻¹) than the standard checks BRRI dhan81 (7.05 t ha⁻¹) and BRRI dhan96 (7.15 t ha⁻¹) with similar growth duration. The average growth duration of BR11318-5R-63 was 135 days which was similar to the check varieties BRRI dhan81 and BRRI dhan96. But two advanced lines BR11337-5R-72 and SVIN109 were with 5-6 days longer growth duration than the checks BRRI dhan81 and BRRI dhan96. Flowering and maturity of these advanced lines was uniform (Table 7).

Investigators: M Z Islam, S C Das and M K H Tarek

Table 1. Grain yield and ancillary characters of proposed variety trial (PVT) genotypes during T. Aman 2022.

Genotypes/code no.	Growth duration (day)	Yield (t ha ⁻¹)
I-044	185	6.47
I-045	184	5.17
I-046	164	2.97
LSD _{0.05}	1.99	0.41

Table 2. Grain yield and ancillary characters of ALART (STR) genotypes during T. Aman 2022.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BR11712-4R-218	92	121	4.6
BR11716-4R-102	89	121	4.9
BR11723-4R-172	98	121	4.4
BRRI dhan73 (Tol. Ck)	118	123	4.0
BRRI dhan87 (Sus. Ck)	121	130	4.4
LSD _{0.05}	2.78	1.49	0.09

Table 3. Grain yield and ancillary characters of ALART (DWR) genotypes during Aman 2022.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BR10230-7-19-2B	159	177	3.5
BR9892-6-2-2B	161	173	2.8
BR9376-6-2-2B	164	167	3.1
BR9392-6-2-1B	154	178	3.1
BR-KM(Mun)-PL-5-7-3-B	205	173	2.6
BR-DL (Hbj)-PL-12-4-7-B	191	171	2.4
Fulkori (Ck)	165	166	2.7
LSD_{0.05}	2.50	2.14	0.37

Table 4. Grain yield and ancillary characters of ALART (SubTR-LD) genotypes during T.Aman 2022.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BR9158-19-9-6-50-2-HR1	141	153	5.4
IR13F441	119	153	4.1
BRR1 dhan44 (Sus. Ck)	122	151	3.7
BRR1 dhan52 (Tol. Ck)	121	150	4.6
LSD_{0.05}	2.50	2.14	0.36

Table 5. Grain yield and ancillary characters of ALART (FBR- Barishal) genotypes during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
V1= BRBa1-4-9	120.33	147	7.89
V2= BRBa14-NGR414-1	101.33	147	6.44
V3= BRBa 3-1-7	95.33	145	8.06
V4= BRBa40-NGR1255-1	118.66	147	6.90
V5= BRR1 dhan58 (ck)	93.66	142	6.90
V6= BRR1 dhan89 (ck)	107.66	148	7.69
LSD_{0.05}	4.21	1.31	0.43
CV%	2.18	0.49	3.25

Table 6. Grain yield and ancillary characters of ALART (FBR, MD) genotypes during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
V1= IR12A173	106.06	140	7.90
V2=IR17A1694	97.56	140	6.86
V3= BRR1 dhan58 (ck)	102.56	142	7.64
V4= BRR1 dhan96 (ck)	94.83	134	6.88
LSD_{0.05}	8.73	1.96	0.55
CV%	4.36	0.7	3.78

Table 7. Grain yield and ancillary characters of ALART (FBR- SD) genotypes during Boro 2022-23.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
V1= BR11318-5R-63	116.60	135	8.16
V2= BR11337-5R-72	106.13	140	7.80
V3= SVIN109	109.13	141	7.64
V4= IR17A1723	94.36	134	6.00
V5= BRR1 dhan81 (ck)	98.90	135	7.05
V6= BRR1 dhan96 (ck)	95.10	134	7.15
LSD_{0.05}	5.87	2.92	0.92
CV%	3.12	1.17	6.95

RYT (Swarna and long slender type), Aman. Five advanced lines along with BRR1 dhan87 and BRR1 dhan94 as checks were tested at BRR1 RS, Gopalganj during T. Aman 2022. None of the advanced lines produced higher yield (5.15-6.03 t ha⁻¹) than the standard check BRR1 dhan87 (6.37 t ha⁻¹). On the other hand, one advanced line BRH9392-6-2-1-3-4 gave higher yield (6.03 t ha⁻¹) than the check BRR1 dhan94 (5.37 t ha⁻¹) (Table 8).

PI: A S M Masuduzzaman , Investigators: M Z Islam and S C Das

RYT (Short slender), Aman. Three advanced lines along with BRRI dhan49 as check were tested at BRRI RS, Gopalganj during T. Aman 2022. Three advanced lines produced slightly higher yield (5.37-5.60 t ha⁻¹) than the standard check BRRI dhan49 (5.03 t ha⁻¹) (Table 9).

PI: A S M Masuduzzaman , Investigators: M Z Islam and S C Das

RYT (Tall breeding materials), Aman. Four advanced lines along with BRRI dhan91 as checks were assessed. The average grain yield of all advanced lines (3.38-3.77 t ha⁻¹) was higher than the checks BRRI dhan91 (2.27 t ha⁻¹) with similar growth durations (Table 10).

PI: A S M Masuduzzaman, Investigators: M Z Islam and S C Das

RYT (DWR-Hbg), Aman. Three advanced lines along with BRRI dhan91 and Sada Jabra as checks were grown. Three advanced lines produced a higher yield (2.93-3.23 t ha⁻¹) than the standard checks BRRI dhan91 (2.43 t ha⁻¹) and Sada Jabra (2.07 t ha⁻¹) with similar growth durations (Table 11).

PI: Md Abu Syed, Investigators: M Z Islam and S C Das

OYT (DWR-Gpg), Aman. Seven local deep water varieties along with BRRI dhan91 checks were grown. Seven local deep water varieties produced lower yield (1.80-2.28 t ha⁻¹) than the standard check BRRI dhan91 (2.35 t ha⁻¹) (Table 12). The yield of deep water rice varieties were reduced due to rat damage.

PI: M Z Islam, CI: S C Das

PYT (Jhum), AUS. Two jhum rice genotypes along with BRRI dhan83 as check were grown. Chibingshe produced higher yield (4.50 t ha⁻¹) than the standard check BRRI dhan83 (4.03 t ha⁻¹) with three days longer growth durations (Table 13). On the other hand, Galong produced similar yield (4.15 t ha⁻¹) than the standard check BRRI dhan83 (4.03 t ha⁻¹) .

PI: M Z Islam, CI: S C Das

RYT (FBR-Barishal), Boro. Nine advanced lines along with BRRI dhan88 and BRRI dhan89 as

checks were grown at BRRI RS, Gopalganj during Boro 2022-23. Three advanced lines produced a higher yield (8.06-8.23 t ha⁻¹) than the standard check BRRI dhan89 (7.7 t ha⁻¹) with similar growth durations. On the other hand, all the advanced lines produced higher yield (7.43-8.23 t ha⁻¹) than the standard check BRRI dhan88 (6.53 t ha⁻¹) (Table 14).

PI: M A Hossain, Investigators: S C Das, M K H Tarek and M Z Islam

RYT (STR), Boro. Seven advanced lines along with BRRI dhan89, BRRI dhan67 and BRRI dhan99 as checks were tested. Three advanced lines produced higher yield (7.18-7.33 t ha⁻¹) than three standard checks (BRRI dhan89, BRRI dhan67 and BRRI dhan99). Yield of BRRI dhan89 reduced due to poor tillering and rat damage. On the other hand, six advanced line produced higher yield (6.66-7.33 t ha⁻¹) than two standard checks (BRRI dhan67 and BRRI dhan99) with similar growth duration of BRRI dhan99 and 8-10 days longer growth duration of BRRI dhan67) (Table 15).

PI: M A Rahman, Investigators: S C Das, M K H Tarek and M Z Islam

RYT (Zira Type), Boro. Five advanced lines along with two checks Zirasail and BRRI dha28 as checks were grown. Three advanced lines produced higher yield (6.65-7.27 t ha⁻¹) than two standard checks Zirasail (6.54 t ha⁻¹) and BRRI dha28 (6.34 t ha⁻¹) with similar growth duration (Table 16).

PI: A S M Masuduzzaman, Investigators: S C Das, M K H Tarek and M Z Islam

RYT (Tall), Boro. Six advanced lines including BR18 as checks were tested. Three advanced lines produced higher yield (6.63-7.00 t ha⁻¹) than the standard check BR18 (6.1 t ha⁻¹) with 4-5 days shorter growth durations. In addition, two advanced lines BRH18-7-14-B (6.2 t ha⁻¹) and BR9390-6-2-1B (6.3 t ha⁻¹) produced similar yield compared to the check BR18 (6.1 t ha⁻¹). However, BR9392-6-2-1B produced lower yield (3.23 t ha⁻¹) due to lodging (Table 17).

PI: A S M Masuduzzaman , Investigators: S C Das, M K H Tarek and M Z Islam

RYT (FBR), Boro. Five advanced lines along with BRRI dhan86 and BRRI dhan96 as checks were evaluated. One advanced line BR (Bio) 13028-AC24-1-2 performed better (7.23 t ha⁻¹) than the checks BRRI dhan86(6.56 t ha⁻¹) and BRRI dhan96 (6.86 t ha⁻¹) with similar growth duration (Table 18). On the other hand, three advanced line produced lower yield (6.02-6.31 t ha⁻¹) than the two standard checks BRRI dhan86 (6.56 t ha⁻¹) and BRRI dhan96 (6.86 t ha⁻¹). In addition, BR (Bio)13028-AC24-3-3 produced slightly higher yield (6.70 t ha⁻¹) than the standard check BRRI dhan86(6.56 t ha⁻¹).

PI: J Ferdous, Investigators: S C Das, M K H Tarek and M Z Islam

RYT (PQR), Boro. A total of 20 premium quality rice including the checks BRRI dhan50, BRRI dhan63, BRRI dhan81, BRRI dhan104, Tepi Boro and Rata Boro were evaluated. Results revealed that Indian Basmati produced the highest yield (4.76 t ha⁻¹) than six standard checks. On the other hand, Basmati (1230) produced the lower yield (2.64 t ha⁻¹) than six standard checks (Table 19).

PI: M A Kader, Investigators: S C Das, M K H Tarek and M Z Islam

Table 8. Grain yield and ancillary characters of RYT (Swarna and long slender type) genotypes during T. Aman 2022.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BRH9392-6-2-1-3-4	158	139	6.03
BR9396-6-2-2B	129	145	5.15
BR10238-5-1-4-2	147	140	5.40
BR9392-10-20-1B	114	116	5.17
BRH11-2-4-7B	113	116	5.47
B R R I dhan94(ck)	125	137	5.37
B R R I dhan87(ck)	121	125	6.37
LSD_{0.05}	5.71	1.53	0.35

Table 9. Grain yield and ancillary characters of RYT (Short Slender) genotypes during T. Aman 2022.

SN	Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
1	BRH13-2-14-2-1B	126	120	5.60
2	BRH17-23-8-2-7B	120	117	5.43
3	BRH13-7-9-3-2B	106	103	5.37
4	BRRI dhan49 (Ck)	124	134	5.03
LSD_{0.05}		7.01	2.28	0.42

Table 10. Grain yield and ancillary characters of RYT (tall breeding materials) genotypes during T. Aman 2022.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BR9892-8-2-2B	165	151	3.63
BR10247-14-18-7-3	160	150	3.77
BR10238-5-1-9-2B	166	151	3.53
BR9392-12-6-2-4B	175	159	3.38
BRRI dhan91 (ck)	174	153	2.27
LSD_{0.05}	7.98	1.14	0.24

Table 11. Grain yield and ancillary characters of RYT (DWR-Hbg) genotypes during Aman 2022.

Genotype	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BR7730-1-1-2B	233.67	168	3.17
BR7918-1-2-3B	189.33	167	2.93
BR79190101-3B	217.67	169	3.23
BRRI dhan91 (Std.ck)	173.00	167	2.43
Sada Jabra (Local check)	223.00	171	2.07
LSD_{0.05}	6.26	0.59	0.48

Table 12. Grain yield and ancillary characters of RYT (DWR-Gpg) genotypes during Aman 2022

Genotype	Plant height (cm)	Yield (t ha ⁻¹)
Shisumati	174	2.28
Debmani	165	2.20
Chamara	208	2.0
Laxmidigha	198	2.1
Patjag	163	1.8
Jabra	185	2.1
Bashiraj	179	1.9
BRRIdhan91 (Std.ck)	170	2.35

Table 13. Grain yield and ancillary characters of PYT (Jhum-Gpg) genotypes during Aus 2022.

Designation	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
Chibingshe	113.10	110	4.50
Galong	109.53	108	4.15
BRRIdhan83	108.37	107	4.03
LSD _{0.05}	6.27	3.66	0.36
CV%	2.91	1.49	3.73

Table 14. Grain yield and ancillary characters of RYT (FBR-Barishal) genotypes during Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
NGR522-2	95.66	147	7.7
NGR270-3	94.86	146	7.63
NGR418-1	96.53	146	8.23
NGR416-1	95.2	147	7.46
NGR968-1	98.66	147	7.63
NGR994-1	96.33	147	7.8
NGR745-2	95.46	146	7.43
NGR590-2	98.6	148	8.06
NGR710-1	100.86	147	8.1
BRRIdhan88(ck)	95	138	6.53
BRRIdhan89(ck)	110	149	7.7
LSD _{0.05}	1.46	2.57	0.57
CV%	0.87	1.03	4.44

Table 15. Grain yield and ancillary characters of RYT(STR) genotypes during Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BR11712-4R-44	124.53	148	7.28
BR11712-4R-93	114.6	144	7.18
BR11717-4R-12	110	144	7.33
BR11724-4R-6	85.36	143	6.66
BR11712-4R-346	95.13	146	6.98
BR11713-4R-70	107.06	148	6.7
BR11722-4R-398	82.4	149	5.73
BRRIdhan67(ck)	99.2	136	6.1
BRRIdhan89(ck)	101.46	151	6.73
BRRIdhan99(ck)	95.26	148	5.93
LSD _{0.05}	1.93	2.34	0.55
CV%	1.11	0.93	4.84

Table 16. Grain yield and ancillary characters of RYT (Zira Type) genotypes during Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BRH13-9-5-3B	95.2	144	6.77
BRH12-1-7B-P1	94.46	143	6.65
BRH9-3-14-2B	101.13	142	6.08
BRH10247-4-7-4B	108.6	147	7.27
BRH13-7-9-3-2B	94.53	149	6.31
BRRIdhan28(ck)	90.8	143	6.34
Zirashail (ck)	96.26	142	6.54
LSD _{0.05}	2.73	2.35	0.78
CV%	1.57	0.91	6.75

Table 17. Grain yield and ancillary characters of RYT (Tall) genotypes during Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BR9396-6-2-2B	114.8	143	7.0
BR9392-6-2-1B	171.33	160	3.23
BRH18-7-14-B	116.2	142	6.2
BRH13-7-9-3-2B	125.06	145	6.63
BR9390-6-2-1B	126.4	133	6.3
BR9392-6-2-1-3-4	134.33	145	6.78
BR18(CK)	135.8	149	6.1
LSD _{0.05}	4.88	3.86	0.52
CV%	2.08	1.49	4.89

Table 18. Grain yield and ancillary characters of RYT(FBR-Boro) genotypes during Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
BR(Bio)13028-AC24-1-2	104.33	142	7.23
BR(Bio)13028-AC24-2-3	103.66	143	6.02
BR(Bio)13028-AC24-2-4	106	141	6.28
BR(Bio)13028-AC24-3-3	105	142	6.70
BR(Bio)13028-AC11-3-1	91.33	142	6.31
BRRIdhan86(ck)	87	139	6.56
BRRIdhan96(ck)	85	141	6.84
LSD _{0.05}	3.1	2.52	0.99
CV%	1.78	1	8.55

Table 19. Grain yield and ancillary characters of RYT (PQR) genotypes during Boro 2022-23.

Designation	Plant height (cm)	Growth duration (day)	Yield (t ha ⁻¹)
Basmati (1230)	128.3	148	2.64
Basmati(D) (3928)	104	140	2.77
Basmati (4488)	133.2	147	3.69
Basmati370 (4489)	121.5	142	3.48
Basmati 37(4491)	125	144	3.43
Basmati (N13) (4493)	123.7	154	4.10
Basmati370 (4494)	119.7	142	3.70
Basmati 107(4501)	130.3	142	3.90
Basmati 377(4507)	125	143	4.07
Basmati 406(4508)	125.5	143	3.55
Basmati (4754)	118	144	3.68
Basmati(6614)	90.3	146	3.35
Super Basmati	93.5	142	2.96
Basmati Sufaid(187)	133	144	3.79
Indian Basmati	103.5	147	4.76
Basmati TAPL-90(2571)	128.7	142	3.78
Basmati Naton439(4496)	133.1	142	3.58
Basmati Pard-nr442(4497)	89.1	144	3.02
Basmati 433(4509)	121.5	145	3.11
Pusha Basmati	107.2	152	3.75
BRRIdhan50(ck)	76.7	148	3.82
BRRIdhan63(ck)	69.1	146	4.20
BRRIdhan81(ck)	75.1	144	4.0
BRRIdhan104(ck)	79.8	150	3.87
Tepi Boro(ck)	142.4	142	3.95
Rata Boro(ck)	142.7	143	3.85
LSD _{0.05}	3.07	3.34	0.65
CV%	1.31	1.12	8.74

RICE GERMPLASM COLLECTION AND CHARACTERIZATION

Germplasm collection and rejuvenation. Two hundred and sixteen Aman rice germplasm were collected from Faridpur and Khulna region. This rice germplasm were rejuvenated to produce more seed for further evaluation and utilization at BRRI RS,

Gopalganj during T. Aman 2022. The experiment was carried out under transplanted conditions using single row of 5.4 m long per accession with 20 × 20 cm spacing between rows and plants respectively. Fertilizers were applied @ 60:20:40 kg NPK/ha in T. Aman 2022. Appropriate control measures were taken for insect pests, diseases and weeds when necessary.

PI: M Z Islam

Morphological Characterization. One experiment was conducted to characterize 50 T. Aman rice germplasm through 51 agro-morphological traits (20 quantitative and 31 qualitative characters) using the Rice Germplasm Descriptors and Evaluation Form, GRSD, BRRI. The experiments were conducted in BRRI RS, Gopalganj. The experiment was conducted using a single row of 5.4 m long

for each entry/accession with a spacing of 20 × 20 cm between rows and plants, respectively during T. Aman 2022 season. Fertilizers were applied @ 60:20:40 kg NPK/ha in Aman season. Appropriate control measures were taken for insect pests, diseases and weeds when necessary.

Results. The majority of the observed attributes of the T. Aman rice germplasm in the present study show notable diversity. A UPGMA dendrogram was generated using 50 T. Aman rice germplasm, and the Euclidean distance was estimated using quantitative data. Using the Euclidean distance of 0.18 as the cutoff, cluster analysis indicated that the 50 T. Aman rice germplasm was divided into three categories (**Fig. 1**). Cluster III consisted of a maximum of 32 germplasm samples, while cluster II comprised 16 samples. The cluster I had the fewest (2) germplasm.

PI: M Z Islam and S C Das

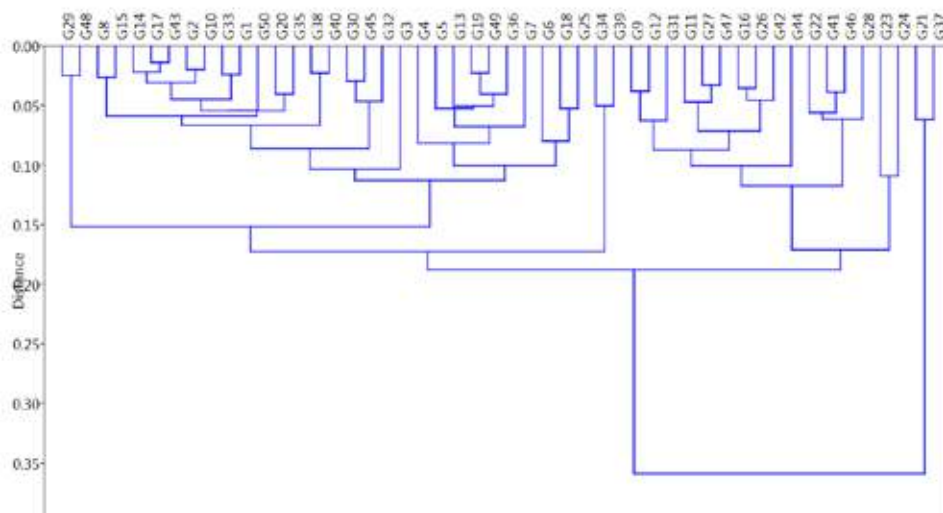


Fig.1. UPGMA dendrogram of 50 T. Aman rice germplasm based on their morphological and yield component traits.

TECHNOLOGY TRANSFER

Variety replacement through Head to Head Adaptive Trial during T. Aman 2022 and Boro 2022-23 under TRB-BRRI project

Eleven Head to Head Adaptive Trails (HHAT) were conducted in seven upazilas under three districts

viz Gopalganj, Bagerhat and Narail during the reporting period.

T. Aman 2022 season

In the T. Aman 2022 season, eight different rice varieties—BRRI dhan33, BRRI dhan39, BRRI dhan71, BRRI dhan75, BINA dhan7, BINA

dhan16, BINA dhan17 and BINA dhan2 were used. All of those varieties were short-duration varieties. In Gopalganj and Bagerhat districts, BINA dhan17 outperformed all other short-duration varieties in terms of yield (6.43 t/ha) and yield (6.53 t/ha), respectively (Tables 20, 21 and 22).

Boro 2022-23 season

In Boro 2022-23 season, two groups (Long duration and short duration) of BRRI modern rice varieties were tested at six locations of Gopalganj, Narail and Bagherhat districts viz BRRI dhan29, BRRI dhan89, BRRI dhan92, BRRI dhan102 and BINA dhan24 were used as long duration (LD) varieties and BRRI dhan28, BRRI dhan74, BRRI dhan88, Bangabandhu dhan100, BINA dhan25 and BAU dhan-3 were used as short duration varieties.

Among those long duration varieties, BRRI dhan92 produced the highest yield in both the locations 8.28 t/ha (Sadar upazila, Gopalganj) and 8.38 t/ha (Kalia upazila, Narail) in Gopalganj and Narail districts, respectively than the other varieties. In case of short duration, Bangabandhu dhan100 produced the highest yield in both the locations that is 7.43 t/ha (Kalia upazila, Narail) and 7.53 t/ha (Mollahat upazila, Bagerhat) in Narail and Bagerhat districts respectively than the other varieties (Tables 23 and 24). Additionally, during the Boro 2022–23 season, the salinity ecosystem (short duration group) of the BRRI modern rice varieties such as BRRI dhan28, BRRI dhan67, BRRI dhan97, and BRRI dhan99 were assessed at two locations in Mongla, Bagerhat. But those trials were damaged due to high salinity (12-17 ds/m) (Table 25).

Table 20. Performance of promising new rice varieties through HHAT trial during T. Aman 2022 season (short duration).

Location	BRRI dhan39		BRRI dhan71		BRRI dhan75		BINA dhan16		BINA dhan17		BINA dhan22	
	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha
Charboira, Sadar Gopalganj	118	4.38	114	4.94	113	4.86	105	5.62	115	6.35	113	5.78
Nilpha, Tungipara, Gopalganj	119	4.45	117	5.10	114	5.07	104	5.48	118	6.43	114	5.76
Farmers' preference (1-6)	6		4		5		3		1		2	

Farmers' preference (1-6): 1-6 means from high to low

Table 21. Performance of promising new rice varieties through HHAT trial during T. Aman 2022 season (short duration)

Location	BRRI dhan71		BRRI dhan75		BINA dhan7		BINA dhan16		BINA dhan17		BINA dhan22	
	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha
Sonakur Gobra Sadar Gopalganj	116	4.98	113	4.96	113	4.62	105	5.71	112	6.41	114	5.71
Kadomtola, Mollahat, Bagerhat	117	4.96	115	5.01	118	4.55	104	5.41	116	6.53	115	5.80
Farmers' preference (1-6)	5		4		6		3		1		2	

Farmers' preference (1-6): 1-6 means from high to low

Table 22. Performance of promising new rice varieties through HHAT trial during T. Aman 2022 season (short duration).

Location	BRRI dhan33		BRRI dhan71		BRRI dhan75		BINA dhan16		BINAIdhan17		BINA dhan22	
	GD (day)	Yd t/ ha	GD (day)	Yd t/ ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha
Chadpur, Kalia, Narail	117	4.08	116	4.97	115	4.98	103	5.58	117	6.50	115	5.73
Farmer Preference (1-6)	6		5		4		3		1		2	

Farmer Preference (1-6): 1-6 means from high to low

Table 23. Performance of promising new rice varieties through HHAT trial during Boro 2022-23 season (long duration)

Location	BRRI dhan29		BRRI dhan89		BRRI dhan92		BRR Idhan102		BINA dhan24	
	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha
Sadar, Gopalganj	158	7.61	155	8.22	158	8.28	148	8.03	147	7.72
Kalia, Narail	159	7.62	156	8.25	158	8.38	150	8.00	147	6.97
Farmers' preference (1-6)	4		2		1		3		5	

Farmers, Preference (1-6): 1-6 means from high to low

Farmers' preference (1-6): 1-6 means from high to low

Table 24. Performance of promising new rice varieties through HHAT trial during Boro 2022-23 season (short duration).

Location	BRRI dhan28		BRRI dhan74		BRRI dhan88		Bangabandhu dhan100		BINA dhan25		BAU dhan3	
	GD (day)	Yd t/ ha	GD (day)	Yd t/ ha	GD (day)	Yd t/ ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ ha
Kalia,Narail	140	6.02	145	7.05	140	6.44	147	7.43	147	6.40	139	5.24
Mollahat, Bagerhat	140	6.31	144	6.97	141	6.12	145	7.53	145	6.94	140	4.16
Farmers' preference (1-6)	4		2		5		1		3		6	

Farmers' preference (1-6): 1-6 means from high to low

Table 25. Performance of promising new rice varieties through HHAT trial during Boro 2022-23 season (short duration).

Location	BRRI dhan28		BRRI dhan67		BRRI dhan97		BRRI dhan99	
	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha	GD (day)	Yd t/ha
L1:Holdebunia, Mongla, Bagerhat								Damaged due to salinity (12-17 ds/m)
L2:Holdebunia, Mongla, Bagerhat								Damaged due to salinity (12-17 ds/m)

Block Demonstration

High yielding hybrid rice variety development through modernization of research project and GoB funded three block demonstrations were conducted in three locations during T. Aus 2022 and Boro 2022-23 season. Two varieties viz BRRI hybrid dhan7 was conducted at Madhohkhuntakata, Shoronkhula, Bagerhat district around hundred bighas areas and BRRI hybrid dhan5 was conducted at Atasibari, Narikelbari union, Kotalipara, Gopalganj district around two hundred bighas. Again, another block demonstration using BRRI hybrid dhan3 was held on 50 acres of land in Kushli, Tungipara, Gopalganj.

The average grain yield of BRRI dhan67 was 6.10 t/ha with a growth duration of 144 days recorded at Shoronkhula, Bagerhat district. On the other hand, the average grain yield of Bangabandhu dhan100 was 7.58 t/ha with growth duration of 147 days recorded at Kotalipara, Gopalganj district. With the help of DAE personnel, two field days were organized at the rice crops' maturity in the both locations. During the field day, the trial farmers shared their experiences with neighbouring farmers, which made them interested in these varieties to cultivate those in their own land and thereby a demand for quality seeds was generated.

Field Demonstration

A total number of 500 (30 in Aus, 220 in T. Aman and 250 in Boro) field demonstrations (about 1 bigha each) of newly released BRRI modern rice varieties were conducted in different farmers' fields in Gopalganj, Bagherhat and Narail districts. Among them, 270 trials in the Gopalganj district, 154 trials in the Bagherhat district and 76 trials in the Narail district were conducted during Aus 2022, T. Aman 2022 and Boro 2022-23 season. Farmers' acceptance of BRRI hybrid dhan7 in T. Aus season; BRRI dhan75, BRRI dhan87, BRRI hybrid dhan6 in T. Aman Season and BRRI dhan67, BRRI dhan74, BRRI dhan92, Bangabandhu dhan100, BRRI hybrid dhan3 and BRRI hybrid dhan5 in Boro season were found very high in those respective areas for their grain size, panicle length and high yield.

Farmers Training

In the reporting year, seven farmers' training programmes were organized in different locations in Gopalganj and Bagerhat districts (Table 26). Among them, 210 farmers participated and improved up

their knowledge about modern rice production technologies and maintenance with the help of DAE and the financial assistance of GoB fund of BRRI.

Table 26. Farmers' training on modern rice cultivation and blast disease management in different regions during 2022-23.

Upazila	No. of trainees				Total trainee
	SAAOs		Farmer		
	M	F	M	F	
GoB fund, BRRI RS, Gopalganj					
Gopalganj	-	-	91	29	120
Bagerhat	-	-	67	23	90
Narail	-	-	0	0	0
Total			158	52	210

Seed production and dissemination

In the reporting year, a total of 810 kg, 3,920 kg and 6,935 kg of truthfully labelled seeds (TLS) were produced in T. Aus, T. Aman and Boro season, respectively. A total of 2,050 kg breeder seed was produced in T. Aman season and 2,892 kg breeder seeds of different BRRI varieties were produced in Boro season. In total, 4,942 kg of breeder seeds were sent to the GRS Division, BRRI, Gazipur. On the other hand, 460 kg of F₁ seeds (BRRI hybrid dhan5) were produced in Boro season (Tables 27 and 28). In three season, 4,730 kg TLS were distributed among the farmers for dissemination in Gopalganj, Bagerhat and Narail districts.

Table 27. Breeder seed and TLS seed production in T. Aus 2022 and T. Aman 2022 season at BRRI, RS, Gopalganj.

Variety	Breeder Seed (kg)	TLS (kg)	Variety	Breeder Seed (kg)	TLS (kg)
T. Aus, 2022			T. Aman, 2022		
BRRI dhan48	-	-	BR23	-	200
BRRI dhan82	-	260	BRRI dhan34	-	70
BRRI dhan85	-	250	BRRI dhan52	-	160
BRRI dhan98	-	300	BRRI dhan75	-	420
			BRRI dhan76	-	770
			BRRI dhan87	2050	1300
			BRRI dhan90	-	80
			BRRI dhan91	-	230
			BRRI dhan93	-	190
			BRRI dhan94	-	180
			BRRI dhan95	-	320
Total		810	Total	2050	3920

Table 28. Breeder seed, TLS and F₁ seed production in Boro 2022-2023 season at BRRI, RS, Gopalganj.

Variety	Breeder Seed (kg)	TLS (kg)	F ₁ Seed (kg)
Boro 2022-23			
BRRI hybrid dhan5	-	-	460
BRRI dhan67	1370	815	-
BRRI dhan74	1370	570	-
BRRI dhan89	-	820	-
BRRI dhan92	-	740	-
BRRI dhan96	-	260	-

Variety	Breeder Seed (kg)	TLS (kg)	F ₁ Seed (kg)
BRRI dhan97	-	475	-
BRRI dhan99	-	645	-
Bangabandu dhan100	-	1215	-
BRRI dhan101	-	685	-
BRRI dhan102	-	710	-
Total	2892	6935	460

Farmers field day and krishi mela

Seventeen field days were organized in the block demonstration in the Gopalganj, Bagerhat and Narail districts during T. Aus 2022; T. Aman 2022 and Boro 2022-23 seasons funded by GoB, High yielding hybrid rice variety development through modernization of research project and Increasing cropping intensity in the coastal Barishal and Khulna region through water resources and soil salinity management project. About 1,500 farmers as well as extension personnels, administrative people, public leaders attended in the field days. Most of the farmers interested to cultivate new rice varieties in their areas specially BRRI dhan67, BRRI dhan87, BRRI dhan88, BRRI dhan89, BRRI dhan92, Bangabandhu dhan100 and BRRI hybrid dhan3, BRRI hybrid dhan4, BRRI hybrid dhan5, BRRI hybrid dhan6 and BRRI hybrid dhan7. BRRI RS, Gopalganj also participated in one Krishi Projukti mela (agriculture fair) and development fair at Rumpal upazila, Bagerhat district.

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BRRI dhan103



BRRI dhan104



BRRI dhan105