BRRI ANNUAL REPORT
2014-2015

Bangladesh Rice Research Institute

BRRI ANNUAL REPORT

For July 2014-June 2015

Bangladesh Rice Research Institute (BRRI)
Gazipur 1701, Bangladesh

Publication no. : 210
350 copies

Published by
Director General
Bangladesh Rice Research Institute

Advisers
Dr Jiban Krishna Biswas
Dr Md Shahjahan Kabir
Dr Md Ansar Ali
Dr M A Saleque

Edited by
M A Kashem

Graphic design, page makeup and proof reading
Md Saiful Malek Majumder

Cover Illustration
Sharmin Akter

Suggested citation
Anonymous (2016). Annual Report of Bangladesh Rice Research Institute 2014-2015, BRRI, Gazipur 1701, Bangladesh, 278 pp.

Printed at
Agami Printing and Publishing Co.
27 Babupura, Nilkhet, Dhaka 1205

Contact address
Publications and Public Relations Division (PPRD)
Bangladesh Rice Research Institute (BRRI)
Gazipur 1701, Bangladesh
Telephone : 88-02-9294149
PABX : 88-02-9294117-21, 9264118, 9264127, Ext. 526
Fax : 88-02-9261110
E-mail : brrihq@yahoo.com, dg@brri.gov.bd
Website : www.brri.gov.bd
www.knowledgebank-brri.org

Contents

Preface

The present volume of BRRI Annual Report is a summary of research works carried out by 19 research divisions and nine regional stations of the institute during July 2014 to June 2015. This document consists of the significant portions of the research covering eight programme areas.

The programme areas, such as crop-soil-water management, rice farming systems, pest management, socio-economics and policy, technology transfer, farm mechanization and regional stations represent the broader conceptual frameworks of BRRI activities.

With a target to provide sustainable food security, BRRI scientists have been engaged in developing different location specific, climate smart, stress tolerant, micro nutrient enriched rice varieties and some premium quality ones that can compete in the international market.

They dedicated their time and energy to develop and disseminate resource-saving profitable technologies along with some management tools such as urea super granule (USG) applicator, rice transplanter, integrated crop management (ICM) practices, alternate wetting and drying (AWD) techniques, rice based farming systems and popularization of BRRI machinery.

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

Above all, the present reports include various research results out of activities that attempted to minimize yield gap between research level and farmer's fields.

In addition, readers interested to look into more details on specific subject of this summarized version may checkout 'Proceedings of BRRI Annual Research Review for 2014-15' which is available in the website (www.brri.gov.bd).

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

We expect that the reports will be useful for the scientists, extension agents, related policy makers and other partners to be updated on rice research at BRRI.

(Dr Jiban Krishna Biswas)
Director General
BRRI

Personnel

Director General's Office
Jiban Krishna Biswas, *PhD*
Director General

Research Wing
Jiban Krishna Biswas, *PhD*
Director (Research)
Md Ansar Ali, *PhD*
(From 2 Oct 2014)
M A Saleque, *PhD*
Coordinator for Advanced Studies and Research
Mohammad Abdul Momin, *BScAg (Hons)*
Senior Liaison Officer

Administrative Wing
Md Shahjahan Kabir, *PhD*
Director (Admin and Common Service)
Emran Hossain, *MS (BAU)*
Deputy Director (Admin)
Md Mohsin Miah, *Dip-in-Engg*
Assistant Director
Md Abdul Aziz, *BA*
Assistant Director
Kawsar Ahmad, *BSS (Hons), MSS (RU)*
Assistant Director (Procurement)
Momotaz Shireen, *MA*
Assistant Director (Store)

Accounts and Finance
Md Golam Rashid, *Mcom (Acct) CMA (Int)*
Deputy Director (Accounts and Finance)
Md Badrudduza, *Bcom (Hons), MCom*
Senior Assistant Director (Finance)
(PRL from 22 Apr 2015)
Kazi Anwarul Azim, *BCom (Hons), MCom*
Assistant Director (Finance)

Aduit cell
Tarique Sala Uddin, *Bcom (Hons), MCom*
Audit Officer

Building and Construction
Md Zahid Hasan, *BScEngg (Civil)*
Executive Engineer
Md Ataul Haque Bhuiyan, *Dip-in-Engg (Civil)*
Assistant Engineer
Md Abdur Rob, *Dip-in-Engg (Civil)*
Assistant Engineer
Md Ashraf Ali
Assistant Engineer (Electrical)
(PRL from 13 Feb 2015)

Publications and Public Relations
Md Abul Kashem, *BA (Hons), MA (MCJ)*
Technical Editor and Head
Md Rasel Rana, *BA (Hons), MA (MCJ)*
Editor

Planning and Evaluation
Md Monirul Islam, *MSc Ag Econ*
Principal Planning Officer
Atia Rokhsana, *MS Ag Econ*
Senior Planning Officer
Md Saidul Islam, *MS Ag Econ*
Planning Officer

Dispensary
Dr Md Ataur Rahman, *MBBS*
Resident Physician
(PRL from 1 Jan 2015)
Dr Habiba Sultana, *MBBS****
Resident Physician

Library
Saleha Khatoon, *MA (Information Sc and Lib Management)*
Senior Librarian
Mahbubur Rashid Talukder, *MA (Information Sc and Lib Management)*
Librarian

Research Division and Regional Station

Plant Breeding

Helal Uddin Ahmed, *PhD***
Chief Scientific Officer and Head
Tamal Lata Aditya, *PhD*
Chief Scientific Officer and Head
Khandakar Md Iftekharuddaula, *PhD*
Principal Scientific Officer
Partha Sarathi Biswas, *PhD*
Principal Scientific Officer
Mohammad Akhlasur Rahman, *PhD*
Principal Scientific Officer
Mohammad Amir Hossain, *PhD*
Principal Scientific Officer
Mahmuda Khatun, *PhD*
Principal Scientific Officer
Md Abdul Kader, *PhD*
Senior Scientific Officer
Md Ruhul Amin Sarker, *PhD*
Senior Scientific Officer
Sharmistha Ghosal, *MS**
Senior Scientific Officer
Md Rafiqul Islam, *MS**
Senior Scientific Officer
Nirmal Sharma, *MS**
Senior Scientific Officer
Ratna Rani Majumder, *MS*
Senior Scientific Officer
Md Anisuzzaman, *MS*
Senior Scientific Officer
Hasina Khatun, *MS*
Scientific Officer
Tapas Kumer Hore, *MS*
Scientific Officer

Biotechnology

Md Enamul Hoque, *PhD*
Chief Scientific Officer
(Additional charge) and Head
Shahanaz Sultana, *PhD*
Senior Scientific Officer
Jannatul Ferdous, *PhD*
Senior Scientific Officer
Nilufar Yasmin Shaikh, *PhD*
Senior Scientific Officer
S M Hisam Al Rabbi, *MS**
Scientific Officer
Ripon Kumar Roy, *MS*
Scientific Officer
Shampa Das Joya, *MS*
Scientific Officer
Md Arafat Hossain, *MS*
Scientific Officer

Genetic Resources and Seed

Mohammad Khalequzzaman, *PhD*
Chief Scientific Officer and Head
Mir Sharf Uddin Ahmed, *PhD*
Principal Scientific Officer
Ebna Syod Md Harunur Rashid, *PhD*
Senior Scientific Officer
Md Abubakar Siddique, *MS*
Senior Scientific Officer
Armin Bhuiya, *MS*
Scientific Officer
Hasina Begum, *PhD*
Scientific Officer
Mohammad Zahidul Islam, *PhD*
Scientific Officer
Md Humayun Kabir Baktiar, *MS*
Scientific Officer

Grain Quality and Nutrition

Muhammad Ali Siddiquee, *PhD*
Chief Scientific Officer and Head
Md Anwarul Haque, *PhD***
Principal Scientific Officer
Sharifa Sultana Dipti, *PhD*
Principal Scientific Officer
Nilufa Ferdous, *MSc*
Senior Scientific Officer
Tapash Kumar Sarkar, *MS*
Senior Scientific Officer
Habibul Bari Shozib, *PhD*
Senior Scientific Officer
Shakir Hosen, *MS*
Scientific Officer

Hybrid Rice

Md Jamil Hasan, *PhD*
Principal Scientific Officer and Head
Ashish Kumar Paul, *MScAg*
Senior Scientific Officer
Priya Lal Biswas, *MS**
Senior Scientific Officer

Md Kamal Hossain, *MS* Senior Scientific Officer* Mosammat Umma Kulsum, *MS*+ Scientific Officer*
Afsana Ansari, *MS**
Scientific Officer
Anowara Akter, *MS*
Scientific Officer
Md Hafizar Rahman, *MS*
Scientific Officer
Laila Ferdousi Lipi, *MS*
Scientific Officer

Agronomy

Md Abdul Jalil Mridha, *PhD*
Chief Scientific Officer and Head
Md Gous Ali, *PhD*
Principal Scientific Officer
Md Abu Bakar Siddique Sarker, *MS*
Principal Scientific Officer
Md Khairul Alam Bhuiyan, *MS*
Senior Scientific Officer
Shah Ashadul Islam, *MS*
Senior Scientific Officer
Rakiba Shultana, *MS*
Senior Scientific Officer
Amena Sultana, *PhD****
Senior Scientific Officer
Md Iftekhar Mahmud Akhand, *MS*
Senior Scientific Officer
Md Masud Rana, *MS*
Scientific Officer
Md Zakaria Ibne Baki, *MS*
Scientific Officer
Md Mostofa Mahbub, *MS*
Scientific Officer
Lutfun Nahar, *MS*
Scientific Officer

Soil Science

Jatish Chandra Biswas, *PhD*
Chief Scientific Officer and Head
Pranesh Kumar Saha, *PhD*
Principal Scientific Officer
(PRL from 3 sep 2014)
A Islam, *PhD***
Senior Scientific Officer
U A Naher, *PhD***
Senior Scientific Officer
M Sajidur Rahman, *MSc*+*
Senior Scientific Officer
F Rahman, *PhD***
Senior Scientific Officer
A T M S Hossain, *MS***
Senior Scientific Officer
M M Haque, *MS*
Senior Scientific Officer
Masuda Akter, *MS*+*
Senior Scientific Officer
S M Mofijul Islam, *MS*+*
Scientific Officer
M M Iqbal, *MS*
Scientific Officer
M N Ahmed, *MS*+*
Scientific Officer
M N Islam, *MS*
Scientific Officer
M I U Sarker, *BS*
Scientific Officer
M Faruk Hossain Khan, *MS*
Scientific Officer
F Alam, *MS***
Scientific Officer

Irrigation and Water Management

Md Towfiqul Islam, *PhD*
Principal Scientific Officer and Head
Md Maniruzzaman, *PhD*
Principal Scientific Officer
Md Mahbubul Alam, *PhD*
Senior Scientific Officer
Ms Shahana Parveen, *PhD*
Senior Scientific Officer
ABM Zahid Hossain, *PhD*
Senior Scientific Officer
Debjit Roy, *MS**
Senior Scientific Officer
Mir Nurul Hasan Mahmud, *MS**
Senior Scientific Officer
Priya Lal Chandra Paul, *MS*
Senior Scientific Officer
Mst Shetara Yesmin, *MS*
Scientific Officer

Plant Physiology

Rumena Yasmeen, *PhD*
Chief Scientific Officer
(Addl. Charge) and Head
Munnujan Khanm, *PhD*
Principal Scientific Officer
(Deputed to TOC)
Salma Pervin, *MS*
Senior Scientific Officer
Md Sazzadur Rahman, *MS*
Senior Scientific Officer
Md Mamunur Rashid, *PhD*
Senior Scientific Officer
Hirendra Nath Barman, *MS*
Senior Scientific Officer
Salma Akter, *MS*
Scientific Officer
Tuhin Halder, *MS*
Scientific Officer
Avijit Biswas, *MS*
Scientific Officer

Entomology

Nur Ahmed, *PhD*
Chief Scientific Officer and Head (CC)
(Divisional Head since 14 Oct 2014)
Sheikh Shamiul Haque, *PhD*
Principal Scientific Officer
Md Mosaddeque Hossain, *MS***
Principal Scientific Officer
Md Mofazzel Hossain, *MS*,
Principal Scientific Officer
Mahfuj Ara Begum, *MS***
Senior Scientific Officer
Md Nazmul Bari, *PhD***
Senior Scientific Officer
ABM Anwar Uddin, *MS*
Senior Scientific Officer
Md Panna Ali, *MS**
Senior Scientific Officer
Jannatul Ferdous, *MS**
Senior Scientific Officer
Mir Md Moniruzzaman Kabir, *MS*
Scientific Officer
Farzana Nowrin, *BSc Ag (Hons)*
Scientific Officer

Plant Pathology

Md Ansar Ali, *PhD*
Chief Scientific Officer and Head
Md Abdul Latif, *PhD*
Principal Scientific Officer and Head
Tahmid Hossain Ansari, *PhD*
Principal Scientific Officer
Q S A Jahan, PhD
Principal Scientific Officer
Md Shahjahan Kabir, *MS**
Senior Scientific Officer
Mohammod Hossain, *PhD*
Principal Scientific Officer
Shamima Akter, *PhD*
Senior Scientific Officer
Mohammad Ashik Iqbal Khan, *PhD*
Senior Scientific Officer
Ahsanul Haque, *PhD*
Senior Scientific Officer
Md Abul Monsur, *MS*
Senior Scientific Officer
Mst Tuhina Khatun, *MS**
Senior Scientific Officer
Md Rejwan Bhuiwan, *MS*
Senior Scientific Officer
Md Mamunur Rashid, *MS**
Senior Scientific Officer
Bodrun Nessa, *MS**
Senior Scientific Officer
Anjuman Ara, *MS*
Scientific Officer

Rice Farming Systems

F M Moinuddin, MS
Chief Scientific Officer and Head
(From 8 February 2014)
Muhammad Nasim, *PhD**
Principal Scientific Officer
S M Shahidullah, *PhD*
Senior Scientific Officer
Md Abdul Muttaleb, *PhD*
Senior Scientific Officer
Md Harunur Rashid, *PhD+*
Senior Scientific Officer
Amina Khatun, *PhD*
Senior Scientific Officer
(From 8 February 2014)

Md Khairul Quais, *MS*
Senior Scientific Officer
Shila Pramanik, *MS*
Senior Scientific Officer
Nargis Parveen, *MS*
Scientific Officer
ABM Jamiul Islam, *MS***
Scientific Officer
Md Asad-Uz-Zaman, *MS*
Scientific Officer
Md Tanbir Rubayet, *MS****
MS, *Scientific Officer*
Bir Jahangir Shirazy, *BSc Ag****
Scientific Officer
Hasina Sultana, *MS****
Scientific Officer

Agricultural Economics
Md Abu Bakr Siddique, *PhD*
Chief Scientific Officer and Head
Md Saiful Islam, *MS*
Principal Scientific Officer
Md Jahangir Kabir, *MS**
Senior Scientific Officer
Md Abdus Salam, *MS**
Senior Scientific Officer
Mohammad Ariful Islam, *MS**
Senior Scientific Officer
Md Imran Omar, *MS*
Senior Scientific Officer
Md Abdur Rouf Sarkar, *MS*
Senior Scientific Officer
Md Chhiddikur Rahman, *MS**
Scientific Officer
Afroza Chowdhury, *MS*
Scientific Officer
Md Shajedur Rahman, *MS*
Scientific Officer
Limon Deb, *MS****
Scientific Officer

Agricultural Statistics
Md Ismail Hossain, *PhD*
Principal Scientific Officer and Head
Niaz Md Farhat Rahman, *MS*
Senior Scientific Officer

ICT Cell
S M Mostafizur Rahman
System Analyst
Ful Miah
Cartographer (Senior IT Officer)
Md Mahfuz Bin Wahab
Programmer
Kabita
Assistant Programmer

Farm Management
Krishna Pada Halder, *PhD*
Chief Scientific Officer and Head
Md Sirajul Islam, *MS*
Principal Scientific Officer
Md Mamunur Rahman, *PhD*
Senior Scientific Officer
Md Rezaul Manir, *MS*
Scientific Officer
Kamal Uddin Ahammed, *Dip-in-Agril*
Farm Manager

Farm Machinery and Postharvest Technology
Muhammed Abdur Rahman, *PhD*
Chief Scientific Officer
Md Durrul Huda, *PhD*
Principal Scientific Officer
Akm Saiful Islam, *PhD*
Principal Scientific Officer
Md Golam Kibria Bhuiyan, *MS*
Senior Scientific Officer
Md Anwar Hossen, *MS*+*
Senior Scientific Officer
Bidhan Chandra Nath, *MS*
Senior Scientific Officer
Md Kamruzzaman, *M Sc*
Senior Scientific officer
Subrata Paul, *M.S*
Scientific Officer
AKM Lutfar Rahman, *MS*
Scientific Officer
Md Ashraful Alam, *MS*+*
Scientific Officer
Md Kamruzzaman, *MS*+*
Scientific officer

Sharmin Islam, *MS****
Agricultural Engineer
Haimonti Paul, *MS****
Agricultural Engineer

Workshop Machinery and Maintenance

Engr Mahbubul Alam Zami, *MS*
Principal Scientific Officer and Head
Engr. Biraj Kumar Biswas, *PhD*
Senior Scientific Officer
Engr Mohammad Afzal Hossain, *MS*+*
Senior Scientific Officer
Engr Hafizur Rahaman, *BSc Agril Engr****
Scientific Officer

Adaptive Research

Md Shafiqul Islam Mamin, *PhD*
Chief Scientific Officer and Head
Md Atiqul Islam, *PhD*
Principal Scientific Officer
Md Rafiqul Islam, *MS*
Principal Scientific Officer
Biswajit Karmaker, *MS*
Senior Scientific Officer
Shahnaz Parveen, *MS*
Senior Scientific Officer
Shamsunnaher, *MS*
Scientific Officer
Afruz Zahan, *MS*
Scientific Officer
Rajesh Barua, *MS*
Scientific Officer
Md Romel Biswash, *MS*
Scientific Officer

Training

Md Islam Uddin Mollah, *PhD*
Chief Scientific Officer and Head
Md Shahadat Hossain, *MS*
Principal Scientific Officer
Md Fazlul Islam, *PhD*
Senior Scientific Officer
Shahnaz Parveen, *MS*
Senior Scientific Officer

BRRI RS, Barisal

M Alamgir Hossain, *PhD*
Chief Scientific Officer and Head
Md Ibrahim, *PhD*
Principal Scientific Officer
Mohammod Hossain, *PhD*
Principal Scientific Officer
Umme Aminun Nahar, *PhD***
Principal Scientific Officer
Mahfuz Ara Begum, *MS*+*
Senior Scientific Officer
M Belal Hossain, *MS***
Senior Scientific Officer
Sheikh Maniruzzaman, *MS*
Scientific Officer
Md Hannan Ali, *MS***
Scientific Officer
Golam Sarwar Jahan *MS****
Scientific Officer

BRRI RS, Bhanga

Mohammad Amir Hossain, *PhD* *Principal Scientific Officer and Head*
Partha Sarathi Biswas, *PhD*** *Principal Scientific Officer and Head*
Shah Asadul Islam, *MS***
Senior Scientific Officer and Head
Md Tanbir Rubayet, *MS***
Scientific Officer
Kazi Md Tareq Aziz, *BSc Ag (Hons)*
Scientific Officer

BRRI RS, Comilla

Helal Uddin Ahmed, *PhD*
Chief Scientific Officer and Head
Abijit Saha, *PhD*
Principal Scientific Officer
Md Salim Mian, *PhD*
Senior Scientific Officer
Mst Selima Zahan, *MS*
Senior Scientific Officer
Md Adil, *MS*
Scientific Officer
Farzana Alam, *MS*
Scientific Officer

BRRI RS, Habiganj

ASM Masuduzzaman, *PhD*
Chief Scientific Officer
Md. Humayun Kabir, *PhD*
Senior Scientific Officer
Fahmida Rahman, *PhD*
Senior Scientific Officer
A T M Sakhawat, *MS*
Senior Scientific Officer
Md Mahbubur Rahman Dewan, *MS*
Senior Scientific Officer
M M Emam Ahmed, *MS*
Scientific Officer

BRRI RS, Rajshahi

Md Mostafa Kamal, *PhD*
Chief Scientific Officer and Head
Md Nazmul Bari, *PhD*
Senior Scientific Officer
Md Shafiqul Alam, *BScAg (Hons)*
Senior Scientific Officer
Md Harun-Al-Rashid, *MS*
Senior Scientific Officer
Md Abu Syed, *PhD*
Scientific Officer
Montasir Ahmed, *BScAg (Hons)*
Scientific Officer

BRRI RS, Rangpur

Md Shahidul Islam, *PhD*
Principal Scientific Officer and Head
Md Adil Badshah, *PhD**
Senior Scientific Officer
Md Rokebul Hasan, MS***
Senior Scientific Officer
Shila Pramanik**
Senior Scientific Officer
Mir Mehedi Hasan**
Scientific Officer

IAPP project

Bishnu Pada Ray
Senior Scientific Officer
Saleh Md Shahriar
Scientific Officer
Md Saju Mia
Scientific Officer

BRRI RS, Satkhira

Md Humayun Kabir, *PhD*
Principal Scientific Officer and Head
Md Mamunur Rahman, *PhD***
Senior Scientific Officer
Satyen Mondal, *MS*+*
Senior Scientific Officer
Avijit Biswas, *MS****
Scientific Officer

BRRI RS, Sonagazi

Jatish Chandra Biswas, *PhD*
Chief Scientific Officer (Current Charge) and Head
Md Rafiqul Islam, *PhD*
Chief Scientific Officer (Current Charge) and Head
Md Anwarul Haque, *PhD*
Principal Scientific Officer
Md Mamunur Rashid, *MS*
Scientific Officer
Md Monsur Habib, *Dip-in-Ag*
Farm Manager

BRRI RS, Kushtia

Md Mosaddeque Hossain, *MS*
Principal Scientific Officer and Head
Mahmuda khatun, *PhD*
Senior Scientific Officer
Md Mahbubur Rahman Dewan, *MS*
Senior Scientific Officer
Md Habibur Rahman Mukul, *MS*
Scientific Officer
Afroze Zahan
Scientific Officer
Md Hannan Ali, *MS*
Scientific Officer
Md Belal Hossain, *MS*
Scientific Officer

---

* Abroad for higher studies
\+ On deputation outside BRRI
*+ On deputation for higher studies
** Transferred
*** Joined BRRI
\++ Resigned from BRRI

Weather information

Manual weather station (July 2014-June 2015)
Weather is an instantaneous state of atmosphere. It influences growth and development as well as pest and diseases. We present here the available weather parameters *viz* maximum and minimum temperature (°C), rainfall (mm), sunshine hours (hours/day), solar radiation (Cal/cm^2/day), relative humidity (%) during the experimental year (July 2014-June 15) as recorded from BRRI headquarter and two regional stations- Rajshahi and Comilla by Plant Physiology Division. We have also four manual weather stations. Among them weather data of BRRI RSs, Barisal and Habiganj are under processing and Bhanga and Rangpur are new stations.

Temperature. During the reporting period, mean monthly maximum temperature ranged from 24.8°C (15 January) to 33.23°C (15 May) in Gazipur. More or less similar trend was observed in other stations. The ranges of maximum temperature was 22.8°C (15 January) to 34.9°C (15 May) at Rajshahi and 24.2°C (14 December) to 33.4°C (15 May) at Comilla. Mean monthly minimum temperature ranged from 25.71°C to 12.60°C in Gazipur. More or less similar trend was observed in other stations. The ranges of minimum temperature was 11.5°C (15 January) to 27.3°C (15 July) at Rajshahi and 13.7°C (15 February) to 26.4°C (15 July) at Comilla (Fig. 1).

Rainfall. During the reporting period monthly total rainfall ranges from 0 to 666.9 mm. The highest amount of monthly total rainfall was recorded at June (633.9 mm), whereas in December total rainfall was nil at Gazipur. At comilla maximum amount of total rainfall was measured in August (512.28 mm), whereas in November, December and January no rainfall was recorded. At Rajshahi maximum amount of rainfall 194 mm was recorded in August, whereas December and January experienced no rain. (Fig. 2).

Relative humidity (RH). The mean relative humidity was the highest 90.38% in December, whereas the lowest RH 60.80% was observed in March at Gazipur. At Comilla RH % was more or less stable and it was near about 90%. At Rajshahi maximum RH (83.8%) was recorded in August, but RH was minimum (72.5%) at in March (Fig. 3).

Bright sunshine hours and solar radiation. At Gazipur the longest period of bright sunshine hours was recorded in March (8.06 h), whereas the shortest was in December (3.74 h). At Rajshahi, the longest period of bright sunshine was observed in March (7.3 h) and the shortest sunshine hours were observed in January (4.3 h). The monthly mean daily solar radiation was relatively lower in December to January. The highest solar radiation 406.16 cal/cm^2/day was recorded in Gazipur during March. At Rajshahi the solar radiation was relatively lower during December to January. The highest solar radiation 396 cal/cm^2/day was recorded in Rajshahi during June. (Fig. 4).

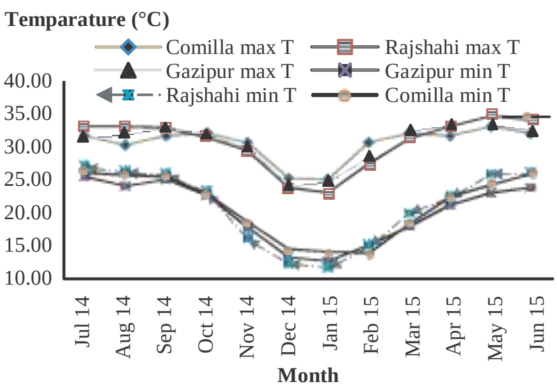


Fig. 1. Monthly mean maximum and minimum temperature °C of Gazipur, Comilla and Rajshahi in 14 July-15 June.

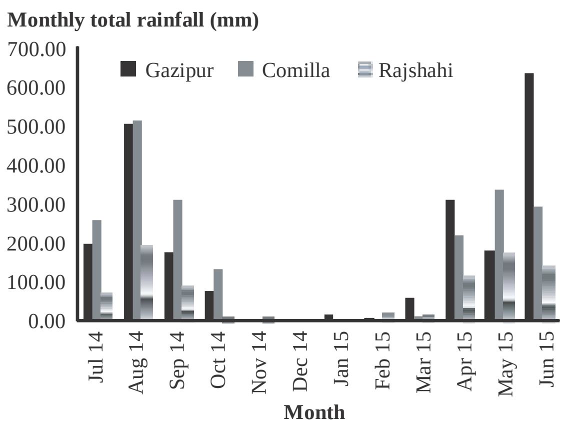


Fig. 2. Monthly total rainfall (mm) of Gazipur, Comilla and Rajshahi in 14 July-15 June.

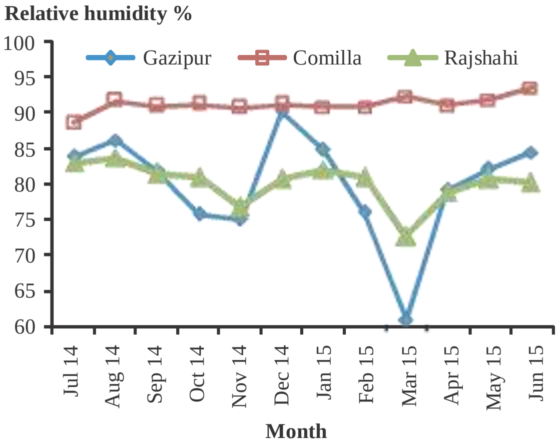


Fig. 3. Monthly mean relative humidity (RH) at 9.00 am in Gazipur, Comilla and Rajshahi in 14 July-15 June.

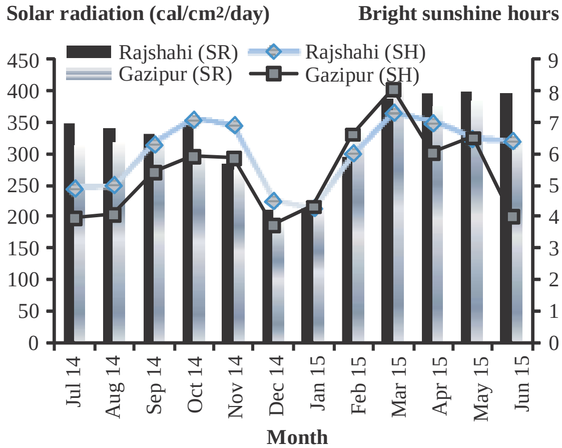


Fig. 4. Monthly mean solar radiations and mean bright sunshine hour at Rajshahi and Gazipur in 14 July-15 June.

Automatic weather station (July 2014-June 2015)

Temperature. The average maximum temperature was the highest in March-May for most of the BRRI RSs while it was the highest in Rangpur. The highest maximum temperature was recorded at Barisal (36.07°C) followed by Comilla (34.35°C), Bhanga (34.03°C), Gazipur (33.26°C) and Rangpur (31.95°C). The mean maximum temperature was quite low during December to January in Rangpur compared to the other stations. However, the mean minimum temperature prevailed as the lowest in January for all the stations and it ranged from 11.39°C in Rangpur followed by Bhanga (12.75°C), Gazipur (13.71°C), Comilla (13.77°C) and (13.91°C) in Barisal. The mean minimum temperature remained below 20°C from November to March for all the stations (Fig. 5).

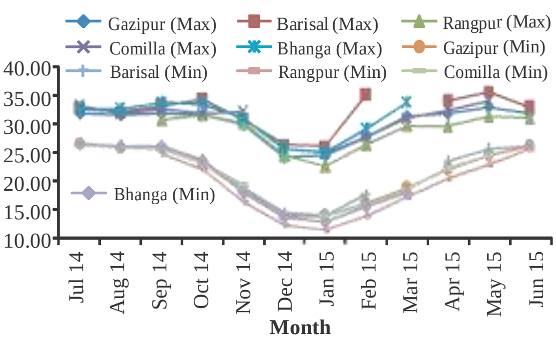


Fig. 5. Monthly mean maximum and minimum temperatures (°C) of Gazipur and four RSs BRRI, 2014-15.

Relative humidity. The monthly mean maximum and minimum relative humidity ranged from 99.34 to 32.12% across five stations. The monthly mean maximum RH was recorded around 100% from October to February in the Gazipur and Comilla, while it ranged 98-99% from October to January at Bhanga and Barisal. It was the lowest in Rangpur 85-96% during the following period. However, monthly minimum humidity was the lowest in February to March for all the stations and it was ranged from 22.81-62.79%. The lowest relative humidity was recorded 22.81% in Rangpur followed by Bhanga (29.97%), Barisal (35.39%), Gazipur (46.97%) and Comilla (58.87%) (Fig. 6).

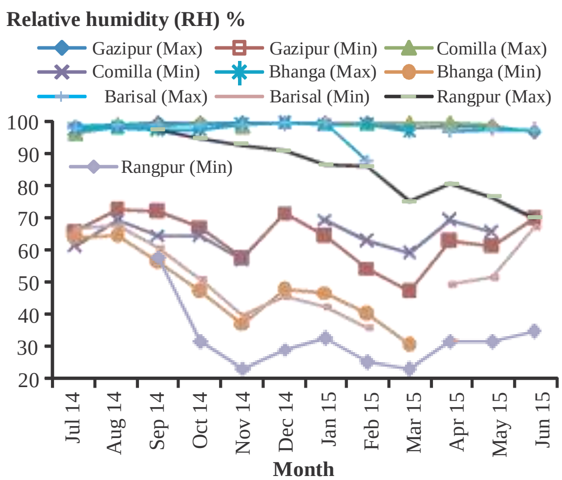


Fig. 6. Monthly mean maximum and minimum relative humidity (%) of Gazipur and four RSs BRRI, 2014-15.

Rainfall. The highest monthly total rainfall of 481.80 mm was recorded in August at Gazipur followed by Comilla (476.00 mm), while it was in July at Barisal (283.20 mm) and Bhanga (119.40 mm) and in May at Rangpur (233.40 mm). Dry condition prevailed from November to March for all the stations, when there were no figure showing few mm rainfalls which is water droplets either mist or dew. The maximum total rainfall was recorded in Comilla (1336.30 mm) for 10 months (except December and June) followed by Gazipur (981.80 mm) for 10 months (except May and June, 2015), Barisal (934.40 mm) for eight months, Rangpur (515.64 mm) for 10 months and Bhanga (277.70 mm) for nine months. The lowest rainfall was recorded from Rangpur and Bhanga mainly due to less recording period compared to the other stations (Fig. 7).

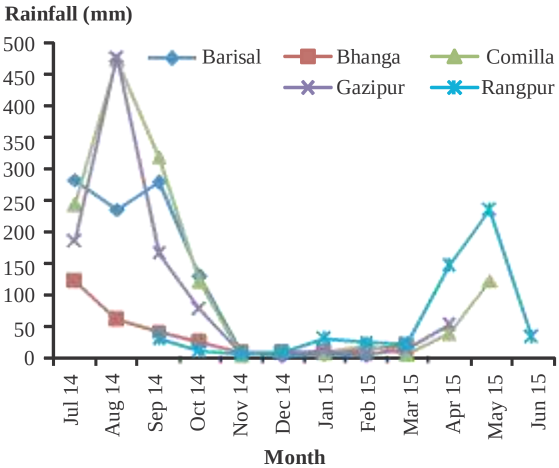


Fig. 7. Monthly total rainfall (mm) of Gazipur and four RSs, BRRI, 2014-15.

Solar radiation and solar hours. The monthly mean solar radiation was relatively lower during the rainy season and also the months of December to February as usual. The highest mean solar radiation prevailed in May at Gazipur, Rangpur and Comilla, while in February at Barisal and March at Bhanga. The mean maximum solar radiation varied from 191.75 to 302.48 wat/m^2 per day during February to May in all the stations, while it varied from 103.68 to 206.18 wat/m^2 per day during rest of the months of the year over all the locations. The highest mean daily solar hours prevailed in July at Gazipur, Comilla and Bhanga, while in May at Barisal and June at Rangpur. The lowest mean daily solar hours prevailed from November to February for all the stations. It ranged from 8.20 to 10.54 hr/day (Fig. 8). The solar hours was considered when the solar radiation exceeding the threshold limit 21 wat/m^2.

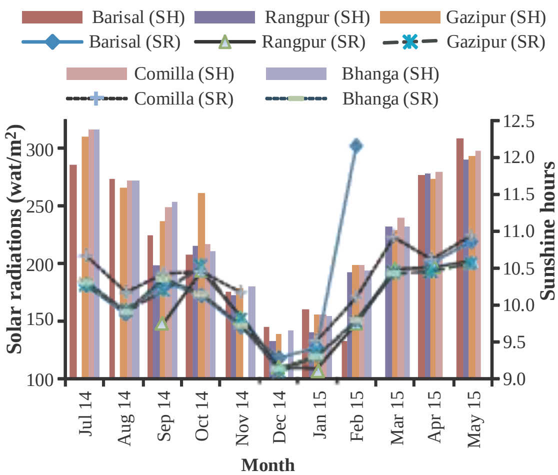


Fig. 8. Monthly mean solar radiation (wat/m^2) and solar hours/day of Gazipur and four RSs, BRRI, 2014-15.

Abbreviation and acronyms

AEZ	=	agroecological zone
ALART	=	advanced line adaptive research trial
ARIMA	=	autoregressive 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	=	backcross
BCR	=	benefit-cost-ratio
BI	=	blast
BLB	=	bacterial leaf blight
BLB	=	bacterial leaf blight
BINA	=	Bangladesh Institute of Nuclear Agriculture
BMDA	=	Barind Multi Purpose Development Authority
BPH	=	brown planthopper
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
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
DTF	=	days to flowering

DWSR	=	Direct wet seeded rice
DWR	=	deepwater rice
ET	=	evapotranspiration
FS	=	foundation seed
GABA	=	gamma amino buteric acid
GH	=	grasshopper
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
HA	=	Habiganj Aman
HAT	=	hours after treatment
HB	=	Habiganj Boro
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
MAS	=	marker assisted selection
ML	=	monogenic line
MLT	=	mulitlocation trial
MMT	=	million metric tons
MR	=	moderately resistant
MT	=	maximum tillering
MV rice	=	modern variety rice
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
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
TSP = triple superphosphate

USG = urea super granule

WBPH = white-backed planthopper
WS = wet season WSR
= wet-seeded rice WTR =
weed tolerant rice wt =
weight

YSB = yellow stem borer

Plant Breeding

SUMMARY

For developing improved rice varieties under different ecosystems, several crosses were made and a number of progenies and fixed lines were selected from F_2 to F_7 populations. A total of 487 crosses were made confirming 291 as true F_1. From segregating generations 26,414 progenies were selected and 833 fixed lines were isolated. Five hundred and four entries from observational trial and 352 advanced lines were selected from yield trials. A total of 76 germplasms from different screening nurseries were selected for using in the breeding programme.

Three promising genotypes viz BR7357-11-2-4-1-1 for exporting quality rice, IR82589-B-B-84-3 for drought tolerant rice and BR7528-2R-19-HR10 for high zinc rice during T. Aman, 2014-15 were evaluated by NSB team and have been recommended as variety. BR7357-11-2-4-1-1 (BRRI dhan70) showed 4.8-5.0 t/ha grain yield with 10 days earlier than BRRI dhan37. IR82589-B-B-84-3 (BRRI dhan71) having 5.05 t/ha grain yield with 111 days growth duration. BR7528-2R-19-HR10 (BRRI dhan72) showed 0.9 t/ha higher yield but matured one week later than BRRI dhan39. Two genotypes IR78767-B-SATB1-28-3-24 and IR78767-B-SATB1-28-3-26 were also evaluated by National Seed Board and IR78767-B-SATB1-28-3-24 released as salt tolerant variety BRRI dhan73 for T. Aman season. It can tolerate 8 dS/m water salinity in its whole life cycle. In Boro 2014-15, BR7671-37-2-2-3-7 produced 1.2 t/ha higher yield and 3-5 days earlier than BRRI dhan64. This line was recommended as BRRI dhan74 by the National Technical Committee of the NSB at its 81th meeting. The selected line IR83142-B-71-B-B performed in proposed variety trial (PVT) and produced 0.7 t/ha higher grain yield than BRRI dhan28 during Boro 2014-15 with similar growth duration.

VARIETY DEVELOPMENT

Upland rice (Aus). Major thrust was given to develop varieties in combination of multiple traits viz quick seedling emergence and vigorous growth, short growth duration (90-95 days), tolerant to lodging, drought and pre-harvest sprouting with medium bold to medium slender grains and good eating quality. In total, 20 crosses were made using 18 parents, 18 crosses were confirmed as true hybrid; 495 progenies and 43 fixed lines were selected from pedigree nurseries. Thirteen entries were selected from OT. Six advanced lines were selected from SYT. Three lines viz BR6855-3B-12, BR6855-3B-13 and BR6848-3B-12 were selected from RYT for further evaluation. The proposed line, OM1490 with average growth duration of 99 days was selected and released as BRRI dhan65.

Transplanted Aus rice. The project was aimed at developing the genotypes having short duration (105-115 days), high yield potential, acceptable grain quality and tolerant to lodging, heat (high temperature) at reproductive phase and pre-harvest sprouting. In total, 16 crosses were made using 21 parents and 264 F_1 seeds were obtained. Seven crosses were confirmed as true hybrid. A total of 262 progenies and 88 fixed lines were selected from pedigree nurseries. Eleven genotypes from observational trial were selected on the basis of homogeneity in respect to plant height, phenotypic acceptability at vegetative and maturity stages. From PYT, two entries were selected for further evaluation based on phenotypic acceptability, grain yield and growth duration. One entry was selected from RYT-1 conducted over seven locations, while three entries were selected from RYT-Somaclone showing better performance than check variety BRRI dhan48 in respect to grain yield with similar growth duration. From Advanced yield trial one promising line was selected from two genotypes.

Improvement of rice varieties for shallow flooded environment. Main objectives were to develop improved genotypes with slow elongation for shallow flooding condition (1.0 m flood depth). Fourteen crosses were made involving eight parents and 674 F_1 seeds were obtained. Nine crosses were confirmed as true hybrid. Totally 23 segregating populations were bulked. From PYT#1, two genotypes were promoted to SYT while from PYT#2, three genotypes were selected and promoted to SYT. Totally 10.3 kg seeds of local cultivars were increased and genetic purity was maintained.

Rainfed lowland rice (RLR). Efforts were made for the development of genotypes superior to standard varieties and adaptable to rainfed lowland environment in T. Aman season. In the reporting year, 22 crosses were made, 16 crosses were confirmed and 259 plants were selected from two F_2 populations. From pedigree nursery 776 segregating progenies and 108 fixed lines were isolated. From OT, 88 genotypes were selected, 30 genotypes were selected from PYT, seven genotypes were selected from SYT, two advanced lines were selected for retrial and four lines were selected from RYT and one advanced line was selected from ALART.

Tidal submergence tolerant rice (T. Aman). The project was aimed to develop high yielding varieties adaptable to tidal non-saline condition in the southern districts. In total, 10 crosses were made using 16 parents, 10 crosses were confirmed as true hybrid. Totally 388 progenies were selected from F_4 and F_5 generations. Forty-one genotypes along with 58 plants were selected from 208 genotypes evaluated in observational trial. Thirteen lines were selected from 36 genotypes from two PYTs. Four promising lines were selected from RYT based on higher grain and acceptable growth duration compared to the check varieties.

Salt tolerant rice. This programme emphasized on the development of salt tolerant rice variety suitable for the saline prone areas of coastal districts in Aus, Aman and Boro seasons. Twenty-six and 58 crosses were made for Aman and Boro season respectively. A total of 19 F_1s for Aman and 25 F_1s for Boro season were confirmed and selected. Twenty-five F_2 populations were grown and 358 progenies were selected and bulked crosswise, 1,292 progenies and 34 fixed lines were selected from pedigree nurseries (F_3-F_6) in T. Aman season. Bulk progenies were selected from 25 F_2 populations, 798 progenies and 63 fixed lines were selected from pedigree nurseries (F_3-F_6) of Boro season. Nineteen advanced lines were selected from observational trial (OT) and seven entries were selected from PYTs. Four (IR77674-3B-8-2-2-14-2-AJY2, IR77674-3B-8-2-2-12-5-5-1, IR83484-3-B-7-1-1-1 and BR8131-24-1) genotypes were selected from SYTs. In three participatory variety selection (PVS) trials, three genotypes (IR98066-102-B, BRRI dhan28-Saltol and IR86385-117-1-1-B) as well as BRRI dhan58 and BRRI dhan61 were selected by the farmers through PVS, which showed consistency with the yield performances. The genotype BR7100-R-6-6 was released as salt tolerant variety BRRI dhan67 for Boro season. IR78767-B-SATB1-28-3-24 and IR78767-B-SATB1-28-3-26 were evaluated (Tables 1 and 2) by National Seed Board and IR78767-B-SATB1-28-3-24 was released as salt tolerant variety BRRI dhan73 for T. Aman season. It can tolerate 8 dS/m water salinity in its whole life cycle (Figs. 1, 2 and 3). Five entries from INGER (IRSSTN) and eight entries from Salt Tolerant Breeding Nursery (STBN) were selected for future evaluation.

Premium quality rice (PQR). Efforts were made to develop aromatic and non-aromatic fine quality rice with national (Kalizira/Chinigura type) and international (Basmati/Banglamati type) standards for domestic use and export. Experiments were conducted in T. Aman and Boro season. In T. Aman, a total of 22 crosses were made, 14 crosses were confirmed and 407 plants were selected from 7 F_2 populations. None of the materials was promoted to ALART from RYT. BR7357-11-2-4-1-1 performed well in PVT having 4.8-5.0 t/ha grain yield with 14 days earlier growth duration than BRRI dhan37 and National Seed Board has

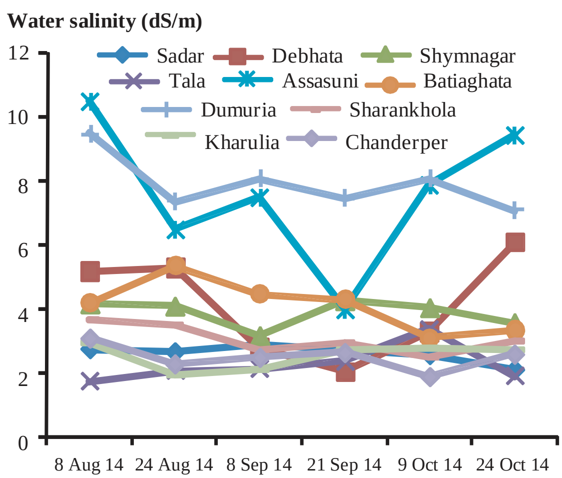


Fig. 1. Water salinity (EC dS/m) levels of different experimental plots (PVT), T. Aman 2014-15.

Table 1. Yield and agronomic performance of the proposed lines in the proposed variety trial (PVT), T. Aman 2014-15.

Genotype	Plant ht (cm)	Growth duration (day)	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	Mean
IR78761-B-SATB1-28-3-24 (BRRI dhan73)	117	120	5.3	4.8	4.1	5.3	2.1	5.3	2.7	4.2	6.1	4.5	5.2	4.5
BRRI dhan53 (ck)	109	123	4.6	4.3	3.6	4.7	1.8	4.5	2.4	3.7	5.4	3.7	4.5	3.9

L1=Satkhira sadar, L2=Debhata, L3=Shymnagar, L4=Tala, L5=Assasuni, L6=Batiaghata, L7=Dumuria, L8=Sharankhola, L9=Kolapara, L10=Cox's Bazar sadar (1), L11=Cox's Bazar sadar (2).

Table 2. Salt stress tolerance score (SES) and survivability (%) of proposed variety at EC of 12 dS/m at seedling stage, T. Aman 2014-15.

Proposed line with std check	Tolerance score (SES)	Survivability (%)
IR78761-B-SATB1-28-3-24 (proposed)	6	66
BRRI dhan53 (ck)	6	60
IRRI 154 (Sensitive ck)	8	32

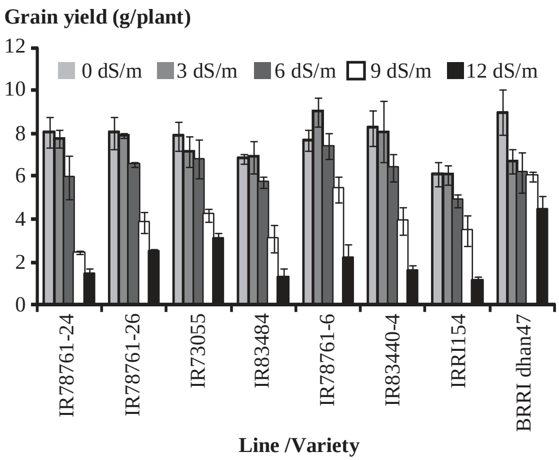


Fig. 2. Yield (g/pot) of different rice genotypes as affected by different salinity levels under net house condition, BRRI, T. Aman 2014-15.

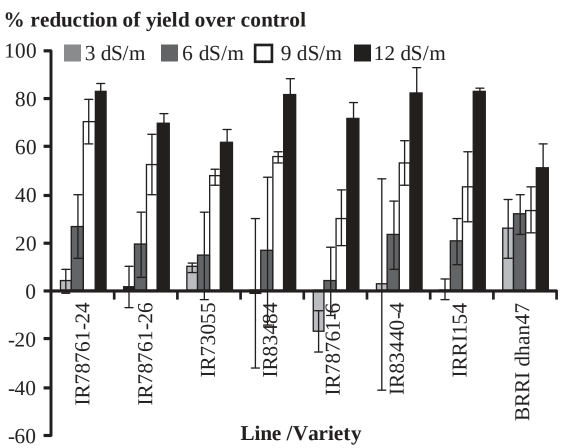


Fig. 3. Reduction of yield over control (%) among the tested genotypes at saline condition. Error bar represents ±SE.

already released BR7357-11-2-4-1-1 as BRRI dhan70 for T. Aman season (Table 3).

In Boro, 41 crosses were made, 18 crosses were confirmed and 2,098 plants were selected from 19 F_2 populations. From pedigree nursery 2,347 segregating progenies and 40 fixed lines were isolated. Fifteen genotypes were selected from OT, 10 genotypes were selected from PYT, none of the materials were selected from SYT and three genotypes were selected from RYT for promoting in ALART. None of the materials was found suitable for promoting to PVT from ALART except NERICA Mutant.

Development of rice varieties for favourable Boro environment. Main objective of the project was to develop improved genotypes with high yield potential (8.0 t/ha), earliness (130-135 days) and acceptable grain quality for favourable irrigated ecosystem in Bangladesh. Sixteen crosses were made. Fourteen crosses were confirmed as true F_1. In total, 1736 superior individual plants were selected from F_2 populations based on phenotypic performance of each cross. From pedigree nurseries, 1,475 individual progenies were selected from 38 crosses of F_3- F_7 populations. Four out of 72 genotypes were selected from OT based on growth duration, yield and homogeneity in other morpho-agronomic traits. From PYT-1, one genotypes, BR9209-5-3 having 1.3 t/ha yield advantage over BRRI dhan28 was selected. From PYT-3, three genotypes viz BR8609-2-B-8-3-B1, BR7671-37-2-2-3-7-3-P3 and BR7831-59-1-1-4-3-1-7 having 0.5 t/ha yield

Table 3. Performance of the proposed variety for premium quality rice, T. Aman 2014-15.

Designation	Plant ht (cm)*	Growth duration (day)*	Grain yield (t/ha)*	Grain char cteristic					
				Head rice yield (%)	L-B ratio	Size and shape	Elongation ratio	Protein (%)	Amylose (%)
BR7357-11-2-4-1-1 (BRRI dhan70)**	125	130	4.77	61.9	4.4	ELS	1.5	9.5	21.7
BRRI dhan37(ck)	125	144	3.39	64.9	3.2	MS	1.2	10.3	23.8

*Mean of 10 locations (Rajshahi, Rangpur, Kushtia, Barisal, Feni, Comilla, Habiganj, Satkhira, Mymensingh and Gazipur). **This proposed variety has already been released by NSB as BRRI dhan70 on 12 July 2015.

advantage over BRRI dhan28 were selected. In SYT-1, 2 and 3, a total of nine genotypes viz BR7988-12-5-1-1-1, BR7988-12-3-4-3-1, BR7988-14-1-4-4-2, BR 8611-10-3-2-2, BR 8247-3-2-2-2, BR 8643-6-4-3, BR 8626-20-9-1-3, BR 8626-19-5-1-2 and BR 8626-19-4-1-1 had 0.6-.07 t/ha yield advantage over check varieties BRRI dhan28, BRRI dhan29 and BRRI dhan55. In RYT, BR7988-10-4-1 was the highest yielder across ten locations followed by BR7683-30-3-3-4 and BRRI dhan29-SC3-28-16-10-8-HR1 (Com).

Cold tolerant rice. Main objective of the project was to develop high yielding rice varieties tolerant to cold injury. Thirty-eight crosses were made. Thirty-three crosses were confirmed as true F_1. In total 1,757 individual plants were selected from F_2 population based on phenotypic performance. From Pedigree nursery, 1098 superior individual plants and 27 fixed lines were isolated from 20 crosses of F_3- F_7 populations. Twelve genotypes were selected from OT#1 and OT# 2 based on growth duration, yield, and homogeneity in other morpho-agronomic traits and superiority in one or more traits over the check variety. In PYT and SYT, no genotype was found superior than the check varieties. Thus none was selected for further evaluation in advanced yield trial. Three genotypes were selected based on yield and growth duration from the International Temperate Rice Observational Nursery (IRTON).

Under IAPP cold programme, two near isogenic lines of BRRI dhan29, IR90688-20-1-1-1-1-1 and IR90688-91-1-1-1-1 showed almost similar yield to check variety BRRI dhan29 at both Gazipur and Rangpur. Since these two lines were found cold tolerant at seedling stage in previous studies, they were selected as parents to use in hybridization programme. From CS1 pedigree nurseries, 223 progenies tolerant to cold at seedling stage were selected considering leaf discoloration (LD) scores under artificial cold treatment and agronomic performance under field condition from 68 plant families. In a PVS baby trial, BR7812-19-1-6-1-P2 and BR7812-19-1-6-1-P4 gave comparatively higher yield (0.36 t/ha to 0.63 t/ha) than the check varieties with almost similar growth duration.

Three mapping populations, BR1×HbjBVI, BR1×BR18 and BRRI dhan28×HbjBVI were phenotyped for cold tolerance. Forty-eight F_{2}- F_3 progenies were selected from two extreme trials of cold sensitivity as most susceptible and most tolerant progenies for genotyping to map QTL(s) confering cold tolerance at seedling stage.

Low amylose rice. The project was aimed at developing high yielding (8.0t/ha) indica rice variety with low amylose content (18-22%) for domestic use particularly for ethnic people. In pedigree nursery, 75 individual progenies comprising 18 from F_7 and 57 from F_8 generation and 31 bulk lines were selected. From observational trial, three genotypes were selected based on growth duration, yield, and homogeneity in other morpho-agronomic traits for preliminary yield trial. In PYT, no genotype was found superior than the check varieties. Thus none was selected for further evaluation in advanced yield trial.

Micronutrient enriched rice (MER). The main objective of the programme was to develop high yielding rice varieties with improved nutritional quality in terms of high zinc content in polished grain. The experiments were conducted at both T. Aman and Boro season. In T. Aman, 55 single and 14 back-, top- and three-way crosses were made. A total of 47 crosses were confirmed as true F_1 comparing with their respective parents. Fourteen crosses were used to make back-, top- and three-way crosses. From F_2 population, 2,208 progenies were selected from 27 crosses. A total of 1,215 individual superior progenies comprising 728 from F_3 and 478 from F_4 generation were selected following pedigree selection method. Eighty-nine fixed progeny rows were bulked from F_7 and advanced generations. Also, 295 perior individual plants were selected from non-uniform entries of observation trial. From OT, 38 uniform genotypes were selected considering initial yield advantage over the check varieties for further evaluation. Sixteen genotypes were selected from PYT having yield advantage of at least 0.5 t/ha over the check varieties. Nine genotypes from SYT were selected for regional trial. Three genotypes in terms of yield advantage (0.4 to 0.8 t/ha) with growth duration more or less similar to check variety were selected from RYT. The breeding lines, BR7528-2R-19-HR10 showing 0.4 t/ha yield advantage over BRRI dhan39 and 128 days growth duration in PVT was released as BRRI dhan72 for T. Aman season by the National Seed Board (Table 4). In Boro season, 68 single crosses and 13 back- and three-way crosses were made for developing breeding and pre-breeding materials. A total of 36 crosses were confirmed as true F_1. From F_2 population, 1,766 individual plants were selected from 34 crosses and bulk selection was performed from two crosses. A total of 3,185 individual progenies comprising 155 from F_3, 125 from F_4, 1,050 from F_5, 763 from F_6, 1,054 from F_7, and 38 from F_8 generation were selected. Ninety-two progeny rows were bulked from advanced generations. Also, 295 individual plants were selected from non-uniform entries of observation trial. From OT, 80 uniform genotypes were selected based on yield advantage over check varieties for further evaluation. Thirteen genotypes were selected from preliminary yield trial considering yield advantage of at least 0.5 t/ha over the check varieties, growth duration and zinc content. Twelve genotypes from SYT were selected for regional trial. Nine genotypes in terms of yield advantage (0.4 to 0.8 t/ha) with growth duration more or less similar to the check varieties were selected from RYT. Two genotypes showing 0.4 t/ha and 0.8 t/ha yield advantage with growth duration more or less similar to the check varieties were selected from RYT. In a proposed variety trial, BR7671-37-2-2-3-7 and BR7833-11-1-1-2-1-2B5 were tested and BR7671-37-2-2-3-7 was showing 1.2 t/ha higher yield with 3-5 days shorter growth duration than BRRI dhan64 (Table 5) was recommended as BRRI dhan74 by the National Technical Committee of the NSB at its 81th meeting.

Insect resistant rice. The main thrust of the project was to develop varieties resistant to brown plant hopper (BPH), white backed plant hopper (WBPH) and gall midge (GM). Eighteen crosses for T. Aman and 45 crosses for Boro season were made. Four and 12 crosses were confirmed in T. Aman and Boro season, 434 progenies in T. Aman from F_2 populations, 790 progenies (907 for BPH and GM in T. Aman season and 609 for BPH and GM in Boro season) and 30 fixed lines for BPH and GM in T. Aman season were selected from pedigree nursery. Eighteen lines from OT, eight lines from PYT, six lines from SYTs and four lines from AYT were selected showing resistance to BPH in T. Aman season. Twenty-five lines from OT, eight lines from PYT, five lines from SYT and five lines from AYT were selected in Boro season.

Disease resistant rice. Efforts were made to develop varieties resistant to bacterial blight (BB), rice tungro virus (RTV) and blast diseases. Twenty-four crosses for BB and 17 crosses for blast in T. Aman and 20 crosses for BB and four crosses for blast were made in Boro season. Twenty-five crosses for BB and one for blast during T. Aman and 20 crosses for BB and four crosses for blast in Boro were confirmed as true F_1.

Table 4. Performance of the proposed lines in the proposed variety trial, T. Aman 2014-15.

Designation	Growth duration (day)	Yield (t/ha)	MY (%)	HRY (%)	Chalk	WGL (mm)	WRB (mm)	L/B ratio	Protein (%)	Amylose (%)	IR
BR7528-2R-19-HR10	128	5.7	72.7	59.5	Tr	6.9	2.5	2.7	8.9	26.0	3.5
BRRI dhan39 (ck)	121	4.8	73.0	60.0	Tr	5.9	2.0	3.0	8.5	26.5	3.7

Tr=Translucence, MY=Milling yield, HRY=Head rice yield, WGL=Whole grain length, WRB=Whole grain breadth, IR=Imbibitional ratio.

Table 5. Performance of the proposed lines in the proposed variety trial, Boro 2014-15.

Designation	Growth duration (day)	Yield (t/ha)	MY (%)	HRY (%)	GL (mm)	GB (mm)	L/B ratio	Size and shape	Protein (%)	Amylose (%)	Zinc (mg/kg)	ER	IR
BR7671-37-2-2-3-7	147	7.1	70.0	67.6	6.1	2.5	2.4	MB	8.3	28	24.2	1.5	4.6
BRRI dhan64 (ck)	150	5.9	72.5	66.0	5.4	2.7	2.0	MB	7.2	26	24.0	1.4	4.3

MY=Milling yield, HRY=Head rice yield, GL=Grain length, GB=Grain breadth, IR=Imbibitional Ratio, ER=Elongation Ratio.

Four hundred ninety-seven resistant progenies for BB were selected in T. Aman season from F_2 population. Ninety-two superior progenies from F_3 generation for BB, 96 for blast and 11 for RTV from F_3 generation were selected in T. Aman. A total of 201 progenies for BB and 162 for blast were selected from F_4 generation in T. Aman, where as 119 superior progenies from F_3-F_4 generations were selected for BB during Boro season. Fifteen fixed lines for BB, 12 for blast and six fixed lines for RTV were isolated during T. Aman season, while 47 fixed lines were isolated from F_5 generation for BB during Boro season. From OT, 11 homogenous lines for BB in T. Aman, while five entries for BB during Boro season showed better yield potential and agronomic performance over the check varieties. In SYT, BR8821-8-1 showed higher yield coupled with growth duration similar to check variety, BRRI dhan39 with. BR8821-10-2 also produced one t/ha higher yield than BRRI dhan49 with almost similar growth duration during T. Aman season. Two entries for BB were selected from SYT during Boro season. One genotype for BB were selected from AYT during T. Aman season. Three lines such as BR7986-2-3, BR7986-7-4 and BR7986-29-4 were selected for BB from AYT during Boro 2014-15.

Submergence and water stagnation tolerant rice. The project was aimed of the development of high yielding rice varieties tolerant to submergence (flash flooding) and medium stagnant water (MSW) stresses in collaboration with IRRI as flash flooding and water stagnation are the major constraints in the rainfed lowland rice ecosystem in Bangladesh. In total, 20 single crosses were made using 14 parents and 2,328 F_1 seeds were produced. Six crosses were selected and confirmed as true F_1s. Pedigree generations were grown under controlled submergence and medium stagnant water condition of BRRI RS, Rangpur and BRRI HQ, Gazipur. A total of 333 progenies from F_2-F_8 and backcross generations were selected and preserved. Fourteen lines were selected for observational trial. In marker-assisted selection, six BRRI dhan49-*Sub1* isogenic lines and 10 recombinant lines, 15 BC_3F_1 plants from BRRI dhan22*2/BRRI dhan51 and 13 BC_4F_1 plants from BRRI dhan39*3/IR64-sub1 were selected through foreground and phenotypic selection approach. From two PYT's conducted under rainfed conditions, nine genotypes were selected based on yield and growth duration. Only one entry was selected from two SYTs. In PVS (Early) trial conducted under flooded and non-flooded/rainfed conditions, totally three genotypes were selected based on grain yield and growth duration. In PVS (Late) trial conducted under both controlled submergence and natural flooded conditions, BR9158-19-9-6-9-9 and BR9159-8-5-49-1-2 genotypes were selected respectively, based on grain yield and submergence tolerance. In 'Head to Head' trial, *Sub1*-varieties were tested over eight locations. There was no significant difference between *Sub1*-varieties and original mega varieties in respect to grain yield, plant height and growth duration. Newly developed pyramided (*Xa21* and *SUB1*) lines developed through backcross breeding were evaluated and five genotypes were selected from eight entries based on grain yield and phenotypic acceptability. Adaptive trials were conducted with BRRI dhan49-*Sub1* lines and BR9159-8-5-40-13-57 produced the highest average grain yield (4.9 t/ha) at four locations of northern region under non-flooded condition. While from adaptive trials with BRRI dhan33-*Sub1*, BRRI dhan44-*Sub1* and BRRI dhan49-Sub1 at BRRI Gazipur, 11 genotypes were selected.

Drought tolerant rice. The project emphasizes for developing high yielding rice varieties tolerant to drought stresses in the rainfed lowland rice ecosystem in Bangladesh.

Experiments were conducted in T. Aman eason. In total, 15 crosses were made, 23 crosses were confirmed and 491 plants were selected from 16 F_2 populations. From pedigree nursery 1,566 segregating progenies were selected. In OYT, 25 genotypes performed better than the local and international check varieties in respect to yield under reproductive stage drought condition. From AYT, 11 genotypes were selected based on yield with 100-120 days growth duration. In PVS trial, three genotypes from 14 genotypes were identified as promising in Rajshahi and in Rangpur IR82589-B-B-84-3 and IR83377-B-B-93-3 were found superior according to farmers' choice. IR82589-B-B-84-3 and IR83377-B-B-93-3 both performed well in PVT. IR82589-B-B-84-3 having 5.05 t/ha grain yield with 111 days growth duration was approved by the NSB to release as BRRI dhan71 for T. Aman season (Table 6).

Water saving and aerobic rice varieties for low water environment. The objective of the project was to develop high yielding rice varieties suitable for low water environment. Thirteen crosses were made using 12 parents and 688 F_1 seeds were produced. Totally 180 progenies from F_3 generation received from IRRI were selected. Again, 26 entries were selected from four observational trials based on grain yield, growth duration and phenotypic acceptability. Validation trials of Boro varieties were conducted under late Boro condition (late February seeding) in four on-farm locations of greater Rangpur region. The grain yield of BRRI dhan48 was the highest having 4.71 t/ha yield with 107 days growth duration among nine BRRI and BINA varieties while BRRI dhan58 produced the second highest grain yield 4.62 t/ha with 115 days growth duration. On the other hand, at BRRI Gazipur, BRRI dhan58 produced the highest grain yield 4.49 t/ha having 121 days growth duration with early February seeding of the same validation trial. In PVT, the selected line IR83142-B-71-B-B produced 0.7 t/ha more grain yield than BRRI dhan28 and growth duration was similar to the check during Boro 2014-15.

Screening and testing of improved Aus rice genotypes suitable for aerobic soil condition. In large portion of rainfed Aus areas of Bangladesh, rainfall is erratic and dry spells may occur during seedling stage (April to May) of Aus crop. Base line information indicates that there is scope to increase Aus areas through adapting short duration aerobic rice varieties under water saving direct seeding methods in Rajshahi and Sylhet regions. Under such situation, this coordinated project has been designed to develop aerobic rice varieties having short duration (100-105 days), high yielding and aerobic soil adaptability. During the reporting period, three separate advanced yield trials were conducted under aerobic soil condition in farmer's field in replicated yield trials to find out the best aerobic rice lines. Out of tested 19 lines, four top ranking varieties (IR91006-88-1-3-1, IR84788-40-3-3-1-1, IR90228-1-3-3-3-2 and IR92240-40-2-2-1) in respect to yield (3.60-4.10 t/ha) and comparatively shorter growth duration (105-109 days) were selected. Further, out of tested 12 lines, five top ranking varieties (BR7182-2B-1-HR4, BR7178-2B-19-10, BR6855-3B-12, BR6848-3B-12 and BI dhan-5) with respect to yield (3.55-4.50 t/ha) and shorter growth duration (97-101 days) were selected.

Higher root length under water stress was used as criteria for selecting aerobic rice lines. IR90228-1-3-3-3-2 and IR91006-88-1-3-1 are the best aerobic rice genotypes with higher root length

Table 6. Performance of the proposed variety under drought prone area, T. Aman, 2014-15.

Designation	Plant ht (cm)*	Growth duration (day)*	Grain yield (t/ha)*	Grain char cteristic					
				Head rice yield (%)	L-B ratio	Size and shape	Elongation ratio	Protein (%)	Amylose (%)
IR82589-B-B-84-3 (BRRI dhan71)**	108	111	5.05	63.6	2.8	MB	1.5	7.0	24.0
BRRI dhan56 (ck)	110	106	4.40	59.5	2.8	MB	1.5	8.0	23.0

*Mean of 9 locations (Godagai, Paba, Tanore of Rajshahi, Nachole of Chapai Nawabganj, Rangpur, Lalmonirhat, Kushtia, Jessore and Gazipur).**This proposed variety has already been released by NSB as BRRI dhan71 on 12 July, 2015.

(55-58 cm) than others. During the 2nd year, a set of diverse lines was used for marker assisted selection having deep rooting ability. One of two markers RM302 amplified a specific allele (112 bp) in all the aerobic rice genotypes, which showed different pattern in short rooted rice genotypes. Thus, RM302 marker on chromosome 1 could be used to differentiate between long and short rooted genotypes. IR92240-40-2-2-1 was the best aerobic rice genotypes possessed deeper root system.

Green super rice (GSR). The project was aimed for developing of less input consuming but high yield potential genotypes with tolerance to different stresses. In T. Aman season, 26 genotypes were selected based on yield, plant type, grain quality, homogeneity in other agronomic traits from observational trial. From PYT (1 and 2), eight genotypes were selected. Considering drought nine genotypes were selected from SYT#1 and eight genotypes were selected for salinity from SYT#2. Therefore, all entries will be evaluated for regional yield trial in next season. One promising genotype (HUA565) has been approved for retrial in the proposed variety trial.

In Boro season, two fixed genotypes were selected based on phenotypic acceptability, yield, and homogeneity in other morpho-agronomic traits and superiority in one or more traits over the check variety. From PYT, 11 genotypes were selected based on yield and growth duration for secondary yield trial. In RYT, the genotypes HHZ15-DT4-DT1-Y1 (6.4 t/ha), HHZ6-SAL3-Y1SUB2 (6.7 t/ha) produced the highest average yield over 10 locations than BRRI dhan60 and growth duration was 4-6 days earlier than BRRI dhan29 (Table 7). Therefore, the two genotypes were selected in Boro season for conducting adaptive yield trials in farmers' field.

International Network for Genetic Evaluation of Rice (INGER). This programme focused on sharing germplasm and breeding lines through international platform for the acceleration of genetic improvement of rice varieties. A total of 62 germplasms were selected from six INGER nursery sets in T. Aman 2014 season. In addition 28 germplasms were selected from four INGER nursery set in Boro 2014-15 season for using in the breeding programme either as parents or for directly using in the yield trials.

Table 7. Performance of genotypes in regional yield trial, Boro 2014-15.

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)											Grain shape
			L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Ave	
HHZ15-SAL13-Y1	89.9	154	5.1	4.1	6.3	7.2	6.6	6.7	6.3	6.9	6.1	7.2	6.2	S
HHZ23-DT16-DT1-DT1	89.9	156	5.9	4.9	7.9	6.4	6.8	6.3	6.6	7.5	6.8	7.2	6.6	S
HHZ15-DT4-DT1-Y1	85.4	153	5.7	4.6	8.0	6.9	6.5	6.7	6.4	6.3	6.4	6.9	6.4	S
HHZ11-DT7-SAL1-SAL1	84.0	150	4.1	4.5	8.6	6.5	6.4	6.0	5.9	6.4	6.2	6.8	6.2	MS
HHZ6-SAL3-Y1-SUB2	91.2	155	5.0	5.0	9.4	6.9	6.7	6.5	7.0	6.4	6.9	7.1	6.7	S
BRRI dhan29	96.1	159	5.9	4.1	7.6	7.6	6.4	6.9	6.1	6.7	7.6	6.6	6.5	
BRRI dhan60	86.8	147	4.9	4.5	7.1	6.1	6.6	5.4	5.7	5.8	5.1	5.4	5.7	

L1=Gazipur, L2=Sonagazi, L3=Rangpur, L4=Rajshahi, L5= Habiganj, L6=Bhangha, L7=Sathkhira, L8=Comilla, L9=Kushtia and L10=Barisal.

Biotechnology Division

SUMMARY

A total of 23 experiments were conducted under four projects during the reporting period. In total 45 green plantlets were regenerated from hybrid anther of four crosses. For developing modern rice variety through anther culture 34 different crosses were made and 4,911F_1 seeds were harvested from those cresses. A total of 341 plants were selected and 16 homozygous lines were bulked from 246 pedigree lines during T. Aman/2014. On the other hand, during Boro 2014-15 season, 87 homozygous lines were bulked from169 pedigree lines for further evaluation. Twenty-nine anther culture derived doubled haploid lines were evaluated in two OTs with standard checks in T. Aman 2014. Among them 16 promising doubled haploid lines were selected for further evaluation as PYT. Forty-two advanced homozygous lines were evaluated in two OTs during Boro 2014-15 with standard checks and 15 lines were selected for further evaluation as PYT. Twenty-nine advanced homozygous lines were evaluated in four PYTs in T. Aman 2014 and among them 20 lines were selected for further evaluation. During Boro 2014-15 season, 41 lines were evaluated in three PYTs and 19 lines were selected for further evaluation. Five advanced doubled haploid lines were evaluated at 10 BRRI regional stations during Boro 2014-15 and two lines were selected for ALART in Boro 2015-16. One advanced Rice-Wheat derived line (BR6158RWBC2-1-2-1-1) was also evaluated at 10 BRRI regional stations during Boro 2014-15. The line BR6158RWBC2-1-2-1-1 showed better performance than those of checks and selected for ALART in Boro 2015-16. Seventeen BB resistant genes (*Xa4* and *Xa21*) pyramided BRRI dhan29 lines were evaluated as OT during Boro 2014-15 with standard check. Among them nine lines were selected depending on the phenotypic acceptability and yield. Genotyping of mapping population of BRRI dhan28/ *Oryza rufipogon* (Ac. no.105890) was completed for QTL analysis. From this mapping population two major QTL for yield and yield contributing traits were identified. BRRI dhan29 and BRRI dhan28 were used for developing salt tolerant transgenic rice with salt tolerant gene *AeMDHAR*. From this study 40 and 20 putative transgenic plants were obtained from BRRI dhan29 and BRRI dhan28, respectively. However, none of the putative transformants amplified by PCR with *AeMDHAR gene* specific primers. In another transgenic study, salt tolerant genes *Gly1* and *GlyII* were introduced into BRRI dhan29 to make it salt tolerant. From this study T_4 seeds were harvested for salinity screening.

DEVELOPMENT OF RICE VARIETY THROUGH TISSUE CULTURE

Anther culture

Twenty-four F_1 populations were grown in the net house under optimum management (Table 1). A total of 91,418 hybrid anthers from 24 crosses were plated in KE amd M10 media for callus induction. Data were taken on number of anther plated, number of calli produced, number of green and albino plant regenerated. A total of 808 calli were obtained from KE and M10 media (Table 1). The highest numbers of calli (167) were obtained from hybrid anthers of BRRI dhan29/Kalizeera cross followed by 105 calli obtained from BR17/Kanaklata cross (Table 1). On the other hand, the highest number of green plant regenerated (26) from hybrid anther of BRRI dhan29/Kalizeera cross (Fig. l) followed by 17 green plants regenerated from BRRI dhan29/FL478 cross. After hardening, green plantlets were transferred into the earthen pots and kept until maturity.

FIELD PERFORMANCE OF TISSUE CULTURE DERIVED LINES

Hybridization

Hybridization was done to generate F_1s for anther culture for developing doubled haploid. Thirty-four crosses were made for developing aromatic, fine grain, high yield potential, salinity tolerant, cold tolerant, low GI and short duration rice variety. In total 4,911 F_1 seeds were harvested from 34 different crosses (Table 2).

Progeny selection

Progeny selection was carried out to select the best

Table 1. Callus induction and plant regeneration from hybrid anther of 24 crosses.

Cross combination	No. of anther plated	No. of calli obtained	No. of plant regenerated
BRRI dhan29/FL478	5013	60	17 green plants
MR219/BR16	7162	55	one green plant
BR16*2/Kanaklata	6247	29	
BR16/BRRI dhan28	3524	34	
BRRI dhan28/BR16	3147	71	
Kanaklata/BR16	802	09	
BR16/Kanaklata	5967	105	
MR219/Kanaklata	2043	22	
BRRI dhan28/Kanaklata	369	18	
BRRI dhan29/Kanaklata	9206	05	
BRRI dhan28/FL478	5402	10	Six Albino plants
BRRI dhan29/BRRI dhan61	2086	9	Four Albino plants
BRRI dhan61/FL478	5660	2	
BRRI dhan50/Tepiboro (Acc. no. 930)	3805	74	one green plant 57 Albino plants
BRRI dhan29/Kalizeera	6335	167	26 green plants 78 Albino plants
BRRI dhan49/Kalizera	3438	37	12 Albino
BRRI dhan28/Tepiboro (Acc. no. 930)	3136	18	Four Albino
BRRI dhan29/Bashful	731	2	
BRRI dhan29/Tepiboro (Acc. no. 930)	2475	15	21 Albino
BRRI dhan55/Tepiboro (Acc. no. 930)	344	2	
BRRI dhan50 /Bashful	3019	29	32 Albino
Chinigura/ BRRI dhan28	1353	2	
NERICA7/BRRI dhan55	5380	22	Eight Albino
NERICA7/BRRI dhan48	4774	11	one Albino
Total	91418	808	45 green plants

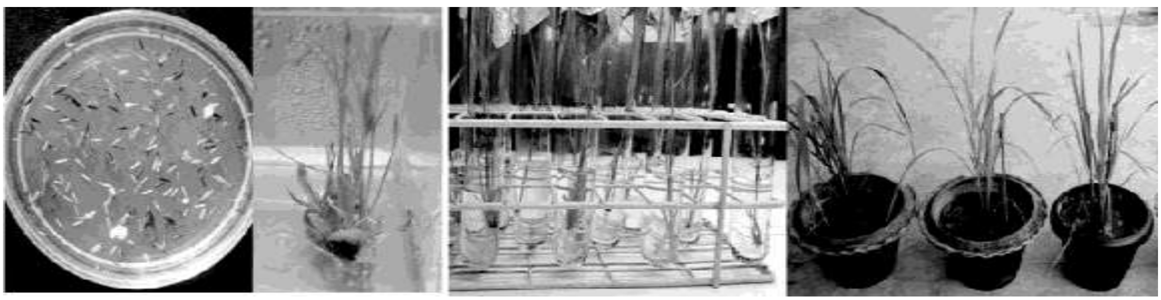


Fig. 1. Anther culture derived doubled haploid plants from BRRI dhan29/Kalizeera cross.

progenies with high yield having desired traits. A total of 341 plants were selected and 16 homozygous lines were bulked from 246 pedigree lines during T. Aman 2014. In addition, 87 homozygous lines were bulked from169 pedigree lines during Boro/14-15 for further evaluation.

Observational trial

During T. Aman 2014, a total of 29 anther culture derived doubled haploids lines were evaluated in two OTs with standard checks to select agronomically desirable and high yield potential materials. Among them 16 doubled haploids lines were selected depending on the duration and comparable yield with checks (Tables 3 and 4). Forty-two advanced homozygous lines were evaluated in two OTs with standard checks in Boro 2014-15. Among them 15 lines were selected depending on the growth duration and comparable yield with checks (Tables 5 and 6).

Preliminary yield trial

Preliminary yield trial was carried out for initial evaluation of agronomically desirable and high

Table 2. List of crosses for anther culture.

Cross	No. of seeds
BRRI dhan29/Kanaklata	260
BR16/Kanaklata	116
BRRI dhan28/Kanaklata	108
MR219/Kanaklata	198
BRRI dhan28/BR16	143
MR219/BR16	190
BRRI dhan29/BR16	123
BR16/ BRRI dhan29	64
BR16/MR219	62
MR219/BR16	190
MR219/BR16*^{3}	22
BR16*^{3}/BRRI dhan28	108
MR219/BR16*^{2}	78
MR219/BR16*^{3}	135
BRRI dhan28*^{2}/Kanaklata	10
MR219*^{2}/BR16	94
MR219*$^{3/}$BR16	21
BRRIdhan29/ BRRI dhan 61	107
BRRI dhan 28/FL 478	166
BRRI dhan 61/FL478	620
BRRI dhan 28/ BRRI dhan 61	314
BRRI dhan 28/IR4630-22-2-5-1-3	48
BRRI dhan 29/IR4630 22-2-5-1-3	156
BRRI dhan29/Tepiboro (Acc. no. 930)	421
BRRI dhan28*^{2}/Tepiboro (Acc. no. 930)	24
BRRI dhan50*^{2}/Tepiboro (Acc. no. 930)	49
BRRI dhan28/Tepiboro (Acc. no. 930)	383
BRRI dhan50/Bashful	28
BRRI dhan29/Kalizeera	65
BRRI dhan49/Kalizeera	123
MR219\NERICA7	112
BRRI dhan28\NERICA7	129
BRRI dhan48\NERICA7	144
BR8072-AC5\NERICA7	100
Total	4911

Table 3. Agronomic characteristics of anther culture derived doubled haploid lines in T. Aman 2014 (OT-1).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BR8018-AC3-2-2-1	112	118	4.36*
BR8018-AC6-2-2-2	110	118	4.90*
BR8018-AC12-4-1-5	107	117	5.38*
BR8018-AC14-4-3-6	129	123	5.88*
BR8019-AC2-1-2-13	116	119	4.54*
BR8019-AC3-1-3-14	112	119	5.38*
BR8019-AC13-1-2-17	103	117	4.56*
BR8019-AC161-3-20	124	120	4.79*
BRRI dhan49 (ck)	105	131	4.45

Sixteen entries were evaluated and eight entries were selected. *=Selected.

yield potential advanced rice lines. During T. Aman 14, twenty-nine lines were evaluated with standard checks in four PYTs and among them 22 lines were selected for further evaluation (Tables 7,

Table 4. Agronomic characteristics of anther culture derived doubled lines in T. Aman 2014, (OT-2).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BR8009-AC15	115	127	4.65*
BR8009-AC16	116	126	4.51*
BR8009-AC20	111	127	4.63*
BR8009-AC21	123	127	4.49*
BR8009-AC23	112	127	4.51*
BR8009-AC24	121	126	4.49*
BR8009-AC25	124	126	4.50*
BR8009-AC26	120	127	4.57*
BRRI dhan49 (ck)	105	133	4.65

Thirteen entries were evaluated and eight entries were selected. *=Selected.

Table 5. Agronomic characteristics of advanced lines in Boro 2014-15, (OT-1).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BR9777-26-4-3	104	152	8.37*
BR9777-26-4-1	103	152	8.63*
BR9777-41-6-1	107	155	8.02*
BR9777-72-12-2	105	150	8.09*
BR9777-79-3-4	98	143	7.07*
BR9777-79-3-5	100	153	8.02*
BR9777-106-7-4	109	151	8.16*
BR9777-120-8-3	99	152	7.94*
BRRI dhan47 (ck)	95	147	6.83
BRRI dhan29 (ck)	112	157	7.93

Eighteen entries were evaluated and eight entries were selected. *=Selected.

Table 6. Agronomic characteristics of advanced lines in Boro 2014-15 (OT-3).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BR9786-BC2-80-1-1	103	156	7.33*
BR9786-BC2-119-1-2	110	158	7.62*
BR9786-BC2-65-1-1	108	158	7.76*
BR9786-BC2-122-1-2	111	156	8.05*
BR9786-BC2-142-1-2	112	162	7.57*
BR9786-BC2-146-2-2	112	161	7.75*
BR9786-BC2-161-1-2	107	158	8.13*
BR9786-BC2-163-1-2	96	162	6.63*
BRRI dhan29 (ck)	103	158	6.87

Twenty-four entries were evaluated and seven entries were selected. *=Selected.

8, 9 and 10). During Boro 14-15, forty-one materials were evaluated with standard checks in three PYTs and 19 lines were selected for further evaluation (Tables 11, 12 and 13; Figs. 2 and 3).

Regional yield trial

Five anther culture derived doubled haploids

Table 7. Agronomic characteristics of anther culture derived lines in T. Aman 2014 (PYT-1).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BR8018-AC2-2-2-1	128	122	5.12*
BR8019-AC4-1-1-3	107	126	5.55*
BR8019-AC5-1-2-1	117	124	5.35*
BR8019-AC8-1-2-2	105	123	5.25*
BR8019-AC9-3-3-1	106	123	5.31*
BR8032-AC3-4-1-3	101	121	4.65*
BR8032-AC4-1-2-2	109	124	4.78
BRRI dhan54 (ck)	118	133	5.15
CV	2.06	0.45	1.79
$LSD_{0.05}$	4.03	0.97	0.16

*=Selected.

Table 8. Agronomic characteristics of anther culture derived lines in T. Aman 2014 (PYT-2).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BR8036-AC6-2-2-1	123	123	4.20*
BR8011-AC2-3-3-3	135	136	4.51*
BR8011-AC3-4-1-2	131	113	4.17*
BR8011-AC3-4-1-4	134	113	4.29*
BR8036-AC3-2-2-3	121	125	3.58
BR8036-AC2-1-2-1	126	128	3.23
BRRI dhan54(ck)	123	134	4.42
CV	2.65	0.45	3.19

*=Selected.

Table 9. Agronomic characteristics of advanced lines in T. Aman 2014 (PYT-3).

Designation	Plant ht	Growth duration	Yield
BR9786-BC2-124-1-2	114	120	4.34*
BR9786-BC2-119-1-1	119	124	4.30*
BR9786-BC2-98-1-2	117	116	3.79
BR9786-BC2-132-1-3	119	127	4.31*
BR9786-BC2-135-4-1	112	124	3.84
BR9786-BC2-117-2-2	112	127	4.09
BR9786-BC2-2-1-1	107	129	4.75*
BR9786-BC2-139-2-3	115	122	4.68*
BR9786-BC2-98-1-1	113	117	3.34
BR9786-BC2-124-1-5	120	120	4.37*
BRRI dhan49 (ck)	105	137	4.25
$LSD_{0.05}$	5.37	0.63	0.96

advanced materials were evaluated at 10 regional stations during Boro 2014-15 as RYT 1. All the materials gave comparable yield and similar growth duration in comparison with the standard check BRRI dhan28 (Table 14 and 15). However, two lines were selected for ALART. One Rice-Wheat derived tissue cultured advanced material

Table 10. Agronomic characteristics of anther culture derived lines in T. Aman 2014 (PYT-4).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)
BR8009-AC2-1-1-2	115	136	4.55*
BR8009-AC4-1-1-3	116	138	4.36*
BR8009-AC7-1-2-2	122	136	4.40*
BR8009-AC8-1-2-4	119	136	4.26
BR8009-AC9-1-3-1	120	138	4.40*
BR8009-AC11-1-5-2	121	136	4.26
BR11(ck)	116	136	4.26
CV	0.61	0.5	0.72
$LSD_{0.05}$	1.34	1.21	0.06

Table 11. Agronomic characteristics of wide crossed materials in Boro 2014-15, (PYT-1).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)	1000-grain wt (g)
BR9787-BC2-63-2-2	87	143	6.49	18.11*
BR9787-BC2-63-2-4	82	143	6.58	18.24*
BR9787-BC2-102-1-4	87	150	6.89	19.76
BR9787-BC2-119-1-6	116	147	6.57	20.91*
BR9787-BC2-127-1-5	90	149	6.96	18.64
BR9787-BC2-173-1-3	90	145	6.87	19.44*
BR9787-BC2-203-1-3	92	152	7.10	19.58
BR9787-BC2-3-6-2	97	151	6.10	19.46
BR9787-BC2-8-7-1	97	153	6.59	17.14
BR9787-BC2-35-4-2	98	151	6.59	20.17
BR9787-BC2-41-3-2	97	154	6.72	19.16
BR9787-BC2-41-8-2	95	151	6.24	19.75
BR9787-BC2-43-6-1	86	146	6.07	17.52*
BR9787-BC2-44-7-1	96	153	6.45	17.71
BR9787-BC2-48-4-1	98	155	6.90	20.21
BR9787-BC2-53-4-1	100	156	6.95	20.31
BRRI dhan28 (ck)	97	145	6.45	21.53
BRRI dhan58 (ck)	97	156	7.25	21.51
CV	0.97	0.40	3.56	0.28
LSD (0.05)	1.5	0.99	0.39	0.89

Table 12. Agronomic characteristics of wide crossed materials in Boro 2014-15) (PYT-2).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)	1000-grain wt (g)
BR9786-BC2-122-1-3	108	158	8.45	24.58*
BR9786-BC2-2-1-1	97	163	7.12	21.62
BR9786-BC2-15-2-2	103	159	7.98	21.93*
BR9786-BC2-15-2-3	102	163	7.83	22.22*
BR9786-BC2-16-1-1	106	162	7.32	22.50
BR9786-BC2-16-1-2	106	165	7.49	22.81
BR9786-BC2-49-1-2	105	159	8.48	22.41*
BR9786-BC2-115-2-1	98	165	7.41	22.78
BR9786-BC2-127-2-3	106	163	6.59	23.16
BR9786-BC2-59-1-2	105	157	8.02	24.40*
BR9786-BC2-124-1-1	106	158	8.08	24.84*

Table 12. Continued.

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)	1000-grain wt (g)
BR9786-BC2-135-4-1	103	162	6.72	21.18
BR9786-BC2-135-4-3	104	162	6.24	20.99
BR9786-BC2-139-3-2	101	162	6.07	22.73
BR9786-BC2-142-1-1	108	161	8.26	23.50*
BRRI dhan58 (ck)	99	154	7.02	21.46
BRRI dhan29 (ck)	99	165	7.50	20.42
CV	2.03	-	2.74	0.78
LSD	0.84	-	0.34	0.28

Table 13. Agronomic characteristics of wide crossed materials in Boro 2014-15, (PYT-3).

Designation	Plant ht (cm)	Growth duration (day)	Yield (t/ha)	1000-grain wt (g)
BR9785-BC2-9-2-3	113	141	6.56	28.17
BR9785-BC2-6-2-2	102	138	6.91	23.53*
BR9785-BC2-19-3-1	100	141	6.95	21.36*
BR9785-BC2-20-1-3	99	142	6.48	23.10*
BR9785-BC2-27-1-1	123	147	7.14	23.89*
BR9785-BC2-19-3-5	100	144	6.48	21.16*
BR9785-BC2-62-2-2	99	142	6.70	21.38*
BR9785-BC2-110-1-3	99	146	7.15	23.01
BRRI dhan28 (ck)	98	141	6.33	21.58
BRRI dhan58 (ck)	99	154	7.01	21.96
CV	3.93	0.55	4.12	-
LSD	6.96	1.33	0.74	-

Fig. 2. Selected lines from PYT-1 (BRRI dhan28 × *O. rufipogon* cross).

Fig. 3. Selected material from PYT-3 (BRRI dhan28 × *O. rufipogon* cross).

was evaluated at 10 regional stations during Boro 2014-15 as RYT 2. The line BR(BE)6158RWBC2-1-2-1-1 showed better performance than those of the standard checks (Tables 16 and 17,Fig. 4).

APPLICATION OF DNA MARKERS

Gene pyramiding for resistance to bacterial blight

Seventeen bacterial blight (BB) gene pyramid BRRI dhan29 rice lines having two BB resistant genes (*Xa4* and *Xa21*) were evaluated as OT during Boro 2014-15 with standard checks. Among them nine lines were selected depending on the phenotypic acceptability and yield performance (Table 18 and Fig. 5). These nine lines were also confirmed by PCR with gene specific primers (Fig. 6).

Identification of yield enhancement QTLs

Crosses were made to identify and introgress high yield QTLs for enhancing grain yield of elite Bangladeshi rice varieties where BRRI dhan28 was used as recurrent parent and *Oryza rufipogon* (Acc. no. 103404 and Acc. no. 105890) were used as donor parents. Genotyping and phenotyping of mapping population of BRRI dhan28/*Oryza rufipogon* (Acc. no.104303) was completed using 102 polymorphic markers. From this mapping population two major QTL for yield contributing traits were identified (Fig. 7). Genotyping of another mapping population (BRRI dhan28*3/*O. rufipogon* (Acc. no. 105890) having population size 238 has been completed with 108 polymorphic marker (Fig. 8).

DEVELOPMENT OF TRANSGENIC RICE

Salt tolerant transgenic rice lines through transformation

BRRI dhan29 and BRRI dhan28 were used for developing salt tolerant transgenic rice with salt tolerant gene *AeMDHAR*. From this study 40 and 20 putative transgenic plants were obtained from BRRI dhan29 and BRRI dhan28 respectively. However, none of the putative transformants

Table 14. Agronomic characteristics of anther culture derived lines in Boro 2014-15 (RYT-1).

Designation	Gazipur	Barisal	Bhanga	Satkhira	Kushtia	Rangpur	Rajshahi	Habiganj	Sonagazi	Comilla	Avg
					Plant height (cm)						
BR8072-AC5-4-2-1-2-1*	85	85	87	84	93	76	83	84	77	85	84
BR8072-AC7-4-1-2-2-4	84	81	87	80	90	77	83	84	74	83	82
BR8072-AC8-1-1-3-1-1*	86	80	84	85	92	79	84	86	75	84	84
BR8072-AC11-1-1-3-1-1	85	85	81	85	90	84	85	85	78	85	84
BR4909-R1-R2	110	**	**	105	113	106	108	108	87	110	106
BRRI dhan28(ck)	95	87	82	84	93	96	86	92	**	95	90
					Growth duration (day)						
BR8072-AC5-4-2-1-2-1*	139	139	146	139	139	149	141	151	144	144	143
BR8072-AC7-4-1-2-2-4	141	138	146	139	137	149	141	145	147	146	143
BR8072-AC8-1-1-3-1-1*	141	138	144	139	138	149	141	146	140	143	142
BR8072-AC11-1-1-3-1-1	141	138	145	139	138	149	141	145	144	143	142
BR4909-R1-R2	149	**	**	143	144	159	154	145	**	150	149
BRRI dhan28(ck)	141	137	145	140	141	143	142	142	143	143	142
					Grain yield (t/ha)						
BR8072-AC5-4-2-1-2-1*	5.66	4.81	5.18	5.68	5.80	4.3	5.23	7.1	4.87	5.2	5.38
BR8072-AC7-4-1-2-2-4	5.86	4.89	4.88	5.32	5.81	5.01	5.49	5.2	5.07	5.1	5.26
BR8072-AC8-1-1-3-1-1*	6.48	4.28	5.55	5.46	6.57	5.12	5.63	5.7	5.01	4.8	5.46
BR8072-AC11-1-1-3-1-1	5.90	4.76	5.33	5.34	5.95	5.54	5.14	5.3	4.93	5.2	5.34
BR4909-R1-R2	5.99	**	**	5.96	5.96	5.54	6.36	5.2	**	6.6	5.94
BRRI dhan28(ck)	6.83	4.14	5.29	5.79	5.69	5.3	5.94	6.7	5.27	4.2	5.51

*=Selected, **=Seedling shortage.

Table 15. Physicochemical properties of anther culture derived lines in Boro 2014-15 (RYT-1).

Variety/Line	MO (%)	Ap	Ck	L (mm)	L/B ratio	SS	Aml (%)	P (%)	ER
BR8072-AC5-4-2-1-2-1*	72	V. good	Tr	6.5	3.2	LS	26.0	9.5	1.2
BR8072-AC7-4-1-2-2-4	74	Good	Wc10-20	6.5	3.1	LS	23.2	9.8	1.2
BR8072-AC8-1-1-3-1-1*	74	Good	Wb 10-20	6.6	3.2	LS	25.0	9.2	1.2
BR8072-AC11-1-1-3-1-1	73	Good	Tr/Wb5	6.5	3.2	LS	27.0	8.6	1.4
BR802-78-2-1-1(ck)	70	Good	Opaque/Tr	6.0	3.0	LS	23.1	8.2	1.2
BRRI dhan28 (ck)	72	Good	Wb10-20	6.0	3.8	LS	26.0	8.9	1.3
Niamat (ck)	72	Good	Wb>20	7.7	3.8	LS	25.7	9.5	1.4

MO=Milling outran, Ap=Appearance, Ck=Chalkiness, L=Length, L/B=Length/Breath, SS=Shape and size, LS=Long slender, Aml=Amylose, P=Protein, ER=Elongation ration. *=Selected.

Table 16. Agronomic characteristics of rice-wheat derived materials in Boro 2014-15 (RYT-2).

Designation	Gazipur	Barisal	Bhanga	Satkhira	Kushtia	Rangpur	Rajshahi	Habiganj	Sonagazi	Comilla	Avg
					Growth duration (day)						
BR(BE)6158RWBC2-1-2-1-1*	161	157	157	142	154	161	164	159	145	157	156
BRRI dhan58 (ck)	154	146	146	142	149	159	153	156	143	149	150
BRRI dhan2 9(ck)	164	154	154	155	154	167	165	161	158	161	159
					Plant height (cm)						
BR(BE)6158RWBC2-1-2-1-1*	111	108	103	104	116	**	109	98	100	125	108
BRRI dhan58 (ck)	98	88	87	91	103	**	91	93	91	119	96
BRRI dhan29 (ck)	99	85	106	92	103	**	97	98	92	123	99
					Grain yield (t/ha)						
BR(BE)6158RWBC2-1-2-1-1*	8.08	6.69	6.83	6.42	7.9	5.75	9.23	7.9	5.83	8.3	7.29
BRRI dhan58 (ck)	7.22	6.32	5.32	5.82	7.24	5.62	7.34	7.6	5.96	5.8	6.42
BRRI dhan29 (ck)	7.68	6.45	6.52	6.02	7.88	6.75	8.67	7.8	5.96	7.6	7.13

*=Selected, **=Seedling shortage.

Table 17. Physicochemical properties of rice-wheat derived lines.

Variety/Line	MO (%)	Ck	L (mm)	L/B ratio	SS	Aml (%)	P (%)	ER
BR(BE)6158RWBC2-1-2-1-1	72	Tr/Opaque	6.5	3.1	LS	26.0	7.5	1.4
BRRI dhan28 (ck)	72	Tr/Wc5	6.5	3.1	LS	27.0	8.4	1.4
BRRI dhan29 (ck)	70	Tr/Wc9	6.5	3.1	LS	26.0	7.1	1.3

MO=Milling outran, Ck=Chalkiness, L=Length, L/B=Length/Breath, SS=Shape and size, LS=Long slender, Aml=Amylose, P=Protein, ER=Elongation ration.

Fig. 4. Filed evaluation of BR (BE) 6158RWBEC2-1-2-1-1 in Boro 2014-15 (RYT-2).

Fig. 5. BB Screening 15 days after inoculation with BXo9 isolate.

Legend : A=Purbachi, B=BB pyramided Line, C=IRBB60, D=BRRI dhan29.

Table 18. Agronomic characteristics of BB resistant gene (*Xa4 and Xa21*) pyramided rice lines in Boro 2014-15 (OT-2).

Designation	Growth duration (day)	Average leaf area damage (%)	BB score	Yield (t/ha)
BR8333-BC5-1-1	155	19.5	5	7.25*
BR8333- BC5-1-12	149	15.8	5	7.22*
BR8333- BC5-1-16	150	11.3	3	7.20*
BR8333- BC5-1-20	150	8.5	3	7.01*
BR8333- BC5-2-1	149	11.0	3	7.52*
BR8333- BC5-2-13	150	6.6	3	7.14*
BR8333- BC5-2-16	149	10.8	3	7.32*
BR8333- BC5-2-22	149	5.6	3	7.33*
BR8333- BC5-3-10	147	10.2	3	7.28*
BRRI dhan29 (ck)	154	86.9	9	7.28
Purbachi (ck)	-	95.3	9	-
IRBB60 (ck)	-	3.85	1	-

Seventeen entries were evaluated and nine entries were selected. *=Selected.

1, 2, 3, 4 and 5=Sample from each entry

Fig. 6. BB pyramided BRRI dhan29 lines confirmed by PCR with Xa21 gene specific primer.

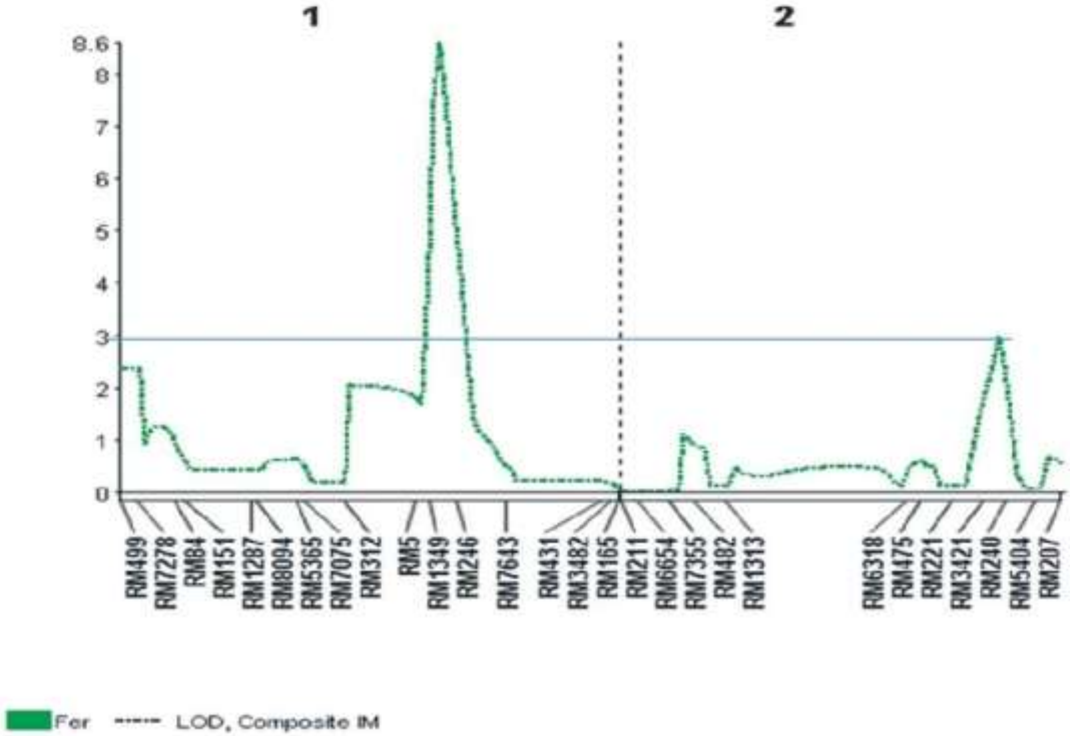


Fig. 7. Chromosomal locations of QTLs for fertility on chromosome 1 and 2 by Composite Interval Mapping (CIM).

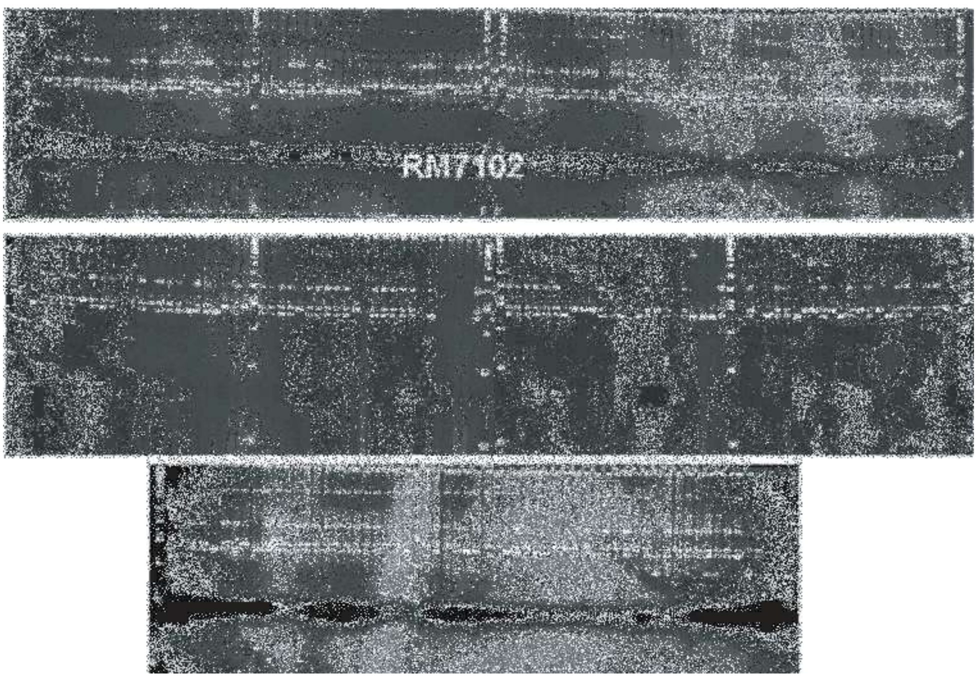


Fig. 8. Genotyping of BR28*3/ *O. rufipogon* (Acc. no. 105890) population with RM7102.

Genetic Resources and Seed Division

SUMMARY

During Aus, T. Aman and Boro 2014-15, 268 rice germplasms were collected from different districts of Bangladesh. Forty germplasm accessions in T. Aus, 49 in T. Aman and 47 in Boro seasons were characterized against 53 morpho-agronomic traits. Rejuvenation of 1,756 accessions was performed during the reporting year of which 572 accessions and 14 new collections were in T. Aus, 603 accessions in T. Aman and 581 accessions in Boro. Again, 566 accessions in Aus, 603 in T. Aman and 581 in Boro were conserved in short term storage, while 200 and 176 accessions in Aus, 356 and 221 accessions in T. Aman and 329 and 398 accessions in Boro were conserved in medium and long term storages respectively, during 2014-15. Apart from this, 60 new germplasms were registered as accession (from accession 7985 to 8044) in BRRI Genebank. Genetic diversity was pronounced in 54 Biroin rice germplasms and 31 BRRI developed Boro rice varieties on the basis of 14 morpho-agronomic and yield contributing characters and the varieties were grouped into six and five clusters respectively. Moreover, 2,529 samples of rice germplasm and BRRI developed rice varieties were supplied to different users.

Nucleus stock of 66 BRRI developed and recommended rice varieties were maintained. In total, 116.98 tons of breeder seed of which 37.17 tons from 31 varieties in T. Aman and 79.81 tons from 14 varieties in Boro were produced. Besides, 106.13 tons of breeder seed of which 31.03 tons from 24 varieties in T. Aman, 71.34 tons from 14 varieties in Boro and 3.76 tons from 10 varieties in Aus were distributed among the ‘Rice Seed Network’ partners. The number of the network partners (GO, NGO and PS) crossed to 700 on 2015. Again, 1,604 kg seeds of T. Aman, 3,047 kg of Boro and 282 kg of Aus varieties were also distributed as quality seed (QS) during the reporting year. Breeder and foundation seed producing plots and farms were also visited to monitor the varietal purity and performance of respective seed.

RICE GERMPLASM CONSERVATION AND MANAGEMENT

Germplasm collection and acquisition. Five collection campaigns were made during the reporting year and 268 rice germplasms of which 47 in Aus, 204 in T. Aman and 17 in Boro were collected from different districts of Bangladesh.

Germplasm rejuvenation for storage. Rice germplasm was rejuvenated to increase the seed for safe storage in the Genebank. The accessions, which possessed less than 80% germination and stored before 2010, were used in the experiment. The experiment was carried out under transplant conditions using single row of 5.4 m long per accession with a spacing of 20 × 20 cm 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.

A total of 1,756 germplasms of which 572 accessions and 14 new collections in T. Aus, 603 accessions in T. Aman and 581 accessions in Boro 2014-15 were rejuvenated in field for getting fresh seed and on average 500 g of seed were produced per accession.

Characterization and documentation of germplasm accessions. Three experiments were conducted to characterize rice germplasm in Aus, T. Aman and Boro using 53 morpho-agronomic traits. The experiments were conducted in BRRI Gazipur using a single row of 5.4 m long for each entry/accession with a spacing of 25 × 20 cm between rows and plants respectively. A total of 136 accessions of which 40 in T. Aus, 49 in T. Aman and 47 in Boro were used for characterization. Fertilizers were applied @ 60:20:40 kg NPK/ha in T. Aus and T. Aman and @ 80:20:40 kg NPK/ha in Boro.

In Aus 2014, fifteen varieties had medium (100-120 days) and 25 had long (>120 days) growth duration (Table 1). Twelve germplasms were found with short (<90 cm) and 28 with moderate (90-125 cm) plant height. Two germplasms were found with very long (>30 cm), 17 with long (26-30 cm), 19 with medium (21-25 cm) and the rest (01) with short (<20 cm) panicle length. Maximum (24) varieties possessed low

Table 1. Some important features of characterized germplasm during T. Aus 2014, T Aman 2014 and Boro 2014-15.

Growth duration		Plant height		Panicle length		No. of tiller		Effective tiller (no.)		Grain LB ratio		1000-grain wt		Yield/hill	
Range (day)	Entry (no.)	Range (cm)	Entry (no.)	Range (cm)	Entry (no.)	Range	Entriy (no.)	Range	Entry (no.)	Range	Entry (no.)	Range (g)	Entry (no.)	Range (g)	Entry (no.)
							T. Aus 2014								
<100	0	<90	12	<20	1	<10	29	<6	24	<1.5	0	<15	15	<5	11
100-120	15	90-125	28	21-25	19	10-15	11	6-10	12	1.5-2.0	11	16-19	16	5-10	21
>120	25	>125	0	26-30	17	>15	0	>10	3	2.1-2.5	19	20-23	8	>10	8
				>30	2					2.6-3.0	8	24-27	0		
										>3.0	1	>27	0		
Shortest (107)	Acc. 50 (Panbira) Acc. 30 (Hasikalmi)	Shortest (66)	Acc.7699 (Sada galon)	Shortest (20)	Acc. 4228 (Kaisa pajra)	Lowest (3.0)	Acc. 7762 (Kapaning dhan)	Lowest (1.00)	Acc. 18 (Dharial)	Lowest (1.54)	Acc. 51 (Paspai)	Lowest (10.00)	Acc. 7756 (Majoaishe), 56 (Pusur), 51 (Paspai)	Lowest (3.02)	Acc. 4228 (Kaisha pajra)
Longest (149)	Acc. 7699 (Sada galon)	Longest (115.4)	Acc. 1936 (Kumari)	Longest (31.25)	Acc. 7762 (Kapaning dhan)	Highest (15)	Acc. 7247 (Tokday)	Highest (14)	Acc. 7247 (Tokday)	Highest (3.06)	Acc. 7697 (Chhuri dhan)	Highest (22.00)	Acc. 7249 (Mong thong)	Highest (19.83)	Acc. 7772 (Dang mese)
Mean	124.90				24.76		8.22		5.44		2.24		16.07		7.92
Std. Dev.	11.29				2.83		2.80		3.11		0.38		3.66		4.02
CV	9.04				11.41		34.03		57.25		17.13		22.78		50.75
LSD	3.50				0.88		0.87		0.96		0.12		1.13		1.24
							T. Aman 2014								
<120	1	<110	4	<20	1	<10	23	<6	6	<1.5	0	<15	9	<5	4
120-130	11	110-130	2	21-25	19	10-15	23	6-10	29	1.5-2.0	25	16-19	11	5-10	20
>130-	37	>130	43	26-30	28	>15	3	>10	14	2.1-2.5	17	20-23	18	>10	25
				>30	1					2.6-3.0	4	24-27	8		
										>3.0	2	>27	3		
Shortest (110)	China irri	Shortest (77.2)	China irri	Shortest (19.4)	China irri	Lowest (6)	Natpasha	Lowest (4)	Natpasha	Lowest (1.639)	Moynamoti	Lowest (7.3)	Kalijira, China irri	Lowest (2.28)	Khoiya motor digha
Longest (159)	Six varieties	Longest (170.2)	Kumra gota	Longest (31.2)	Kalojira	Highest (17)	Chapalaish	Highest (15)	Kuri agrahani	Highest (3.621)	Nizersail	Highest (30.1)	Kumra gota	Highest (31.25)	Lal joyna
Mean	138				25.24		10.30		8.94		2.18		20.09		11.58
Std. Dev.	10.90				4.13		2.59		2.39		0.38		5.55		6.15
CV	7.89				16.36		25.20		26.70		17.82		27.68		53.12
LSD	3.05				1.15		0.72		0.67		0.10		1.55		1.72

Table 1. (Continued).

Growth duration		Plant height		Panicle length		No. of tiller		Effective tiller (no.)		Grain LB ratio		1000-grain wt.		Yield/hill	
Range (day)	Entry (no.)	Range (cm)	Entry (no.)	Range (cm)	Entry (no.)	Range	Entriy (no.)	Range	Entry (no.)	Range	Entry (no.)	Range (g)	Entry (no.)	Range (g)	Entry (no.)
							Boro 2014-15								
<135-	0	<100	12	<20	4	<10	18	<6	6	<1.5	0	<15	2	<5	37
135-150	17	100-120	19	21-25	35	10-15	24	6-10	25	1.5-2.0	1	16-19	15	5-10	10
>150	30	>120	16	26-30	7	>15	5	>10	16	2.1-2.5	20	20-23	19	>10	0
				>30	1					2.6-3.0	16	24-27	10		
										>3.0	10	>27	1		
Shortest (147)	Acc. 72 (Tupa boro)	Shortest (64.2)	Acc. 1795 (Dud saita)	Shortest (16.4)	Acc. 1795 (Dud saita)	Lowest (5)	Acc. 9 (Boro HY dhan)	Lowest (4)	Acc. 1795 (Dud saita)	Lowest (1.72)	Acc. 2189 (Kali boro)	Lowest (11.6)	Acc.1794 (Saita)	Lowest (2.00)	Acc.2272 (Zhong-HUA09)
Longest (173)	Acc. 3803 BR1083-49-2-3-1	Longest (140.4)	Acc. 2238 (Boro734)	Longest (32.2)	Acc. 5671 (Lal chikon)	Highest (28)	Acc. 938 (Boro deshi)	Highest (25)	Acc. 938 (Boro deshi)	Highest (4.66)	Acc. 5671 (Lal chikon)	Highest (29.2)	Acc. 1050 (Sonar geye)	Highest (6.29)	Acc. 257 (Kumri boro)
Mean	123.14				23.23		10.94		9.56		2.79		21.32		3.94
Std. Dev.	5.83				2.93		3.94		3.57		0.52		3.78		1.08
CV	4.74				12.62		35.94		37.34		18.68		17.73		27.58
LSD	0.94				0.47		0.63		0.57		0.08		0.61		0.17

number (<6) of effective tillers, whereas 12 varieties possessed intermediate (6-10) and three had many (>10) effective tillers. Considering grain length breadth ratio, maximum varieties (19) were found with medium (2.1-2.5) type, 11 were bold (<1.5), eight were medium slender (2.6-3.0) and only one variety was slender (>3.0) type. For 1000-grain weight (TGW), 15 varieties had very low (<15 g), 16 with low (16-19) and eight varieties had medium (20-23 g). Eight varieties/accessions had higher (>10 g) yield/hill which may be used in future breeding programme if other characters satisfy the breeding objective.

The shortest growth duration (107 days) was observed in Panbira (acc. 50) and Hasikalmi (acc. 30) and the longest (149 days) in Sada galon (acc. 7699). Also the shortest plant height (71.66 cm) was observed in Sada galon (acc. 7699) and the longest (115.4 cm) in Kumari (acc. 1936). The highest number of effective tillers (14) was observed in Tokday (acc. 7247) and the lowest (1.0) in Dharial (acc. 18). The highest grain length breadth ratio (3.06) was observed in Chhuri dhan (Acc. 7697) and the lowest (1.54) in Paspai (Acc. 51). Three varieties namely Majoaishe (Acc. 7756), Pusur (Acc. 56) and Paspai (Acc. 51) had the lowest (10 g) and the variety Mongthong (Acc. 7249) had the highest (22 g) TGW. The highest yield per hill (19.8 g) was observed in Dang mese (acc. 7772) and the lowest (3.0 g) in Kaisha pajra (acc. 4228).

In T. Aman 2014, one accession had short growth duration (<120 days), 11 had medium (120-130 days) and 37 had long (>130 days) growth duration (Table 1). Four germplasms were found with short (<110 cm), two with moderate (110-130 cm) and the rest (43) with long (>130 cm) plant height. Twenty-eight germplasms were found with long (26-30 cm), 19 with medium (21-25 cm), one had very long (>30 cm) and the rest (1) with short (<20 cm) panicle length. Twenty-nine varieties possessed intermediate (6-10), 14 varieties possessed many (>10) and six varieties possessed few (<6) number of effective tillers. Considering grain length breadth ratio, 25 varieties were found with bold (<1.5) type, 17 with medium (2.1-2.5), four with medium slender (2.6-3.0) and only two varieties were slender (>3.0) type. TGW of nine varieties was found very low (<15 g), 11 low (16-19 g), 18 medium (20-23), eight high (24-27 g) and the rest (three) of the varieties/accessions very high (>27 g). Four varieties possessed low (<5 g), 20 moderate (5-10 g) and the rest (25) had higher (>10 g) yield/hill.

The shortest growth duration (110 days) was observed in China irri and the longest (159 days) in six varieties. The shortest plant height (77.2 cm) was observed in China irri and the longest (170.2 cm) in Kumra gota. Kuri agrahani was found with the highest number of effective tillers (16) and Natpasha with the lowest (4). The highest grain length breadth ratio (3.6) was observed in Nizersail and the lowest (1.6) in Moynamoti. TGW of Kalojira and China irri had the lowest (7.3 g) and the Kumra gota had the highest (30.1 g). The highest yield per hill (31.3 g) was observed in Lal Joyna and the lowest (2.3 g) in Khoiya motor digha.

In Boro 2014-15, 17 germplasms had medium (135-150 days) and 30 had long (>150 days) growth duration (Table 1). Twelve germplasms were found with short (<100 cm), 19 moderate (100-120 cm) and the rest (16) with long (>120 cm) plant height. Four germplasms were found with short (<20 cm), 35 medium (21-25 cm), seven long (26-30 cm) and the rest (one) with very long (>30 cm) panicle length. Six varieties possessed low (<6), 25 intermediate (6-10) and 16 high (>10) number of effective tillers. Grains of ten varieties were slender (>3.0) type, 16 medium slender (2.6-3.0), 20 medium (2.1-2.5) and one was bold type revealed from grain length breadth ratio. Considering TGW, two varieties had very low (<15 g), 15 low (16-19 g), 19 medium (20-23 g), 10 high (24-27 g) and one had very high (>27 g). Thirty-seven varieties possessed low (<5 g/hill) and 10 varieties possessed moderate (5-10 g/hill) yield.

The shortest growth duration (147 days) was observed in Tupa Boro (Acc. 62) and the longest (173 days) in BR1083-49-2-3-1 (Acc. 3803). The shortest plant height (64.2 cm) was observed in Dud saita (Acc. 1795) and the longest (140.4 cm) in Badal Boro 734 (Acc. 2238). The highest number of effective tillers (25) was observed in Boro deshi (Acc. 938) and the lowest (4) in Dud saita (Acc. 1795). Accession number 1794 (Saita) has the lowest (11.6 g) and the accession number 1050 (Sonar geye) has the highest (29.2 g) TGW. The highest yield per hill (6.29 g) was observed in Kumri boro (Acc. 257) and the lowest (2.0 g) in Zhong-HUA-no. 09 (Acc. 2272). The variety having higher yield would be utilized in crossing programme, if other characters satisfy the breeder's objectives.

Germplasm processing, registration and storage. In total 1,756 germplasms were processed to conserve with respective accession number in different storages of Genebank. The germplasm were cleaned and dried with a seed moisture content of less than 9%.

Out of 1,756 germplasms, 566 accessions in Aus, 603 in T. Aman and 581 in Boro 2014-15 were processed and stored in short term storage. Similarly, 200 and 176 accessions in Aus, 356 and 221 accessions in T. Aman and 329 and 398 accessions in Boro were stored in medium and long term storages respectively. On the other hand, 60 germplasms were registered in accession book as new accession of which eight in Aus (from accession number 7985 to 7992) and 52 in T. Aman (from accession number 7993 to 8044).

Viability testing, periodic evaluation and routine monitoring of stored germplasm. One hundred accessions in Aus, 150 in T. Aman and 125 in Boro seasons were checked randomly for viability (germination %) test in short term storage during 2014-15. Five varieties namely Dharial (Acc. 649), Hashikalmi (3575), Purbachi (6207), Nizersail (1229) and Patnai-23 (52) were used as testers in the medium and long term storages and their viability were measured on six month interval usually in October and March of each year to predict the viability of germplasm in respective storages. Before storage of rice germplasm in the Genebank, viability of the seed was also monitored.

Among the randomly selected 375 stored germplasms, 262 had viability between 80-90% and 35 had viability above 90%. The germplasm accessions stored during 2014-15 in short term storage were also found with more than 90% germination. Only 95 germplasms possessed less than 80% germination, which will be grown in the following season. On the other hand, the range of germination percentages of the five test samples/testers in the medium and long term storages conducted in October 2014 and March 2015 were 76-96% and 72-97% respectively, which indicate the viability condition of stored germplasm in medium and long term storages.

Rice germplasm distribution/exchange. A total of 2,529 samples of rice germplasm as well as BRRI developed rice varieties in Aus, Aman and Boro seasons were supplied to different users. Among the samples, 1,759 germplasm samples were supplied for research purpose and 770 samples of BRRI varieties were supplied to Department of Agricultural Extension (DAE) personnel and university students for research, demonstration as well as other purposes during the reporting year.

SEED PRODUCTION AND VARIETY MAINTENANCE

Variety maintenance. Using panicle to row method, 80 BRRI developed and recommended rice varieties including 14 local improved varieties (LIV) were maintained (Table 2).

Nucleus seed production. A total of 45 modern varieties (MV's) of which 31 in T. Aman and 14 in Boro were grown as nucleus stock to maintain genetic purity and homogeneity of morphological characteristics of BRRI developed rice varieties and to keep as the source of breeder seed. These nucleus seeds would be used for production of breeder seed in the following seasons.

'Panicle to row' method was used to maintain nucleus stocks, where intact panicles were sown instead of threshed seeds. Off-type plants were identified and rogued out in each growth stage. At maturity, panicles from true to type plants of all the varieties were harvested and stored in controlled temperature (20°C with 40% RH).

Breeder seed production and distribution. GRS, Farm Management Divisions and eight regional stations of BRRI were engaged in breeder seed (BS) production as per national demand during 2014-15. The BS plots were visited to

Table 2. List of BRRI developed and recommended rice varieties maintained as nucleus stock.

Type	Number	Variety
		T. Aman
MV	33	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 dhan 62
LIV	8	Nizersail, Latisail, Rajasail, Kalijira, Kataribhog, Basmati-D, Patnai23, Tilockkachari
		Boro
MV	33	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
LIV	6	Hbj Boro II, Hbj Boro IV, Hbj Boro VI, Hbj Boro VIII, Purbachi, IR8

monitor the varietal purity and performances. Off-type plants were identified and rogued out in each growth stage. After harvesting of each 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 lot for getting 'tag' from SCA for distribution.

A total of 116.98 tons of breeder seed, of which 37.17 tons from 31 varieties in T. Aman and 79.81 tons from 14 varieties in Boro were produced during 2014-15 (Table 3). On the other hand, 106.13 tons of breeder seed, of which 71.34 tons from 14 varieties in Boro and 3.76 tons from 10 varieties in Aus and 31.03 tons from 24 varieties in T. Aman were distributed among the 'Rice Seed Network' partners (Tables 4, 5 and 6). Besides, 1,604 kg seeds from 18 varieties of T. Aman, 3,047 kg from seven varieties of Boro and 282 kg from eight varieties of Aus were also distributed as quality seed (QS) during 2014-15.

Monitoring seed production plots/farms. Breeder seed production plots of BRRI RSs Rajshahi, Rangpur, Habiganj, Comilla and Satkhira and foundation seed production farms of ACI (Rangpur), BRAC (Rangpur and Sirajganj) and BADC (Madhupur) were visited to monitor the varietal purity and performances of breeder and foundation seed. During the visit, no major insect-pest damage was noticed in the plots. Varietal purity (%) was observed as an average of more than 99% in all the varieties except BRRI dhan48 in Madhupur BADC farm during Aus. The crops were found almost free from weeds. In maximum cases, isolation distance was properly maintained. Foundation Seed (FS) producers were advised to discard three meters boarder lines, where isolation distance was not maintained. Overall crop conditions and management was satisfactory. The seed producers were also advised for thorough rouging by themselves for one more time before harvesting.

Table 3. Production of breeder seed in 2014-15.

Variety	Production (kg)										
	GRS Division	Farm Division	BRRI RS, Rangpur	BRRI RS, Rajshahi	BRRI RS, Habiganj	BRRI RS, Comilla	BRRI RS, Bhanga	BRRI RS, Sonagazi	BRRI RS, Barisal	BRRI RS, Satkhira	Total
						T. Aman					
BR10	140					1120					1260
BR11	520			2040							2560
BR21	140										140
BR22	140	1000									1140
BR23	160								520		680
BR24	70										70

Table 3. (Continued).

Variety	Production (kg)										
	GRS Division	Farm Division	BRRI RS, Rangpur	BRRI RS, Rajshahi	BRRI RS, Habiganj	BRRI RS, Comilla	BRRI RS, Bhanga	BRRI RS, Sonagazi	BRRI RS, Barisal	BRRI RS, Satkhira	Total
					T. Aman						
BR25	120										120
BRRI dhan27	100								340		440
BRRI dhan30	480										480
BRRI dhan31	100										100
BRRI dhan32	140							720			860
BRRI dhan33	220			2120							2340
BRRI dhan34	120			1520				440			2080
BRRI dhan37	120										120
BRRI dhan38	100										100
BRRI dhan39	140										140
BRRI dhan40	140										140
BRRI dhan41	140								400		540
BRRI dhan42	250										250
BRRI dhan43	150										150
BRRI dhan44	280							400			680
BRRI dhan48	170				600	720			130		1620
BRRI dhan49	360	2600				3680				3200	9840
BRRI dhan51	800										800
BRRI dhan52	720		1000		2440				1480		5640
BRRI dhan53	140									400	540
BRRI dhan54	240										240
BRRI dhan56	380		880	400							1660
BRRI dhan57	120		760			400					1280
BRRI dhan62	200		840								1040
Nizersail	120										120
Sub total	7020	3600	3480	6080	3040	5920		1560	2350	3600	37170
					Boro						
BR3	360										360
BR14	520							720			1240
BR16	440				960			1000			2400
BR26	200										200
BRRI dhan28	2400	3240	1440	3680	5720	5880	6120	1000	4280	4580	38340
BRRI dhan29	800		840	4120	840	10680	3680	1160	800	1720	24640
BRRI dhan36	720										720
BRRI dhan45	440										440
BRRI dhan47	240								1960		2200
BRRI dhan50	880					960					1840
BRRI dhan55	2040										2040
BRRI dhan58	680		1000			840				2400	4920
BRRI dhan59	250										250
BRRI dhan61	220										220
Sub total	10190	3240	3280	7800	7520	18360	9800	3880	7040	8700	79810
Grand total											**116,980**

Table 4. Distribution of beeder seed in Boro 2014-15.

		Variety and quantity (in kg)														
Organization	Organizations (no.)	BR3	BR14	BR16	BR26	BRRI dhan28	BRRI dhan29	BRRI dhan36	BRRI dhan45	BRRI dhan47	BRRI dhan50	BRRI dhan55	BRRI dhan58	BRRI dhan59	BRRI dhan61	Total
GO	5	140	110	50	160	6800	4340	0	0	700	30	30	430	50	60	12900
NGO	13	0	60	80	0	2100	880	0	0	10	80	0	230	20	10	3470
PS	673	0	230	1450	0	28780	18360	130	110	130	1655	470	3540	40	80	54975
Total	691	140	400	1580	160	37680	23580	130	110	840	1765	500	4200	110	150	71345

Table 5. Distribution of breeder seed in Aus 2014-15.

		Variety and quantity (in kg)										
Organization	Organizations (no.)	BR3	BR14	BR16	BR21	BR24	BRRI dhan27	BRRI dhan42	BRRI dhan43	BRRI dhan48	BRRI dhan55	Total
GO	3	260	60	90	140	70	440	250	150	1150	390	3000
PS	12	0	0	0	0	0	0	0	0	580	180	460
Total	15	260	60	90	140	70	440	250	150	1730	570	3760

Table 6. Distribution of breeder seed in T. Aman 2014-15.

		Variety and quantity (in kg)																								
Organization	Organizations (no.)	BR10	BR11	BR22	BR23	BR25	BRRI dhan30	BRRI dhan31	BRRI dhan32	BRRI dhan33	BRRI dhan34	BRRI dhan38	BRRI dhan39	BRRI dhan40	BRRI dhan41	BRRI dhan44	BRRI dhan49	BRRI dhan51	BRRI dhan52	BRRI dhan53	BRRI dhan54	BRRI dhan56	BRRI dhan57	BRRI dhan62	Nizersail	Total
GO	8	1820	540	100	250	0	450	10	300	1000	150	50	140	100	200	60	4610	570	1330	350	240	880	780	840	50	13820
NGO	9	20	230	60	140	0	0	0	0	20	20	0	0	10	70	0	260	10	260	30	0	140	40	0	0	1310
PS	241	360	1730	710	370	110	60	50	520	1230	1670	40	20	30	270	220	4730	200	2640	0	0	490	220	200	30	15900
Total	258	1200	2500	870	760	110	510	60	820	2250	1840	90	160	140	540	280	9600	780	4230	380	240	1510	1040	1040	80	31030

EXPLORATORY AND GENETIC STUDIES

Assessment of genetic diversity and genotype selection

Fifty-four Biroin and 31 BRRI developed Boro rice were evaluated for morpho-agronomic characters. On the other hand, 35 popular rice germplasms of southern region were evaluated for distributing their seed to the framers.

Biroin rice accessions. Based on D2 analysis, the genotypes were grouped into six clusters. The highest cluster means for grain yield hill^{-1} (14 g) along with panicle length (27.8 cm), grain length (8.7 mm) and grain length breadth ratio (3.0) were obtained in cluster IV (Boron dhan/acc. 394, Boruin/833, Dulaiboron/1193, Holud Boron/3265, Boron/3637, Biran/4104, Aikka Birion/5697, Hati Birion/5705, Kaika Biruin/7589) and the shortest growth duration (118 days), the highest flag leaf length (45.4 cm) and plant height (108 cm) were obtained from cluster III (Kalaboron/acc. 1158, Biron/1972, Dharia Boron/3707), whereas the highest effective number of tillers hill^{-1} (9) and filled grain number panicle^{-1} (143) were observed in cluster VI (Brani Dhan/acc. 5281, Khara Birion/5703, Lal Birion/5704, Sada Birion/5706, Kalo Biruin/7532, Kala Biruin/7536, Mikal Biruin/7556, Boaincha Biruin/7573), which also produced higher inter cluster-values over other clusters. Therefore, the genotypes of cluster IV, III and VI can be used in hybridization programme to produce higher yielding varieties/genotypes.

Boro varieties. The varieties were grouped into five clusters on the basis of Mahalanobis' D2 statistics. The highest cluster means for yield hill-1 (9.2 g) along with seedling height (25 cm), flag leaf width (1.4 cm), panicle length (26.9 cm) and 1000-grain weight (25.3 g) were obtained from cluster III (BR8, BR9, BR17, BR18, BR19) and the shortest growth duration (162) and the longest grain length (9.1 mm) from cluster IV (BRRI dhan45, BRRI dhan47, BRRI dhan50, BRRI dhan55, BRRI dhan60, BRRI dhan68, BRRI dhan69), whereas the highest flag leaf length (35 cm), effective number of tillers hill-1 (12) and the lowest un-filled grain number panicle-1 (21) were obtained from cluster I (BR2, BR7). Therefore, the genotypes of cluster III, IV and I can be hybridized for getting genotype with maximum good characters in segregating generations.

Popular rice germplasm of southern region. For yield contributing characters, *Sadamota* (acc. no. 1040, 1576, 7788 and 7923), *Lalmota* (acc. no. 1583, 1584 and 7889), *Jesso-Balam* (acc. no. 2464), *Khejur Jhupi* (acc. no. 40, 2551 and 2552), *Khejur Chhori* (acc. no. 4246) and *Bashful* (acc. no. 466, 1300, 3996 and 4010) germplasm were selected for the next T. Aman 2016 season.

Yield performance of *Monibandhobi.* The *Monibandhabi* was evaluated for yield performance and yield contributing characters were also recorded. Based on the performance this variety was selected for preliminary yield trial.

Grain Quality and Nutrition Division

SUMMARY

A total of 207 breeding lines were evaluated for physicochemical and cooking properties for superior quality. Based on the performance on grain quality, we recommend few breeding lines for both Boro (BR 9157-12-2-37-13-17-32, BR7988-4-5-3-4, BRRI dhan29-SC328-16-10-8HR1, BR7372-35-3-3-HR9(com), BR7372-35-3-3-HR5(com), NERICA mutant; HHZ23-DT16-DT1-DT1, BR9787-BC2-63-2-2, BR9787-BC2-63-2-4, BR9787-BC2-102-1-4, BR9787-BC2-16-3-1, BR9787-BC 2-41-3-2, BR9787-BC2-41-8-2, BR9787-BC2-48-4-1, BR9785-BC2-20-1-3, BR9785-BC 2-19-3-5, BRC266-5-1-1-1) and Aman (BR8821-8-1, BR8821-10-2, IR73885-1-4-3-2-1, IR70213-10-CPA-4-2-2-2, BR8214-19-3-4-1, BR8214-23-1-31, NERICA mutant, IR79156A, IR79156A/BRRI20RF1, IR79156A/BasmatiRF1, BR(BE)6158RWBC2-1-2-1-1, BR8072-AC11-1-1-3-11) for further advancement.

Physicochemical and cooking properties of fourteen recently released BRRI varieties were analyzed for updating database. Among the varieties BRRI dhan55, BRRI dhan57, BRRI dhan60 and BRRI dhan63 had long slender and other had medium bold grain. All the varieties had good eating qualities.

A total of 24 BRRI released rice varieties were used for determination of conserved energy, elongation ratio, volume expansion ratio and protein content on the basis of non-parboiled condition. Result showed that variation of soaking time (0.75h, 0.5h and 1.0h) had positive effect on energy consumption and volume expansion but had no effect found for elongation and protein content of rice.

A total of six rice varieties including one salinity sensitive as IR154 and five salinity tolerant such as IR58443-6B-10-3, BRRI dhan47, BRRI dhan61, BINA dhan8 and BINA dhan10 were selected to evaluate the effect of salinity on grain quality. Plants were grown in preferred plastic pots filled with grounded soil. The soil was fertilized with Yoshida cultured solution. The pots were placed inside a bucket serving as water bath. Salt stress (EC 9 dSm^{-1}) was applied on 31 days after sowing. Salinity stress was made by adding NaCl in the bucket and maintained up to the maturity. Our data reveal that in salinity condition apparent amylose content (AAC) of grain reduced significantly compared to normal condition. The genotypes lowering in amylose content might face adaptation related problem at salinity prone zone. So, we recommend that higher amylose content is desirable for developing salinity tolerant plant breeding material in future.

Sensory properties of two rice variety/line were evaluated with the aim of consumer preference and relate sensory attributes with consumer acceptability. A twenty-nine member panelist comprising male and female category took part in the assessment process of samples. Based on sensory evaluation score the difference between BR7671-37-2-2-3-7 and BRRI dhan64 are not much visible for the panelist although BR7671-37-2-2-3-7 line got little good score for appearance.

Rice bran oil produced from rice bran could be suitable for substitution of imported edible oil. Rice bran oil is good quality edible oil having balanced fatty acid composition and valuable micro components. Our data reveal that the highest oil content was found in BR22 (28.7%) bran and on the other hand the lowest was in BR23 (25.25%) bran among eight tested varieties. We analyzed bran oil of BRRI dhan28 at different storage condition but could not find any significant difference. There is a tremendous scope to meet half of the total demand of our edible oil by replacing rice bran oil. For attaining this goal we will need a comprehensive collaborative approach involving producers, millers, exporters and financial institutions.

In vivo experiments of Glycemic Index (GI) for 72 BRRI released rice varieties we found BR16, BRRI dhan46 and BRRI dhan69 as low GI rice varieties. A total of 50 rice varieties are categorized as intermediate GI and 19 rice varieties are categorized as high GI. We will further analyze 53 varieties including low GI and intermediate GI for both in vitro chemical and enzymatic tests like RDS (Rapidly Digestible Starch), SDS (Slowly Digestible Starch), RS (Resistant Starch) and α-amylase inhibitor assay respectively for validation. Then after only definite low GI grouped rice varieties will be subjected for in vivo human trial for confirmation.

Comparative analysis of antioxidant status for dietary administration of high, intermediate and low antioxidant enriched HYV rice varieties such as BR5, BRRI dhan28 and BR16 respectively in vivo rat model significantly correlates the content of antioxidant properties of rice and antioxidant status in rat blood serum. We clinically investigated serum free Fe^{++}, TIBC (Total iron binding capacity), ferritin, uric acid and albumin to assess the antioxidant status in blood serum of experimental rat. We concluded that dietary administration of antioxidant enriched BR5 rice is improving the antioxidant status in rat blood serum, which has a significant impact to improve body immunity.

We aimed to investigate on the use of rice flour (*Oryza Sativa)* as alternate flour over wheat flour (*Triticum Aestivum*) for the preparation of gluten free biscuits. We formulated biscuits from flours of both BR16 and BRRI dhan46 rice varieties, which contain 437 and 520 (calories $100g^{-1}$ serving) respectively.

Our research reveal that BRRI dhan31 generates elevated level of bio-active component, γ-aminobutyric acid (GABA) at pre-germinated brown rice condition among ten tested rice varieties. In GQN Division, we have formulated three value added rice products like GABA rice ball, GABA plain cake and GABA biscuits from pre germinated brown rice (PGBR) which contain 393, 464 and 478 (calories 100 g^{-1} serving) respectively.

GRAIN QUALITY CHARACTERISTICS FOR VARIETY DEVELOPMENT

Determination of physicochemical and cooking properties of rice grain

A total of 207 breeding lines were evaluated for physicochemical and cooking properties for superior quality. In case of milling outturn 53.6% breeding samples had more than 70% milling outturn. Approximately 94.2% samples had less than 68% head rice yield. In case of chalkiness, 60% samples had translucence appearance. In case of length of milled rice, 49.2% samples had long shape, 50.2% samples had medium and only 0.48% had short type. Regarding L/B ratio, approximately 32.4% samples had L/B ratio more than 3.0 and 67.6% samples had L/B ratio between 2.0-3.0. In terms of grain size and shape, 30.9% samples had long and slender grain. Regarding protein content 8.5% samples had more than 9.0% protein and 78% samples had protein content between 7-9%. In case of apparent amylose content, we analyzed 288 samples. Among these 55.5% samples had high apparent amylose content (AAC >25%) and 30% samples had intermediate AAC (AAC ranges from 20.0-5.0%). Regarding elongation ratio (ER), 9.7% samples had elongation ratio more than 1.5 and majority of samples (70.2%) had elongation ratio between 1.3 to 1.5. In case of imbibition ratio (IR) 15.1% samples had more than IR ratio 4.0 and 29.2% samples had IR ratio between 3.5 to 4.0 but majority of samples (55.6%) had IR ratio less than IR ratio 3.5. Most of the samples (79.6%) had intermediate alkali spreading value (ASV) ranges from 3.1 to 5.9 and 16% samples had high ASV score ranges from 6.0 to 7.0. In terms of cooking time 85.3% samples had cooking time between 15 minutes to 20 minutes. Based on the performance on grain quality, we recommend few breeding lines for both Boro (BR 9157-12-2-37-13-17-32, BR7988-4-5-3-4, BRRI dhan29-SC328-16-10-8HR1, BR7372-35-3-3-HR9(com), BR7372-35-3-3-HR5(com), NERICA mutant; HHZ23-DT16-DT1-DT1, BR9787-BC2-63-2-2, BR9787-BC2-63-2-4, BR9787-BC2-102-1-4, BR9787-BC2-16-3-1, BR9787-BC 2-41-3-2, BR9787-BC2-41-8-2, BR9787-BC 2-48-4-1, BR9785-BC2-20-1-3,BR9785-BC 2-19-3-5, BRC266-5-1-1-1) and Aman (BR8821-8-1, BR8821-10-2, IR73885-1-4-3-2-1, IR70213-10-CPA-4-2-2-2, BR8214-19-3-4-1, BR8214-23-1-3-1, NERICA mutant, IR79156A, IR791 56A/BRRI20RF1, IR79156A/BasmatiRF1, BR(BE)61 58RWBC2-1-2-1-1, BR8072-AC11-1-1-3-11) for further advancement.

Physicochemical and cooking properties of recently released BRRI varieties

Fourteen recently released BRRI varieties BRRI dhan51, BRRI dhan52, BRRI dhan53, BRRI dhan54, BRRI dhan55, BRRI dhan56, BRRI dhan57, BRRI dhan58, BRRI dhan59, BRRI dhan60, BRRI dhan61, BRRI dhan62, BRRI dhan63, BRRI dhan64 were grown at BRRI farm and analyzed for milling performance, physical properties of rough rice (length, breadth), brown rice (length, breadth, pericarp colour and protein) and milled rice (Chalkiness, amylose content, cooking time, elongation and imbibitions ratio) following standard methods. Rough rice length is important for milling performance. The length of rough rice varied from 8.3 to 11.0 mm and breadth varied from 2.0 to 3.3 mm. Brown rice is the dehulled rough rice. The length of brown varied from 5.8 to 7.7 mm and breadth varied from 1.9 to 2.9 mm. Most of the lines had either light or dark brown pericarp. Thousand grain weights varied from 18.4 to 29.0 gm. Milling yield of the varieties varied from 68 to 73%. BRRI dhan52, BRRI dhan62, BRRI dhan63 and BRRI dhan64 had high milling yield (73%). Head rice recovery of the cultivars ranged from 38 to 70% (rough rice basis). BRRI dhan64 had the highest (70%) and BRRI dhan55 had the lowest (38%) head rice yield. Milled rice length of the varieties varied from 5.3 to 7.0 mm. BRRI dhan53, BRRI dhan54, BRRI dhan55, BRRI dhan57, BRRI dhan60, BRRI dhan62 and BRRI dhan63 had long grain. The other had medium long grain. Grain length and breadth ratio determines grain size and shape. BRRI dhan55, BRRI dhan57, BRRI dhan60 and BRRI dhan63 had long slender and other had medium bold grain. BRRI dhan57 had translucent grain and BRRI dhan51 had less than 10% chalkiness. The others had 10-20% or more than 20% chalkiness in the grain. Amylose is an important fraction of rice starch that influences eating and cooking qualities of rice. Amylose content of the varieties varied from 19 to 26% and protein content from 6.4 to 8.5%. ASV determines the grain gelatinization temperature and it is indicated that most of the varieties had intermediate gelatinization temperature except BRRI dhan56 that had high gelatinization temperature. Elongation ratio of milled rice of tested varieties ranged 1.2 to 1.6 and their volume expansion ratio varied from 2.4 to 3.5.

Effect of soaking time on grain and nutritional quality of cooked rice

A total of 24 BRRI varieties such as BR5, BR10, BR11, BR16, BR22, BRRI23, BRRI dhan28, BRRI dhan29, BRRI dhan33, BRRI dhan34, BRRI dhan39, BRRI dhan40, BRRI dhan41, BRRI dhan47, BRRI dhan49, BRRI dhan50, BRRI dhan51, BRRI dhan53, BRRI dhan54, BRRI dhan55, BRRI dhan57, BRRI dhan60, BRRI dhan61, BRRI dhan62 were used for determination of conserved energy, elongation ratio, volume expansion ratio and protein content on the basis of un-parboiled condition to determine the grain and nutritional quality of minimum cooking time for BRRI released rice varieties owing to save the fuel consumption. Rough rice of these BRRI released rice varieties were milled and analyzed by using standard procedure of the GQN Division. Energy consumption of HYVs varied from 0.33 to 0.58 kWh at 0 h, 0.23 to 0.33 kWh at 0.5h, 0.21 to 0.30 kWh at 0.75h and finally 0.18 to 0.28 kWh at 1h with the mean value of 0.45 kWh, 0.29 kWh, 0.27 kWh and 0.25 kWh respectively. Energy consumption of HYVs for 1h soaking cooked rice was highly significant but negatively correlated with 0 h soaking cooked rice whereas energy consumption of HYVs for 1h soaking cooked rice was highly significant but positively correlated with 0.5 h and 0.75 h soaking cooked rice. Consumed energy of HYVs at 0 h was highly significant and higher than consumed energy at 0.5 h, 0.75 h and 1h. But consumed energy at 0.5, 0.75 and 1.0 h had no significant difference. Variation of soaking time (0.75 h, 0.5 h and 1.0h) had positive effect on energy consumption. So, soaking before cooking is very important for energy consumption. Elongation of HYVs varied from 1.0 to 1.5 at 0 h, 1.33 to 1.7 at 0.5 h, 1.39 to 1.8 at 0.75 h and 1.3 to 2.0 at 1h with the mean value of 1.3, 1.6, 1.6 and 1.6 respectively. Elongation ratio of HYVs for 1h soaking cooked rice was highly significant but negatively correlated with 0 h soaking cooked rice whereas elongation ratio of HYVs for 1 h soaking cooked rice was highly significant but positively correlated with 0.5 h and 0.75 h soaking cooked rice. Elongation ratio of HYVs at 0 h was highly significant and lower than elongation ratio at 0.5 h, 0.75 h and 1h. But elongation ratio of HYVs at 0.5 0.75 and 1.0 h had no significant difference. So, soaking before cooking is very important for elongation. But variation of soaking time 0.75 h, 0.5 h and 1.0 h had a little effect on elongation. Volume expansion of HYVs varied from 3.5 to 3.75 at 0h, 3.7 to 4.6 at 0.5h, 3.6 to 4.2 at 0.75 h and 3.4 to 4.0 at 1h with the mean value of 3.64, 3.99, 3.85 and 3.63 respectively. Volume expansion ratio of HYVs for 1h soaking cooked rice was highly significant but negatively correlated with 0 h soaking cooked rice where as volume expansion ratio of HYVs for 1 h soaking cooked rice was highly significant but positively correlated with 0.5 h and 0.75 h soaking cooked rice. Volume expansion ratio of HYVs at 0 h had highly significant and lower than volume expansion ratio at 0.5 h and 0.75 h. Furthermore, volume expansion ratio at 0.75 was highly significant and higher than volume expansion ratio at 1.0 h. Volume expansion ratio at 0.5 was highly significant and higher than volume expansion ratio at 1.0 hr as well as volume expansion ratio at 0.5 was slightly significant and higher than volume expansion ratio at 0.75 h. But volume expansion ratio of HYVs at 0 h and 1 h was statistically similar. Variation of soaking time such as 0.75h, 0.5h and 1.0 h had positive effect on volume expansion ratio. So, soaking before cooking is very important for volume expansion. Protein content of HYVs varied from 5.3 to 8.6% at 0 h, 5.0 to 8.4 % at 0.5h, 4.5 to 8.3 % at 0.75h and 4.4 to 8.3 % at 1h with the mean value of 6.66 %, 6.49 %, 6.35 % and 6.22 % respectively. Protein content of HYVs for 1h soaking cooked rice was highly significant as well as positively correlated with 0 h, 0.5 h and 0.75 h soaking cooked rice. Protein content of HYVs at 0 h was slightly significant and higher than protein content at 1h. But protein content of HYVs at 0 h, 0.5 h and 0.75 h had statistically similar. So, variation of soaking time before cooking had no effect on protein content of HYVs up to certain time 0.75 h but after that protein content of HYVs may slightly reduce.

Effect of salinity on grain quality and nutritional status of salt tolerant rice

A total number of six rice varieties including one salinity sensitive IR154 and five salinity tolerant ones such as IR58443-6B-10-3, BRRI dhan47, BRRI dhan61, BINA dhan-8 and BINA dhan-10 were selected to evaluate the effect of salinity on grain of salt tolerant rice varieties in Bangladesh. Plants were grown in preferred plastic pots filled with grounded soil. The soil was fertilized with Yoshida cultured solution. The pots were placed inside a basket serving as water bath. Salt stress (EC 9 $dS^{-1}m$) was applied on 31 days after sowing. Salinity stress was made by adding NaCl in the bucket and maintained up to the maturity. The Physiology Division, BRRI took all necessary parameters related to salinity and we had collected grain samples from them to analyze few selective physicochemical parameters like amylose content, length of milled rice, L/B ratio and cooking time at both control and stress conditions. These four parameters can evaluate the salinity effects on plant materials especially on grain samples. All physicochemical and cooking properties were evaluated using methods established in GQN Division. Since this experiment will be conducted for both Aman and Boro season 2015-16, a small scale net house based experiment was conducted as a preliminary investigation at Plant Physiology Division net house in BRRI to evaluate the salinity effects on grain. Our data revealed that apparent amylose content (AAC) of BRRI dhan47 reduced maximum of 7.7% and BINA dhan8 had the lowest reduction of 4% among all tested varieties. BRRI dhan61 had the lowest AAC of 21% among all tested varieties. BINA dhan8 and IR154 showed the maximum reduction of 7.1% and 11.4% in milled rice length (mm) and L/B ratio respectively. Both BRRI dhan47 and BRRI dhan61 showed the reduction of cooking time. In this experiment, we found reduction in amylose content, milled rice length and L/B ratio as well as cooking times at salt stress (EC 9 dSm^{-1}) condition compare to control. Our results are correlating with other previous reports like Rao, 2013 and Chen et al, 2012. This research will continue for next Aman and Boro seasons and we will collect grain samples from different salinity affected areas to evaluate actual scenario of salinity stress on rice grain. Since a significant reduction in amylose content was seen in this salinity experiment, genotypes lowering in amylose content might face adaptation related problems. So, we concluded that higher amylose content is desirable for developing salinity tolerant plant breeding material in future.

GRAIN QUALITY PARAMETERS FOR CONSUMER PREFERENCE

Evaluation of high zinc rice through sensory evaluation

Sensory evaluation is often described as scientific method used to evoke, measure, analyse and interpret those responses perceived through the senses of sight, smell, touch, taste and hearing. Sensory evaluation is vital in introducing new rice varieties. Data are needed about product preferences, product optimization, consumer acceptance etc. Since rice consumption continues to expand and markets become more competitive, there is an increasing need for quantitative data regarding the effects of postharvest handling on sensory characteristics of cooked rice. A 29 member panelist comprising male and female category took part in the assessment process of samples for the evaluation of high zinc rice through sensory evaluation. Rice samples were placed in white plastic box, labeled and placed on table. Evaluation was based on appearance, tenderness, taste and aroma. For evaluating appearance and taste, score were used as excellent, very good, good and fair. For evaluating tenderness, score was used soft, semisoft, medium soft and hard. For evaluating aroma, score was used as none, mild, moderate and strong. Among the two zinc rich rice variety/line BR7671-37-2-2-3-7 was used as sample and BRRI dhan64 was used as check. BR7671-37-2-2-3-7 and BRRI dhan64 were coarse varieties and were collected from Plant Breeding Division. Both the sample were processed as parboiled condition in GQN Division laboratory. Cooked samples were kept in a closed container, allowed to cool to a comfortable tasting temperature and kept warm unless they are assessed immediately. Appearance is the visible characteristics of the product. The assessor noted the appearance of the product and recorded any unusual features. In BR7671-37-2-2-3-7 (line), 34.5% of the panelists categorized good appearance and 50% of the panelists categorized fair in appearance. For BRRI dhan64 (variety), 31% of the panelists expressed good appearance and 59% of the panelists expressed fair in appearance. Tenderness is the soft or delicate substance; not hard or tough. For BR7671-37-2-2-3-7, 47% of the panelists expressed hard and 30% expressed medium soft similarly for BRRI dhan64, 44.3% scored hard and 38% scored medium soft. Taste is one of the senses, the receptors for which are located in the mouth and activated by compounds in solution. Taste is limited to sweet, salty, sour and bitter. 38% of the panelists scored good taste for both the BR7671-37-2-2-3-7 and BRRI dhan64 variety/line. Aroma described the sensation due to stimulation of the olfactory receptors in the nasal cavity. The aroma should be smelled and its' character and strength were recoded, particularly any unusual odors like chemical taints. Assessors encouraged to taste cooked samples as some compounds can only be detected by mouth. In case of both the lines aroma was not found.

Determination of oil content and chemical composition of rice bran oil extracted from different aged bran

Rice bran is a good source of bran oil. Rice bran oil is good quality edible oil having balanced fatty acid composition and valuable micro components. Rice bran is a vital source of the vitamins, minerals, amino acids, essential fatty acids, dietary fiber and more than 100 antioxidant nutrients that helps to fight against disease and promote good health. Rice bran contained high amount of beneficial antioxidants including tocopherols and oryzanols. It is a rich source of vitamins and minerals such as phosphorus, potassium, iron, copper and zinc. The protein found in rice bran is reported approximately from 12-15 %. We have collected BR22, BR23, BRRI dhan28, BRRI dhan33, BRRI dhan41, BRRI dhan47 and BRRI dhan49 paddy from Genetic Resourse and Seed Division of BRRI to determine the nutritional composition of HYV variety in parboiled rice bran oil under different treatments and oil contentment in different rice varieties especially for BRRI dhan28. GQN Division of BRRI carried out the experiment on oil content in rice bran of different rice varieties also if there was any variation of oil content on different storage conditions. Sample prepared in the GQN laboratory using Satake laboratory scale rice husker and polisher. Samples were kept at normal atmospheric temperature for storage. Solvent extraction method was followed to extract oil from bran. First we collected rice bran oil extracting from different aged rice bran. Analysis of chemical composition (e.g. rancidity, vitamin, minerals, peroxide value, saponification number, iodine value and fatty acid composition) as per standard protocol. The proximate composition of all the fractions of BRRI dhan28 variety parboiled rice bran was carried out. Moisture content was determined by oven-dry method as the loss in weight due to evaporation from sample at a temperature of (100±2)°C. The weight loss in each case represented the amount of moisture present in the sample. The crude protein content was determined following the micro Kjeldahl method (AOAC 2005). Crude fat determined by the Soxhlet extraction technique followed by AOAC (2005). Fat content of the dried samples can be easily extracted into organic solvent (n-Hexane) at 40 to 60°C and followed to reflux for 6 h. fat content were expressed in percentage. Ash content determined by combusting the samples in a muffle furnace at 600°C for 8 h according to the method of AOAC (2005).Acid insoluble ash determined by adding 25 ml of dilute HCI to the ash and boiled for 10 minutes and then filtered, incinerate, cool and weight according to the method of AOAC (2005). The bulk of roughage in food is referred to as the fiber and is called crude fiber. Milled sample dried, defatted with ethanol acetone mixture and then the experiment carried out using the standard method as described in AOAC (2005). The carbohydrate content estimated by the difference method and calculated by subtracting the sum of percentage of moisture, fat, protein and ash contents from 100% according to AOAC (2005). The total energy value of the food formulation calculated according to the method of Mahgoub (1999). Rice bran was chemically analyzed for their proximate compositions i.e. moisture, ash, crude protein, crude fat, crude fiber, crude carbohydrate and energy. The moisture content of different fraction of parboiled rice bran was ranged from 6.52 to 9.20 %. The lowest and the highest moisture contents in parboiled rice bran were shown by the second polish (6.52%) and the silky polish (9.20%) respectively. The ash content of parboiled rice bran was ranged from 10 to 10.61 %. The bran of first polish (FP) showed the highest (10.61%) and triple polish (TP) showed the lowest amount (10%) of ash content. Fat content ranged from 24.60 to 27.81%, carbohydrate content 42.17 to 43.2% and Total energy lowest in first polish as 456.54 calories100 g^{-1} and the highest in triple polish (TP) as 482 calories100 g^{-1}. FP, SP and TP represent first polish, second polish and third polish of 80 mesh (Newwark,USA) respectively. We used soxhlet apparatus and n-Hexane as solvent to extract rice bran oil in GQN laboratory. The sample bran was prepared in the Grain Quality and Nutrition Laboratory. The highest oil content in bran found in BR22 as 28.7% on the other hand, the lowest 25.25% found in BR23.We analyzed bran oil of BRRI dhan28 at different storage conditions but could not find any significant difference (P>0.0148). There is a tremendous scope to meet half of the total demand of our edible oil by replacing rice bran oil. For attaining this goal we will need a comprehensive collaborative approach involving producers, millers, exporters and financial institutions.

NUTRITIONAL QUALITY ASSESSMENT OF RICE

In vivo experiment of glycemic index (GI) for BRRI released rice varieties (Long Evan rat)

In this study, glycemic response was studied using BRRI developed 72 HYV rice varieties. The study was aimed at estimating the glycemic index subjected to rice, in Long Evan experimental rats using glucose as standard (control). A total of 219 rats were separated into 73 groups of three rats: one control group and 72 experimental groups. Group one was given 50g equivalent standard glucose, group two to group seventy two were given seventy two different HYV varieties including four hybrid rice, in an amount of 50g equivalent carbohydrate. Glucose response curves were measured by standard AUC (Area under curve) method considering 0 (fasting), 30, 60 and 120 minutes post feed respectively. Blood glucose level was determined using Accu-Chek glucometer and test strips.The aim of the experiment was to explore low and intermediate GI (glycemic index) rice varieties among BRRI released HYV and hybrid rice in vivo using experimental Long Evan rat model. The animals used for this experiment were Long Evan rats obtained from department of Physiology of Bangladesh University of Health Science (BUHS), Mirpur, Dhaka and experiment took place at rat room facilities (controlled condition) in GQN Division, BRRI, Gazipur. The rats were divided into 73 groups of three rats each. The rats weighed between 150 and 160 g. A total of 72 HYV including 68 inbred and four hybrid rice varieties such as from BR1 to BRRI dhan69 (sequentially except no 13 as there is no BRRI rice named BR13) and from hybrid dhan1 to BRRI hybrid dhan4 were surveyed for glucose response in this experiment. For the purpose of consistency, the samples were ground into flour and made into viscous paste using flour and water in a ratio of 1:3 respectively. Blood samples were collected from the tip of rats' tails at fasting and also at 30, 60 and 120 minutes post feed respectively. Blood glucose level was determined using Accu-Chek glucometer and test strips. They were fed with rice for seven days to get them accustomed to it, with a preliminary monitoring of the glycemic level. The rats were fasted for 15-18 hours after the seven day period, and their fasting blood glucose was determined with glucose meter as well as test strips. Blood glucose level of all groups were monitored with glucometer at time intervals of 30 minutes, 60 minutes and 120 minutes after diet withdrawal. The estimation of glycemic response is an important parameter to take into consideration in order to better understand the physiological effects of foods with high carbohydrate levels. Among cereals, rice is one of the major source of carbohydrate. Since rice is the staple food of Bangladeshi people and we consume approximately 416 g rice per day per person on average, it is high time to focus our scientific attention on rice in terms of different aspects of health related issues. Usually we consume milled rice and the outer layers of bran and germ are removed during milling, which significantly reduces the vitamin, mineral and fiber content of rice. GI is the measure of the glycemic effect of carbohydrate in a particular food, compared to an equivalent amount of carbohydrate in a standard amount of glucose or white bread. The GI is also a ranking (on a 100 point scale) of how quickly 50 g of carbohydrates from foods elevates blood sugar levels. The higher the number, the quicker the carbohydrate enters the blood stream. Glycemic index, glycemic load and glycemic response each helps to provide an understanding of how the foods we eat can impact blood glucose level, glycemic response seems to be a better reflection of how people really eat, because in addition to carbohydrates, it also considers the fiber, protein and fat content found in a typical meal. The study was aimed at estimating the glycemic index of rice using glucose as standard. Among 72 rice varieties we found BR16, BRRI dhan46 and BRRI dhan69 as low GI rice varieties (4.2% of tested 72 BRRI varieties). A total of 50 rice varieties are categorized as intermediate GI (69.44% of the tested 72 BRRI varieties) and 19 rice varieties are categorized as high GI (26.38% of the tested 72 BRRI varieties). Rat blood glucose level were measured in $mmoleL^{-1}$ unit. We will further analyze 53 varieties including both low GI and intermediate GI for both in vitro chemical and enzymatic tests like RDS (Rapidly Digestible Starch), SDS (Slowly Digestible Starch), RS (Resistant Starch) test and -amylase inhibitor. Then after only few selected low GI grouped rice varieties will be subjected for in vivo human trial in association with BIRDEM and BUHS.

Estimation of antioxidant status of BRRI released rice varieties using in vivo experimental rat model

Free radicals have been implicated in the progression of numerous conditions including cancer, diabetes, cardiovascular disease, ageing and neurological disorders. Human body has three levels of defense against free radical attack. Firstly, Preventative antioxidants inhibit the formation of free radicals e.g. metal binding proteins like Ceruloplasmin, Metallothionine, Albumin, Transferrin, Ferritin and Myoglobin. Secondly, Scavenging antioxidants remove any reactive species once formed. e.g. Superoxide Dismutase (SOD), Glutathione Peroxidase, Catalase and small molecules such as Ascorbate, Tocopherol, Bilirubin, Uric Acid, Carotenoids and Flavonoids.

Finally Repair enzymes correct the damaged biomolecules e.g. DNA repair enzymes. Rice has the potential to promote human health, due to its content of phenolic compounds that are able to inhibit the formation or reduction of the concentrations of reactive cell-damaging free radicals, thereby reducing the risk of coronary heart disease and cancer (Victor et al, 2009 and Wahle et al, 2010) and preventing oxidative damage of lipid and low-density lipoproteins (Vauzour et al, 2010). It is reported that BR5 rice contained the highest level of total phenolic content (TPC), ferric reducing antioxidant power (FRAP) and total antioxidant capacity (TAC), BRRI dhan28 and BRRI dhan29 had intermediate level and BR16 had the lowest among 10 tested HYV rice varieties (Alak *et al.*, 2012). BRRI has developed 77 high yielding rice varieties (HYV) but have not yet tested any of its' antioxidant effects on human or any other mammalian subjects although rice is the staple food in Bangladesh and in some Asian countries. In the present study, we have selected BR5, BR16, BRRI dhan28 and BRRI dhan29 among the HYV rice developed by BRRI to test the effect of antioxidant properties in mammalian host like rat. Our study resembled the potential impact of antioxidant properties in the studied rice varieties on the improvement of mammalian immunity. The aim of the study was to evaluate the dietary administration of rice in improving the antioxidant status in vivo by a rat model of Long-Evan rat. Twenty-three adult male Long-Evan rats aged about three months old (12 weeks), weighing 150 ± 2g, were used in this study. Animals were housed individually in cages in a room maintained at 22-24°C with a controlled 12 hrs light-dark cycle, and had free access to tap water and cooked rice feed. Four rice BR5, BRRI dhan28, BRRI dhan29, BR16 samples were cleaned and milled on a Satake test mill (Satake Corporation, Japan) for separating into bran and brown rice fraction. Brown rice was then polished 10% as milled rice. These milled rice were subjected to feed individual rat group for four weeks' time at twice meal per day as per requirement (0.89 g cooked rice per meal for each rat equivalent to 5.94 g kg^{-1} body weight of rat). Following two week acclimatization with BRRI dhan29 at twice a day, the rats were allocated randomly to three groups of five rats each, ensuring the groups were balanced for body weight. After one week of interval for washout the effect of BRRI dhan29, commercial rat foods were served. Then after Group 1, Group 2 and Group 3 were fed BR5, BRRI dhan28 and BR16 respectively. Feeding of the experimental diets to rats lasted four weeks at twice meal a day. Unhemolyzed serum or heparinized or EDTA plasma was needed for clinical analysis. Thus, we anesthetized the rats by using Diethyl ether and collected blood from jugular vein. Then blood samples were centrifuged at 6000 rpm for 15 minutes to get serum. Serum was stored at 4°C in a refrigerator until analysis. Serum albumin, uric acid and free iron were measured at 623 nm, 550 nm, 546 nm wavelength respectively. In quantification of serum TIBC and transferrin, excess ferric iron ($FeCl_3$) was added to rat serum specimen to saturate the transferrin. Remaining ferric iron was absorbed on $MgCO_3$. Bound iron in the supernatant is termed as TIBC, and assayed by iron detection procedure of ferrozine method. Duncan's multiple range test (DMRT) was applied on iron, TIBC, transferrin, uric acid and albumin parameter for statistical analysis using SPSS, version 20.0. We fed our rats BRRI dhan29 as a control for 14 days to accustom with food habit (only cooked rice) and controlled conditioned environment in a rat room of GQN laboratory, BRRI, Gazipur. Then we used eight healthy rats to established normal range of different clinical parameters such as albumin, uric acid, TIBC and transferrin in rat serum in our laboratory. Clinical data explains the normal range of albumin, uric acid, TIBC and transferrin in Lang Evan rat by 2.59 ± 0.18 g dL^{-1}, 2.32±0.29 mg dL^{-1}, 257.59 ± 16.36 µg dL^{-1} and 214.66±13.63 µg dL^{-1} (n=8) respectively. After one week of interval for washout the effect of BRRI dhan29, commercial rat food were served. Then after cooked BR5 rice was fed for 28 days twice meal per day in group 1 rats (n=5). We found the lowest level of free iron content 53.75 µg dL^{-1} but very elevated level of TIBC 311.23 µg dL^{-1}, transferrin 259.36 µg dL^{-1} uric acid 3.23 mg dL^{-1} and albumin 3.36 g dL^{-1}in rat blood serum of group 1. On the other hand in group 3 where BR16 cooked rice were fed, we found the highest level of free iron content 103.74 µg dL^{-1}but the lowest amount of TIBC 161.26 µg dL^{-1}, transferrin 134.39 µg dL^{-1}, uric acid 2.40 mg dL^{-1} and albumin 3.01 g dL^{-1} in rat blood serum. In group 2 rats revealed intermediate range of values for free iron 88.79 µg dL^{-1}, TIBC 266.38 µg dL^{-1}, transferrin 221.99 mg dL^{-1}, uric acid 2.86 mg $dL^{-1}$and albumin 3.06 g dL^{-1} in rat blood serum. Total iron binding capacity (TIBC) measures the blood's capacity to bind iron with transferrin and is therefore an indirect measurement of transferrin. Iron is capable of stimulating the production of harmful free radicals. Plasma levels of transferrin are regulated by the availability of iron and increase when plasma levels of iron are low. In Bangladesh, BRRI dhan28 and BRRI dhan29 are two mega high yielding rice varieties, which covers most of the rice production area during Boro season. On the other hand, BR5 is a popular aromatic rice with strong fragrance and BR16 is a low glycemic rice (Howlader, 2009, Shozib, 2015). In 2012, Alak et al, in a comparative study on antioxidant properties of ten high yielding rice varieties of Bangladesh, reported that TPC was the highest in BR5 (25.30±0.52 mg GAE $100g^{-1}$) and the lowest was in BR16 (10.78±0.70 mg GAE $100g^{-1}$) among all the 10 tested varieties (data not shown). BRRI dhan28 and BRRI dhan29 had an intermediate score of 18.42±0.45 mg GAE $100g^{-1}$ and 17.67±0.08 mg GAE $100g^{-1}$ respectively (data not shown). Both antioxidant parameters like FRAP and TAC of these rice varieties were positively correlated with TPC (data not shown). We have selected these varieties in this experiment. Since there were three different groups having three treatments, so DMRT was applied on iron, TIBC, transferrin, uric acid and albumin parameter for statistical analysis using SPSS, version 20.0. Our data revealed that high antioxidant enriched rice BR5 showed the lowest free iron content 53.75 µg dL^{-1}among other rice varieties BR16 and BRRI dhan28. Since plasma levels of transferrin are regulated by the availability of iron and increase when plasma levels of iron are low, we found the content of transferrin in Group 1 (rats) was a mean of 259.36 µg dL^{-1}. Mean values of TIBC, uric acid and albumin were elevated in Group 1 rats, compare to Group 2 and Group 3. Group 3 had the highest free iron content of 103.74 µgdL^{-1} and the lowest level of TIBC, transferrin, uric acid and albumin among three groups. So, we conclude that dietary administration of BR5 rice might increase total antioxidant status in blood serum, which ultimately improve body immunity.

COMMERCIAL RICE BASED PRODUCTS

Rice based biscuit and nutritional characteristics
The objectives of our study were to formulate different gluten free flours for using in biscuits making and to evaluate these formulations (from BRRI dhan46 and BR16 rice varieties) for quality biscuits. In Bangladesh rice biscuit is still not introduced to the customers, even though rice is the main crop and about 50 million ton paddy produced in 2011-12. Therefore there is a huge scope to introduce rice based food products. Rice flour, sugar, edible oil, egg, nut, vanilla, butter, baking powder, baking soda, milk powder, salt were used. Rice flour from BR16 and BRRI dhan46 was prepared in the GQN Laboratory. Mix all ingredients to form dough. Manually knead everything together. Rolled it out and cut out as desired. Baked at 180°C for 8-10 minutes. Leave it to cool before decorating. Analyze nutrition value (e.g. protein, fat, total calorie). Data on Protein value, total fat, and total calorie were calculated as per GQN, BRRI manual. We have formulated rice based biscuits by following ingredients like from two varieties of flour like BRRI dhan46 and BR16 respectively. Both BRRI dhan46 and BR16 are low glycemic indexed Rice (Shozib, 2015), so we are hopeful that these rice based biscuits might play a good role in diabetic dietary management. Total energy obtained from rice biscuits of two different varieties namely BRRI dhan46 and BR16 were 437 calories 100 g^{-1} serving and 520 calories100 g^{-1} serving respectively.

Identification of γ-Aminobutyric acid (GABA) in rice and its health benefits as a value added food
Pre-germinated brown Rice (PGBR) alias germinated brown rice (GBR) or sprouted brown rice (SBR) enhances the bio-availability of nutrients by neutralizing phytic acid during

germination process. Brown rice (BR) can be soaked in water at 30°C for specified hours for germination to get PGBR. Soaking for 3 h and sprouting for 21 h has been found to be optimum for getting the highest GABA content in PGBR, which is the main reason behind the popularity of PGBR. During the process of germination, nutrients in the brown rice change dramatically. The nutrients, which have increased significantly, include GABA, Lysine, vitamin E, dietary fiber, niacin, magnesium, vitamin B_1, and vitamin B_6. BR contains more nutritional components than ordinary white rice. PGBR has been reported to exhibit many physiological effects, including anti-hyperlipidemia, anti-hypertension, and the reduction in the risk of some chronic diseases, such as cancer, diabetes, cardiovascular disease, and Alzheimer's disease. Therefore, it is likely that PGBR will become a popular health food in Bangladesh. As the protein supply for ever increasing world population becomes limiting, the need for accurate data on the amino acids of major foods, such as rice becomes more critical. In this experiment we investigated the potential of our both Bangladeshi HYV and local rice varieties for the preparation of PGBR as well as quantification of some selective amino acids, such as GABA, glutamic acid, methionine, lysine, histidine and arginine in these tested rice varieties. This study might widen the scopes of developing of new food from rice and rice by-products based on the available content of beneficial amino acids specially GABA. Grains of ten Bangladeshi rice varieties including five traditionals such as Ghungshe, Kajalsail, Monteshor, Moulata, Sadamota and five BRRI HYVs like BR22, BR23, BRRI dhan31, BRRI dhan40, BRRI dhan41 were subjected to determine the protein content, apparent amylose content (AAC) and amino acid content of GABA, glutamic acid, methionine, lysine, histidine and arginine at both PBR and PGBR conditions. Amylose contents were measured by Juliano, 1971. Estimation of protein were measured by standard micro Kjeldahl procedure of AOAC 1995. The amino acid was estimated by the method of Moore and Stein (1963) using amino acid analyzer. The SPSS, version 20 was applied for statistical analysis of the experimental data. Analysis of variance (ANOVA) followed by Duncan's multiple range test (DMRT) was applied on changing fold data of amino acid content parameters from PBR to PGBR condition. The level of significance was set at $p < 0.05$. In protein analysis, it is clearly revealed that protein content increased in PGBR compared to BR in all tested varieties that ranges from 13.73 % to 46.86 %. Ghungshe, BRRI dhan41 and BR23 showed maximum increase in protein content in PGBR stage compared to PBR. In amylose content assay, all tested varieties showed decreasing AAC in PGBR compared to PBR and PMR. In amino acid analysis, in case of quantification glutamic acid content, BR23 has the lowest content of 1.40±0.35 mg 100^{-1}g at PGBR and all tested varieties has a decreasing trends from BR towards PGBR except BRRI dhan41. In GABA quantification, BRRI dhan31 has the highest content of 12.00±0.50 mg 100^{-1}g at PGBR among all varieties and it showed an increasing trends from BR towards PGBR for all varieties. In case of histidide quantification, Ghungshe has the lowest content of 0.60±0.01 mg 100^{-1}g and BRRI dhan31 has the highest content of 2.34±0.06 mg 100^{-1}g. All the varieties showed increasing trend from BR towards PGBR except Ghungshe and Kajalsail. In quantification of methionine, Ghungshe has the lowest content of 0.9±0.02 mg 100^{-1}g and BR22 has the highest content of 2.43±0.15 mg 100^{-1}g among all varieties. All varieties showed increasing trends from BR toward PGBR except Kajalsail, Montesshor and BRRI dhan40. In case of Lysine quantification, BRRI dhan40 has the lowest content of 0.42±0.030 mg 100^{-1}g and BRRI dhan41 has the highest content of 3.40±0.11 mg 100^{-1}g among all varieties at PGBR. Finally, in arginine quantification, BR22 has the lowest content of 0.09±0.01 mg 100^{-1}g and Sadamota has the highest content of 4.02±0.51 mg 100^{-1}g among all varieties at PGBR condition. In analyzing of changing folds of amino acid content from BR to PGBR, Ghungshe has increased the maximum folds of 22.51 for GABA, Moulata has 14.11 folds for methionine, BRRI dhan31 has 3.40 folds for histidine, BRRI dhan41 has 3.51 folds for lysine and Sadamota has 1.82 folds for arginine, compared to other traditional HYV rice varieties.

PGBR could be acceptable to consumers and food industry as a promising foodstuff that contains more nutritional proteins, amino acid and bio-functional components than ordinary rice products for malnourished children and aged population who have been suffering from different chronic diseases. PGBR and rice bread may be cited as two promising rice based products that hold much more nutrition over milled rice and ordinary brown rice. To improve food security in food shortage regions can be attained by consumption of PGBR. PGBR can be a dietary food for health improvement. The reason behind the popularity of PGBR among health-conscious consumers and bio-techno-scientists is the significant increase in GABA and its extensive bio-functional properties to maintain a good human health. PGBR has potential to become innovative rice by preserving all nutrients in the rice grain for human consumption in order to create the highest value from rice. The PGBR technology can be transferred for empowerment of rural people, by transforming them into a successful entrepreneurs starting with their own food (PGBR) processing units and to contribute in the national development of health and nutritional security and improvement in the living standards in Bangladesh. In our experiment, we concluded that Ghungshe, seems the most suitable rice varieties among the tested varieties as it possesses highest protein and BRRI dhan31 has the highest GABA content of 12.00±0.50 mg 100^{-1}g at PGBR stage. These findings can be an important information to our rice based agro food industries in Bangladesh. Lathyrism is due to absolute methionine deficiency. It is apparent that the low nutritive value of lentil protein is due to methionine deficiency instead of cystine deficiency and the better quality of rice protein is due to the higher methionine content. In this case, BR22 which has the highest content of methionine 2.43±0.15 mg 100^{-1}g among all varieties, could be beneficial for rice consumer who have tendency of lathyrism related disorders. Histidine is utilized by our body to develop and maintain healthy tissues. Antidiarrheal effects of l-histidine-supplemented rice-based oral rehydration solution in the treatment of adults with severe cholera in Bangladesh (Golam, 2005). Since BRRI dhan31 has the highest histidine content of 2.34±0.06 mg 100^{-1}g among all varieties, it could be a good carbohydrate source for histidine-supplemented rice based oral rehydration solution for Bangladesh. In addition in this study we have prepared some value added GABA rice byproducts like GABA rice ball, GABA plain cake and GABA biscuit. We used BRRI dhan31 to produce PGBR and then grind to powder to get GABA enriched flour for preparing different cookies like cake and biscuit. In GQN Division, we have prepared a healthy rice ball from PGBR which contain around 393 calories per 100 g serving. For protein we can use egg, chicken, beef, mutton, fish instead of shrimp. We can keep this product at 4°C in refrigerator for several days. GABA plain cake contain around 464 calories $100g^{-1}$ serving and it was prepared from PGBR flour. GABA biscuit contains around 478 calories 100 g^{-1} serving and it was also prepared from PGBR flour. Detailed cooking protocols of the above rice by-products are available in GQN Division, BRRI, Gazipur. Our research findings reveal that BRRI dhan31 generates elevated level of bio-active component, γ-aminobutyric acid (GABA) at pre-germinated brown rice condition and in conclusion we are hopeful that GABA enriched rice could widen the scopes of developing new rice based value addition as well as nutritional food products in Bangladesh in near future.

Hybrid Rice Division

SUMMARY

During T. Aman season 2014, fifty-nine test crosses and 56 (A × R) crosses were made from source nursery. A total of 242 test crosses (F_1s) were evaluated for their pollen fertility status of which nine 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. Nineteen entries were found completely sterile and their corresponding male parents were regarded as suspected maintainer lines. All the backcross generations were stable in terms of pollen sterility with other desirable agronomic traits and advanced for next generation. One hundred eighteen CMS lines along with their respective maintainer lines were maintained by hand crossing. A total of 120 BB resistant parental lines were selected from pedigree nursery and advanced as F_4 generations.

One hundred eight test crosses and 130 (A × R) crosses were made using seven CMS lines during Boro season 2014-15. Eighty-six testcrosses (F_1s) were evaluated for their pollen fertility status. Among them seven entries showed complete sterility and immediately backcrossed with their corresponding male parents for conversion. On the other hand, three entries have been selected for their high yielding ability compared with the check varieties. One BC_6 generation was found stable in pollen sterility and other desirable agronomic characteristics and designated as new CMS lines in the background of their corresponding male parents. Other generations were advanced as BC_5 and BC_2 generations except two entries due to fluctuation in pollen sterility. Sixty-six CMS lines along with their respective maintainer lines were maintained by hand crossing.

In T. Aman, out of 142 test hybrids under observational trials three (3) hybrid combinations were selected based on yield, duration and grain type. They gave more than 15-20% yield advantage over check variety BR11 and BRRI dhan49 with two to three week shorter growth duration. Out of 123 test hybrids 10 hybrid combinations were selected based on yield, duration and grain type and showed yield advantage ranging from 16-31% over BRRI dhan28 and 8-22% over BRRI dhan29 in Boro 2014-15. Under preliminary yield trials three hybrids out of nine gave 14 to 20% yield advantage over BR11 and BRRI dhan49 respectively during T. Aman 2014 and during Boro season 2014-15. Two combinations IR75608A/ BRRI31R and IR75608A/BAU521R gave 1.01 and 1.49 t/ha yield advantage over respectively BRRI dhan28 with similar growth duration. On the other hand, BRRI33A/BRRI31R, IR79156A/BRRI20R and BRRI33A/BAU521R gave 2.12, 1.66 and 1.45 t/ha yield advantage respectively over BRRI dhan28 and BRRI33A/BRRI31R and IR79156A/ BRRI20R gave 1.54 and 1.12 t/ha yield advantage respectively over BRRI dhan29. National hybrid rice yield trials were conducted through SCA during T. Aman 2014 and Boro 2014-15 which included 16 and 50 hybrids. Results were compiled by SCA.

Seed yield of 70 kg/plot (1.5 t/ha), 75 kg/plot (1.6 t/ha) and 18 kg/plot (1.1 t/ha) were obtained from BRRI10A, BRRI11A line and IR58025A respectively in T. Aman season. On the other hand, during Boro 2014-15 seasons, CMS seed yield of 110 kg (2.20 t/ha), 130 kg (2.35 t/ha) and 90 kg (1.72 t/ha) was obtained from BRRI10A/B, BRRI11A/B and IR58025A/B respectively. A total of 115 kg (1.5 t/ha), 50 kg (1.45 t/ha) and 22 kg (1.2 t/ha) hybrid seeds were produced from BRRI11A/BRRI15R, BRRI10A/BRRI10R and IR58025A/BRRI10R respectively during T. Aman 2014. In Boro 2014-15 season, F_1 seeds of released hybrids were obtained 110 kg (2.2 t/ha) from BRRI hybrid dhan2, 130 kg (2.35 t/ha) from BRRI hybrid dhan3 and 90 kg (1.7.2 t/ha) from BRRI hybrid dhan4.

In the last reporting year, Hybrid Rice Division (HRD) supplied 1,238 kg of parental lines and F_1 seeds among 36 farmers, seven seed companies, scientists and staffs of BRRI and BADC. A total of 30,150 kg F_1 seed was produced during Boro season 2014-15 with the technical assistance from BRRI under four seed companies and regional stations of BRRI.

DEVELOPMENT OF PARENTAL MATERIALS

Source nursery

A total of 59 test crosses and 56 (A × R) crosses were made using eight CMS lines during T. Aman season 2014. One hundred eight test crosses and 130 (A × R) crosses were made using seven CMS lines during Boro season 2014-15.

Test cross nursery

During T. Aman 2014, out of 242 testcrosses (F_1s) nine entries have been found heterotic over check varieties and nineteen entries were found completely sterile**.** Pollen parents heterotic combinations were regarded as suspected restorers and pollen parents of completely sterile combinations were regarded as suspected maintainer lines. During Boro season 2014-15, out of 86 test crosses (F_1s), seven tested entries showed complete sterility and immediately backcrossed with their corresponding male parents for conversion. On the other hand, three entries have been selected for their high yielding ability compared with the check variety.

Back cross nursery

In T. Aman 2014, all the backcross generations were stable in terms of pollen sterility and advanced for next generation. In Boro 2014-15, tested BC_6 generation was found stable in pollen sterility and other desirable agronomic characteristics and designated as new CMS lines in the background of their corresponding male parents. Other generations were advanced as BC_5 and BC_2 generations except two entries due to fluctuation in pollen sterility (Table 1).

CMS maintenance and evaluation nursery

One hundred eighteen CMS lines were maintained by hand crossing for seed increase and genetic purity in T. Aman 2014 and in Boro 2014-15, sixty-six CMS lines were maintained through hand crossing for seed increase and genetic purity.

Pedigree nursery for development of BB resistant parental lines of hybrid rice

A total of 120 BB resistant parental lines were selected from pedigree nursery and advanced as F_4 generations during T. Aman 2014 and 169 progenies were selected from the seven F_4 populations as F_5 generation from Boro 2014-15**.**

Evaluation of experimental hybrids

Out of 142 hybrids three hybrid combinations were selected based on yield, duration and grain type during T. Aman 2014 (Table 2). Around 15 to 20 % yield advantage was observed of the selected hybrids over the inbred check variety.

During Boro 2014-15, out of 123 hybrids 10 combinations were selected based on yield, duration and grain type (Table 3). Upon commercial seed production feasibility of these selected hybrid combinations advanced lines adaptive research trials (ALART) will be conducted and based on satisfactory yield advantage over check, hybrid combination will be submitted to SCA trials.

Preliminary yield trials of promising hybrids

In T. Aman 2014, three hybrid combinations out of nine (IR79156A/PL-1, IR75608A/BRRI31R and BRRI21A/BasmatiR) were selected based on yield and growth duration and it was around 15 to 20 % and two to three weeks earlier than check varieties (Table 4). In Boro 2014-15, two hybrid combinations IR75608A/BRRI31R and IR75608A/BAU521R gave 1.01 t/ha and 1.49 t/ha yield advantage over BRRI dhan28 with similar growth duration. On the other hand, BRRI33A/BRRI31R, IR79156A/BRRI20R and BRRI33A/BAU521R gave 2.12 t/ha, 1.66 t/ha and 1.45 t/ha yield advantage over BRRI dhan28 and BRRI33A/BRRI31R and IR79156A/BRRI20R gave 1.54 t/ha and 1.12 t/ha yield advantage over BRRI dhan29 (Table 5).

SEED PRODUCTION OF PARENTAL LINES AND HYBRIDS

CMS line multiplication of released hybrids

During T. Aman 2014, seed yield 70 kg/plot (1.5 t/ha), 75 kg/plot (1.6 t/ha) and 18 kg/plot (1.1 t/ha) were obtained from BRRI10A, BRRI11A and IR58025A respectively (Table 6). In Boro 2014-15, seed yield of 110 kg (2.20 t/ha), 130 kg (2.35 t/ha)

Table 1. Performance of backcross entries during Boro seasons of 2014-15.

BC gen	Designation	Sterility status	DFF	D50%F	DTM	Grain type	Base colour	Remark
BC_4	BRRI53A/BR7873-5-(NILS)-51-HR6	CS	108	111	137	Slender	Base green	Advanced as BC_5 generation
BC_1	BRRI60A/EL140	CS	110	113	139	Slender	Base green	Advanced as BC_2 generation
BC_1	BRRI28A/EL140	CS	108	111	137	Slender	Mixed	Advanced as BC_2 generation
BC_1	BRRI60A/EL135	CS	97	100	126	Medium	Base purple	Advanced as BC_2 generation
BC_1	IR77803A/EL135	CS	99	103	129	Medium bold	Base purple	Advanced as BC_2 generation
BC_1	BRRI60A/EL110	CS	109	112	138	Slender	Base purple	Advanced as BC_2 generation
BC_1	D. ShanA /EL109	S	104	107	133	Slender	Base purple	Discarded
BC_1	PMS8A/EL30	CS	101	105	131	Medium bold	Base purple	Advanced as BC_2 generation
BC_1	BRRI7A/EL116	CS	114	117	142	Slender	Base purple	Advanced as BC_2 gen, little awn
BC_1	BRRI7A/EL125	CS	115	118	143	Slender	Base purple	Advanced as BC_2 generation
BC_1	BRRI7A/EL145	CS	111	114	140	Slender	Mixed	Advanced as BC_2 generation
BC_1	BRRI28A/EL256	CS	111	114	140	Slender	Base purple	Advanced as BC_2 generation
BC_1	BRRI71A/EL70	CS	99	102	128	Medium slender	Base purple	Advanced as BC_2 generation
BC_1	BRRI7A/EL211	CS	116	119	144	Medium slender	Base purple	Advanced as BC_2 generation
BC_1	BRRI7A/EL211	CS	116	119	144	Medium slender	Base purple	Advanced as BC_2 generation
BC_1	BRRI7A/EL210	CS	115	118	143	Medium slender	Base green	Advanced as BC_2 gen, little awn
BC_1	BRRI7A/EL207	CS	118	121	144	Medium slender	Mixed	Advanced as BC_2 generation
BC_1	BRRI7A/EL196	CS	118	121	144	Medium slender	Mixed	Advanced as BC_2 generation
BC_1	BRRI7A/EL50	CS	113	116	141	Medium slender	Base purple	Advanced as BC_2 generation
BC_1	BRRI7A/EL184	S	118	122	147	Medium	Mixed	Discarded
BC_1	BRRI7A/EL195	CS	116	119	144	Medium slender	Base purple	Advanced as BC_2 generation
BC_1	BRRI56A/EL23	CS	102	105	131	Medium	Base purple	Advanced as BC_2 generation
BC_1	BRRI32A/EL36	CS	105	109	135	Medium slender	Base purple	Advanced as BC_2 generation

D/S : P_1=2 Dec 2014; P_2/F_1=5 Dec 2014; P_3=8 Dec 2014; D/T : 8 Jan 2015. CS=completely sterile, S=sterile.

Table 2. List of experimental hybrids found heterotic over check variety in T. Aman 2014.

Entry no.	Designation	Plant ht (cm)	E/T	DFF	SF (%)	Maturity (day)	Yield (t/ha)	Grain type	Yield advantage (%) over		
									Ck-1	Ck-2	Ck-3
1	IR79156A/PL-1	105.8	13	93	84.2	120	8.15	S	18.12	19.68	4.49
2	BRRI21A/BasmatiR	111.6	11	88	81.0	117	7.90	S	14.49	16.0	1.28
3	IR75608A/BAU521R	103.8	12	87	83.2	116	8.10	S	17.39	18.94	3.84
Ck-1	BR11	112	10	114	75.40	142	6.90	B	-	-	-
Ck-2	BRRI dhan49	101	11	107	74.09	135	6.81	MS	-	-	-
Ck-3	BRRI hybrid dhan4	109.5	10	91	81.50	120	7.80	S	13.04	14.54	

D/S : 12 Jul 2014, D/T : 8 Aug 2014. S=Slender, M=Medium, B=Bold, MS=Medium slender.

Table 3. List of the hybrid combinations found heterotic from observational nursery during Boro 2014-15.

Cross combination	Plant ht (cm)	No. of effective tiller/hill	Spikelet fertility (%)	Panicle length (cm)	TGW (g)	Grain yield (t/ha)	Grain type	DTM	Yield advantage (%) over		
									Ck-1	Ck-2	Ck-3
BRRI13A/PR812R	110	9.2	86.52	25.2	32.56	9.0	M	140	16.88	8.43	-
BRRI28A/PR585R	97.4	9.6	83.60	18	34.42	9.31	M	138	20.90	12.16	-
BRRI28A/PR812R	103.4	8.6	93.18	22.2	33.96	8.94	M	141	16.10	7.71	-
BRRI28A/PR874R	103	9.8	91.88	24.2	28.78	9.0	M	141	16.88	8.43	-
BRRI28A/PR3028R	102.2	12	91.99	22.2	29.46	10	M	140	29.87	20.48	5.2
BRRI33A/BRRI22R	103.8	11.8	92.61	20.6	30.18	10.12	MS	150	31.42	21.92	6.52
BRRI33A/BRRI16R	102	11	88.12	22.8	31.04	9.02	MS	146	17.14	8.6	-
BRRI33A/BRRI28R	106.6	11	93.37	23.8	25.74	10	MS	147	29.87	20.48	5.26
BRRI33A/BRRI29R	105	8.2	91.39	21.8	24.24	9.24	M	145	20	11.32	-
BRRI33A/PR368R	103.4	8	83.65	21.4	29.14	9.5	M	146	23.37	14.45	0
BRRI dhan28 (Ck-1)	110	12.6	72.49	18.6	20.96	7.7	S	141			
BRRI dhan29 (Ck-2)	102.8	13	91.76	23	18.46	8.3	MS	156			
BRRI hybrid dhan3 (Ck-3)	112.6	12	96.63	25.6	28.29	9.5	M	146			
Average	104.8	10.5	89.0	22.3	28.2	9.2	-	144.4			
Lsd $_{(0.05)}$	2.9	1.2	4.5	1.6	3.4	0.5	-	3.5			
CV (%)	3.9	16.3	7.1	10.2	16.9	7.4	-	3.4			

D/S: 5 Dec 2014, D/T: 10 Jan 2015. MS=Medium slender, M=Medium, S=Slender, TGW=Thousand grain wt, DTM=Days to

Table 4. Results of preliminary yield trials during T. Aman 2014.

Entry no.	Designation	Plant ht (cm)	E/T	DFF	SF (%)	Maturity (day)	Yield (t/ha)	Grain type	Yield advantage (%) over		
									Ck-1	Ck-2	Ck-3
1	IR79156A/PL-1	105.8	13	93	84.2	120	8.15	S	18.12	19.68	4.49
2	BRRI21A/BasmatiR	111.6	11	88	81.0	117	7.90	S	14.49	16.0	1.28
3	IR75608A/BRRI31R	103.8	12	87	83.2	116	8.10	S	17.39	18.94	3.84
Ck-1	BR11	112	10	114	75.40	142	6.90	B	-	-	-
Ck-2	BRRI dhan49	101	11	107	74.09	135	6.81	MS	-	-	-
Ck-3	BRRI hybrid dhan4	109.5	10	91	81.50	120	7.80	S	13.04	14.54	

D/S : 12 Jul 2014, D/T : 8 Aug 2014; Plot size=30 m^2.

Table 5. Results of preliminary yield trials in Boro 2014-15.

Combination	Maturity (day)	Plant ht (cm)	ET/m^2	SF (%)	Yield (t/ha)	Yield advantage over check (%)		
						Ck-1	Ck-2	Ck-3
IR75608A/BRRI31R	144	100.7	276.1	86.52	8.38	1.01	-	-
BRRI33A/BRRI31R	149	102.6	290.4	89.99	9.45	2.12	1.54	0.76
IR79156A/BasmatiR	148	110.8	316.8	94.22	8.44	1.07	0.53	-
BRRI33A/BasmatiR	147	107.4	283.8	92.2	6.64			
BRRI21A/BasmatiR	141	106.9	297.0	92.14	7.98			
IR75608A/BasmatiR	142	096.1	277.2	74.49	7.58			
BRRI42A/BasmatiR	148	095.0	390.9	73.73	7.96			
BRRI43A/BasmatiR	142	101.4	297.0	95.59	7.10			
IR79156A/BRRI20R	149	096.6	310.2	83.77	9.03	1.66	1.12	0.34
IR75608A/BAU521R	142	097.6	369.6	84.36	8.86	1.49	0.95	0.17
BRRI21A/BAU521R	145	099.7	325.6	83.42	8.16	0.79	0.25	-
BRRI33A/BAU521R	152	104.0	282.3	97.23	8.82	1.45	0.91	0.12
BRRIdhan28 (Ck-1)	142	105.6	280.5	86.63	7.37			
BRRI dhan29 (Ck-2)	158	103.0	275.0	88.20	7.91			
BRRI hybrid dhan3 (Ck-3)	148	104.2	376.2	90.69	8.69			
Average	146.7	102.1	309.9	87.5	8.2			
Lsd $_{(0.05)}$	3.1	3.0	26.0	4.6	0.5			
CV (%)	3.1	4.5	12.6	7.9	9.4			

D/S: 5 Dec 2014; D/T: 11 Jan 2015; Plot size: 30 m^2; ET/m^2=No. of effective tillers per meter; SF (%)=Spikelet fertility.

and 90 kg (1.72 t/ha) were obtained from BRRI10A/B, BRRI11A/B and IR58025A/B respectively (Table 7).

F_1 hybrid seed production of BRRI hybrid dhan2, BRRI hybrid dhan3 and BRRI hybrid dhan4 during T. Aman 2014 and Boro 2014-15.

During T. Aman 2014, seed yield was obtained 50 kg (1450 kg/ha) from BRRI10A/BRRI10R, 115 kg (1500 kg/ha) from BRRI11A/BRRI15R and 22 kg (1200 kg/ha) from IR58025A/BRRI10R (Table 8).

In Boro 2014-15, seed yield was obtained 100 kg (2.5 t/ha), 120 kg (2.65 t/ha) and 450 kg (1.7 t/ha) respectively from BRRI10A/BRRI10R, BRRI11A/BRRI15R and IR58025A/BRRI10R respectively (Table 9).

Seed production of promising hybrids

Seed yield were obtained 130 kg (2.6 t/ha), 130 kg (2.6 t/ha), 30 kg (1.5 t/ha) respectively from IR79156A/BasmatiR, IR79156A/BRRI20R and IR79156A/PL-1R respectively during Boro 2014-15 (Table 10).

Dissemination of hybrid rice technology

In the reporting year, HRD supplied 1,238 kg of parental lines and F_1 seeds to seven seed companies along with BADC, farmers, BRRI staffs and different projects (Table 11). A total of 30,150 kg F_1 seed was produced during Boro 2014-15 with the technical assistance from BRRI under four seed companies and regional stations of BRRI (Table 12).

Table 6. CMS multiplication of BRRI10A, BRRI11A and IR58025A lines during T. Aman 2014.

Combination	Plant ht (cm)		50% flowering (day)		PER (%)	OCR (%)	Yield (kg/plot)	Yield (t/ha)
	A line	B line	A line	B line	A line	A line		
BRRI10A/B	82	86	71	70	72	32	70	1.5
BRRI11A/B	80	83	73	71	75	34	75	1.6
IR58025A/B	86	90	77	77	69	29	18	1.1

D/S : B_1=4 Jul 2014, A/B_2=7 Jul 2014, B_3=10 Jul 2014, D/T : A/B=27 Jul 2014; D/S : B_1=6 Jul 2014, A/B_2=9 Jul 2014, B_3=12 Jul 2014, D/T : A/B=29 Jul 2014; D/S : B_1=3 Jul 2014, A/B_2=6 Jul 2014, B_3=9 Jul 2014, D/T : A/B=28 Jul 2014.

Table 7. CMS multiplication of BRRI hybrid dhan2, BRRI hybrid dhan3 and BRRI hybrid dhan4 during Boro 2014-15.

Combination	Plant ht (cm)		50% flowering (day)		PER (%)	OCR (%)	F_1 seed	
	A line	B line	A line	B line	A line	A line	Yield (kg/plot)	Yield (kg/ha)
BRRI10 A/B	82	83	121	122	86	45	110	2200
BRRI11A/B	84	85	124	125	85	47	130	2350
IR58025A/B	86	88	121	120	81	40	90	1720

Location- Gazipur. D/S: B^1=29 Nov 2014, A/B_2=2 Dec 204, B_3=5 Dec 2014; D/T: A/B=31 Dec 2014; D/S: B_1=1 Dec 2014, A/B_2=4 Dec 2014, B_3=7 Dec 204; D/T: A/B=4 Jan 2015; D/S: B_1=3 Dec 2014, A/B_2=6 Dec 2014, B_3=9 Dec 2014; D/T: A/B=5 Jan 2015. PER=Panicle exertion rate, OCR= Out crossing rate.

Table 8. F_1 seed production of BRRI hybrid dhan2, BRRI hybrid dhan3 and BRRI hybrid dhan4 in T. Aman 2014.

Combination	Plant ht (cm)		50% flowering (day)		PER (%)	OCR (%)	Yield (kg/plot)	Yield (kg/ha)
	A line	R line	A line	R line	A line	A line		
BRRI hybrid dhan2 (BRRI10A/ BRRI10R)	75	102	88	86	75	44	50	1450
BRRI hybrid dhan3 (BRRI11A/ BRRI15R)	81	89	77	74	74	35	115	1500
BRRI hybrid dhan4 (IR58025A/ BRRI10R)	76	109	129	132	76	39	22	1200

D/S: R_1=6 Jul 2013, A=9 Jul 2013, R_2=12 Jul 2013, D/T : R/A=30 Jul 2013; D/S: R_1=9 Jul 2013, A=13 Jul 2013, R_2=17 Jul 2013, D/T : R/A= 3 Aug 2013; D/S: R_1=6 Jul 2013, A=9 July 2013, R_2=12 Jul 2013, D/T : R/A=30 Jul 2013. PER=Panicle exertion rate, OCR= Out crossing rate.

Table 9. F_1 seed production of BRRI hybrid dhan2, BRRI hybrid dhan3 and BRRI hybrid dhan4 during Boro 2014-15.

Combination	Plant ht (cm)		50% flowering (day)		PER (%)	OCR (%)	F_1 seed	
	A line	R line	A line	R line	A line	A line	Yield (kg/plot)	Yield (kg/ha)
BRRI hybrid dhan2	81	88	119	121	85	48	100	2500
BRRI hybrid dhan3	83	90	121	122	87	49	120	2650
BRRI hybrid dhan4	85	89	120	121	87	41	450	1700

Location- BRRI, Gazipur. D/S: R_1=27 Nov 2014, A=30 Nov 2014, R_2=3 Dec 2014; D/T: A/R=30 Dec 2014; D/S: R_1=3 Dec 2014, A=7 Dec 2014, R_2=11 Dec 2014; D/T: A/R=6-Jan 2015; D/S: R_1=1 Dec 2014, A=4 Dec 2014, R_2=7 Dec 2014; D/T: A/R=3 Jan 2015. PER=Panicle exertion rate, OCR=Out crossing rate.

Table 10. Seed amount got from promising hybrid rice combinations in Boro 2014-15.

Designation	Plant ht (cm)		50% flowering (day)		PER (%)	OCR (%)	Plot area	Yield	Seed yield
	A line	R line	A line	R line			(m^2)	(kg/plot)	(t/ha)
IR79156A/BasmatiR	95.5	101.3	128	128	73.3	45.2	500	130 kg	2.6
IR79156A/ BRRI20R	96.4	102.0	127	129	74.2	47.2	500	130 kg	2.6
IR79156A/PL-1R	98.4	106.5	126	129	68.0	46.0	200	30 kg	1.5

D/S: R_1=7 Dec 2014, R_2=10 Dec 2014, R_3=13 Dec 2014, D/T : R/A=17 Jan 2015/20 Jan 2015; D/S: R_1=7 Dec 2014, A=10 Dec 2014, R_2=13 Dec 2014, D/T: A/R=20 Jan 2015; D/S: R_1=7 Dec 2014, A=10 Dec 2014, R_2=13 Dec 2014; D/T: A/R=20 Jan 2015.

Table 11. Amount of parental line and hybrid seeds supplied to different organizations.

Recipient	No.	F_1 (kg)	A line (kg)	B line (kg)	R line (kg)
BADC	1	0	20	-	8
Seed Companies	7	70	300	-	100
Farmers	36	250	30	-	10
BRRI Scientists + staffs	10	100	-	-	-
IAPP + PGB+ CSISA	3	350	-	-	-
Total	57	770	350	0	118
Grand total			1238		

Table 12. Seed production activities of BRRI developed hybrids during Boro of 2014-15 both at private and public sectors.

Company	Variety	Location	Area (Acre)	Seed produced (kg)
Nayan seed, Shibganj, Bogra	BHD2	Shibganj, Bogra	11.0	13000
Nayan seed, Shibganj, Bogra	BHD3	Shibganj, Bogra	10.7	11000
M/S A Hoque, Gaibandha	BHD2	Gaibandha	1.25	1400
Hanif Seed Company Pirgong, Rangpur	BHD3	Pirganj	0.33	300
Hi- Tech Agro (HITCO), Thakurgaon	BHD3	Thankurgaon	0.66	500
Matiur Rahman Sadek (farmer)	BHD3	Habiganj	0.66	800
Sohel Ahmed	BHD3	Nilphamari	1.0	700
Barisal (Farmer’s field) IAPP	BHD3	Gajalia, Barisal	0.66	650
Rangpur R/S GOB	BHD3	Rangpur RS	0.40	120
Bhanga R/S GOB	BHD3	Near by Bhanga RS	0.40	150
Barisal (Farmer’s field) GOB	BHD3	Gajalia, Barisal	0.33	350
BRRI HQ PGB project	BHD3	BRRI HQ	0.25	250
BRRI HQ PGB project	BHD2	BRRI HQ	0.38	260
BRRI HQ, GOB	BHD2	BRRI HQ	0.25	100
BRRI HQ, GOB	BHD3	BRRI HQ	0.25	120
BRRI HQ, GOB	BHD4	BRRI HQ	0.75	450
Total			29.27	3015

Agronomy Division

SUMMARY

Yield performance was found significantly higher of BRRI dhan48 at Barguna sadar in Aus season as well as BRRI dhan52 and BRRI dhan62 at Uzirpur and BRRI dhan49 at Kolapara in T. Aman season with BRRI recommended practices.

Among eight promising lines, BR7697-16-2-2-1-1 gave comparable grain yield with BRRI dhan49 and it matured 2-6 days earlier in T. Aman season.

Among six promising lines in Boro season, BR7833-11-1-1-3-4 and BR7369-10-5-2-3 produced significantly higher grain yield irrespective of planting date and matured 2-4 days earlier than BRRI dhan28 and BRRI dhan63 respectively.

The estimated optimum doses of nitrogen for BRRI dhan49, BRRI dhan56, BRRI dhan57 and BRRI dhan62 were 79, 66, 66 and 65 kg N ha^{-1} respectively. The optimum nitrogen doses for BRRI dhan58, BRRI dhan59, BRRI dhan60 and BRRI dhan61 were 138, 142, 148 and 142 kg N ha^{-1} respectively.

BRRI dhan57 produced significantly higher yield (4.16 t/ha) than both NERICA-1 and NERICA-10 with 150 kg ha^{-1} urea.

NPK briquette produced 22-34% and 23% higher grain yield over farmer's practice during Aus and Boro season respectively in three and four locations of Barisal region. However, USG application gave 18-32% higher grain yield in T. Aman season over farmer's practice in four locations of Barisal region.

Along with a hand weeding both post emergence herbicides Pretilachlor+ Pyrazosulfuran ethyl @ 750 g/ha controlled *Cyperus difformis* and Bispyribac sodium @ 150 g ha^{-1} controlled *Cyperus difformis* and *Scripus maritimus* more than 80% in direct seeded Aus rice.

In Rangpur region, both BRRI dhan51 and BRRI dhan52 produced additional grain yield by transplanting of 45-day-old seedling with 20 × 20 cm spacing and four seedlings per hill on 3rd week of July and applying 30 kg ha^{-1} additional N after 15 days of de submerge.

In Rangpur region, BRRI dhan56, BRRI dhan57 and BRRI dhan62 planted on 4th week of July by 25-day-old seedling with 20 × 15 cm spacing, two seedlings per hill and weed management by either pre emergence herbicide or post emergence herbicide along with one hand weeding produced higher yield under drought prone area during T. Aman season.

Nitrogen application (168 kg ha^{-1}) in four splits gave the highest grain yield (7.61 t ha^{-1}) followed by USG application plot (7.16 t ha^{-1}) in mechanical transplanted condition in Boro season.

BRRI dhan60, BRRI dhan29 and BRRI dhan58 gave 21, 16 and 10 percent higher grain yield respectively with USG application than farmers' practice in Gopalganj district.

Yield improvement of BRRI varieties were on average 23% due to herbicide and BRRI weeder used and 59% and 50% weeding cost were reduced by herbicide and BRRI weeder used over hand weeding.

PLANTING PRACTICES

Comparative yield performance of rice by applying BRRI recommended practices during Aus and T. Aman seasons in Barisal region

Field trials were conducted at Barguna in Aus 2014 and at Uzirpur of Barisal and Kolapara, of Patuakhali in T. Aman 2014 to find out the suitable rice varieties for these locations. BRRI recommended fertilizer doses of TSP, MOP, gypsum and $ZnSO_4$ were applied during final land preparation except urea, which was top dressed as equal splits.

During Aus season at Barguna, BRRI dhan48 produced the highest yield, which is statistically identical to BRRI dhan27, BINA dhan14 and BRRI dhan55. The lowest grain yield was found in local variety (Gotairri). The highest yield by BRRI dhan48 might be because of the highest number of grain panicle^{-1} and the lowest percentage of sterility (Table 1). During T. Aman season in Uzirpur, BRRI dhan52 produced the highest grain yield. Grain yield of BRRI dhan62 and local variety Kaoathoti was similar but growth duration of local variety was one month longer than BRRI dhan62. In Kolapara, BRRI dhan49 gave the highest grain yield among the tested varieties (Table 2).

Table 1. Yield performance of modern rice varieties in Barguna Sadar, Baguna, Aus 2014.

Treatment	Plant ht at harvest (cm)	Panicle/m^2	Grain/panicle	Sterility (%)	Grain yield (t/ha)
BRRI dhan27	130.67	358	88	15.33	3.65
BRRI dhan48	99.00	375	109	14.33	4.06
BRRI dhan55	96.67	358	83	15.20	3.06
BINA dhan14	95.67	333	77	15.40	3.48
Local variety (Gotairri)	112.67	359	62	18.10	2.77
CV (%)	0.40	1.80	6.90	6.30	0.80
LSD $_{(0.05)}$	0.87	12.15	10.90	1.81	0.53

Table 2. Yield performance of modern rice varieties in T. Aman season at Barisal region.

Uzirpur, Barisal			Kolapara, Patuakhali		
Treatment	Growth duration	Grain yield (t ha^{-1})	Treatment	Growth duration	Grain yield (t ha^{-1})
BRRI dhan41	149	4.40	BRRI dhan44	142	5.07
BRRI dhan52	147	5.09	BRRI dhan49	136	5.70
BRRI dhan62	103	3.28	BRRI dhan52	142	5.04
Local variety(Kaoathoti)	147	3.31	Local variety (Tepu)	132	4.10
CV%	0.60	5.00	CV (%)	0.70	3.50
LSD (0.05)	1.72	0.41	LSD $_{(0.05)}$	1.91	0.36

Effect of planting time on growth and yield of advanced lines in T. Aman season

Planting time is one of the key factors to release a variety and considering this, a trial was conducted at the BRRI, Gazipur in Aman 2014 to select the best promising lines. Eight promising lines viz BR7697-15-4-4-2-1, BR7697-15-4-4-2-1, BR7697-15-4-4-2-2, BR7697-16-2-2-1-1, BR7369-52-3-2-1-1, BR7468-12-1-1-1-1, BR7472-16-2-1-2-1, BR7638-7-2-5-2 were evaluated with check varieties BRRI dhan32, BRRI dhan37 and BRRI dhan49. Entries were planted from 14 July to 12 September with 15 days intervals. Thirty-day-old seedling was transplanted with 20 × 20 cm spacing. The treatments were distributed in a split-plot design, placing planting date in the main plots and entries in the sub-plots. Grain yield and growth duration gradually decreased with the advancement of planting dates irrespective of entry. None of the promising line produced higher grain yield over the check varieties irrespective of planting date. However, only BR7697-16-2-2-1-1 showed comparable grain yield with BRRI dhan49 and it matured 2-6 days earlier (Table 3).

Effect of planting time on growth and yield of advanced lines in Boro season

Trials were conducted at the BRRI farm, Gazipur during Boro 2014-15 to find out the optimum planting time of potential promising lines. Six lines viz BR7781-10-2-3-2, BR7369-10-5-2-3, NERICA Mutant, BR7833-11-1-1-3-4, BR7830-16-1-5-9-9, BR7369-52-3-2-1- 1 including check BRRI dhan28, BRRI dhan45, BRRI dhan50, BRRI dhan63 and BRRI dhan64 were planted from 15 January to 15 March with 15 days interval. Forty-day-old seedlings were transplanted with application of N-P-K-S as urea, TSP, MOP and gypsum at 120-35-60-10 kg ha^{-1}. The grain yield and field duration were gradually decreased in delayed planting circumstances. BR7833-11-1-1-3-4 produced significantly higher grain yield irrespective of planting date and matured 3-4 days earlier than BRRI dhan28. BR7369-10-5-2-3 also produced higher grain yield compared to BRRI dhan63 and matured 2-3 days earlier (Table 4).

FERTILIZER MANAGEMENT

Determination of nitrogen requirement for newly released Boro and T. Aman varieties

Nitrogen fertilizer is one of the major concerns for having potential grain yield and economic benefit by reducing the use of urea. It increases nitrogen use efficiency (NUE) and also improves soil environment. Therefore, two field experiments were conducted at BRRI, Gazipur to determine nitrogen requirement for newly developed varieties in T. Aman (2013 and 2014) and Boro (2013-14,

Table 3. Effect of planting time on yield and growth duration (in the parenthesis) of advanced lines/varieties in Aman, 2014-15, BRRI, Gazipur.

Advanced line/variety	Transplanting date				
	14 Jul	29 Jul	13 Aug	28 Aug	12 Sep
BR7697-15-4-4-2-1	4.77(135)	3.97(131)	3.77 (127)	3.53(123)	1.2(118)
BR7697-15-4-4-2-2	4.30(137)	3.80(133)	3.30(128)	3.20(124)	*NF
BR7697-16-2-2-1-1	5.20(134)	4.07(130)	3.50(126)	3.30(122)	1.30(118)
BR7369-52-3-2-1-1	3.90(136)	3.83(133)	3.57(128)	3.23(125)	*NF
BRRI dhan 37(ck)	3.73(138)	3.07(135)	2.93(130)	2.73(126)	*NF
BR7468-12-1-1-1-1	4.57(132)	4.30(128)	4.03(124)	3.60(120)	0.58(116)
BR7472-16-2-1-2-1	4.43(135)	3.93(131)	3.87(127)	3.67(123)	*NF
BR7638-7-2-5-2	4.77(133)	4.0(129)	3.37(125)	3.10(120)	*NF
BRRI dhan 32(ck)	4.87(129)	4.47(125)	4.20(121)	3.15(118)	*NF
BRRI dhan 49(ck)	5.57(136)	5.50(132)	5.20(129)	4.0(125)	1.25(121)

Table 4. Effect of planting time on yield and growth duration (in the parenthesis) of advanced lines/varieties in Boro 2014-15, BRRI, Gazipur.

Advanced line/variety	Transplanting date				
	15 Jan	30 Jan	14 Feb	1 Mar	15 Mar
BR7781-10-2-3-2	5.43(145)	5.40(142)	5.07(138)	4.17(134)	2.07(130)
BR7369-10-5-2-3	6.90(148)	6.67(144)	6.23(141)	4.13(137)	*NF
NERICA Mutant	6.0(145)	5.40(141)	5.23(137)	4.0(135)	1.8(132)
BR7833-11-1-1-3-4	7.23(140)	6.65(137)	5.96(134)	4.23(131)	3.73(127)
BR7830-16-1-5-9-9	6.83(152)	6.40(148)	5.70(144)	3.33(141)	2.80(137)
BR7369-52-3-2-1-1	6.5(156)	5.90(152)	5.37(146)	*NF	*NF
BRRI dhan28 (ck)	7.06(143)	6.50(140)	5.83(137)	4.13(134)	3.67(129)
BRRI dhan45 (ck)	5.97(142)	5.67(139)	5.13(136)	3.70(132)	2.63(128)
BRRI dhan50 (ck)	6.07(156)	5.73(153)	5.40(150)	4.20(146)	2.67(142)
BRRI dhan63 (ck)	7.02(150)	6.77(147)	5.93(145)	4.07(141)	3.37(137)
BRRI dhan64 (ck)	6.63(155)	6.27(151)	6.0(147)	3.57(143)	2.67(141)

2014-15) season. BRRI dhan49, BRRI dhan56, BRRI dhan57 and BRRI dhan62 were tested in T. Aman and four varieties BRRI dhan58, BRRI dhan59, BRRI dhan60 and BRRI dhan61 were tested under Boro season. In T. Aman, N were applied @ 25, 50, 75 kg ha^{-1} as prilled urea, LCC based (52 kg N ha^{-1}), USG (50 kg N ha^{-1}) and control (without N). In Boro, N were managed by 80, 120, 160, 200 kg ha^{-1} as prilled urea, USG (75 kg N ha^{-1}) and control. The treatments were laid with split plot design, placing varieties in main plot and N management in the sub plot with three replications. Two years pooled data were considered to calculate the yield and optimum N rate. The optimum N doses of each variety were determined by regression of grain yield with N rates: $Y = a + bN + cN^2$. Where, Y is rice yield (kg/ha), N is nitrogen dose (kg/ha), a means intercept (estimated yield without N application), b and c are coefficients respectively (Saleque *et al.*, 2004). Differentiating Y with respect to N of the Eqn gives the nitrogen dose for the maximum yield. The estimated nitrogen dose for maximum yield N= -b/2c. The grain yield of T. Aman varieties showed at different levels of N and USG application was estimated through regression equation from two years pooled data (Fig. 1A). The relationship of grain yield and applied nitrogen in different varieties were quadric. The quadratic regression equation of BRRI dhan49, BRRI dhan56, BRRI dhan57 and BRRI dhan57 were, $y = -0.0003x^2 + 0.0467x + 2.8507$; $R^2 = 0.992^{**}$, $y = -0.0004x^2 + 0.0515x + 2.7003$; $R^2 = 0.957^{**}$, $y = 0.0003x^2 + 0.0438x + 2.64$; $R^2 = 0.982^{**}$ and $y = 0.0003x^2 + 0.0369x + 2.620$; $R^2 = 0.944^{**}$ respectively. Nitrogen treatment accounted for about 99, 95, 98 and 94% variation in grain yield of BRRI dhan49, BRRI dhan56, BRRI dhan57 and BRRI dhan62 consequently. The estimated optimum dose of nitrogen for BRRI dhan49, BRRI dhan56, BRRI dhan57 and BRRI dhan62 were 78, 73, 64 and 61.5 kg N ha^{-1} respectively.

The variation of grain yield of Boro rice varieties at different levels of N with USG application was also estimated through regression equation using two years pooled data (Fig. 1B). The relationship of grain yield and applied nitrogen in different varieties was quadric. The quadratic regression equation of BRRI dhan58, BRRI dhan59, BRRI dhan60 and BRRI dhan61 were, $y = -0.0002x^2 + 0.0555x + 3.20$, $R^2 = 0.971^{**}$, $y = 0.000x^2 + 0.0495x + 3.14$, $R^2 = 0.953^{**}$, $y = -0.000x^2 + 0.0521x + 3.03$, $R^2 = 0.977^{**}$ and $y = 0.0002x^2 + 0.052x^2 + 3.0635$, $R^2 = 0.967^{**}$ respectively. Nitrogen treatment accounted for about 97, 95, 98 and 96% variation in grain yield of BRRI dhan58, BRRI dhan59, BRRI dhan60 and BRRI dhan61 respectively. The optimum nitrogen dose for BRRI dhan58, BRRI dhan59, BRRI dhan60 and BRRI dhan61were 138, 124, 130 and 125 kg N ha^{-1} respectively.

Response of Nerica rice to nitrogen fertilization in Aman season

An experiment was conducted during T. Aman 2014 at BRRI, Gazipur with three rice varieties viz NERICA-1, NERICA-10 and BRRI dhan57 and five urea doses viz 0, 50, 100, 150 and 200 kg ha^{-1}. TSP, MOP, gypsum and zinc was applied at 150-52.5-82.5-0 kg ha^{-1}. The experimental design was RCBD and replicated thrice. BRRI dhan57 produced significantly higher yield (4.16 t ha^{-1}) than both of NERICA-1 and NERICA-10 with 150 kg ha^{-1} urea. Although, grains panicle^{-1} and 1000-grain weight were not influenced by urea application in any tested entry, number of panicle production was significantly higher in BRRI dhan57 with higher level of urea application (Table 5).

Validation of nutrient management options for increasing yield at farmer's condition during Aus, Aman and Boro seasons in Barisal region

The experiment was conducted to findout the best option of fertilizer requirement for growing rice in Aus, Aman and Boro seasons at farmer's field. The treatments were; i) BRRI recommended fertilizer, ii) USG application, iii) NPK briquette application and iv) Farmer’s practice. The experiment area was laid out in RCB design with three replications. BRRI recommended fertilizer dose of TSP, MOP, gypsum and $ZnSO_4$ were applied during final land preparation except urea. USG or NPK briquettes were applied after 7 DAT and prilled urea was top dressed at three equal splits. In Aus and T. Aman 2014, USG one piece (weight 1.8 g) and NPK briquette one piece (weight 3.4 g) and in Boro 2014-15, USG one piece (weight 2.7 g) and NPK briquette two pieces (weight 2.4 g each) were applied within four hills of rice plants as per-treatment. NPK briquette treatment produced 22-34% higher grain yield during Aus season over

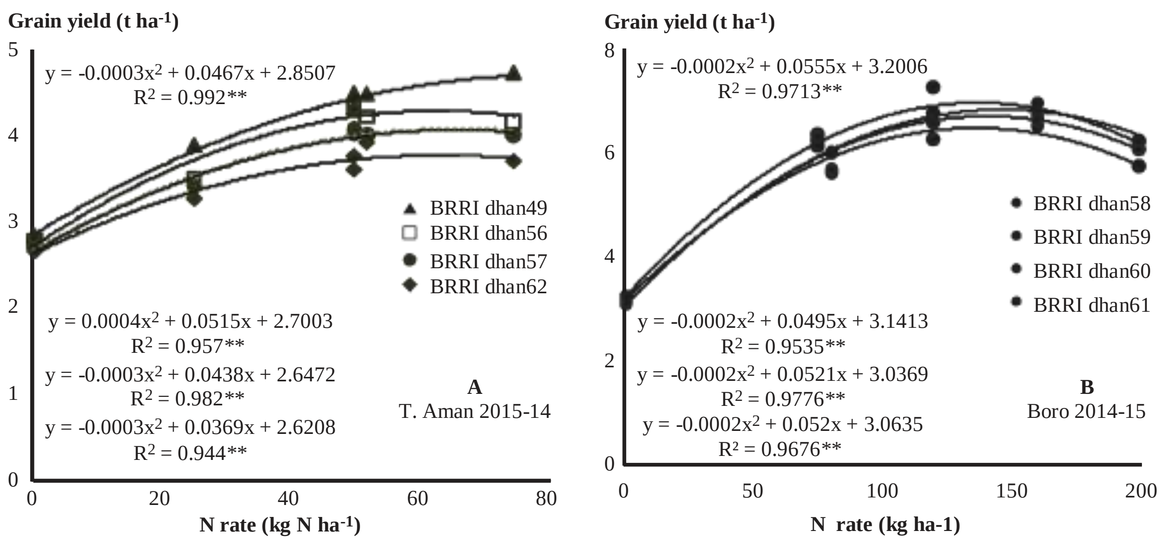


Fig. 1. Grain yield of modern T. Aman and Boro varieties as affected by N levels from prilled urea and USG.

Table 5. Effect of urea fertilizer on the performance of rice varieties in Aman 2014, BRRI, Gazipur.

Urea dose (kg/ha)	Panicle/m^2	Grains/ Panicle	TGW (g)	Grain yield (t/ha)
		Nerica-1		
0	121	52	26.90	1.17
50	115	68	27.23	1.32
100	146	65	25.47	2.13
150	135	73	28.90	2.67
200	132	75	28.63	2.66
		Nerica-10		
0	131	68	24.13	1.37
50	127	79	25.13	1.67
100	143	77	22.83	2.35
150	150	76	24.90	2.65
200	147	74	25.26	2.64
		BRRI dhan57		
0	176	129	18.73	2.71
50	167	133	18.47	3.17
100	178	151	18.57	3.84
150	202	144	17.83	4.16
200	203	141	18.33	4.06
CV(%)	2.52	17.68	6.42	2.17
LSD (0.05)	6.50	Ns	Ns	0.093

farmer's practice in three locations (Table 6). On the other hand, USG treatment gave 18-32% higher grain yield in T. Aman season over farmer's practice in four locations (Table 7). During Boro season, NPK briquette treatment produced 23% higher grain yield over farmer's practice in four locations of Barisal region (Table 8).

WEED MANAGEMENT

Weed control methods on productivity of direct dry seeded rice in Aus season

A study was undertaken at the BRRI farm, Gazipur to determine effective weed control methods in B. Aus rice. BRRI dhan43 were sown in line on 22 April 2014 with 20 cm spacing. The treatments

Table 6. Effect of nutrient management options on the yield of BRRI dhan48 during Aus 2014 in Barisal region.

Treatment	Grain yield (t ha^{-1})		
	Bakerganj	Rajapur	Amtoli
BRRI recommended dose	4.53	4.75	4.66
USG treated plot	4.76	4.88	5.02
NPK briquette plot	4.95	5.01	5.53
Farmer's practice	3.70	3.77	4.54
CV (%)	3.50	1.00	0.90
LSD $_{(0.05)}$	0.31	0.91	0.81

were; i) Post-emergence herbicide + 1 HW, ii) Post-emergence herbicide+ 2 HW, iii) Hand weeding at 15 and 30 DAS and compared with iv) control (No weeding). The post-emergence herbicides Pretilachlor + Pyrazosulfuran ethyl @ 750 g/ha, and Bispyribac sodium @ 150 g/ha applied at 6 DAS in direct seeding method. The treatments were distributed following RCB design with three replications. BRRI recommended fertilizer dose and other cultural management practices were followed. Six different weed species were observed in unweeded (control) plot where most dominating weeds were grass and sedges. post-emergence herbicide Pretilachlor+ Pyrazosulfuran ethyl + 1HW controls *Cyperus difformis* more than 80% whereas, post-emergence herbicide bispyribac sodium + 1 HW control *Cyperus difformis* and *Scripus maritimus,* 80.97% and 81.23%, respectively (Table 9). So, post-emergence herbicide application along with one hand weeding effectively control weeds in direct dry seeded condition and consequently gave higher yield.

YIELD MAXIMIZATION

Validation of nutrient and crop management options

BRRI dhan51 and BRRI dhan52. Two experiments were conducted at three different farmer's fields separately at Pirgasa, Rangpur, Lalmonirhat sadar and Sayedpur, Nilphamari to identify recommend appropriate nutrient management and other crop management option for yield maximization of submergence tolerant varieties BRRI dhan51 and BRRI dhan52.

The tested management options were: T_1=Management 1 + AEZ Fertilizer based recommended nutrient management + 30 kg Nha^{-1} additional after 10 days desubmerge, T_2=Management 1 + AEZ Fertilizer based recommended nutrient management + 30 kg Nha^{-1} additional after 15-day desubmerge, T_3=Management 2 + AEZ Fertilizer based recommended nutrient management + 30 kg Nha^{-1} additional after 10 days desubmergence, T_4=Management 2 + AEZ Fertilizer based

Table 7. Effect of nutrient management options on the yield of rice varieties during T. Aman 2014 in Barisal region.

Treatment	Grain yield (t ha^{-1})			
	Babuganj	Jhalokathi sadar	Barguna sadar	Amtoli
	BRRI dhan52	Moulata	Sadamota	BRRI dhan52
BRRI recom. dose	4.70	2.21	3.25	5.02
USG treated plot	4.94	2.50	3.42	5.42
Farmer's practice	3.73	1.86	2.91	4.56
CV (%)	3.30	3.20	2.80	1.80
LSD $_{(0.05)}$	0.33	0.16	0.23	0.21

Table 8. Effect of nutrient management options on the yield of rice varieties in Boro 2014-15 in Barisal region.

Treatment	Grain yield (t ha^{-1})			
Location	Banaripara	Nolchiti	Barguna Sadar	Betagi
	BRRI dhan29	BRRI dhan55	BRRI dhan55	BRRI dhan28
BRRI recom. dose	7.34	6.98	5.89	6.16
USG treated plot	7.05	7.08	6.14	6.21
NPK briquette	7.80	7.14	6.18	6.40
Farmer's practice	6.32	5.79	5.03	5.56
CV (%)	2.2	1.3	2.2	0.8
LSD $_{(0.05)}$	0.31	0.18	0.26	0.95

Table 9. Performance of the integrated weed control option for increasing yield of rice in Boro at Barisal region.

Treatment	Grain yield (t/ha)		
Location	Banaripara	Aguiljhara	Betagi
	BRRI dhan29	BRRI dhan28	BRRI dhan28
Pretilachlor+ Pyrazosulfuran ethyl +1HW	7.19	6.18	6.21
Post Bispyribac sodium +1HW	7.28	-	-
Hand weeding	7.34	6.27	6.39
Farmer’s practice	5.55	5.41	5.57
CV (%)	4.6	2.1	1.6
LSD $_{(0.05)}$	0.62	0.28	0.22

recommended nutrient management + 30 kg Nha^{-1} additional after 15-days desubmerge and T_5=Farmer management. Where Management 1 was 30-day-old seedling with 20 × 25 cm spacing, two seedlings per hill and 1st week of July transplanting and Management 2 was 45-day-old seedling with 20 × 20 cm spacing and four seedlings per hill and 3rd week of July. The experiment was laid down in RCB design with three replications. All fertilizers were applied as basal before transplanting except urea. Other intercultural operations were done as and when necessary.

Grain yield of BRRI dhan51 and BRRI dhan52 were significantly affected by different treatments during T. Aman 2014 season (Figs. 2 and 3) at different locations. The highest grain yield was observed at treatment T_4 followed by T_2 both the experiment by BRRI dhan51 and BRRI dhan52 but the lowest grain yield was obtained from treatment T_5 at each locations. Based on these two experiment results from three different locations it may be concluded that for obtaining higher grain yield from BRRI dhan51 and BRRI dhan52 at Rangpur region at submergence ecosystem in T. Aman season transplanting should be done on the third week of July with 45-day-old seedling and four seedlings per hill, maintaining 20 × 20 cm spacing. Additional 30 kg ha^{-1} N with recommended rate after 15 days of desubmergence at the vegetative stage should be applied. (Note: BRRI dhan52 was totally damaged by 16 days submergence at Sayedpur, Nilphamari).

BRRI dhan56, BRRI dhan57 and BRRI dhan62. These three experiments were conducted at three different farmer's field separately at

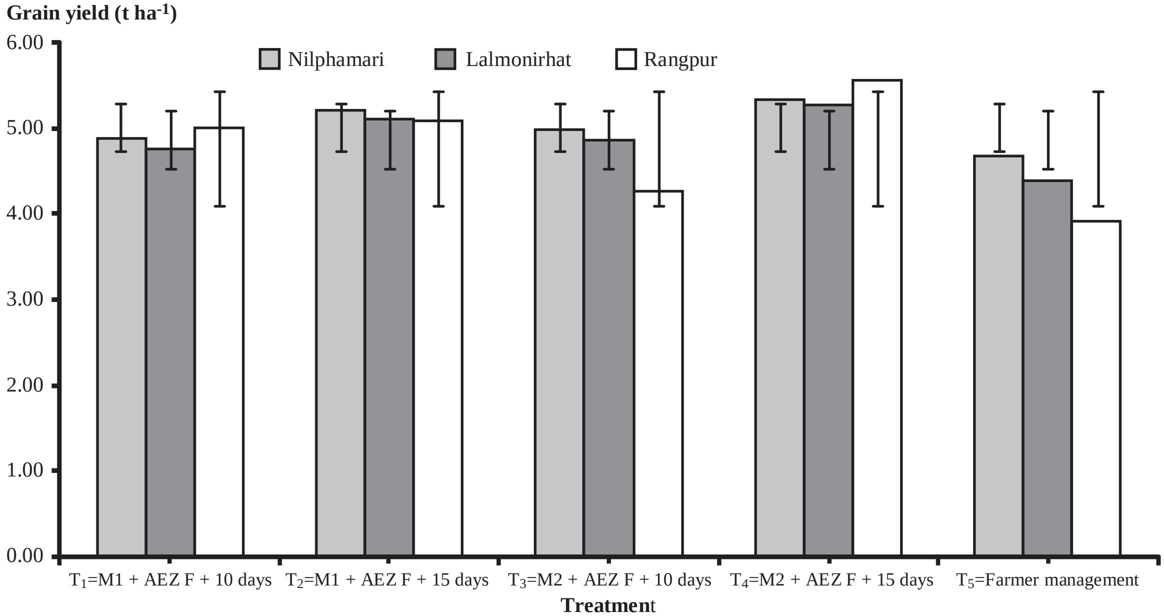


Fig. 2. Effect of different nitrogen and crop management options for yield maximization of BRRI dhan51 at three different locations in Rangpur region in T. Aman.

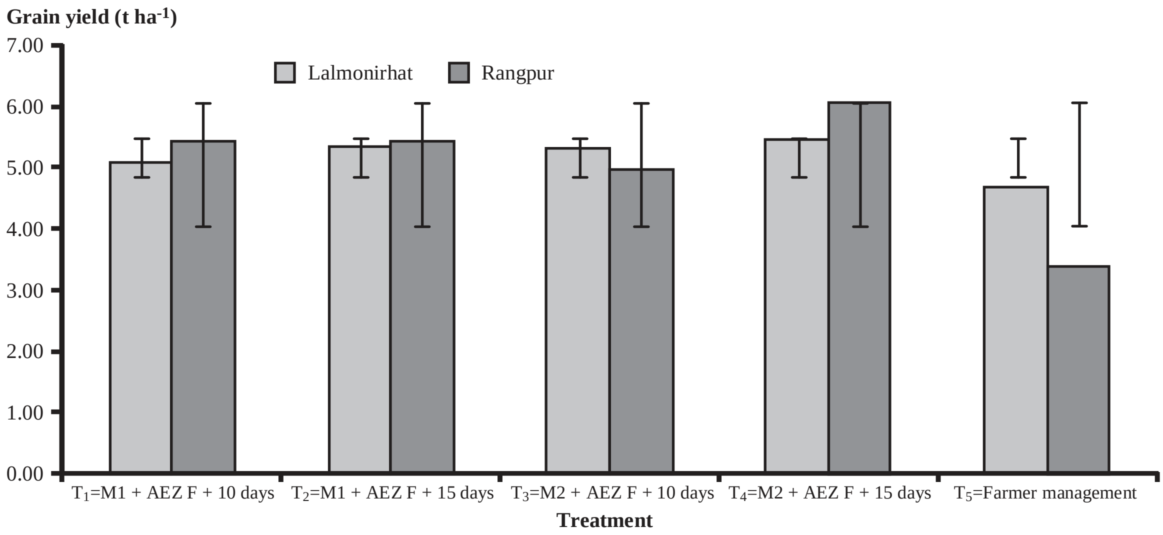


Fig. 3. Effect of different nitrogen and crop management options for yield maximization of BRRI dhan52 at three different locations in Rangpur region in T. Aman.

Pirgasa, Rangpur, Kaliganj, Lalmonirhat and Sayedpur, Nilphamari to identify and recommend appropriate weed and crop management option for yield maximization of BRRI dhan56, BRRI dhan57 and BRRI dhan62 under drought condition during T. Aman season. The tested management options were: T_1=Crop management-1 + pre-emergence herbicide + one hand weeding, T_2=Crop management-1 + post-emergence herbicide + one hand weeding, T_3=Crop management-1 + pre-emergence herbicide + post emergence herbicide, T_4=Crop management-2 + pre emergence herbicide + one hand weeding, T_5=Crop management-2 + post emergence herbicide + one hand weeding,

T_6=Crop management-2 + pre emergence herbicide + post emergence herbicide and T_7=Farmer's practice. Where Crop management-1: 25-day- old seedling with 20 × 15 cm spacing, two seedlings per hill and 4th week of July transplanting and Crop management-2: 35-day-old seedling with 20 × 20 cm spacing, two seedlings per hill and 1st week of August transplanting. The experiment was laid down in RCB design with three replications. All fertilizers were applied as basal before transplanting except N.

Grain yield of BRRI dhan56, BRRI dhan57 and BRRI dhan62 were significantly affected by different treatments at all locations (Figs. 4-6) in T. Aman 2013. The highest grain yield was observed from treatment $T_{1,}$ T_2 and T_3 by all the tested varieties which mean management-1 performed higher grain yield than management-2 at all the locations by both the tested varieties. Similarly, the tested weed control options have no significant yield difference under both the managements in all locations. Based on the three location's results it may be concluded that crop management-1 i.e. 25-day-old seedling with 20 × 15 cm spacing, two seedlings per hill and 4th week of July transplanting with any one of the tested three weed management options ie pre-emergence herbicide + one hand weeding or post-emergence herbicide + one hand weeding or pre-emergence herbicide + post-emergence herbicide may be adopted for higher yield for BRRI dhan56, BRRI dhan57, and BRRI dhan62 under drought prone ecosystem of Rangpur region in T. Aman.

PROJECT ACTIVITY

Livelihood improvement through resource conservation of farmer by PGB IADP. Field demonstrations were carried out with balanced fertilizer application and weed management technologies to show the effect of balanced fertilization and cost effective weed management in the farmers field of Pirojpur, Gopalganj and Bagerhat district during T. Aman 2014 and Boro 2015 under the project of IADP-PGB. During T. Aman 2014 season, a number of 17 demonstrations were carried out regarding fertilizer management (Table 10). BRRI recommended rate of urea, TSP, MoP, gypsum and zinc fertilizer were used to compare with farmers' practice (fertilizer application). Different BRRI developed T. Aman varieties were used to popularize in different locations. In every location, BRRI recommended fertilizer management practice over yielded

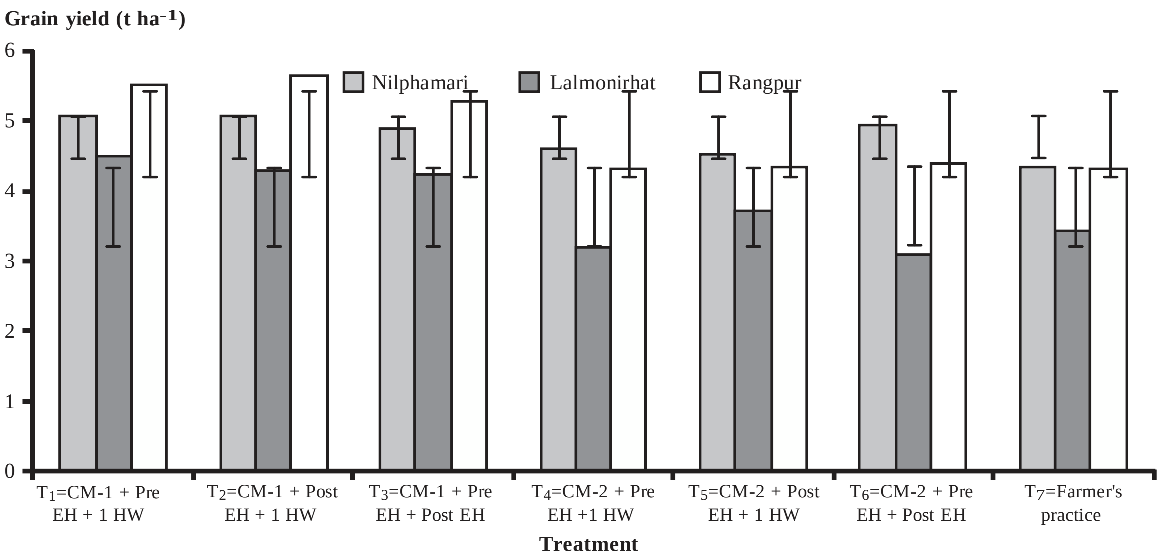


Fig. 4. Effect of different weed control options and crop management for yield maximization of BRRI dhan56 at three different locations in Rangpur region in T. Aman.

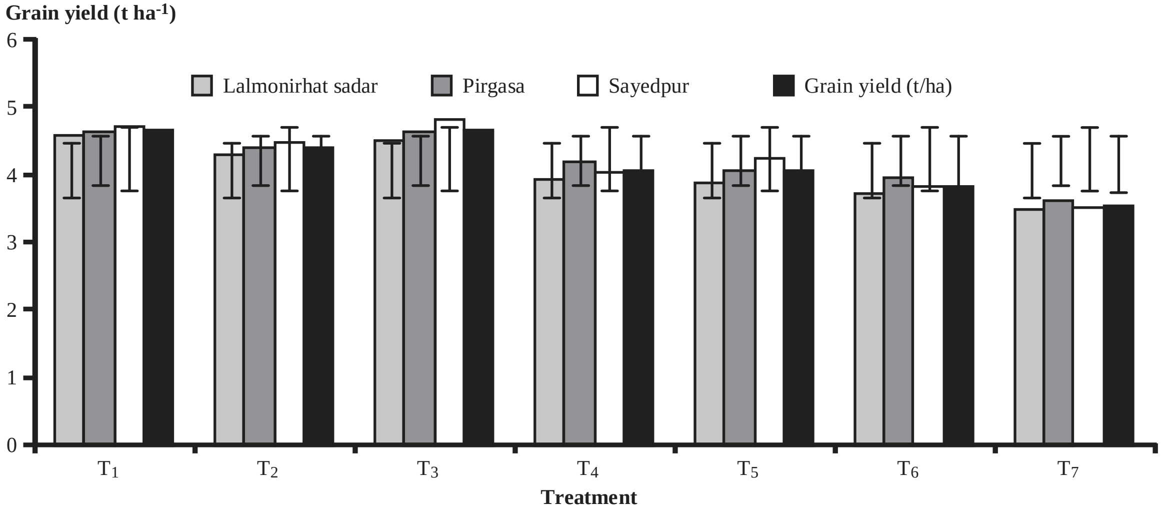


Fig. 6. Effect of different weed control options and crop management for yield maximization of BRRI dhan62 at three different locations in Rangpur region in T. Aman.

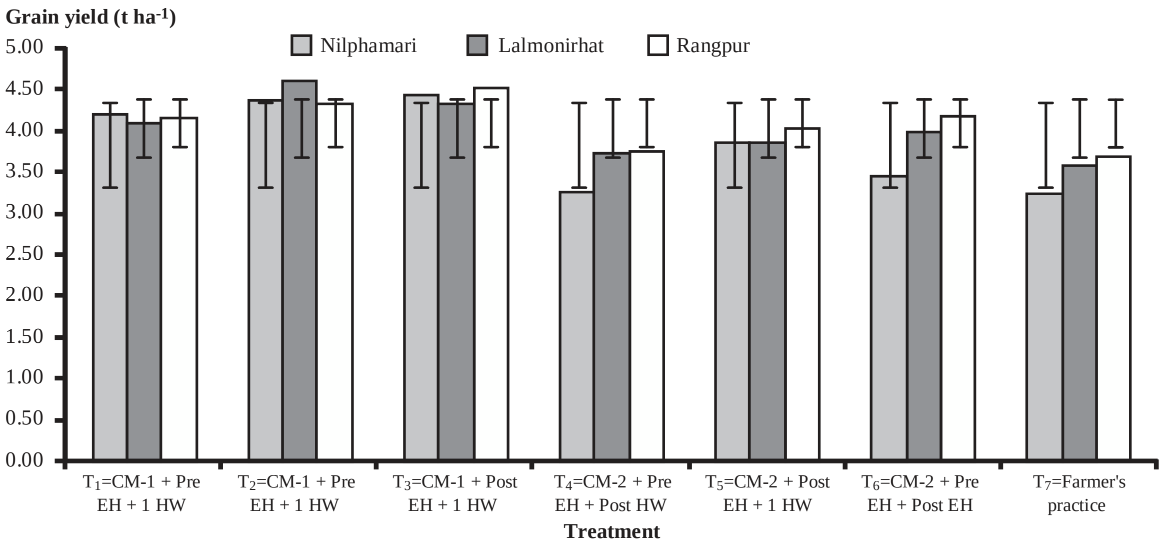


Fig. 5. Effect of different weed control options and crop management for yield maximization of BRRI dhan57 at three different locations in Rangpur region in T. Aman.

compared to farmers' practice. On verage 15% grain yield were increased over variety and locations with BRRI recommended fertilizer management.

Eighteen weed management demonstrations were conducted at different upazilas of Pirojpur, Gopalganj and Bagerhat districts during T. Aman 2014. In each upazila three trials were set up. Weed management treatments were: Herbicide + 1HW, BRRI weeder + 1HW, which were compared with farmers practice. In every location, farmers used to practice hand weeding. Data shows that (Table 11) in all the locations herbicide+1HW and BRRI weeder+1HW produced more grain yield compared to farmer's practice. For herbicide treatment, average yield improvement over farmer's practice was 23% and for BRRI weeder+1HW treatment average yield improvement over farmer's practice wsa 21%. Table 12 shows that about 59% cost was reduced due to herbicide use whereas, 50% cost

Table 10. Grain yield of modern T. Aman varieties in different upazilas of Pirojpur, Gopalganj and Bagerhat district compared to farmers practice in T. Aman 2014.

Upazilla	Village	Variety	BRRI RP	FP	% yield increase
Kashiani	Majraghat	BRRI dhan41	4.94	4.41	10.74
Gopalganj sadar	Kobra	BRRI hybrid dhan4	4.83	4.5	6.89
	Kobra	BRRI dhan34	3.84	3.8	0.99
	Gonapara	BRRI dhan33	4.90	4.3	12.32
	Manikda	BRRI hybrid dhan4	5.38	5.1	5.22
Tungipara	Kulsa	BRRI hybrid dhan4	5.29	4.45	15.85
	Nilpha	BRRI dhan39	5.37	4.22	21.41
Mollarhat	Voirabnagar	BRRI hybrid dhan4	5.81	4.33	25.43
	Garfa	BRRI dhan62	4.63	3.44	25.66
	Doibokandhi	BRRI dhan49	5.28	4.56	13.62
Fakirhat	Pagla	BRRI dhan54	5.29	4.23	20.10
	Betaga	BRRI dhan62	4.74	4.00	15.69
	Artaki	BRRI dhan52	5.72	4.73	17.28
Mukshudpur	Tangrakhala	BRRI dhan39	5.12	4.24	17.20
	Gopinathpur	BRRI dhan54	5.49	4.83	12.03
Sarupkathi	Krishnakathi	BRRI dhan41	5.02	4.32	13.91
	Krishnakathi	BRRI dhan41	4.88	4.2	13.94
Average yield improvement over FP irrespective of varietiy					15

Table 11. Weed management technology validation in the farmer's field of Pirojpur, Gopalganj and Bagerhat district compared to farmers' practice in T. Aman 2014.

Location	Variety	Weed management treatment	Yield (t/ha)	% yield increase over FP
Mollarhat, Bagerhat	BRRI dhan49	Farmer's practice (2HW)	4.32	-
		Pyrazosulfuron ethyl+ 1HW	5.12	19
		BRRI weeder+ 1HW	5.00	16
Nesarabad, Pirojpur	BRRI dhan49	Farmer's practice (2HW)	4.25	-
		Pyrazosulfuron ethyl+ 1HW	5.32	25
		BRRI weeder+ 1HW	5.12	20
Kashani, Gopalganj	BRRI dhan33	Farmer's practice (2HW)	4.49	-
		Pretilachlor+ 1HW	5.44	21
		BRRI weeder+ 1HW	5.10	14
Goplaganj sadar, Gopalganj	BRRI dhan52	Farmer's practice	4.20	-
		Pyrazosulfuron ethyl+ 1HW	5.30	26
		BRRI weeder+ 1HW	4.95	17
Tungipara, Gopalganj	BRRI dhan52	Farmer's practice	4.30	-
		Pyrazosulfuron ethyl+ 1HW	5.25	22
		BRRI weeder+ 1HW	5.11	19
Fakirhat, Bagerhat	BRRI dhan49	Farmer's practice	4.40	-
		Pretilachlor+ 1HW	5.28	21
		BRRI weeder+ 1HW	4.90	16
Average yield increase in herbicide treated plot over FP				23
Average yield increase in BRRI weeder+1HW treated plot over FP				21

Table 12. Weed management cost reduction by using BRRI developed technology.

Weed management	Yield (t/ha)	% yield increase	Cost of weeding/ha	% cost reduction over FP
FP	4.49		13,500	-
Herbicide+ HW	5.44	21	5500	59
BRRI weeder + 1HW	5.10	14	6750	50

was reduced when used BRRI weeder+1HW for weed management of rice.

In Boro 2014-15, a total of 45 field trials were conducted regarding fertilizer management of modern Boro rice in different upazilas of Pirojpur, Gopalganj and Bagerhat district. BRRI dhan28, BRRI dhan29, BRRI dhan50, BRRI dhan58, BRRI dhan60, BRRI dhan61, BRRI hybrid dhan2 and

BRRI hybrid dhan3 were demonstrated with BRRI recommended balanced fertilizer compared with farmers' practice. Results show that in all locations, all the varieties gave 2-10% higher yield with BRRI recommended balanced fertilizer compared to farmers' practice. Over locations BRRI dhan58 produced the highest grain yield compared to BRRI dhan28 and BRRI dhan29. BRRI dhan58 may be replaced with BRRI dhan29 in that area (Fig. 7).

Fertilizer management options of Boro rice established by rice transplanter. The experiment was conducted under AFACI project to find out a suitable fertilizer management schedule for rice that was transplanted by rice transplanter in Boro 2014-15 at BRRI farm, Gazipur. The urea application treatments were T_1=N 140 kg/ha at 3 split, T_2=N 168 kg/ha at 3 split, T_3=N 140 kg/ha at 4 split, T_4=N 168 kg/ha at 4 split, T_5 USG (N75 kg/ha) and T_6 Control (No nitrogen). BRRI recommended basal fertilizer of P, K, S and Zn were applied on the basis of Agro ecological zone in the plots and urea were applied according to treatment. In USG applied plot additional 40 kg/ha N was applied before panicle initiation stage when N deficiency symptoms were shown on leaf. The experiment was conducted in a RCB design and replicated thrice. BRRI dhan29 were transplanted by machine with 24-day-old seedlings on 12 January 2015 using a walking type six rows transplanter. Nitrogen application (168 kg/ha) in four splits gave the highest grain yield (7.61 t/ha) followed by USG application plot (7.16 t/ha) in mechanical transplanted condition (Table 13).

Field validation of USG and BRRI recommended fertilizer management practice at Gopalganj region (PGB IADP). The experiment was conducted at 22 and 20 farmers' field respectively in T. Aman and Boro season at Gopalganj areas under PGB IADP project to validate and disseminate a suitable fertilizer management for rice. BRRI recommended basal fertilizer of P, K, S and Zn were applied on the basis of Agro ecological Zone in the plots and urea were applied as USG and BRRI management. In USG applied plot of BRRI dhan58 and BRRI dhan29 an additional 40 kg/ha N was applied before panicle initiation stage in some plots where N deficiency symptoms were found. BRRI dhan29, BRRI dhan58 and BRRI dhan60 were planted in different upazila of Gopalganj. BRRI dhan60, BRRI dhan29 and BRRI dhan58 gave higher grain yield in USG applied plots and the increasing trends gave 21, 16 and 10 percent higher grain yields irrespective of location with almost same growth duration between the treatments (Table 14).

Table 13. Grain yield and yield components of Nitrogen management options in rice transplanter plot.

Treatment	Panicle no./m^2	Grains /panicle	1000 grains weight (g)	Duration (day)	Grain yield (t/ha)
N 140 kg/ha @ 3 splits	302	104	22.56	154	6.50
N 168 kg/ha @ 3 splits	304	111	22.59	153	6.63
N 140 kg/ha @ 4 splits	307	109	22.65	153	6.87
N 168 kg/ha @ 4 splits	317	114	22.94	155	7.61
USG	314	109	22.61	154	7.16
No urea	274	100	22.34	151	5.71
CV%	5.2	9.2	1.5	0.4	6.3
$LSD_{0.05}$	27.83	17.43	0.60	1.14	0.75

Table 14. Yield increased due to USG application over farmers' practice in different upazilas of Gopalganj district.

Variety	Location	Fertilizer management	Grain yield (t/ha)	Duration (day)	Yield increase (%)
BRRI dhan60	Kashiani, Tungipara	USG	7.89	154.29	21%
No. of farmer 8		Farmers' practice	6.52	154.00	-
BRRI dhan58	Tungipara, Kotalipara	USG	8.69	161.00	10%
No. of farmer 6		BRRI	8.42	160.00	7%
		Farmers' practice	7.98	158.00	-
BRRI dhan29	Gopalganj sadar, Muksudpur	USG	8.97	163.00	16%
No. of farmer 6		BRRI	8.29	165.00	8%
		Farmers' practice	7.71	162.00	-

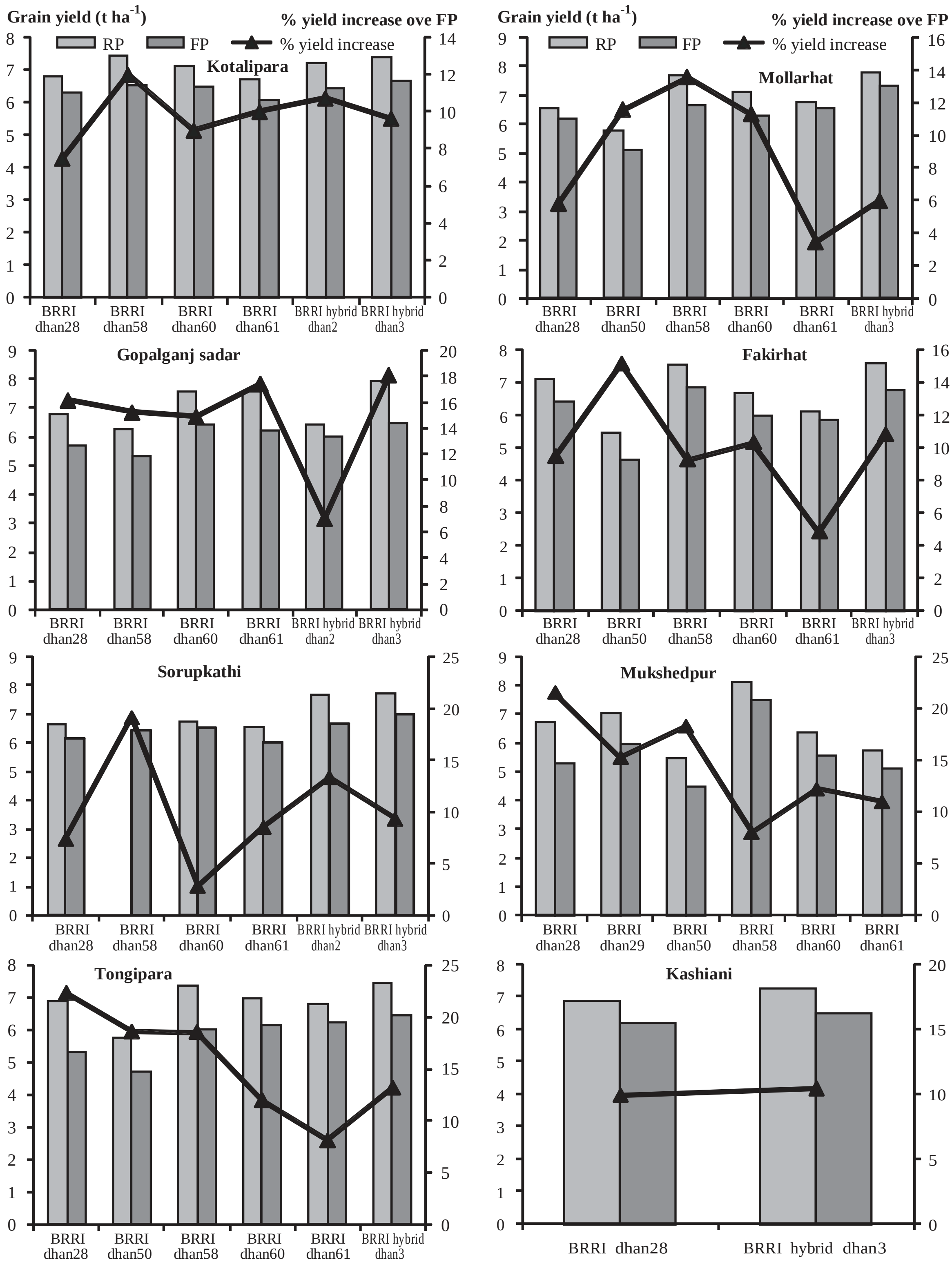


Fig. 7. Grain yield of modern Boro varieties in different upazilas of Pirojpur, Gopalganj and Bagerhat district compared to farmers' practice in Boro 2015.

Soil Science Division

SUMMARY

In T. Aman season, premium quality rice (PQR) genotypes needed maintenance dose of NPK while rainfed lowland rice (RLR) genotype, BR7468-12-1-1-1-1 required only 111 kg N ha^{-1} N and BR7638-7-2-5-2 required no K fertilizer. In Boro season, PQR genotypes required much lower P and K than applied nutrients. BR7369-52-3-2-1-1 required 190 kg N ha^{-1} but BR7781-10-2-3-2 needed 145 kg N ha^{-1}. Nerica Mutant needed 143, 40 and 32 kg ha^{-1} of N, P and K respectively. Micronutrient genotype BR7833-11-1-1-3-4 required more N (176 kg ha^{-1}) than BR7830-16-1-5-9-9 (155 kg ha^{-1}). But both the materials required higher P and lower K than applied rate.

A combination of 50 kg K and 50 kg N ha^{-1} for T. Aman rice (BRRI dhan49) and 150 kg K ha^{-1} and 100 kg N ha^{-1} for Boro rice (BRRI dhan29) cultivation seems to be suitable for desired grain yield of rice.

In AWD condition, Boro rice yield could be increased with the additional (50% more than recommended dose) N and K application.

In Grey Terrace soils (AEZ 28), BRRI dhan58 and BRRI dhan69 were able to produce 5.08-5.60 t ha^{-1} grain yield with 10% and 20% less of recommended fertilizer dose.

Long-term omission of N, P, K an S adversely affected rice yield though S and Zn omission had no negative effect on rice production in Grey Terrace soil of BRRI farm, Gazipur. Long-term application IPNS based chemical fertilizer showed increasing trend of rice yield, while inorganic fertilizer alone showed yield plateau.

Intensive rice cropping without fertilizer reduced grain yield of Boro rice to 0.50 t ha^{-1}. The trend in grain yield with NPKS fertilization over 33 years showed a positive increment compared to base year (1981). Soil productivity can be recuperated to its original state by addition of complete fertilizer dose. The STB fertilizer dose and INM could be good options for higher grain yield of rice in double or triple rice cropping pattern.

Vermicompost at 0.5 Mg ha^{-1} with full doses of chemical fertilizers could be used for sustaining rice productivity and paddy soil health.

Application of N as prilled urea (PU) and USG by applicators gave similar grain yield and N use-efficiency.

In both Rangpur and Barisal regions, BRRI recommended fertilizer dose and rice straw applied with IPNS based chemical fertilizer maximized rice yield. Application of rice straw with IPNS based chemical fertilizer can substitute full dose of K fertilizer in submergence and cold areas. Rice straw applied with IPNS based chemical fertilizer (except N) is a good practice to maximize rice yield in tidal flood ecosystem (Barisal, Jhalkathi, Barguna and Patuakhali).

The amount of floodwater NH_4^+-N was higher in broadcast PU, while it was negligible in deep placement of either urea or NPK briquettes. Deep placement of urea gave significantly higher biomass yield as well as total N uptake in both AWD and CSW conditions. Nitrous oxide and NO fluxes were higher in UDP compared to PU treatment under AWD condition.

Significant variations existed in microbial population at different soil depths. A decreasing trend of population was found with increasing soil depth. Application of organic matter increased total nitrogen fixing and phosphate solubilizing populations. Missing of N and K significantly reduced microbial populations. Significantly high amount of phosphatase phytase and urease enzyme activities were found in organic matter amended treatments.

The effect of NPC fertilizer on Boro rice yield was promising. It helped in obtaining comparable grain yield with DAP and saved about 30% N.

SOIL FERTILITY AND PLANT NUTRITION

Site specific nutrient management for advanced lines

In site specific nutrient management (SSNM) technique, N, P and K fertilizer recommendations are calculated based on i) nutrient requirement for selected grain yield goal, ii) indigenous nutrient supply capacity and iii) recovery of applied nutrients by the plants. However, nutrient requirements vary depending on genotypes, season and growing conditions. So, it is necessary to determine the requirement of these primary nutrients before releasing a new variety.

Field trials were conducted at BRRI farm, Gazipur during T. Aman 2014 and Boro 2014-15 seasons. In T. Aman, four PQR genotypes (BR7697-15-4-4-2-1, BR7697-15-4-4-2-2, BR7697-16-2-2-1-1 and BR7369-52-3-2-1-1) were evaluated with BRRI dhan37, three RLR genotypes (BR7468-12-1-1-1-1, BR7472-16-2-1-2-1 and BR7638-7-2-5-2) were evaluated against BRRI dhan32 and BRRI dhan49. In Boro season, three PQR genotypes (BR7781-10-2-3-2, BR7369-10-5-2-3 and BR7369-52-3-2-1-1) were compared with BRRI dhan50 and BRRI dhan63, two micronutrient genotypes (BR7833-11-1-1-3-4 and BR7830-16-1-5-9-9) were compared with BRRI dhan28 and BRRI dhan64; Nerica Mutant was compared with BRRI dhan28 and BRRI dhan45. Four fertilizer treatments viz T_1=NPK (AEZ-basis), T_2=N omission (-N), T_3=P omission (-P) and T_4=K omission (-K) were imposed in the main plots and rice genotypes in the subplots with three replications. Sulphur was applied as blanket dose. NPKS @ 160-25-65-10 kg ha^{-1} in Boro and 120-15-60-8 kg ha^{-1} in T. Aman were used.

In T. Aman 2014, all PQR genotypes and check variety produced about 2 t ha^{-1} grain yields with added NPK fertilizers. However, PQR genotypes were 10 days earlier than BRRI dhan37. Omission of N, P and K from complete treatment had no effect on grain yield of tested genotypes indicating that a maintenance dose of fertilizer is enough for these entries.

All RLR genotypes out yielded BRRI dha32 with complete NPK fertilizer application. However, BR7638-7-2-5-2 genotype produced significantly higher grain yield (7.04 t/ha) than BRRI dhan49 (6.66 t/ha). Grain yield decreased significantly due to N omission. BR7468-12-1-1-1-1 was not responsive to P and K omission. BR7472-16-2-1-2-1 and BR7638-7-2-5-2 were also responsive to P omission, while all the rice genotypes except BRRI dhan49 were not responsive to K omission. The magnitude of yield reduction due to nutrient omission was higher in N (0.2-2.25 t/ha) than P (0-1.79) and K (0-1.22 t/ha). The amount of fertilizers requirement of tested genotypes are given in Table 1.

In Boro 2014-15, the PQR lines out yielded BRRI dhan50 with complete NPK fertilization. BR7369-10-5-2-3 produced the highest grain yield (5.79 t ha^{-1}) followed by BR7369-52-3-2-1-1 (5.59 t ha^{-1}). All the tested PQR genotypes were responsive to N omission. The magnitude of yield reduction due to nutrient omission was higher with N (2.41-3.16 t ha^{-1}) followed by P (0.30-0.61 t ha^{-1}) and K (0.31-0.71 t ha^{-1}). Nutrients requirement of the tested genotypes are given in Table 2.

Nerica Mutant gave similar yield with BRRI dhan28 but required four days more to mature than the check variety. Grain yield decreased significantly in all the tested genotypes with omission of N and P nutrients. Nutrients requirement are given in Table 3.

Micronutrient enriched genotypes gave similar yield with check varieties under complete fertilization. Grain yield decreased significantly with omission of N and P fertilizer nutrients. Potassium omission slightly decreased the grain yield of all genotypes except BRRI dhan28. Nutrients requirement for satisfactory grain yield are given in Table 4.

Nitrogen and potassium rates for modern rice

The objectives of present study were to find out suitable ratio of N and K for MV rice cultivation and to study N and K dynamics in soil plant systems.

The experiments were conducted at BRRI farm, Gazipur (AEZ 28) during 2014-15 seasons. Potassium was used at 0, 50, 100, 150 and 200 kg ha^{-1}) in the main plot and N at 0, 50, 75 and 100 kg ha^{-1} in T. Aman and 0, 100, 120 and 140 kg ha^{-1} in Boro season in the subplots and compared with BRRI dhan49 in T. Aman and BRRI dhan29 in Boro season. Phosphorus and S was applied as blanket dose.

Grain and straw yields. In T. Aman 2014, effect of K, N and their interaction on grain yield of BRRI dhan29 was significant (Table 5). At K_0, N rates significantly increased grain yield. At N_0, K rate was also responsible for increased grain yield. The highest grain yield of BRRI dhan49 (5.64 t ha^{-1}) was recorded when 150 kg K ha^{-1} and 75 kg N ha^{-1} were used but it was statistically identical with 50 kg K and 50 kg N combination.

Table 1. Requirement of N, P and K fertilizers for satisfactory grain yield of RLR genotypes, T. Aman 2014, BRRI, Gazipur.

Genotype	Nutrient requirement (kg ha^{-1})			Grain yield (t ha^{-1})
	N	P	K	
BR7468-12-1-1-1-1	111	-	-	5.68
BR7472-16-2-1-2-1	123	22	34	6.61
BR7638-7-2-5-2	135	27	-	7.04
BRRI dhan32	12	6	-	5.01
BRRI dhan49	77	22	49	6.66
Applied nutrient	120	15	60	

Table 2. Requirement of N, P and K fertilizer for satisfactory grain yield of PQR genotypes, Boro 2014-15, BRRI, Gazipur.

Genotype	Nutrient requirement (kg ha^{-1})			Grain yield (t ha^{-1})
	N	P	K	
BR7781-10-2-3-2	145	9	28	5.37
BR7369-10-5-2-3	160	7	14	5.79
BR7369-52-3-2-1-1	190	9	27	5.59
BRRI dhan50	148	5	12	5.00
BRRI dhan63	169	5	22	5.40
Applied nutrient	160	25	65	

Table 3. Requirement of N, P and K fertilizer for satisfactory grain yield of short duration ALART materials, Boro 2014-15, BRRI farm, Gazipur.

Genotype	Nutrient requirement (kg ha^{-1})			Grain yield (t ha^{-1})
	N	P	K	
Nerica mutant	143	40	32	4.56
BRRI dhan28	164	35	31	4.37
BRRI dhan45	140	46	28	4.42
Applied nutrient	160	25	65	

Table 4. Requirement of N, P and K fertilizer for micronutrient genotypes, Boro 2014-15, BRRI, Gazipur.

Genotype	Nutrient requirement (kg ha^{-1})			Grain yield (t ha^{-1})
	N	P	K	
BR7833-11-1-1-3-4	176	54	24	5.06
BR7830-16-1-5-9-9	155	50	13	4.92
BRRI dhan28	187	52	51	5.08
BRRI dhan64	180	50	30	4.94
Applied nutrient	160	25	65	

Table 5. Effect of N and K rates on grain and straw yields of BRRI dhan49, T. Aman 2014, BRRI, Gazipur.

K dose (kg ha^{-1})	N dose (kg ha^{-1})							
	0		50		75		100	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
0	3.39	4.91	3.65	5.60	3.70	5.78	4.39	5.66
50	4.72	5.32	5.25	5.74	4.94	5.56	4.94	6.39
100	4.62	4.92	5.34	6.01	4.94	6.79	4.96	6.74
150	4.85	5.04	5.24	6.62	5.64	6.19	5.58	7.49
200	4.82	5.52	5.33	6.47	5.22	6.25	4.94	7.05
N mean	4.48	4.91	4.96	5.60	4.89	5.78	4.96	5.66
$LSD_{0.05}$	for grain yield, K=0.38, N=0.20, K×N=0.46 for straw yield, K=0.58, N=0.46, K×N=NS							

So, this combination may be suitable for BRRI dhan49 rice cultivation to get optimum yield. Straw yield was significantly affected by K and N applications but the interaction effect was insignificant.

Uptake of N and K. In T. Aman season, total N uptake was not much influenced by K rates in a specific N rate, but its uptake was significantly influenced because of synergistic effect of K and N rates. The highest N uptake (83 kg ha^{-1}) was recorded with 150 kg K and 75 kg N combination. Potassium, N and their interaction significantly affected the total K uptake. The lowest K uptake was observed in $K_0 \times N_0$ (96 kg ha^{-1}) and $K_0 \times N_{100}$ (90 kg ha^{-1}) treatment combinations. The highest K uptake (176 kg ha^{-1}) was obtained in combination of 100 kg N ha^{-1} and 150 kg K ha^{-1}. In Boro season, K, N and their interaction significantly affected gain and straw yields of BRRI dhan29 (Table 6). The highest grain yield (6.57 t ha^{-1}) was recorded in 150 kg K and 100 N combinations. In K deficient condition, increasing N levels significantly reduced grain yield. Straw yields increased with increasing N levels at K_0 condition and the highest straw yield was recorded in 100 kg K and 120 kg N combination.

Nitrogen and K dose for rice under AWD situations

The objective of present study was to find out optimum N and K doses with standard P and S rates for AWD situations (10-20% water saving).

In Boro 2014-15, IR83140-B-36-B-B and IR83142-B-71-B-B lines along with BRRI dhan28 and BRRI dhan29 were tested under five fertilizer management options at BRRI farm, Gazipur. Treatment combinations were: T_1 = control (native nutrients), T_2 = standard dose of NPKS @ 138-18-64-11 kg ha^{-1}, T_3 = 25% more NK + standard dose of PS, T_4 = 50% more NK + standard dose of PS and T_5 = 75% more NK + standard dose PS. Experiment was laid out in a split-plot design with three replications. Fertilizer management was placed in the main plots and rice genotypes in the subplots. Forty-five-day-old seedlings were transplanted at 20- × 20-cm spacing. Irrigation was applied following AWD method. All plots were surrounded by 30 cm soil levee to avoid contamination between plots.

Grain yield at native nutrient conditions varied from 2.09 to 3.66 t ha^{-1}, being the highest in BRRI dhan29 (Table 7). Significant grain yield increase was observed in all rice genotypes due to application of recommended dose. IR83140-B-36-B-B produced the highest grain yield in T_5 (75% more NK) and it was identical with T_4 (50% more NK). IR83142-B-71-B-B gave the highest grain yield in T_4 treatment, which was significantly higher than other treatments. However, none of the tested lines out yielded check varieties. Similar trend was observed in straw yield.

Fertilizer package for low input rice variety (BRRI dhan69)

Most of the MVs express their yield potential only under high fertilizer management conditions; but farmers invariably apply lower levels of fertilizers to reduce cost of production. Further, application of higher levels of nutrients, especially N, usually invites pests and disease problems that will entail additional cost. Under such circumstances, the varieties that provide fairly good grain yield with

Table 6. Effect of N and K on grain and straw yields of BRRI dhan29, Boro 2014-15, BRRI, Gazipur.

K dose (kg ha^{-1})	N dose (kg ha^{-1})							
	0		100		120		140	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
0	3.23	2.83	2.77	4.38	2.59	4.27	2.29	4.30
50	3.32	3.38	5.76	5.13	5.95	5.75	5.47	5.97
100	3.49	3.12	6.10	5.80	6.34	6.23	5.80	6.68
150	3.48	3.06	6.57	5.51	6.47	5.81	6.27	6.09
200	3.88	3.15	6.57	6.43	6.33	7.06	5.84	6.40
N mean	3.48	3.11	5.55	5.45	5.53	5.82	5.14	5.87
$LSD_{0.05}$	for grain yield, K=0.27, N=0.24, K×N=0.55							
	for straw yield, K=0.58, N=0.46, K×N=NS							

Table 7. Grain yield (t ha^{-1}) of rice genotypes as influenced by fertilizer management options under AWD conditions, Boro 2014-15, BRRI, Gazipur.

Fertilizer dose (kg ha^{-1})	Genotype				
	IR83140-B-36-B-B	IR83142-B-71-B-B	BRRI dhan28	BRRI dhan29	Treat. Mean
T_1 = Control	2.12	2.09	2.13	3.66	2.50
T_2 = *Std. NPKS	5.25	5.19	5.29	6.24	5.50
T_3 = 25% more NK + Std. PS	5.39	5.13	5.20	6.22	5.49
T_4 = 50% more NK + Std. PS	5.53	5.73	5.49	6.29	5.76
T_5 = 75% more NK + Std. PS	5.64	5.48	5.63	6.06	5.70
Variety mean	4.79	4.72	4.75	5.70	
CV (%)			6.6		
$LSD_{0.05}$	Treat.=0.28	Variety=0.25		Treat.×Variety=NS	

*Std. = Standard dose for Boro season.

moderate levels of fertilizer application will be of much economic importance. Such varieties also would exploit and use both soil and fertilizer nutrients efficiently. A low input Boro rice variety (BRRI dhan69) has been released recently by BRRI for which fertilizer package development is needed.

A field experiment was conducted in Boro 2014-15 at BRRI farm, Gazipur with seven fertilizer treatments- T_1 = recommended dose (RD), T_2 = 10% less of RD, T_3 = 20% less of RD, T_4 = 30% less of RD, T_5 = 40% less of RD, T_6 = 50% less of RD and T_7 = control (without fertilizer). The recommended fertilizer dose was N-P-K-S-Zn @ 138-18-64-11-1.5 kg ha^{-1}, respectively. All fertilizers except urea were applied at basal; but urea was applied in equal three splits. BRRI dhan69 was tested with BRRI dhan58. Experimental design was split-plot with three replications, where fertilizer treatments were in the main plots and varieties were in the subplots.

Tiller and panicle productions varied significantly because of fertilizer levels and variety. At control conditions, tiller and panicle production of both the varieties were almost same and the lowest number of tiller m^{-2} (182 in BRRI dhan58 and 183 in BRRI dhan69) and panicles m^{-2} (168 in BRRI dhan58 and BRRI dhan69) were recorded. Reduction in panicle number was insignificant up to 30% less of RD. Fertilizer treatments significantly affected grain yield of BRRI dhan58 and BRRI dhan69 (Table 8), but varietal differences and interaction effect on grain yield was insignificant. The recommended fertilizer dose (T_1) produced the highest grain yield in BRRI dhan58; whereas BRRI dhan69 gave the highest with 10% less than RD. Yield potential of BRRI dhan58 and BRRI dhan69 could be achieved at 10% and 20% less fertilizer dose respectively compared to RD.

Table 8. Effect of reduced fertilizer doses on grain yield of low-input rice variety (BRRI dhan69), Boro 2014-15, BRRI, Gazipur.

Treatment	Grain yield (t ha^{-1})	
	BRRI dhan58	BRRI dhan69
T_1 = Recommended dose (RD)	5.60	5.08
T_2 = 10% less of RD	5.46	5.14
T_3 = 20% less of RD	5.12	5.09
T_4 = 30% less of RD	5.04	4.72
T_5 = 40% less of RD	4.20	4.44
T_6 = 50% less of RD	4.04	3.85
T_7 = control (without fertilizer)	1.72	1.70
CV (%)	7.8	
$LSD_{0.05}$ for treatment	0.40	
$LSD_{0.05}$ for variety	NS	
$LSD_{0.05}$ for treatment × variety	NS	

MANAGEMENT OF NUTRITIONAL DISORDERS IN RICE

Long-term effect of organic and inorganic nutrients on yield low land rice

Long-term missing element trial reflects a mirror image of rice response behavior under deficit conditions and it provides the opportunity of reverse response study. It can also be considered as an effective medium for crop growth response study for finding out nutrient use-efficient genotypes. So, a long term experiment was initiated on a permanent layout at BRRI farm Gazipur in 1985 Boro season having 12 treatments assigned in a RCB design with four replications

(Table 9). Since Boro 2000, each plot was divided into two to include a reverse treatment and additional varieties, BRRI dhan29 and BRRI dhan31 to evaluate the reverse trends of missing elements. In Boro, NPKSZn was used @ 120-25-35-20-5 kg ha^{-1}, but in T. Aman it was 100-25-35-20-5 kg ha^{-1}. After 47th crop, treatments were modified with omission of Zn because of its sufficiency in the soil. The STB dose of NPKS was 138-10-80-5 kg ha^{-1} and 100-10-80-5 kg ha^{-1} for Boro and T. Aman respectively after 47th crop according to Fertilizer Guide-2005 (BARC, 2005). Higher level of available S in control plot compared to initial soil may be due to recent industrial urbanization effect and thus S dose was reduced. Urea N was applied in three equal splits at final land preparation, at active tillering and at 5-7 days before PI. The rest of the fertilizers were applied at final land preparation.

In Boro 2009-10, organic materials were used as third modification in T_5, T_8, T_9, T_{10} and T_{11} treatments. Oil cake (OC, 2 t ha^{-1}), saw dust (SD, 3 t/ha), cow dung (CD, 3 t ha^{-1}), mixed manure (CD:PM:SD:OC=1:1:1:0.5) and poultry manure (PM, 2 t ha^{-1}) in T_{10}, T_9, T_5, T_{11} and T_8 treatments. Only N @ 138 kg ha^{-1} was applied as top dress with organic amended treatments. However, both missing and reverse management plots were merged for making 12 treatments. In T. Aman 2011-12, T_9 and T_{11} treatments were changed to accommodate 60 and 40 kg K ha^{-1} respectively. NPKSZn @ 100-7-80-3-5 kg ha^{-1} was used in T. Aman 2013 and it was 138-7-80-3-5 kg ha^{-1} in Boro 2013-2014. CD (3 t ha^{-1}), PM (2 t ha^{-1}) and mustard OC (2 t ha^{-1}) were used in T_5, T_8 and T_{10} treatments. Grain yield was recorded at 14% moisture content and straw yield as oven dry basis.

In T. Aman 2014, Zn omission plot produced the highest grain yield (4.90 t ha^{-1}), which was statistically identical with complete fertilizer treatment (4.80 t ha^{-1}). Omission of N, P, K and S significantly decreased rice yield to 2.96, 3.65, 3.56 and 3.96 t ha^{-1} respectively (Table 10). Among organic materials treated plots, CD treated plot had the highest grain yield (4.02 t ha^{-1}) followed by OC (3.84 t ha^{-1}) and PM (3.75 t ha^{-1}). The K rates in complete fertilizers significantly influenced rice yield of BRRI dhan49. The highest rice yield (4.80 t ha^{-1}) was obtained with 80 kg K ha^{-1} and the lowest (3.79 t ha^{-1}) with 40 kg K ha^{-1} but there was no significant difference between 40 kg and 60 kg K ha^{-1}. In Boro 2014-15, grain yield decreased due to omission of nutrient s. Complete fertilizer treatment gave 6.68 t ha^{-1} grain yield, which significantly decreased to 2.1, 2.62, 3.90 and 3.95 t ha^{-1} due to omission of all nutrients, N, P and K, respectively (Table 10). Application of poultry manure @ 2 t ha^{-1} with IPNS based chemical fertilizer produced the highest grain yield (6.92 t ha^{-1}) and it was statistically similar with complete fertilizer treatment. Application of CD and OC with IPNS based chemical fertilizer produced statistically similar but slightly lower grain yield than complete fertilizer treatment. K at 60 kg ha^{-1} produced similar grain yield with complete fertilizer treatment but K at 40 kg ha^{-1} significantly reduced grain yield. Straw yield in complete fertilizer treatment was the highest

Table 9. Treatment details of long-term missing element experiment, BRRI, Gazipur, 1985-2015.

Original treat. 1985	Reverse treat. 2000	Treat. 2009-10	Treat. 2011-15
NPKSZn	All missing	NPKSZn	NPKSZn @138/100-7-80-3-5 kg ha^{-1}
NPSZn (-K)	NSZn (+K)	NPSZn (-K)	NPSZn (-K)
NKSZn (-P)	NKSZn (+P)	NKSZn (-P)	NKSZn (-P)
PKSZn (-N)	PKSZn (+N)	PKSZn (-N)	PKSZn (-N)
NSZn (-PK)	NSZn (+PK)	Cow dung @ 3.0 t ha^{-1}	Cow dung (3 t ha^{-1}) + IPNS fert.
NPKS (-Zn)	NPKS (+Zn)	NPKS (-Zn)	NPKS (-Zn)
NPKZn (-S)	NPKZn (+S)	NPKZn (-S)	NPKZn (-S)
NPK (-SZn)	NPK (+SZn)	PM @ 2 t ha^{-1}	PM (2 t ha^{-1}) + IPNS fert.
NP (-KSZn)	NP (+KSZn)	Saw dust @ 3 t ha^{-1}	NPKSZn @ 138/100-7-60-3-5 kg ha^{-1}
NK (- PSZn)	NK (+PSZn)	Oilcake @ 2.0 t ha^{-1}	Oil cake (2 t ha^{-1}) + IPNS fert.
N (-PKSZn)	N (+PKSZn)	Mixed Manure	NPKSZn @ 138/100-7-40-3-5 kg ha^{-1}
All missing	+ NPKSZn	Control	Control

Table 10. Effect of long-term missing element on grain and straw yields (t ha^{-1}), T. Aman 2014 and Boro 2014-15, BRRI, Gazipur.

Treatment	BRRI dhan49, T. Aman 2014		BRRI dhan29, Boro 2014- 2015	
	Grain	Straw	Grain	Straw
NPKSZn @138/100-7-80-3-5 kg ha^{-1}	4.80	6.89	6.68	5.62
NPSZn (-K)	3.56	6.05	3.95	3.54
NKSZn (-P)	3.65	6.47	3.90	4.64
PKSZn (-N)	2.96	4.90	2.62	2.45
CD (3 t/ha) + IPNS	4.02	7.13	6.57	4.17
NPKS (-Zn)	4.90	6.79	6.33	4.76
NPKZn (-S)	3.96	7.14	6.46	4.94
PM (2 t/ha) + IPNS	3.75	7.08	6.92	5.22
NPKSZn @ 138/100-7-60-3-5 kg ha^{-1}	3.93	6.71	6.29	4.62
OC (2 t/ha) + IPNS	3.84	7.66	6.09	4.91
NPKSZn @ 138/100-7-40-3-5 kg ha^{-1}	3.79	6.65	5.67	4.51
Control	2.67	4.53	2.1	1.81
$LSD_{(0.05)}$	0.45	0.65	0.63	0.62
CV (%)	8.2	7.0	8.29	10.16

*NPKSZn@ 100-7-80-3-5 kg ha^{-1} for T. Aman and 138-7-80-3-5 kg ha^{-1} for Boro.

(5.62 t ha^{-1}) followed by PM + IPNS based chemical fertilizer (5.22 t ha^{-1}). Omission of N, P, K, S and Zn decreased straw yield by 3.17, 0.98, 2.08, 0.68 and 0.86 t ha^{-1}, respectively.

Yield trend. Rice yield trends over the years were increasing when nutrients were added from organic and inorganic sources, but it was stagnant under inorganic fertilizer alone (Figs. 1 and 2).

Integrated nutrient management for double and triple rice cropping

The experiment was initiated in Boro 2008-09 at BRRI farm Gazipur in a clay loam soil. In Boro-Fallow-T. Aman pattern, BRRI dhan29 and BRRI

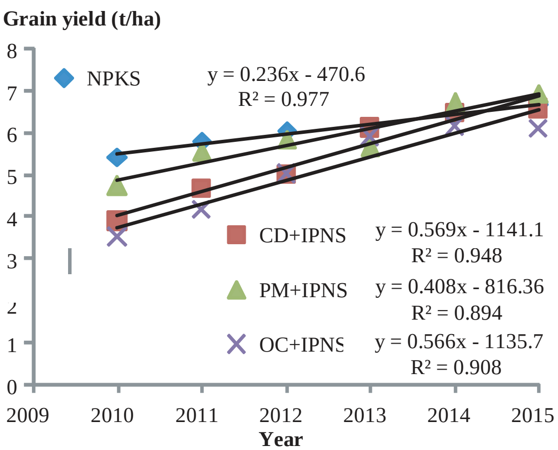


Fig. 1. Trend of Boro rice yield under organic and inorganic fertilizer management practices in a Boro Fallow-T. Aman cropping pattern, BRRI, 2010-2015.

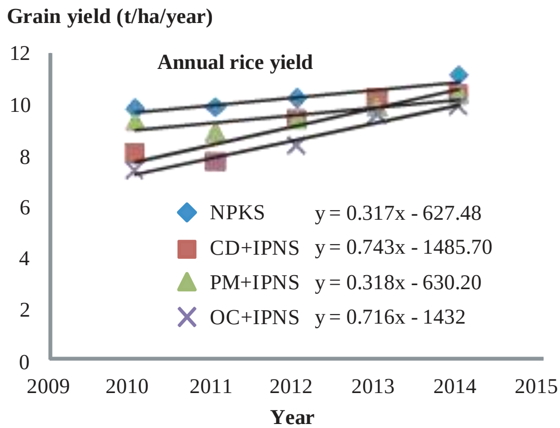


Fig. 2. Trend of annual rice yield underorganic and inorganic fertilizer management practices in a Boro Fallow-T. Aman-cropping pattern, BRRI, 2010-2014.

dhan49 were used. In Boro-T. Aus-T. Aman pattern, BRRI dhan29, BRRI dhan43 and BR22

T =control, T =STB dose (NPKS @ 160-25-60-20 kg ha^{-1} for Boro, 70-12-48-10 kg ha^{-1} for T. Aus and 84-15-54-14 kg ha^{-1} for T. Aman), T_3=STB (50%) + MM (CD @ 2 t ha + ash @ 1 t ha oven dried), T_4=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.

Table 11 presents the grain yield of both double and triple rice cropping pattern. In Boro 2013-14 under triple cropping pattern, STB

Table 11. Annual grain production (t ha^{-1}) of double and triple cropping pattern under continuous wetland condition, BRRI farm, Gazipur, 2014.

Treatment	Double cropping			
	Boro 2013-14 (BRRI dhan29)	Fallow	T. Aman 2014 (BRRI dhan49)	Total
T_1 = Control	2.18	-	3.44	5.62
T_2 = STB	5.78	-	5.11	10.89
T_3 = 50% STB+MM	5.40	-	5.20	10.60
T_4 = FP	4.17	-	4.10	8.27
$LSD_{0.05}$	0.60	-	0.63	
CV (%)	6.8	-	7.0	
	Triple cropping			
	Boro 2013-14 (BRRI dhan29)	T. Aus 2014 (BRRI dhan43)	T. Aman 2014 (BR 22)	Total
T_1 = Control	1.89	1.84	2.45	6.18
T_2 = STB	5.59	2.89	3.29	11.77
T_3 = 50% STB+MM	5.29	3.00	3.37	11.66
T_4 = FP	4.27	2.60	2.84	9.71
$LSD_{0.05}$	0.22	0.16	0.48	
CV (%)	12	3.0	8.0	

fertilizer dose produced significantly higher yield than 50% STB + MM treatment and FP. However, 50% STB + MM treatment gave significantly higher yield than FP under double and triple cropping pattern. The highest grain yield (3.00 t ha^{-1}) of BRRI dhan43 was found in 50% STB + MM treatment, which was statistically similar with STB dose (2.89 t ha^{-1}). In T. Aman 2014, under double cropping pattern, both STB dose and 50% STB + MM produced significantly higher grain and straw yields than FP. However, the highest value of grain yield (5.28 t ha^{-1}) was found with 50% STB + MM. Under triple cropping pattern, the highest grain yield (3.37 t ha^{-1}) was found with 50% STB + MM, which was statistically similar with STB dose. However, cumulative yield of triple cropping was always higher than double rice cropping pattern irrespective of treatments.

In Boro 2014-15, under double and triple cropping pattern, STB dose and 50% STB + MM produced significantly higher grain yield than FP. However, the highest grain yield (5.13 and 5.22 t ha^{-1}) was found with STB dose in both cropping patterns but it was statistically similar with 50% STB + MM. Grain yield of triple cropping was increased over double cropping except control treatment (Table 12). It may be concluded that STB (100%) dose of fertilizer and integrated nutrient management (INM) are good options for obtaining higher rice yields in double or triple rice cropping pattern.

SOIL AND ENVIRONMENTAL PROBLEMS

Greenhouse gas emission from rice field

Soil is considered to be one of the most important sources and sinks of greenhouse gases. So, experiments were conducted to study the effects of broadcast urea (BU), urea deep placement (UDP) and NPK briquette on flood water NH_4^+-N dynamics, biomass, grain yield and total NPK uptake by rice and N_2O and NO emission under ADW and continuous standing water (CSW) conditions.

Two field experiments were set up at BRRI farm, Gazipur. Experimental field soil was clay-loam in texture. Initial soil pH was 6.22, 1.75% organic C, 0.17% total N, 16 ppm available P and 0.25 cmol kg^{-1} exchangeable K. Table 13 shows the treatments. Rice varieties used were BRRI dhan46, BRRI dhan28 and BRRI dhan48 for T. Aman, Boro and T. Aus season respectively. Water samples from all plots were collected for NH_4^+-N determination in acid washed plastic bottles in the morning after N fertilizer application for 7 days. First water sampling was done before and immediately after application of UDP, NPK briquettes and PU. Nitric oxide was measured with a Teledyne API T200 Chemiluminescence Analyzer and N_2O was measured with a Teledyne API T320U Gas Filter Correlation Analyzer and calibration was done by a Teledyne API T700 Dynamic Dilution Calibrator.

Table 12. Yield scenario of Boro rice under different treatments of double and triple cropping pattern at BRRI farm, Gazipur, 2014-15.

Treatment	Yield (t ha^{-1})			
	Double cropping 2013-14 (11th crop)	Double cropping 2014-15 (13th crop)	Triple cropping 2013-14 (16th crop)	Triple cropping 2014-15 (19th crop)
T_1 control	2.18	1.69	1.89	1.53
T_2 STB	5.78	5.13	5.59	5.22
T_3 STB(50%) + MM	5.40	4.96	5.29	5.07
T_4 Farmer practice	4.17	3.98	4.27	4.04
$LSD_{0.05}$	0.60	0.86	0.56	0.71
CV (%)	6.8	10.96	6.6	8.93

Table 13. Treatment description for T. Aus, T. Aman 2014 and Boro 2015.

Treatment no.	Description*	N rate (kg ha^{-1})		
		Aus	Aman	Boro
T_1	Check	0	0	0
T_2	Urea Briq	52	52	78
T_3	Urea Briq	78	78	104
T_4	Prilled Urea	104	78	156
T_5	Urea Briq	104	104	156
T_6	NPK Briq	51	51	81
T_7	Prilled Urea	78	52	104
T_8	NPK Briq	78	78	102

*Urea briquette considered as UDP.

Ammonium-N in flood water. Deep placement of both UDP and NPK briq resulted in the lowest flood water NH_4^+-N compared to broadcasting of PU. Flood water NH_4^+-N concentration increased with increasing N rates from PU but it was not observed with increased N rates either from UDP and NPK briq. In PU, flood water NH_4^+-N was higher during initial 2 to 3 days after fertilization and then decreased steadily.

Grain yield and N uptake. Application of N irrespective of source and method of placement produced significantly higher grain and straw yields over N control in AWD condition (Table 14). In T. Aus 2014, there was no significant yield advantage among treatments. In T. Aman 2014, UDP at 78 kg N ha^{-1} gave significantly higher grain yield than PU treatment at similar rate under AWD conditions. Grain yield did not vary significantly because of N rates under CSW conditions; although UDP resulted in 33% save of N use. Total N uptake was significantly influenced by UDP-N_{78} under CSW conditions, but not under AWD conditions. In Boro 2015, UDP at 104 kg N ha^{-1} produced significantly higher grain yield than PU at similar N rate. In T. Aus 2014, total N uptake was not influenced by AWD, but significantly influenced by same N rates between PU and UDP under CSW conditions (Table 15). PU, UDP and NPK briq @ 52 kg N ha^{-1} produced similar result in T. Aman 2014. UDP at 78 kg N

Table 14. Grain yield of rice as influenced by N rates, sources and water management in different seasons, BRRI, Gazipur.

Treatment*	T. Aus, 2014 (BRRI dhan48)		T. Aman, 2014 (BRRI dhan46)		Boro, 2015(BRRI dhan28)	
	AWD	CSW	AWD	CSW	AWD	CSW
T_1	3.72b	3.82b	3.13c	3.54b	1.54c	1.84c
T_2	4.39a	4.49a	3.59ab	4.12a	4.64a	4.97ab
T_3	4.57a	4.64a	3.42bc	3.95a	5.12a	5.40a
T_4	4.40a	4.24a	3.78a	4.08a	4.60a	4.49b
T_5	4.32a	4.47a	3.66ab	3.95a	4.52a	5.06ab
T_6	4.57a	4.38a	3.54ab	4.04a	3.58b	4.82ab
T_7	4.36a	4.51a	3.50ab	4.12a	3.68b	4.32b
T_8	4.59a	4.31a	3.74ab	4.20a	4.57a	5.02ab
CV (%)	5.18	5.32	5.1	5.5	9.11	9.51

Table 15. Effect of N sources, rates and water management on total N uptake (kg ha^{-1}), BRRI, Gazipur.

Treatment*	T. Aus, 2014 (BRRI dhan48)		T. Aman, 2014 (BRRI dhan46)		Boro, 2015 (BRRI dhan28)	
	AWD	CSW	AWD	CSW	AWD	CSW
T_1	41c	45c	36b	39f	20.08d	22.89c
T_2	60b	65b	48bc	58cde	61.69b	65.49b
T_3	80a	86a	58a	65abc	74.30a	80.24a
T_4	68ab	67b	52ab	53e	61.73b	59.19b
T_5	78a	85a	60a	71a	82.26a	89.76a
T_6	62b	58b	48bc	61bcd	52.84b	63.87b
T_7	79a	67b	44c	53de	41.63c	56.45b
T_8	83a	56bc	50bc	68ab	59.99b	65.83b
CV (%)	12.82	10.11	8.71	8.18	9.44	8.78

ha^{-1} significantly influenced N uptake than PU at similar rate under CSW (Table 15). In Boro 2015, total N uptake was also significantly influenced by deep placement of urea both at 104 and 156 kg N ha^{-1} compared to PU under both the conditions (Table 15).

Emissions of N_2O and NO. In Aus 2014, N_2O and NO emissions under AWD option were higher with UDP, but it was lower under CSW conditions (Fig. 3). Emissions of N_2O and NO from Urea Briq were higher (Figs. 3 and 4) might be because of higher substrate availability during drying period. However, measurements under AWD conditions were non-replicated except in Boro 2015. Therefore, more measurements are needed to confirm these results. Nitric oxide emission was the least under CSW conditions. In Aus and Boro seasons, N_2O emissions were higher when UDP was used under AWD conditions. However, both N_2O and NO emissions were higher during Boro season (Fig. 4). In monsoon, frequent rainfall disrupted AWD conditions, but in Boro season it was fully maintained. This might has acted favourably for higher N_2O and NO emission from UDP treated plots.

SOIL MICROBIOLOGY

Influence of fertilizer management on microbes and soil health

Biological indicators of soil health offer certain advantages over physicochemical methods. Among the various biological indicators that have been proposed to monitor soil health, soil enzyme activities have great potential to provide a unique integrative biological assessment of soils and the possibility of assessing the health of soil biota. The specific objectives of this study were to determine microbial population and enzyme

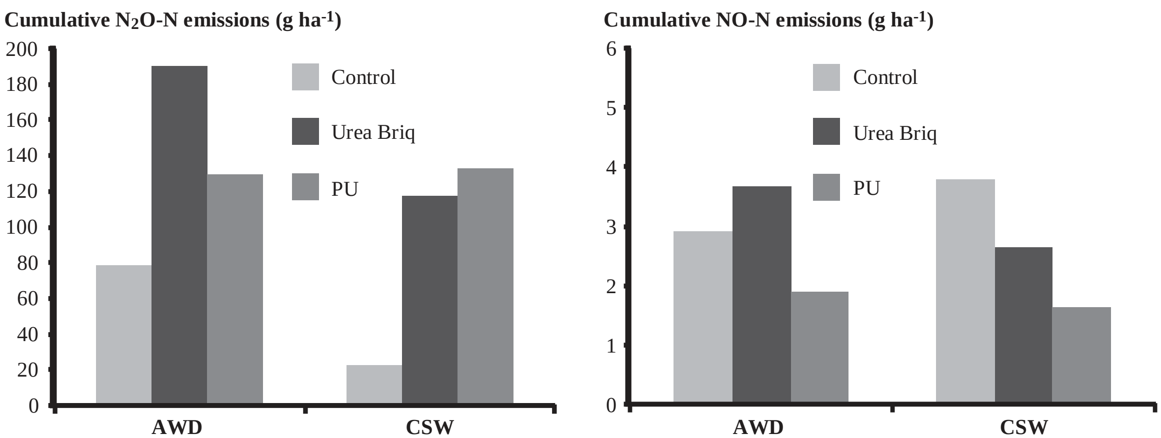


Fig. 3. Total nitrous and nitric oxide emissions during T. Aus 2014 as influenced by N sources and water management, BRRI, Gazipur.

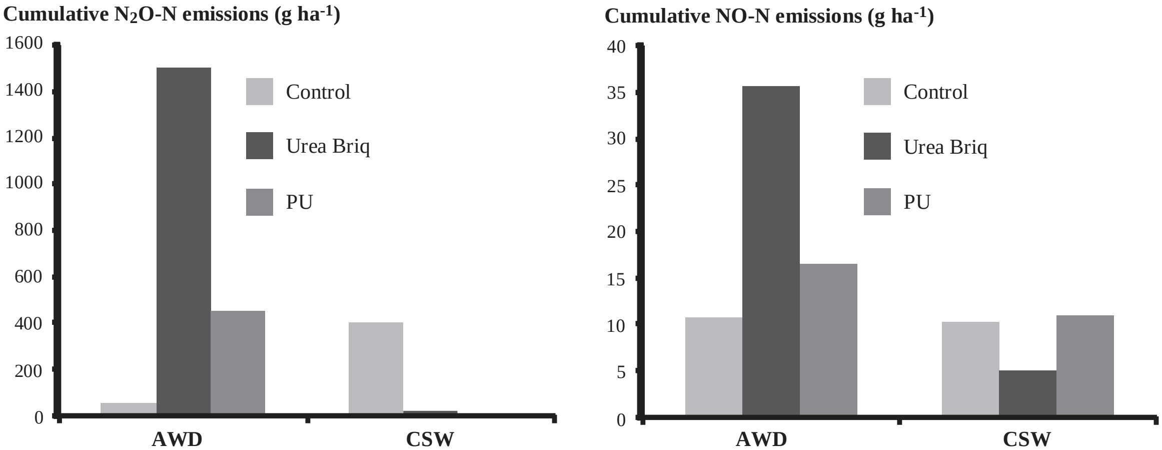


Fig. 4. Total nitrous and nitric oxide emissions during Boro 2015 as influenced by N sources and water management, BRRI, Gazipur.

activity in soil as an indicator of N and P nutrient availability, which is related to soil health and crop productivity in long term nutrient management study.

The study was conducted at BRRI, Gazipur 2014-15 to find out the effect of long term nutrient management on soil microbial population and soil enzyme activity. Soil samples (0-60 cm) were collected after T. Aman 2014 harvest from complete fertilizer, -N, -P, -K, cow dung (CD) and PM treated plots and compared with control. Total microbial population, nitrogen fixing, phosphate solubilizing, phosphatase, phytase and urease enzyme activities were determined.

Microaerophilic bacteria. There were significant variations in total microaerophilic bacterial populations because of fertilizer management at variable soil depths. The highest population was found in CD (9.2×10^8 Cfu g^{-1} dry soil) and PM (6.7×10^8 Cfu g^{-1} dry soil) amended plots and the lowest in missing of N (9.3×10^4 Cfu g^{-1} dry soil), K (3.5×10^5 Cfu g^{-1} dry soil) and control (2.7×10^5 Cfu g^{-1} dry soil) treatments. Occurrences of higher population in PM and CD treated plots might be a resultant effect of soil carbon and other available nutrients that favored their growth. Population was significantly low in -N, -K and control treatment where these nutrients were not added for last 45 years. This result reflected the need of major nutrients for their growth and survival. However, microbial population in -P treatment was higher than -N and -K treatments indicating that native soil P was enough for their survival.

Microbial population was high up to 20 cm depth in most of the treatments and then declined gradually. The lowest population was recorded at 45-60 cm soil depth. The levels of higher population up to 20 cm depth may be due to root activity. In the complete fertilizer treatment, total bacterial population was high up to 15 cm depth. However in K missing treatment, slightly lower population was found at the same soil depth. This may be due to competition of bacteria and plant root for limited soil K. In the missing N treatment, higher population was found only in the top soil (0-5 cm). Top soil contained higher amount of organic matter, which may have supported its growth. At 45 to 60 cm soil depth, no bacteria were found.

Free-living N_2 fixing bacteria. Among treatments, significantly higher free-living N_2 fixing bacterial population was recorded in PM and CD amended plots than others (Table 16). Organic matter provides carbon sources, which induces metabolic activity of these bacteria. In N missing treatment, population was high up to 30 cm soil depth and none at 45-60 cm. Substantial amount of population was also noticed in control treatment. On the other hand, N_2 fixing population was significantly low in complete fertilizer treatment and the lowest N_2 at 15 to 30 cm depth. From this finding it was clear that long term N fertilization significantly reduces N_2 fixing bacterial population in paddy soil. Long term absence of K fertilizer

Table 16. Effect of long term nutrient management on free-living nitrogen fixing population (Cfu/g soil) at variable soil depth, BRRI, Gazipur.

Treatment	Soil depth (cm)						
	0-5	5-10	10-15	15-20	20-30	30-45	45-60
Complete	1.4×10^5e	2.0×10^5d	1.2×10^5d	2.3×10^3f	1.8×10^3g	5.5×10^3e	3.7×10^3d
-K	2.6×10^5d	2.9×10^5c	1.1×10^5d	1.7×10^4e	4.9×10^3f	4.2×10^3e	1.7×10^2e
-P	3.4×10^5c	5.5×10^5b	2.5×10^5b	4.0×10^5b	1.0×10^5d	4.0×10^5b	1.0×10^5b
-N	2.8×10^5cd	2.6×10^5cd	2.1×10^5bc	2.0×10^5c	2.0×10^5c	3.4×10^4d	0.0
CD	5.8×10^6b	4.8×10^6a	2.2×10^6a	2.4×10^5c	3.1×10^5b	2.1×10^5c	9.2×10^4b
PM	8.1×10^6a	4.8×10^6a	2.1×10^6a	2.9×10^6a	2.4×10^6a	2.7×10^6a	1.9×10^6a
Control	1.7×10^5e	1.8×10^5d	1.8×10^5c	1.4×10^5d	7.2×10^4e	4.3×10^4d	8.6×10^3c

also reduced N_2 fixing population after 5-10 cm soil depth, which also indicates that limitation of soil K influence N_2 fixing population.

Phosphate solubilizing bacteria. Phosphate solubilizing bacterial (PSB) population was lower than N_2 fixing bacteria and significantly high population was found in PM and CD amended plots. The lowest population was found in N missing treatment and after 15 cm depth there was no PSB population (Table 17). Missing of P and K element also affected PSB population and after 20 cm soil depth their growth was absent. However, PSB population was found till 60 cm depth in control treatment. This finding proved that imbalanced fertilization hampered PSB population in paddy soil. In complete fertilizer treatment, PSB population gradually decreased from top soil to deeper layers and it was lower than CD and PM treatments. In general, a number of PSB populations were maintained around root zone in all of the treatments, which may be the effect of rice root exudates.

Urease and Phosphatase activity. In the present study the highest urease activity (102.2 µg NH_4-N g^{-1} soil 2 hr^{-1}) was found in PM amended plot at 0-5 cm soil depth, which was statistically similar (100.4 µg NH_4-N g^{-1} soil 2 hr^{-1}) to CD amended plot at 5-10 cm depth. However urease activity was higher up to 0-15 cm depth. Urease activity was comparatively lower in missing of N and K and control treatments (Table 18).

Soil organic P mineralization depends on enzymatic activity of the phosphate solubilizing microbes. Among them, phosphatase and phytase are the major ones for solubilizing organic P. In this study, phosphatase activity was determined. There were significant variations in phosphatase enzyme among treatments and soil depth (Table 19). Irrespective of treatments, the highest amount of acid phosphatase was found in CD and PM amended soils. However, enzyme production decreased with increasing soil depth. In general, enzyme production was high in all of the treatments up to root zone. The lowest amount of phosphatase enzyme was produced in missing of N and K.

EVALUATION OF NEW FERTILIZER

Performance of NP compound fertilizer

A new fertilizer, NP compound (NPC) was

Table 17. Effect of long term nutrient management on phosphate solubilizing bacteria population (Cfu/g soil) at variable soil depth, BRRI, Gazipur.

Treatment	Soil depth (cm)						
	0-5	5-10	10-15	15-20	20-30	30-45	45-60
Complete	3.8×10^4a	1.2×10^4e	7.0×10^3e	1.0×10^3e	4.0×10^2d	3.9×10^2d	0.0
-K	6.9×10^3c	1.1×10^4e	1.3×10^3c	2.8×10^3d	2.7×10^2c	0.0	0.0
-P	4.9×10^4a	6.2×10^4a	5.2×10^4a	4.0×10^4a	0.0	0.0	0.0
-N	1.7×10^3d	2.7×10^2f	1.1×10^2g	0.0	0.0	0.0	0.0
CD	5.1×10^4a	2.5×10^4c	2.3×10^2b	1.3×10^4c	8.8×10^3b	1.1×10^3c	1.1×10^3b
PM	4.9×10^4a	4.3×10^4b	8.5×10^3d	2.7×10^4b	3.3×10^4a	2.1×10^4a	1.9×10^3a
Control	1.5×10^4b	1.5×10^4d	5.1×10^3f	3.1×10^3d	3.0×10^3c	2.3×10^3b	1.2×10^2c

Table 18. Effect of long term nutrient management on urease activity (µg NH_4-N g^{-1} soil 2 hr-1) at variable soil depth, BRRI, Gazipur.

Treatment	Soil depth (cm)						
	0-5	5-10	10-15	15-20	20-30	30-45	45-60
Complete	59.6	68.6	52.7	32.0	25.8	21.2	20.3
-K	41.7	21.3	21.2	27.5	27.4	24.5	15.2
-P	61.5	84.3	44.3	31.1	44.6	20.8	15.5
-N	37.4	40.2	36.1	34.6	39.1	28.7	20.3
CD	85.1	100.4	62.8	36.9	36.2	32.7	27.1
PM	102.2	80.7	41.8	46.7	28.1	28.0	19.9
Control	42.6	52.3	35.2	26.4	24.4	15.3	11.9

Table 19. Effect of long term nutrient management on phosphatase production (µg/g-soil/hr) at variable soil depth, BRRI, Gazipur.

Treatment	Soil depth (cm)						
	0-5	5-10	10-15	15-20	20-30	30-45	45-60
Complete	104.59	97.81	31.07	6.74	5.97	0.00	0.00
-K	49.31	76.27	80.80	34.08	4.60	0.00	0.00
-P	96.68	99.03	72.71	68.91	0.00	0.00	0.00
-N	21.99	8.15	2.42	0.00	0.00	0.00	0.00
CD	112.23	103.52	97.32	82.25	43.62	25.56	20.96
PM	122.24	129.45	71.88	84.75	76.97	75.68	7.56
Control	81.27	72.58	57.11	38.99	30.74	25.56	2.72

evaluated at variable rates and compared the performances with di-ammonium phosphate (DAP). Field experiments were conducted in Boro 2014-15 at two locations- one at BRRI HQ farm, Gazipur and another at BRRI RS farm, Sonagazi, Feni. In Gazipur, soil was clay loam in texture and deficient in soil available P (<2 mg kg^{-1}). Soil contained 1.15% OC, 0.14% total N, 0.16 cmol kg^{-1} exchangeable K, 17 mg kg^{-1} available S and 4 mg kg^{-1} available Zn (DTPA extracted). Chemical composition of NPC is: 20.90% total N, 10.20% total P_2O_5 and 16.20% SO_3. The soil of BRRI RS, Sonagazi farm was slightly alkaline in reaction with medium P level. Treatments were, T_1=P control, T_2=S control (P as DAP), T_3=DAP (100% N), T_4=NPC (100% N), T_5=DAP (30% less N of T_3), T_6=NPC (30% less N of T_3). Urea was applied in three equal splits at basal, at active tillering stage and at 7 DBPI.

The effect of NPC fertilizer on Boro rice yield was promising. It helped in obtaining comparable grain yield with DAP and saved about 30% N. It may be considered as a new fertilizer in Bangladesh.

Irrigation and Water Management Division

SUMMARY

Irrigation in AWD-15 cm below ground level was the best water application method for Boro rice production and water saving was around 8% for BRRI dhan28 and 15% for BRRI dhan29 along with the higher water productivity at Gazipur. There was no conflict in USG application in AWD method of irrigation. Based on indicators of evaluation for canopy cover and biomass and the required irrigation amounts by AquaCrop model, the AWD-15 irrigation regime appears to be the best water-saving option for rice production during the dry season in Bangladesh.

The survey data in four upazilas of Rajshahi district indicate that Boro coverage is decreasing day by day due to depletion of groundwater level below suction limit of STW. The number of deep-set (when pump is set below the ground surface) and very deep-set STWs is increasing with an increase of non-rice crop coverage.

The early establishment of T. Aman through supplemental irrigation effectively mitigated the terminal drought occurred at reproductive and ripening phases during T. Aman 2014. Both short and long duration T. Aman varieties suffered less drought and showed good yield performance as they were transplanted before 24 July. So, transplanting before 24 July would be of low risk drought period and after that it would be high risk period.

There were no considerable yield differences when parch water table (PWT) went up to 25 cm below ground surface. The highest yield was found 5.65 t/ha for PWT at 15 cm and the lowest 5.63 t/ha for PWT at 25 cm.

Among the 10 study locations, the groundwater level of Gazipur, Comilla, Habiganj and Kushtia were found below the suction limit. So no STW is functioning there. Groundwater could be withdrawn by using force mood pump like DTW.

Low irrigation water depth (3 cm) with alternate wetting and drying (AWD) irrigation method showed the best performance of solar pump in terms of irrigation coverage

WATER USE EFFICIENCY IMPROVEMENT IN IRRIGATED AGRICULTURE

Validation of AquaCrop model and effect of USG in rice production

The field experiment was conducted at BRRI farm, Gazipur, during dry season of 2014-15 to determine the crop yield under different fertilizer and water management options and validating the yield and water requirement with AquaCrop model. BRRI dhan28 and BRRI dhan29 were used as test variety. The water and nitrogen treatments were:

Water

I_1=Continuous standing water

I_2=Irrigation when water level reached 15 cm below soil surface and

I_3=Irrigation when water level reached 20 cm below soil surface

Nitrogen

N_0=No nitrogen

N_1=Prilled urea applied @220 kg ha^{-1} and

N_2=USG applied @2.70 gm between four hills

The experiment was laid out in a split-split-plot design with three replications. The water treatments were in main plot and variety in sub plot and fertilizer management in sub-sub-plot. Forty-two-day-old seedlings were transplanted with 20 cm × 20 cm spacing. Transplanting was done on 5 January in 2015 and harvested in late April for BRRI dhan28 and first week of May for BRRI dhan29. Measured quantities of irrigation water were supplied from a deep tubewell. Field water depths for different water regimes were monitored by installing a partly perforated PVC pipe of 25 and 30 cm length and 10 cm diameter.

Input to the AquaCrop model consists of climatic parameters, crop, soil, field and irrigation management data. The weather data included daily values of maximum and minimum air temperatures, reference crop evapo-transpiration (ETo), rainfall and mean annual carbon dioxide concentration (CO_2). For crop data, canopy cover and biomass were measured in every 15 days interval. Dry biomass of the above ground plant was also obtained by weighing the total biomass of the samples collected for LAI determination, after keeping them in the oven for 48 hours at 65°C. In this study, soil layers were considered upto 0.5 m, which consists of silty-clay textured soil. In CSW, water was ponding on the soil surface continuously, whereas, in AWD, ponding water was allowed to deplete to a certain level in the two treatments.

The model was validated against above ground biomass and grain yield from the field experiment during the 2014-15 growth season of transplanted Boro rice for BRRI dhan28 only. Subsequently, the predicted output values were statistically compared with the observed biomass and yield data obtained from the experimental plot. The difference between model predicted and observed data was minimized using a trial and error approach in which one specific input variable was chosen as the reference variable at a time and adjusting only those parameters that influenced the reference variable the most. Statistical evaluation of the simulation results was made for calibration phases. The goodness of fit between simulated and observed values was corroborated by using various prediction error statistics. Model performance was evaluated in terms of prediction error (P_e), coefficient of determination (R^2), root mean square error (RMSE), the normalized root mean square error (NRSME), the Nash-Sutcliffe model efficiency coefficient (EF) and Willmott's index of agreement (*d*) (Raes *et al.*, 2012).

Tables 1 and 2 show the field experimental results of applied irrigation water, rainfall, grain yield, above ground biomass, water productivity (WP) and harvest index under different water regimes during the growing season for model validation (2014-15) based on three replicates. The lowest grain yield and biomass was observed to be 2.50 and 4.96 t ha^{-1} under the AWD-20 water regime in N0 fertilizer and the highest was 4.90 and 9.89 t ha^{-1} under AWD-15 water regime with USG fertilizer for BRRI dhan28 respectively (Table 1). Water productivity ranged between 3.22-3.50 kg ha^{-1} mm^{-1} (N0), 5.75-6.18 kg ha^{-1} mm^{-1} (Prilled urea) and 6.09-6.47 kg ha^{-1} mm^{-1} (USG) respectively (Table 1). Whereas, for BRRI dhan29, the lowest grain yield and biomass was observed to be 2.69 and 5.46 t ha^{-1} under the AWD-20 water regime in N0 fertilizer and the highest were 5.37 in AWD-15 and 10.89 t ha^{-1} under CSW water regime with USG fertilizer respectively (Table 2). WP ranged between 2.48-3.13 kg ha^{-1} mm^{-1} (N0), 5.30-5.43 kg ha^{-1} mm^{-1} (Prilled urea) and 4.69-5.77 kg ha^{-1} mm^{-1} (USG) respectively (Table 2). It appears that from the three irrigation regimes and fertilizer management, the AWD-15 water regime provided the best option for water productivity, i.e. providing high yield relative to the water use. While this option resulted in the highest yields, it used significantly lesser water than the CSW option. The AWD-20 irrigation regime caused some apparent stress to the crop, reducing both biomass and yield production noticeably. The WP of the AWD-20 option seems to be in par with that of the AWD-15 option, but there is an increased risk of crop stress with the AWD-20 option, which should be carefully considered when irrigation water is not very scarce, and maximizing yield is of more interest than maximizing water efficiency – both in terms of water amount or its cost. On the other hand, during Boro season, without N fertilizer yield should be reduced drastically, so, N fertilizer is necessary for optimum yield production.

Table 3 presents comparisons of observed and modelled grain yield and biomass. Biomass and yield estimates were slightly over the observed values, yielding 2.74 to 11.46% overestimation for yield and 2.71 to 4.11% overestimation of biomass, depending on the irrigation regime and fertilizer doses. The differences in biomass vs yield in the observations and the simulations indicate that the final HI value that the model used differed slightly from the observations, but the difference in HI remained at 1%.

The AquaCrop model was validated to predict biomass and crop grain yield under three irrigation water regimes. Based on indicators of evaluation for biomass and the required irrigation amounts, the AWD-15 irrigation regime appears to be the best water-saving option for rice production during the dry season in Bangladesh. Regardless, the obtained season-end metrics in terms of simulated biomass and crop yield are suggesting high potential for the AquaCrop model to be reliably used in irrigation scheduling, yield prediction or

Table 1. Irrigation water depth, grain yield, above ground biomass, water productivity (WP) and harvest index for BRRI dhan28 under different water treatments at BRRI, Gazipur, Boro 2014-15.

Treatment	Irrigation water applied (mm)	Rainfall (mm)	Grain yield (t ha^{-1})	WP (kg ha^{-1} mm^{-1})	Biomass (t ha^{-1})	HI (%)
			N0 fertilizer			
CSW	520	264	2.526	3.22	5.082	0.49
AWD-15	486	264	2.622	3.50	5.220	0.50
AWD-20	462	264	2.496	3.44	4.962	0.50
			Prilled urea (140 kg N/ha)			
CSW	520	264	4.609	5.75	8.954	0.50
AWD-15	486	264	4.635	6.18	9.171	0.51
AWD-20	462	264	4.242	5.84	8.580	0.49
USG						
CSW	520	264	4.778	6.09	9.733	0.49
AWD-15	486	264	4.895	6.53	9.890	0.49
AWD-20	462	264	4.695	6.47	9.590	0.49
LSD (5%)			0.16		0.22	

CSW=Continuous standing water. AWD-15=Irrigation applied when water level at 15 cm below ground surface. AWD-20=Irrigation applied when water level at 20 cm below ground surface.

Table 2. Irrigation water depth, grain yield, above ground biomass, water productivity (WP) and harvest index for BRRI dhan29 under different water treatments at BRRI, Gazipur, Boro 2014-15.

Treatment	Irrigation water applied (mm)	Rainfall (mm)	Grain yield (t ha^{-1})	WP (kg ha^{-1} mm^{-1})	Biomass (t ha^{-1})	HI (%)
			N0 fertilizer			
CSW	789	326	2.768	2.48	5.582	0.49
AWD-15	606	326	2.798	2.88	5.596	0.50
AWD-20	567	326	2.688	3.13	5.462	0.49
			Prilled urea (140 kg N/ha)			
CSW	789	326	5.010	5.30	10.437	0.48
AWD-15	606	326	4.948	5.30	10.098	0.49
AWD-20	567	326	4.850	5.43	9.898	0.49
USG						
CSW	789	326	5.230	4.69	10.896	0.48
AWD-15	606	326	5.374	5.77	10.748	0.50
AWD-20	567	326	4.833	5.41	9.863	0.49
LDS (5%)			0.12		0.13	

CSW=Continuous standing water, AWD-15=Irrigation applied when water level at 15 cm below ground surface, AWD-20=Irrigation applied when water level at 20 cm below ground surface.

Table 3. Validation results of biomass and grain yield under different water regimes for BRRI dhan28 at BRRI, Gazipur, Boro 2014-2015.

Treatment	Yield (t ha^{-1})		P_e	Biomass (t ha^{-1})		P_e
	Obs.	Sim.	(±%)	Obs.	Sim.	(±%)
CSW × N0	2.526	2.621	3.76	5.082	5.245	3.21
AWD-15 × PU	4.635	4.762	2.74	9.171	9.548	4.11
AWD-20 × USG	4.695	5.233	11.46	9.590	10.450	2.71

CSW=Continuous standing water. AWD-15=Irrigation applied when water level at 15 cm below ground surface. AWD-20=Irrigation applied when water level at 20 cm below ground surface.

potential in climate related scenario studies in Bangladesh. Based on the validation performance of the model the probabilistic yield will be estimated under AWD method for similar climatic condition.

Development of soil moisture declination model for alternate wetting and drying (AWD) irrigation for rice cultivation

The experiment was set up in BRRI farm, Gazipur, in Boro season 2014-15 to study the soil water dynamics for development of irrigation scheduling model. The experiment contains six treatments and each of them was replicated thrice. The treatments were-

T_1=Continuous standing water (CSW)

T_2=CSW with polythene protection around the field and levee

T_3=Irrigation when water level 15 cm below ground level (GL)

T_4=T_3 with polythene protection around the field and levee

T_5=Irrigation when water level 30 cm below GL

T_6=T_5 with polythene protection around the field and levee

RCB design was followed. BRRI dhan28 was the tested variety. Seeding was done on 20th November 2014. Forty-five-day-old seedlings were transplanted on 4 January 2015. Individual plot size was 5 m × 4 m and each plot was separated from others with 1 m buffer area. A spacing of 20 cm × 20 cm was maintained. Recommended fertilizer management and cultural practices were followed. To protect seepage losses polythene sheets were placed around the plots and levees of treatment T_2, T_4 and T_6. Irrigations were applied by measuring with a flow meter.

Soil samples were collected from different depths to determine the moisture content under different water level conditions. In the continuous standing water plots, a closed bottom cylinder (steel drum) was placed to determine the daily

in the drum to measure the daily water level in the drum. Partially perforated PVC pipe were installed in each plots to measure the daily water level. PVC pipe of 25 cm height and 15 cm perforation were installed below soil surface in treatment T_1, T_2, T_3 and T_4. PVC pipe having 40 cm height and 30 cm perforation were below soil surface installed in treatment T_5 and T_6. Water levels in the plots were measured daily. Daily temperature, relative humidity, sunshine hours, wind speed and rainfall data were collected from Plant Physiology Division, BRRI. Daily reference crop evapotranspiration (ET_0) was calculated using ETo Calculator. Seepage and percolation rate was assessed from the daily water level fluctuation data of polythene protected and unprotected plots.

The experimental soil type is silty-clay loam. Soil samples were collected from different layers having 5 cm depth. In T_3 and T_4 samples were collected from 0-15 cm depths when water level in the PVC pipe reached different levels. In T_5 and T_6 samples were collected from 0-30 cm depths when the water level in the PVC pipe reaches different levels below the ground surface. Soil moisture content was determined by gravimetric method. Graphs were plotted for different layers with the soil moisture content and water level data. A relationship is also developed between parched water level below ground surface and soil moisture content in different layers.

Figure 1 shows the soil moisture content at different layers for different perched water levels below the ground surface in T_6. It shows that even near saturation, the soil moisture content decreases with soil depths. At the water level of 6.0 cm the soil moisture content in the 1st, 2nd, 3rd, 4th, 5th and 6th layers are 40.0, 33.5, 34.5, 30.0, 28.0 and 29.6 percent respectively. It also shows that soil moisture content in the 1st, 2nd, 3rd, 4th, 5th and 6th layers reaches to 22.5, 23.1, 23.4, 23.5, 23.6 and 23.8 percent respectively when the parched water level reached at 30 cm below the ground surface.

Figure 2 shows different conditions that plant experienced during water depletion. When parched water level remains within 15 cm below ground surface the soil moisture content in the effective rootzone (0-30 cm) is greater than the field

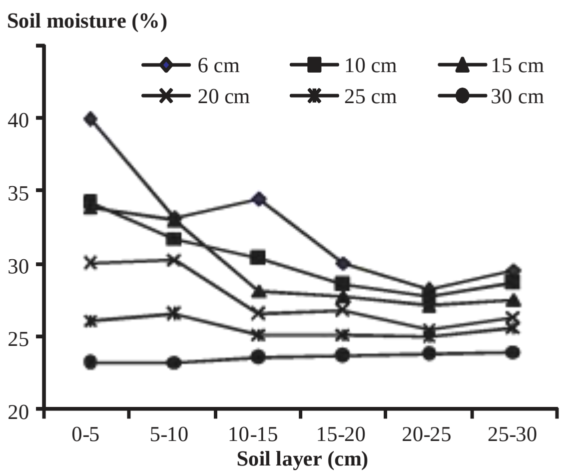


Fig. 1. Soil moisture content in different soil layers (0-30 cm) for different parched water levels in the field.

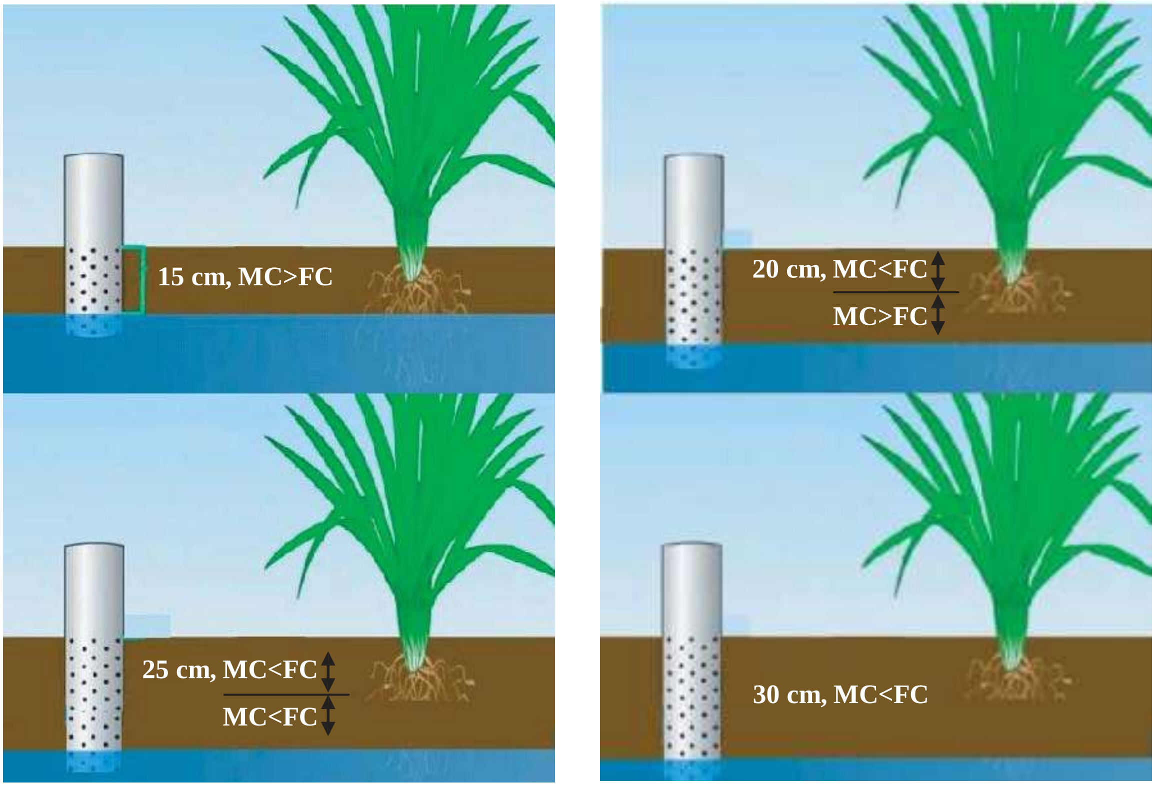


Fig. 2. Soil moisture condition in the effective rootzone of rice for different parched water levels in the field.

capacity and no stress is observed. When parched water level falls at 20 cm below ground surface the soil moisture content in the upper part (0-15 cm) of the effective rootzone is less than the field capacity and slight stress is observed. When parched water level falls at 30 cm below ground surface the soil moisture content in the effective rootzone is less than the field capacity and moderate stress is observed.

Different water regimes maintained in the treatments during the growth duration. The field growth duration was 100 days. In treatment T_1 and T_2 continuous standing water was maintained for 90 days and below saturated condition for 10 days (before harvest). Plots were remained in standing water condition for 61, 62, 46 and 49 days in T_3, T_4, T_5 and T_6 respectively.

Table 4 shows the number and amount of irrigation applied under different treatments. For land preparation (LP) 210 mm irrigation water was applied in the field. The number of irrigation was the highest in T_1 (17) and the lowest in T_6 (10). Total amount of irrigation applied in T_1, T_2, T_3, T_4, T_5 and T_6 during the growth season were 700, 584, 539, 482, 405 and 356 mm respectively. A total of 90 mm rainfall was recorded during the field growth span. Table 4 also shows that irrespective of treatments polythene protected plots save more water than the non-protected plots. This result also indicates polythene protection could be an effective measure for saving irrigation water in rice field.

Table 5 shows the yield of BRRI dhan28 under different irrigation treatments. Yield data showed that among the treatments, highest yield was obtained from continuous standing water plots (T_1=5636 kg/ha, T_2=5563 kg/ha) followed by 15 cm (T_3=4951 kg/ha, T_4=4894 kg/ha) and 30 cm (T_5=4896 kg/ha, T_6=4676 kg/ha) AWD plots. Yield were much lower in T_3 and T_4 plots compared to T_1 and T_2 plots for uncontrolled water stress occurred during the reproductive phase due to few days disorder of irrigation pump (DTW). Irrespective of treatments, higher yield was obtained from non-protected plots compared to the

Table 4. Number of irrigation, irrigation water applied and total water used for BRRI dhan28 under different treatments, Boro 2014, BRRI farm, Gazipur.

Treatment	No. of irrigation applied	Water applied for LP (mm)	Irrigation during growing (mm)	Rainfall (mm)	Total water used (mm)	Total water requirement (mm)	Irrigation water saved over T_1 (%)
T_1	17	210	700	90	1000	631.1	-
T_2	14	210	584	90	874	631.1	16.6
T_3	13	210	539	90	839	631.1	23.0
T_4	12	210	482	90	782	631.1	31.1
T_5	11	210	405	90	705	631.1	42.1
T_6	10	210	356	90	656	631.1	49.1

Table 5. Yield, yield loss and water productivity of BRRI dhan28 under different treatments, Boro 2015, BRRI farm, Gazipur.

Treatment	No. of irrigation applied	Total water used (mm)	Grain yield (kg/ha)	Yield loss over T_1 (%)	Water productivity (kg/ha-mm)
T_1	12	1000	5636	-	5.636
T_2	10	874	5564	1.28	6.366
T_3	9	839	4951	12.15	5.901
T_4	8	726	4894	13.16	6.741
T_5	7	675	4896	13.13	7.253
T_6	6	646	4676	17.03	7.238

ploythene protected plots. This may be due to the obstruction of the border plants to extract nutrients from adjacent areas. Table 5 also shows the relative yield loss compared to the continuous standing water treatment (T_1). Water productivity was the highest for treatment T_5 (7.25 kg/ha-mm) and the lowest for T_1 (5.63 kg/ha-mm). Yield loss was the highest in T_6 (17%) and the lowest in T_2 (1.3%). Therefore, considering yield loss, water productivity and water saving T_2 and T_4 are found better than the others for irrigated rice cultivation.

The study will be continued to determine soil moisture characteristics curve at different layers. Further analysis will be done to complete the work. Soil moisture characteristics curve at different layers will be developed to evaluate the field capacity, permanent wilting point and available soil water content to develop a model for soil moisture dynamics. Prediction of irrigation schedule will be possible after development of the model.

Delineation of areas having water shortage during Boro rice cultivation in north-west Bangladesh

The study was conducted in Pabna and Rajshahi districts of Bangladesh to locate STW areas facing water scarcity during Boro season and finding possible remedies in crop production.

Survey was conducted at five upazilas (Atgharia, Chatmohor, Bhangura, Ishwardi and Faridpur) of Pabna district and four upazials (Mohanpur, Bagmara, Durgapur and Puthia) of Rajshahi district (Fig. 3). A pre-structured questionnaire was used for the survey. Information was collected from ten STWs in each upazila.

The groundwater level in Chatmohor, Bhangura and Faridpur upazilas of Pabna district decline to 9.15-10.68 m below the ground surface during April-June. Whereas, the groundwater level in Mohanpur, Bagmara, Durgapur and Puthia upazilas of Rajshshi district declines to 6.40-10.68 m below the ground surface during April-June. Due to the water level declination STW operation hampers significantly and Boro coverage decreased day by day. In some places STWs were converted to DSSTW (Deep-set shallow tubewell) and VDSSTW (Very deep-set shallow tubewell). It reduced the discharge significantly. As a result irrigation cost was increased and it was less reliable. Therefore, farmers converted Boro rice area to Rabi crops (wheat, maize, grasspea, onion, garlic etc.) area to combat the water shortage. On average 2,139 ha and 608 ha Boro area has been decreased in the upazilas of Pabna and Rajshahi district respectively.

Average ground water level during dry period remains within 6.40-10.68 m in Pabna and Rajshahi district. Therefore, the pump of STW has to be set 1.5-4.5 m and 1.5-6.0 m below ground surface to withdraw the groundwater for crop

a. Upazila of Pabna district

b. Upazila of Rajshahi district

c. DSSTW at Pabna district

d. DSSTW at Rajshahi district

Fig. 3. Study location (a and b) and STW placed at different depth below the soil surface at (c) Pabna and (d) Rajshahi.

irrigation in Pabna and Rajshahi district (Fig. 3) respectively.

USE OF WATER RESOURCES IN RAINFED ENVIRONMENT

Terminal drought mitigation adopting transplanting dates in T. Aman 2014

The experiment was conducted in Kushtia to determine the effect of drought for different transplanting dates in T. Aman rice. A long duration variety (BR11) and a short duration variety (BRRI dhan33) were tested during T. Aman season. There were six treatments with three replications in the experiment and the treatments were transplanting at 10 July (T_1), transplanting at 17 July (T_2), transplanting at 24 July (T_3), transplanting at 31 July (T_4), transplanting at 7 August (T_5) and transplanting at 14 August (T_6).

Thirty-day-old rice seedlings were transplanted with 20 cm × 20 cm spacing. Individual plot size was 8 m × 6 m with 60 cm buffer zones. A USWB class-A evaporation pan and a rain gauge were installed near the experimental field to determine evaporation and rainfall amounts during the rice growing season. A slopping gauge was also placed in the field for seepage and percolation measurement. Data were recorded at 09:00h daily to determine seepage and percolation, rainfall and evaporation from the experimental field. The historical rainfall data were collected from the Department of Agricultural Extension, Kushtia. Drought amount (deficit water in soil) was calculated using drought model (developed by Dr Towfiqul Islam).

Table 6 shows the drought amount at different growth stages of rice for different dates of transplanting. BRRI dhan33 suffered comparatively less drought than BR11 due to its shorter growth duration. From the drought pattern of the previous year in case of BRRI dhan33 drought in reproductive and ripening phases increased with delay transplanting (Fig. 4). In 2014, drought amount were almost same during reproductive phase when they transplanted up to 24 July and for the period 24-31 July drought amount slightly increased, after the period it increased rapidly. In ripening phases drought gradually increased (Fig. 5) for transplanting after 17 July. When short duration variety transplanted before 24 July it can escape terminal drought.

For long duration variety, drought amount increased with delay transplanting. Fig. 6 presents average terminal drought over transplanting dates in the previous years (2009-13) and Fig. 7 presents drought in 2014 at Kushtia. Drought in vegetative phase shows decreasing trends over transplanting dates (Fig. 6), reproductive and ripening phases have rising trends after transplanting on 24 July and ripening phase has almost similar trend. In 2014, vegetative phase shows decreasing trend on delay transplanting. But in reproductive and ripening phases severe drought occurred in case of transplanting after 24 July.

Table 7 shows the yield and yield contributing character. BRRI dhan33 the yielded the highest

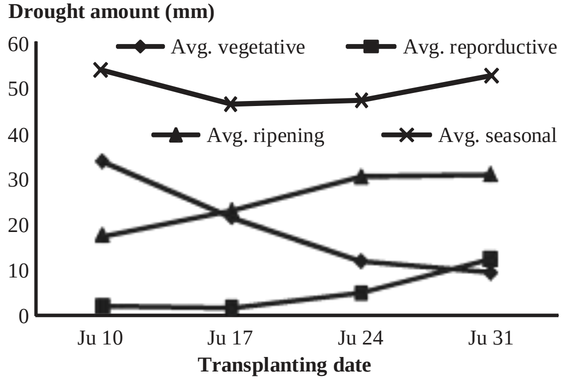


Fig. 4. Average drought pattern (2009-13) for BRRI dhan33 at Kushtia.

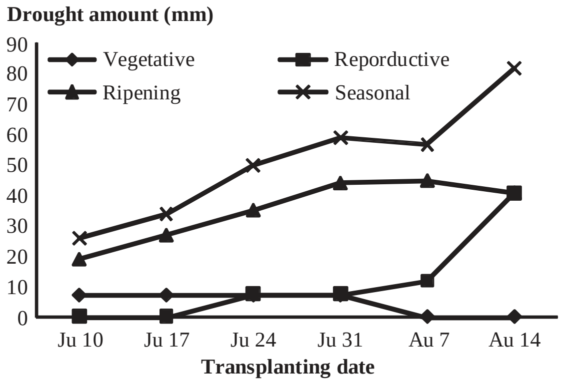


Fig. 5. Drought pattern in 2014 for BRRI dhan33 at Kushtia.

(5.46 t/ha) when it was transplanted on July 17 and the lowest yield was found 4.07 t/ha in case of transplanting on 14 August. For BR11, the highest yield was found for July 17 transplanting (5.76 t/ha) and the lowest yield was observed in case of

Table 6. Drought amount at different growth stages of rice, T. Aman 2014, Kushtia.

Treatment	Vegetative phase (mm)	Reproductive phase (mm)	Ripening phase (mm)	Total (mm)
		BRRI dhan33		
10 July (T_1)	7.1	0	18.8	25.9
17 July (T_2)	7.1	0	26.8	33.9
24 July (T_3)	7.1	7.6	35.1	49.9
31 July (T_4)	7.1	7.6	44.1	58.8
07 August (T_5)	0	11.8	44.9	56.7
14 August (T_6)	0	40.8	40.9	81.7
		BR11		
10 July (T_1)	7.1	40.8	39.9	87.8
17 July (T_2)	7.1	42.8	49.9	99.8
24 July (T_3)	10.3	39.6	54.9	104.8
31 July (T_4)	14.7	40.1	58.0	112.8
07 August (T_5)	7.6	59.1	57.0	123.7
14 August (T_6)	7.6	64.1	58.0	129.7

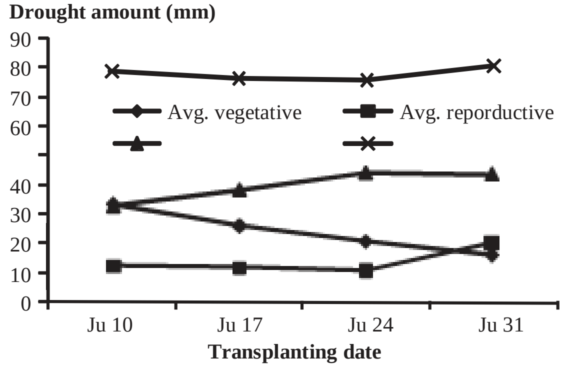


Fig. 6. Average drought pattern (2009-13) for BR11 at Kushtia.

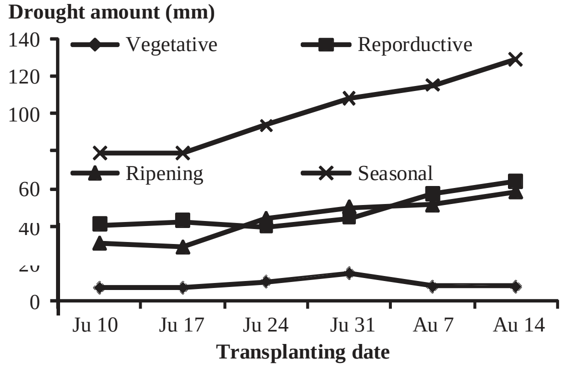


Fig. 7. Drought pattern in 2014 for BR11 at Kushtia.

Table 7. Yield and yield components for different transplanting dates, T. Aman 2014, Kushtia.

Treatment	Transplanting date	Plant ht (cm)	Panicle /m^2	Filled grain/ panicle	1000-grain wt (gm)	Yield (t/ha)
			BRRI dhan33			
T_1	10 July	114.67	261	139	25.36	5.26
T_2	17 July	115.67	285	127.33	25.42	5.46
T_3	24 July	111.67	248.3	130.33	23.39	5.23
T_4	31 July	101.67	224	135.33	24.47	4.67
T_5	7 Aug	102.63	262.3	121	23.02	4.35
T_6	14 Aug	102.67	301.6	102.67	24.02	4.07
$LSD_{0.05}$		4.73	17.48	18.01	1.2	0.39
CV (%)		2.4	3.6	7.9	2.7	4.4
			BR11			
T_1	10 July	120.2	265.33	107.2	24.55	5.70
T_2	17 July	116.0	333.3	106.3	24.47	5.76
T_3	24 July	109.7	275.0	102.2	24.13	5.46
T_4	31 July	107.3	304.3	143.5	24.79	5.21
T_5	7 Aug	108.4	302.3	140.4	23.53	4.75
T_6	14 Aug	104.3	296.7	127.4	23.85	4.44
$LSD_{0.05}$		5.97	34.7	17.7	0.91	0.37
CV (%)		3	6.4	8	2.1	3.6

14 August (4.44 t/ha). Yield decreased for both short and long duration variety after transplanting on 24 July.

Drought is an unpredictable phenomenon and it reappears after 5-10 years. Short duration variety faced fewer droughts due to its shorter growth duration. But both the short and long duration varieties faced fewer droughts when they were transplanted before 24 July. So, transplanting before 24 July would be low risk period, 24-31 July would be medium risk period and after that it would be high risk period of drought.

Plant Physiology Division

SUMMARY

Plant Physiology Division mainly works on different aspects of abiotic stress tolerance such as salinity, submergence, drought, heat and cold etc. The division also covers other aspects of rice physiology such as growth behaviour, photo-sensitivity, photosynthesis, climate change and crop weather information. About 189 rice genotypes from different sources, i.e. IRSSTN, OT, advanced breeding lines, anther cultured lines and 200 germplasms from BRRI Gene Bank were screened for seedling stage salinity tolerance. Out of them 60 lines and 25 germplasms were selected as tolerant to moderately tolerant. Among the tested advanced breeding lines for reproductive stage salinity tolerance four advanced lines were selected of which IR78761-B-SATB1-28-3-24 is now release as salt tolerant variety. Three germplasms and one advanced breeding line were characterized for salinity tolerance of whole growth period and identified Lambra, Bazail dhan and Kechrail as tolerant genotype. In comparative study with four salt tolerant varieties for salinity tolerance of whole growth period BRRI dhan47, BINA dhan-10 and BINA dhan-8 demonstrated similar level of tolerance reaction. All high-yielding salt tolerant varieties were tested for salinity tolerance at germination, post-emergence and seedling stage. Salinity level 25, 10 and 8 dS/m could be the critical level for discriminating tolerant to sensitive varieties for germination, post-germination and seedling stage respectively. Germination stage was relatively tolerant than post-germination and early seedling growth stage. About 108 rice genotypes were characterized for submergence tolerance identifying Kalaba, Kerani dhan, Thakor and IR77092-B-2R-B-10 as tolerant and non-elongating type genotypes with 100% survival and better recovery. Performance of NERICA, ALART and anther cultured lines were studied for drought stress at reproductive stage, where NERICA Mutant, two ALART and one anther cultured line found better under drought stress. Of which, one advanced breeding lines IR82589-B-B-84-3 is released as drought tolerant variety. Among the tested lines for low water condition IR83142-B-71-B-B performed better at field capacity having good rooting ability. To improve the spikelet fertility of BRRI dhan28 and BRRI dhan29 at flowering stage a MABC programme is on-going to introgress spikelet fertility QTL (*qSF4.1*) from heat tolerant genotype N22. At third backcrossing 40 and 109 BC_3F_1 seeds were produced for BRRI dhan28/N22///BRRI dhan28 and BRRI dhan29/N22///BRRI dhan29 respectively. About 147 rice genotypes from BRRI Genebank germplasms and INGER materials were screened for cold tolerance and 14 genotypes were selected as tolerant. Advanced rice genotypes IR77496-31-2-1-3-1 and IR62266-42-6-2 showed cold tolerance at seedling stage and two other advanced breeding lines BR7812-19-1-6-1-P4 and BR7813-1-3-1 had higher recovery after cold spell. The polythene covered seedbed technique has visible benefits in raising seedling at low temperature condition. A study has been initiated last year for the development of field-based seedling raising technique for Boro season's extreme low temperature condition. Based on two years results it should be recommended to use rice husk amendment in addition to polythene cover for raising better and healthy seedling only when temperature remains extremely low during Boro season.

SALINITY TOLERANCE

Identification of new sources of salinity tolerant donor from Bangladeshi rice germplasms

Some 200 BRRI Gene Bank accessions (Acc. No. 208 to 458) were characterized through IRRI standard method described by Gregorio *et al*., 1997 for seedling stage. Among the tested germplasms, none found tolerant, while only 25 germplasms showed average visual score (SES) 5.0 to 5.5 that is classified as moderately tolerant. However, other genotypes showed visual score 6 to 9 that is susceptible to highly susceptible. The selected accessions are 244 (Kashia Binni (2)), 254 (Ausha Boro), 275 (Naria Buchi), 282 (Gojol Goria), 305 (Kala Jira), 306 (Joluya), 319 (Bhog), 320 (Depa), 339 (Lal Mughi), 367 (Jolo Koia), 368 (Sapahar), 382 (Mal Sira (2)), 385 (Bhat Raj), 386 (Mugi (s)), 393 (Sindur Kowta), 394 (Boron Dhan), 400 (Indar

Sail (2)), 408 (Muta Ganji), 409 (Loha Dang), 419 (Sona Sail (4)), 432 (Bada dhan), 433 (Buchi), 434 (Rowal Doh), 435 (Mohini Sail).

Screening for salinity tolerance of some advanced breeding materials and existing salt tolerant varieties

To identify salt tolerant genotypes at seedling stage 15 genotypes along with tolerant and sensitive check IR58443-6B-10-3 and IRRI154 respectively were screened under 12 dS/m salinity stress. Out of 15 genotypes, seven genotypes IR78761-B-SATB1-28-3-26, IR83440-4-B-11-2-1-1-AJY1-B, IR77092-2R-B-10, Kechrail (Local), BRRI dhan47, BRRI dhan61 and BRRI dhan41were identified as moderately tolerant having visual score 5.

Screening for salinity tolerance of INGER materials

Forty genotypes along with BRRIdhan47 and BRRIdhan61 as tolerant and IRRI154 and IR29 as sensitive checks were screened for salinity tolerance at seedling stage under 12 dS/m salinity stress. Among tested genotypes, 11 genotypes such as IR11T129, IR12T254, IR12T133, IR12T260, A-69-1, CSR28, IR58443-6B-10-3, IRRI 147, IR66946-3R-178-1-1, Nona Bokra and Pokkali were identified as tolerant to moderately tolerant having visual score ranged 3 to 5.

Screening for salinity tolerance of OT materials

Forty three genotypes along with BRRI dhan53 and BRRI dhan54 as tolerant and IR29, BRRI dhan49 and IRRI154 as sensitive checks were screened for salinity tolerance at seedling stage with 12 dS/m salinity stress. Out of 43 genotypes, 8 genotypes namely IR86385-98-2-1-B, IR8638586385-117-3-1-B, IR83460-4-B-2-1-1, BR8780-16-8-3-9, BR9090-2, BR8729-2, BR8738-2 and BR8742-2 were identified as moderately tolerant having visual score 5.

Screening for salinity tolerance of STBN materials

Twenty-one genotypes along with BRRI dhan47, BRRI dhan61 as tolerant and IRRI154 and IR29 as sensitive checks were screened for salinity tolerance at seedling stage under 12 dS/m salinity stress. Out of 20 genotypes, 16 genotypes namely IR87830-B-SDO1-2-3-B, IR87830-B-SDO1-2-2-B, IR87938-1-1-3-2-1-B, IR87830-B-SDO2-1-3-B, IR87916-4-1-2-1-1-B, IR87938-1-2-2-1-3-B, IR87831-3-1-1-2-2-BAY B, IR87938-1-1-1-2-1-3-B, IR87870-6-1-1-1-1-B, IR87872-7-1-1-2-1-B, IR87938-1-1-2-3-3-B, IR87938-1-2-2-2-1-B, IR87937-6-1-3-2-2-B, IR8786359-302-1-1-2-3-B, IR87948-6-1-1-1-3-B and IR87938-1-2-2-2-3-2-B were identified as tolerant to moderately tolerant with visual score 3 to 5.

Screening for salinity tolerance of some anther cultured lines

Fifty-five anther cultured lines along with FL378 and BRRI dhan40 as tolerant and BRRI dhan28, IR29 as sensitive checks were screened for salinity tolerance at seedling stage under 12 dS/m salinity stress. Out of them, eight lines namely BR8019-AC4-1-1-3, BR8019- AC5-1-2-1, BR8019-AC8-1-2-2, BR8036-AC3-2-2-3, BR8036-AC2-1-2-1, BR8009-AC3-1-1-2, BR8009-AC8-1-2-2 and BR8033-AC3-3-2-3 were identified as moderately tolerant having visual score 5.

Screening for salinity tolerance of advanced breeding materials and germplasms

Nine genotypes along with tolerant and sensitive check FL378 and BRRI dhan49 respectively were screened for salinity tolerance at seedling stage under 12 dS/m salinity stress. Among the tested genotypes BR7941-116-1-2-1, BR7941-30-1-1-1, FL 378 and Dudkalom were identified as moderately tolerant to salt stress than other genotypes, due to less uptake of Na^+ and maintenance of good balance of Na^+/K^+ ratio in shoot.

Characterization and evaluation of advanced breeding materials for salinity tolerance

Two PVT and four ALART lines along with tolerant and sensitive checks, i.e. BRRI dhan47 and IRRI154 were considered for this study during T. Aman season to find out the yield potential and tolerance reaction in varying salinity level at reproductive stage. Salt stress was applied at 31 days after sowing; stress was applied to the water in the bucket by adding NaCl @ 3, 6, 9 and 12 dS/m. One set without salt was considered as control.

The salinity developed as saturation paste extract (ECe) in the soil ranged from 0 to 1 dS/m, 2 to 3.5 dS/m, 6 to 9 dS/m and 8.5 to 11 dS/m for the applied level 0, 3, 6, 9 and 12 dS/m respectively. BRRI dhan47 and other three lines IR73055-8-1-1-3-1, IR78761-B-SATB1-28-3-26 and IR78761-B-SATB1-68-6 yielded better than other genotypes at high levels of salinity (9 and 12 dS/m) (Fig. 1). All the tested genotypes and checks had shown increasing trends of yield reduction with increasing salinity level (Fig. 2). Genotype IR78761-B-SATB1-28-3-24 performed better up to 8 dS/m but

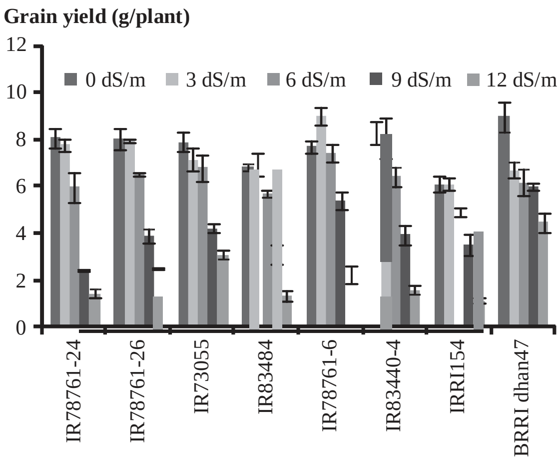


Fig. 1. Yield potential at varying salinity levels. Error bar represents mean±SE.

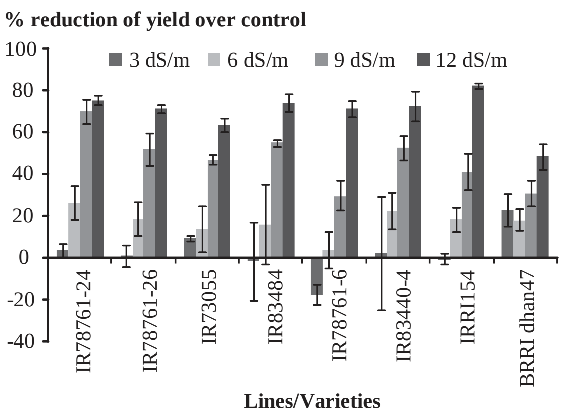


Fig. 2. Reduction of yield over control at varying salinity levels. Error bar represents mean±SE.

its yield reduction was higher at 9 dS/m. The reduction was less than 25% up to 6 dS/m but it was more than 60% at 12 dS/m for all the tested lines excluding tolerant check BRRI dhan47 (Fig. 2). However, the discrimination level between tolerant and susceptible genotypes would be considered at 9 dS/m salinity level. Days to heading was earlier for the genotype IR78761-B-SATB1-28-3-26 followed by IR78761-B-SATB1-68-6 and IR73055-8-1-1-3-1 than the tolerant check BRRI dhan47 at 12 dS/m salinity level. Considering the yield potentiality and tolerance reaction at different salinity level, four lines IR73055-8-1-1-3-1, IR78761-B-SATB1-28-3-26, IR78761-B-SATB1-68-6 and IR78761-B-SATB1-28-3-24 could be proposed for further evaluation at field condition.

Characterization of germplasms for salinity tolerance

Three germplasms and one advanced line along with tolerant and susceptible check BRRI dhan53 and IRRI154 were considered for this study to find out the yield potential and tolerance reaction under salinity stress at reproductive stage during T. Aman season. Salt stress @ 8 dS/m was applied 35 days after sowing by adding NaCl in the bucket. One set without salt was considered as control.

The salinity developed as saturation paste extract (ECe) in the soil ranged from 0 to 0.5 dS/m and 4.5 to 5.5 dS/m for the applied level 0 and 8 dS/m respectively at harvest. Rice germplasms Lambra, Bazail dhan and Kechrail produced better yield than other tested genotypes at 8 dS/m (Fig. 3). Yield of rice genotypes were reduced significantly in salt treated condition than control. Grain yield reduction was highest for sensitive check IRRI154 (>50%) (Fig. 4). Considering the yield reduction under 8 dS/m salinity level, the tested three germplasms (Lambra, Bazail dhan and Kechrail) were found tolerant at the reproductive stage and could be recommended for use in salinity breeding programme.

Comparative physiological study of salt tolerant varieties

Four tolerant varieties, BRRI dhan47, BRRI dhan61, BINA dhan-10 and BINA dhan-8 with salt

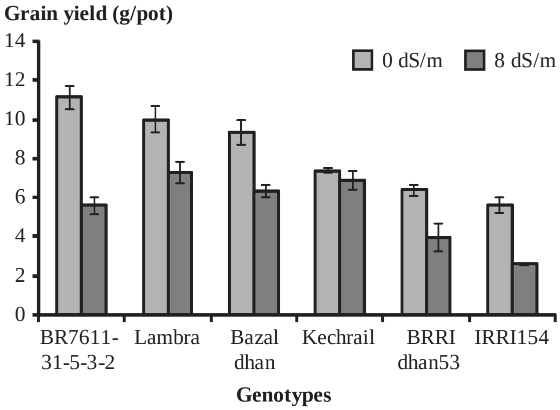


Fig. 3. Yield potential at varying salinity level. Error bar represents mean±SE.

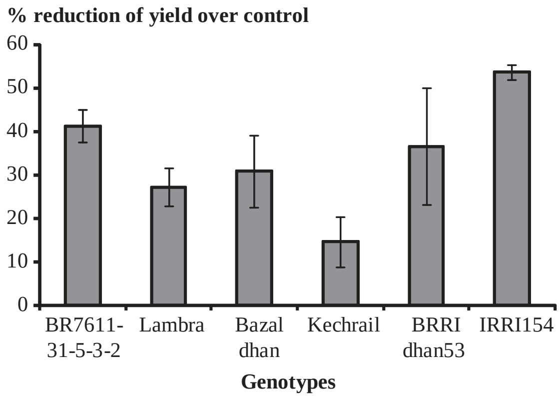


Fig. 4. Reduction of yield over control (%) at varying salinity level. Error bar represents mean±SE.

tolerant and susceptible check, i.e. IR58443-6B-10-3 and IRRI154 were considered for this study during T. Aman season to find out the yield potential and salinity tolerance in varying salinity stress at reproductive stage. Salt stress was applied 31 days after sowing. Stress was applied to the water in the bucket by adding NaCl @ 3, 6, 9 and 12dS/m. One set without salt was considered as control.

The salinity developed as saturation paste extract (ECe) in the soil as 0.1, ~ 2.4, ~4.5, ~ 6.0 and ~8.5 dS/m for the applied levels 0, 3, 6, 9 and 12 dS/m respectively. Grain yield was statistically similar for all the tested genotypes at 0 and 3 dS/m salinity stress. Interestingly, the yield was increased at 6 dS/m salinity stress for BRRI dhan47, BINA dhan-8 and 10 (Fig. 5). But after that, the yield was decreased gradually for all the

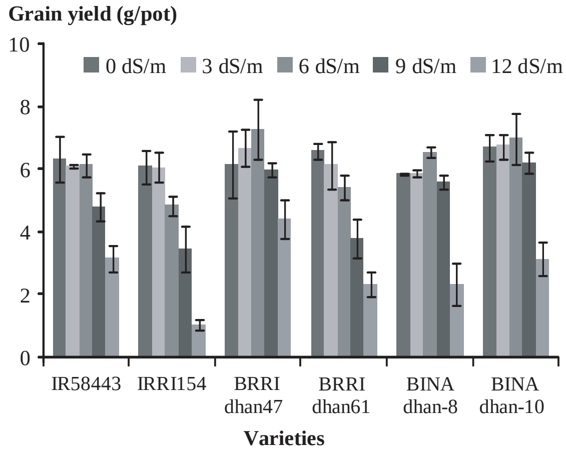


Fig. 5. Yield potential at varying salinity level. Error bar represents mean±SE.

genotypes. Yield is drastically reduced for all the genotypes at 12 dS/m salinity stress. At higher salinity level (6, 9 and 12 dS/m), BRRI dhan47 and BINA dhan-8 took more time for heading. Days to heading were observed lowest in the genotype BINA dhan-10 and IR58443-6B-10-3 at all salinity stress. Based on yield potential and reduction of yield under different degrees of salinity at controlled condition, BRRI dhan47 was found as the best tolerant followed by BINA dhan-10, BINA dhan-8 and BRRI dhan61.

Evaluation of salt tolerant Boro varieties at different salinity stress at different sowing time

An experiment was conducted in the nethouse of Plant Physiology Division of BRRI during Boro season. BRRI dhan67, BRRI dhan61, BRRI dhan55, BRRI dhan47 and BINA dhan-10 were considered for this study. Plants were grown in the perforated plastic pots filled with grinded soil. Three sets of plants were grown at 15 days sowing interval where 1st set was sown at 12 December 2014. Salt stress was applied 60 days after sowing. Stress was made by adding NaCl in the bucket at 4 and 8 dS/m. One set of plants was used as control (without salt). Considering yield and yield components BRRI dhan67 and BINA dhan-10 were the best performer at all sowing time. All the varieties gave comparatively better performance in 2nd sowing due to low sterility with high filled grain number at salt stressed condition (Fig. 6).

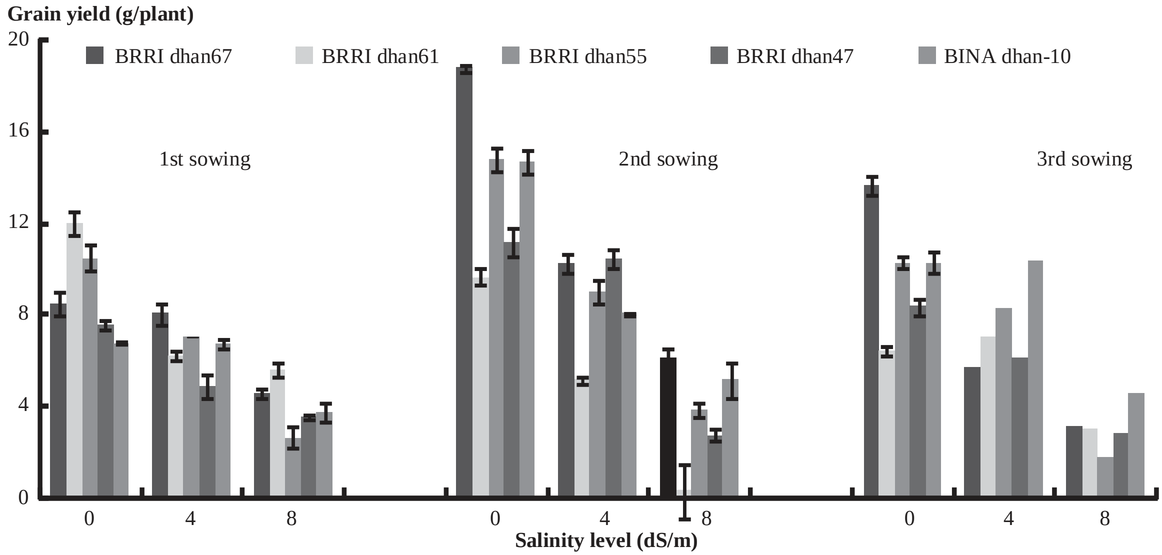


Fig. 6. Grain yield of tested varieties at different salinity level during 1st, 2nd and 3rd sowing. Error bar represents ±SE.

Investigation on tolerance level of modern salinity tolerant rice varieties

Studies were undertaken and designed to determine the level of tolerance of all released high yielding salt tolerant varieties during germination, post-germination and seedling stages. Two different sets of salinity stress level were employed i.e. 0, 5, 10, 15, 20 and 25 dS/m for germination and post-germination growth study and 0, 4, 8, 12 dS/m for seedling stage.

Tolerance at germination stage. The effects of salinity stress on germination was judged by three parameters i.e. final germination percent (FGP), speed of germination (SG), and germination energy percentage (GE %). At 25 dS/m salinity, FGP was inhibited greatly and ranged 0-11.67% for BRRI dhan40, BRRI dhan41, BRRI dhan53, BRRI dhan54, Pokkali and IRRI154, which are regarded as sensitive to moderately sensitive. Two varieties BRRI dhan67 and BINA dhan-10 maintained FGP 31.67% and 36.67% respectively and these could be termed as moderately tolerant. However, only three varieties BRRI dhan47, BRRI dhan61 and BINA dhan-8 maintained FGP >50% at 25 dS/m could be considered as tolerant at germination stage.

Tolerance at post-germination growth. Post-germination growth was characterized through plumule and radicle dry weight reduction. All varieties showed inconsistency on their salinity tolerance with the increasing of salt concentration. They showed gradual sensitivity from their previous salt tolerant ranking from T to MT, MT to MS and MS to S respectively. Therefore, in this study, BRRI dhan47, BRRI dhan61, BINA dhan-8 and BINA dhan-10 showed relatively better tolerance capacity compared to other varieties at high salinity level (Table 1).

Tolerance at seedling stage. The investigation was designed to know the behaviour of tested varieties for whole seedling growth period in to different levels of salinity stress at seedling stage. The results revealed that, even at low concentration of salt for prolonged period could also be destructive. At 8 dS/m, only two varieties BRRI dhan47 and BINA dhan-10 showed SES 7.25 (moderately sensitive) but the rest was highly sensitive. At 12 dS/m, the SES ranged 8.33 to 9.00 that means all were shown highly sensitive. The threshold salinity at which growth of rice begins to be affected by the salt can be as low as 3 dS/m (~30 mM salt).

Based on all parameters at germination, post-germination and seedling stage, three varieties BRRI dhan47, BRRI dhan61 and BINA dhan-8 were found tolerant; two varieties BRRI dhan61 and BINA dhan-10 was found moderately tolerant; four varieties BRRI dhan40, BRRI

Table 1. Reduction of total dry weight (plumule and radicle) compared to control and classification of varieties for tolerance.

Varietiy	Dry weight reduction at salinity level (dS/m)					Classification for tolerance at salinity level (dS/m)				
	5	10	15	20	25	5	10	15	20	25
BRRI dhan40	-3.88	13.17	-67.82	-54.91	-100.00	T	T	S	MS	S
BRRI dhan41	-15.65	-30.43	-41.65	-46.53	-75.59	T	MT	MS	MS	S
BRRI dhan47	-0.21	-19.21	-28.65	-36.39	-58.75	T	T	MT	MT	MS
BRRI dhan53	-20.62	-23.36	-33.51	-60.67	-87.94	MT	MT	MT	S	S
BRRI dhan54	5.96	-32.22	-36.35	-67.01	-82.61	T	MT	MT	S	S
BRRI dhan61	-7.79	-13.65	-32.91	-38.44	-58.76	T	T	MT	MT	MS
BRRI dhan67	-4.18	-23.08	-33.00	-40.93	-54.83	T	MT	MT	MS	MS
Pokkali	-28.91	-56.39	-43.10	-63.70	-100.00	MT	MS	MS	S	S
IRRI154	-26.65	-29.07	-44.42	-56.02	-61.33	MT	MT	MS	MS	S
BINA dhan-8	2.02	-19.58	-32.36	-22.10	-51.17	T	T	MT	MT	MS
BINA dhan-10	-4.89	-17.96	-39.78	-36.05	-58.73	T	T	MT	MT	MS

(T=Tolerant; MT=Moderately tolerant; MS=Moderately sensitive; S=Sensitive). (Classification was adapted according to Fageria, 1985)

dhan41, BRRI dhan53 and BRRI dhan54 was found moderately susceptible and two varieties Pokkali and IRRI154 was found susceptible. Salinity level 25, 10 and 8dS/m could be the critical level for discriminating tolerant to sensitive varieties for germination, post-germination and seedling stage respectively. Germination stage was relatively tolerant than post-germination and early seedling growth stage.

SUBMERGENCE TOLERANCE

Characterization of rice germplasms and advanced breeding lines against complete submergence

An experiment was conducted at submergence tank of Plant Physiology Division, BRRI during T. Aman, 2014. A total of 99 germplasms, four advanced breeding lines along with BR5 and FR13A as sensitive and tolerant check respectively were characterized and tested for complete submergence tolerance. The crop was completely submerged at 14 days after transplanting by maintaining 75 cm water depth for 14 days. At 14 days after submergence, the water was drained out from the submergence tank. The recovery and survivability scoring was done by SES (IRRI, 1996). Among the tested genotypes, Kalaba, Kerani dhan, Thakor and IR77092-B-2R-B-10 have showed 100% survivability with SES 1. Other eight genotypes (Muirol, Bhoban, Maitya cheng, Pathor nuti, Sadadangor boro, IR7867-4R, IR72046-B-14-8-3-1, BR9377-9-14-7) were also shown good survivability (58.3-91.7%) and very good recovery. All those genotypes were non-elongating type (relative elongation ranged 9.2-59.6%). Survivability of FR13A and BR5 was 100% and 0% respectively. The selected germplasms and advanced lines could be recommended for further evaluation and then used for future submergence breeding programme.

Effect of submergence on Rice genotypes under different water turbid condition

An experiment was conducted at submergence tank of Plant Physiology Division, BRRI HQ during T. Aman 2014. Two germplasms Pathornuti- (Acc. 1838) and Saddangor boro (Acc 4069), two submergence tolerant BRRI varieties-BRRI dhan51 and BRRI dhan52 and three breeding lines- IR72046-B-14-8-3-3-1, IR77092-B-2R-B-10 and BR9377-9-14-7 along with BR5 and FR13A as sensitive and tolerant check respectively were used. After 14 days of sowing, the crop was allowed to complete submergence maintaining 75 cm water depth from the plant base for 14 days. During submergence period, water of the tank was made turbid twice and thrice daily for T_2 and T_3 tank respectively and one tank kept normal water condition (T_1). Water temperature, light intensity and dissolved O_2 were also measured during submergence for all three tanks. Breeding line IR72046-B-14-8-3-3-1 showed very sensitive to chlorophyll degradation with lower survivability while submerged. Submergence condition of both normal and turbid water caused degradation of leaf chlorophyll. However, BRRI dhan51 had lower effect on chlorophyll degradation at 14 days submergence for different turbid condition.

DROUGHT TOLERANCE

Performance of NERICA and ALART materials

An experiment was conducted at BRRI HQ, Gazipur during T. Aman 2014 to evaluate six NERICA and two ALART materials with check variety BRRI dhan56 shaded by polythene sheet. Twenty-five-day-old seedlings were transplanted in drum (56 cm x 43 cm) containing 110 kg puddled soil in two sets where 1st set was grown in well-watered conditions and 2nd set under stress condition. At panicle initiation stage water was drained out from the 2nd set so that the plants experience drought stress from the reduction division stage. During the reduction division stage and flowering period the average soil moisture was below field capacity (14-30%) which revealed plants suffered severe water stress both the reproductive and ripening stage. Due to water stress plant height and straw yield reduced remarkably in all varieties. Grain yield of all the varieties reduced significantly under stress condition than control (Table 2). Compared to the control plant, the percent yield reduction of BRRI dhan56 at stress condition was less (71.8%) than other varieties. Among the NERICA materials the lowest yield reduction was recorded in NERICA Mutant (85%). The sterility percentage was increased due to water stress. Under stress condition, among the tested genotypes the lowest sterility percentage was found in IR82589-B-B-84-3 followed by IR83377-B-B-93-3 and NERICA Mutant. The yield reduction might be due to increase in sterility. Considering yield reduction and percent sterility NERICA Mutant and two ALART materials IR82589-B-B-84-3 and IR83377-B-B-93-3 performed better under drought stress.

Performance of six advanced anther cultured breeding materials

Six advanced anther cultured breeding materials namely BR8009-AC2-1-1-2, BR8009-AC4-1-1-3, BR8009-AC7-1-2-2, BR009-AC8-1-2-4, BR8009-AC9-1-3-1 and BR8009-AC11-1-5-2 along with BRRI dhan56 were tested under control drought condition. The methodology was same as previous experiment. Under drought condition significant reduction was observed in straw yield in all the genotypes. All the tested rice genotypes had higher yield reduction than the check variety BRRI dhan56 (75%) (Table 3). Among the tested genotypes, drought stress caused lowest reduction of grain yield with BR8009-AC11-1-5-2 (85%) which showed lowest percent sterility (14%) under drought condition. Based on the yield reduction, percent sterility and root characters it might be concluded that among the tested anther cultured genotypes BR8009-AC11-1-5-2 performed better under drought stress.

Screening for deep rooting ability

Fifteen genotypes and a local upland variety Morichboti were tested following BRRI protocol (2006) to identify genotypes having deep rooting

Table 2. Straw weight, grain weight and percent sterility of tested varieties as affected by water stress at reproductive stage.

Designation	Straw wt (g/plant)			Grain wt (g/plant)			% sterility	
	Con.	Stress	Reduc. (%)	Con.	Stress	Reduc. (%)	Con.	Stress
WAS 122-IDSA 14-WAS B-FKRL. (NERICA-L8)	72.2	45.9	36.4	54.47	2.63	95.2	23.6	90.5
WAS 122-IDSA 1-WAS-2-B-1TGR 123(NERICA-L16)	71.6	55.3	22.8	40.38	3.18	92.1	33.4	84.9
WAS 161-B-6-B-1(NERICA-L-36)	72.2	49.1	31.9	45.60	1.20	97.4	21.0	95.5
WAS 161-B-4-1-TGR 51 (NERICA-L-32)	56.5	39.5	30.0	52.20	0.71	98.6	14.3	96.7
WAS 191-4-10(NERICA-L-54)	60.0	37.4	37.6	57.64	1.08	98.1	11.9	92.3
NERICA mutant	57.3	35.9	37.2	46.42	6.92	85.1	14.1	72.9
IR83377-B-B-93-3	61.0	49.4	19.0	51.00	10.18	80.0	23.5	63.9
IR82589-B-B-84-3	56.2	44.9	20.1	58.88	12.81	78.2	14.0	59.7
BRRI dhan56	54.2	42.6	21.4	53.09	14.98	71.8	16.6	56.3
LSD (0.05)		5.1			6.10		7.8	

Table 3. Straw weight, grain weight and percent sterility of tested varieties as affected by water stress at reproductive stage.

Designation	Straw wt (g/plant)			Grain wt (g/plant)			% Ssterility	
	Con.	Stress	Reduction (%)	Cont.	Stress	Reduction (%)	Cont.	Stress
BR8009-AC2-1-1-2	66.8	48.1	28.0	44.92	2.57	94.3	20.1	80.2
BR8009-AC4-1-1-3	62.9	51.1	18.9	60.17	2.64	95.6	16.2	83.4
BR8009-AC7-1-2-2	69.8	55.6	20.4	59.87	4.47	92.5	22.5	75.6
BR009-AC8-1-2-4	64.3	50.1	22.1	50.62	1.96	96.1	18.7	79.9
BR8009-AC9-1-3-1	75.9	58.5	23.1	52.34	3.90	92.5	15.7	86.4
BR8009-AC11-1-5-2	65.3	51.9	20.5	51.58	7.66	85.1	14.0	66.5
BRRI dhan56	58.4	47.0	19.5	56.45	14.03	75.1	19.6	57.8
LSD (0.05)		3.4			3.38		12.3	

ability. There was genotypic variation in root characters among the tested genotypes. All the tested materials produced more than 40 cm long root. The longest root was produced by check variety Morichboti followed by BRRI dhan56. Among the NERICA lines, NERICA Mutant produced the longest root (57.5 cm). The check variety Morichboti produced 72.3 cm long root. Considerable variation was present in cumulative root length (CRL). The highest CRL was also observed in check variety Morichboti. The highest amount of root produced by the anther cultured line BR8009-AC11-1-5-2 (237.5mg/g of shoot) followed by BR8009-AC2-1-1-2 (224.7 mg/g of shoot).

AEROBIC RICE

Characterization and evaluation of aerobic rice genotypes

Two aerobic rice genotypes IR83140-B-36-B-B and IR83142-B-71-B-B along with standard Boro varieties BRRI dhan28 and BRRI dhan29 were tested in different watered condition. Forty-day-old seedlings were transplanted in metal drum (56 cm × 43 cm) containing 110 kg puddled soil. There were three levels of water i.e. saturated; field capacity and well-watered condition having 4cm standing water serve as control. At tillering stage, water treatments were applied. Considering growth parameters as tiller number, root biomass, root shoot ratio, photosynthesis rate, total dry matter, grain yield and its reduction percentage compared to control genotype IR83142-B-71-B-B could perform better at field capacity condition. But yield potential of this line was low compared to BRRI dhan28 and BRRI dhan29.

HEAT TOLERANCE

Development of heat tolerant BRRI dhan28 and BRRI dhan29 by introgressing spikelet fertility QTLs *(qSF4.1)* through marker-assisted selection

This research was undertaken for improving heat tolerance of BRRI dhan28 and BRRI dhan29 by introgressing spikelet fertility QTL *(qSF4.1)* from N22 (IRGC19379). A total of 18 and 22 progenies of BRRI dhan28 and BRRI dhan29 background were selected as heterozygotes in the *qSF4.1* QTL region through InDEl marker R4M30 (Figs. 7 and 8). After selection through marker, the selected progenies were further compared for similarity with BRRI dhan28 and BRRI dhan29 phenotypically i.e. by similarity of flowering, plant height, tillering, grain shape and size etc. After comparing five progenies from each cross combination were backcrossed with respective recurrent parent for getting third backcross generation. At third backcrossing 40 and 109 BC_3F_1 seeds were produced for BRRI dhan28/N22///BRRI dhan28 and BRRI dhan29/N22///BRRI dhan29 respectively.

COLD TOLERANCE

Screening for cold tolerance at seedling stage under natural condition

Some 140 rice germplasms collected from Genebank and one breeding line from the Biotechnology Division of BRRI along with three check varieties namely BR18, BRRI dhan28 and BRRI dhan36 were tested for seedling stage cold tolerance. All tested rice genotypes had normal

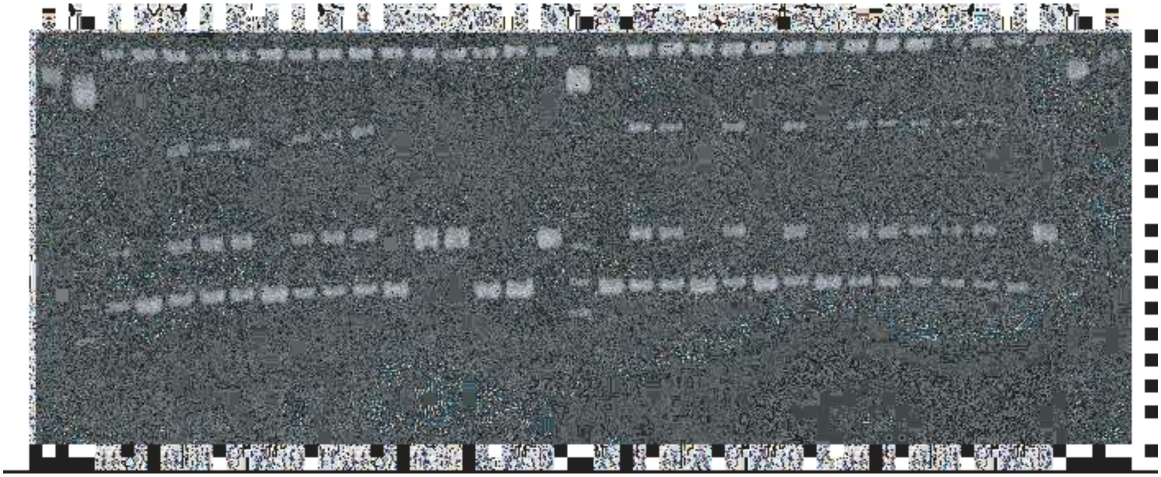


Fig. 7. PAGE1-Polyacrylamide Gel Electrophoresis (8%) of BC_2F_1 progenies of BRRI dhan28/N22//BRRI dhan28 genotyping through InDel marker R4M30 (where, B=BR28 and N=N22).

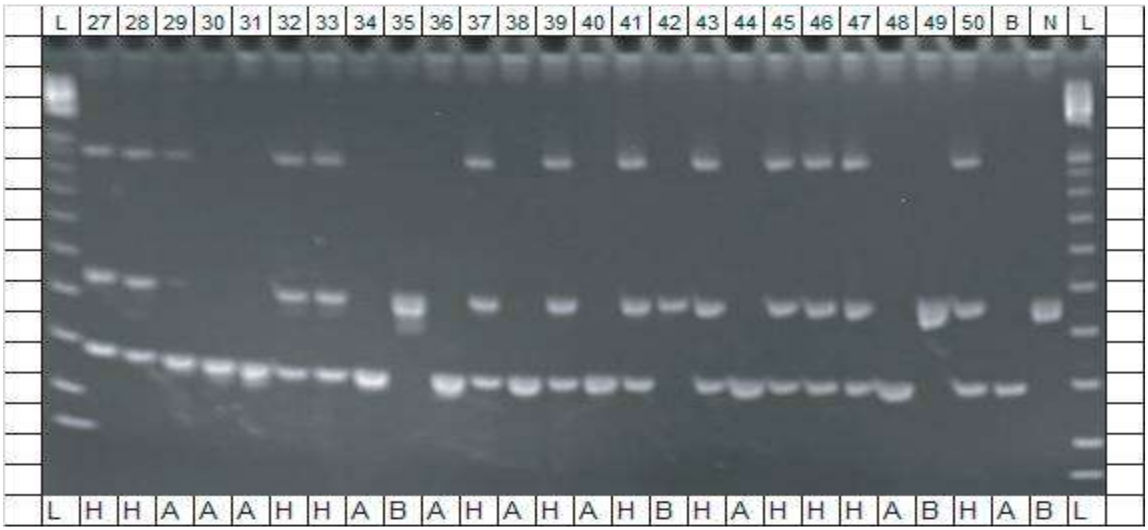


Fig. 8. PAGE1-Polyacrylamide Gel Electrophoresis (8%) of BC_2F_1 progenies of BRRI dhan29/N22//BRRI dhan29 genotyping through InDel marker R4M30 (where, B=BR29 and N=N22).

seedling growth as prevailing ambient temperature during experimental periods (21 December 2014 to 31 January 2015) was above critical level. All entries including susceptible check BRRI dhan28 showed better vegetative growth with SES score ranging from 3 to 5 and none of the genotype was selected.

Evaluation of advanced breeding lines for cold tolerance

An experiment was conducted in BRRI farm, Gazipur during Boro 2014-15 season to observe the cold tolerance of advanced breeding lines. Four genotypes namely IR7749-31-2-1-3-1, IR2266-42-6-2, BR7812-19-1-6-1-P4 and BR7813-1-3-1 were evaluated along with BRRI dhan28, BRRI dhan36 and BR18 as checks. There were four seeding dates from 10 to 31 December 2014 at seven days interval, so that rice plants suffer for cold at seedling stage. Data on different seedling parameters were recorded at 40 days after seeding and other parameters were measured at maturity. Chlorophyll content of the two advanced lines IR7749-31-2-1-3-1 and IR2266-42-6-2 were comparatively higher in 1st to 3rd sets than other genotypes (Table 4), which indicate their seedling stage cold tolerance. However, two other genotypes BR7812-19-1-6-1-P4 and BR7813-1-3-1 had higher chlorophyl content in 4th set (Table 4), which indicate their faster recover ability from cold injury. Seedling strength was also higher in IR7749-31-2-1-3-1 and IR2266-42-6-2 than BRRI dhan28 in 1st to 3rd sets but it was recorded higher for BR7812-19-1-6-1-P4 and BR7813-1-3-1 at 4th set (Table 4). The genotype BR7812-19-1-6-1-P4 had the highest grain yield with a plant height of 101 cm and growth duration 148 days. Considering seedling strength, plant height, growth duration and yield, BR7812-19-1-6-1-P4 and IR7749-31-2-1-3-1 are regarded as promising genotypes.

Characterization and evaluation of some cold tolerant rice genotypes for whole growth periods under natural condition

Twenty-three rice genotypes were characterized and evaluated for cold tolerance along with BRRI dhan28 and BRRI dhan36 as check in BRRI farm, Gazipur during Boro 2014-15 season. There were two seeding dates i.e. 15 October and 15 November 2014. Vegetative vigour showed that rice genotypes MILYANG240 and HANARIUM were more tolerant genotypes than the other genotypes including checks at vetative phase. Fifteen October seeded rice plants suffer to cold at reproductive phase which resulted in longer growth duration and lower yield as a result of higher sterility. October seeding also reduced plant height and panicle, last internode, last leaf sheath and flag leaf length. Reduction of last internode length might resulted in lower percentage of panicle exersion of those rice genotypes, which are succeptible to cold at reproductive phase. Panicles per hill and sterility were significantly higher in October seeded plants than November seeding. Considering panicle emergence, last internode length, sterility, plant height, growth duration and yield,the genotypes IR87322-65-2, JINMIBYEO, SAEGYEJINMI, IR02K101 and IR10K150 were selected as cold tolerant at reproductive phase, which could be used as donor parents.

International temperate rice observational nursery (IRTON, 2014)

Twenty-two rice genotypes of IRTON-IRRI along with two HYV check namely, BRRI dhan28 and BRRI dhan36 (moderately cold tolerant variety at seedling stage) were tested in BRRI RS, Rangpur. Vegetative vigour (Vg) and tillering ability were measured at seedling stage and other parameters except heading were measured at maturity. Out of 22 genotypes four genotypes did not germinate. Among the tested genotypes three genotypes (IR68333-R-R-B-19, IR83222-F11-85 and HR20654-54-3-5) were selected as moderately tolerant to cold with other good agronomic characteristics specially yield. Rice genotypes IR68333-R-R-B-19 showed the best performance in relation to cold tolerance and yield.

Demonstration of nursery management by polythene covering technique for seedling raising in cold prone northern region of Bangladesh during Boro season

A demonstration program of polythene covering technique for raising healthy seedling was taken with the help of IAPP fund at the cold prone

Table 4. Total chlorophyll content and seedling strength of rice genotypes at 40 days after sowing.

Genotype	Set 1		Set2		Set3		Set4	
	Total chl (mg/g)	Seedling strength (mg/cm)	Total chl (mg/g)	Seedling strength (mg/cm)	Total chl (mg/g)	Seedling strength (mg/cm)	Total chl (mg/g)	Seedling strength (mg/cm)
IR7749-31-2-1-3-1	4.894	3.35	4.955	3.44	5.114	3.55	5.190	3.55
BR7812-19-1-6-1-P4	4.348	2.62	4.400	3.24	4.823	3.50	5.288	3.62
BR7813-1-3-1	3.471	2.63	4.203	3.34	4.808	3.40	5.249	3.76
IR2266-42-6-2	4.850	3.39	4.900	3.46	4.881	3.63	5.005	3.47
BRRI dhan28	3.418	2.39	3.491	3.15	4.674	2.83	4.963	3.50
BRRI dhan36	3.713	3.22	4.430	3.35	4.574	3.45	4.633	3.38
BR18	3.970	3.38	4.315	3.40	4.501	3.14	4.942	3.25
LSD at 0.05	0.61	0.21	0.61	0.21	0.61	0.21	0.61	0.21

Northern region of Bangladesh during Boro 2014-15. From the result it was revealed that the polythene covering seedbed techniques have visible benefits in raising healthy seedling at low temperature condition. Therefore, the polythene covering seedbed technology can be recommended for massive diffusion through extension service providers like DAE in cold prone northern region of Bangladesh.

Development of field-based seedling raising technique for low temperature condition in the Boro season

A study was conducted by combining rice husk, seed priming and polythene cover for developing a field-based seedling raising technique for low temperature condition in the Boro season. The prevailing air temperature during the growth of seedling remains quite high (~20°C) compared to previous year, especially during day time. Therefore, the low temperature effects on seedling growth were not prominent. However, from the present investigation, it should be recommended to use rice husk amendment for growing better seedling only when temperature remains similar as prevailing condition and/or in combination with polythene cover if temperature falls below than the prevailing condition or when there is long cold spells.

GROWTH STUDIES

Determination of growth stages of some rice varieties at Boro season as affected by sowing time

Seedlings of BRRI dhan28, BRRI dhan59, BRRI dhan63 and BRRI dhan64 were grown in plastic bowl containing culture solution. Seedlings were transplanted in the field at five-leaf stage. Seed sowing schedule was from 15 December to 30 January at an interval of 15 days. Delay sowing resulted decreasing the duration of panicle initiation and flowering ultimately total growth duration. When seeds were sown at mid-December, seedling stage was 35 days, whereas the stage required to 25 days when seeded at the end of January. The time required for tiller formation was the highest when seeds were sown during mid-December and the lowest when seeded at the end of January. The panicle initiation stage decreased with delay of sowing time as well as 50% flowering. When seeds were sown at mid-December the growth duration was the highest. As sowing dates advanced, the growth duration gradually decreased irrespective of variety. The highest sterility percentage was observed when the seed was sowing at the end of the January.

Characterization of some B. Aus rice genotypes

The seeds of 100 Aus rice germplasm of BRRI were direct seeded on 14 April 2014 after first shower in a 2m-4-row plot with 25cm spacing between rows. Data were recorded on plant height, growth duration, HI, grain yield and spikelet fertility. At maturity all the plants were lodged. Several Aus cultivars possessed desirable characters like intermediate plant height, high harvest index and outperformed yield. Based on the traits all the germplasms were classified into five clusters of which 10 genotypes under group 1, 33 under group 2, 12 under group 3, 30 under group 4 and 12 under group 5.

Entomology Division

SUMMARY

The rice field and seedbeds of BRRI farm, Gazipur harboured GLH, WLH and GH in high number. In all five habitats spider, DF, LBB and CDB were represented. In 20 hill counts SB, GH, LHC, RLF and WM appeared in the rice field.

Brown planthopper population was higher followed by green leafhopper, yellow stem borer and white-backed planthopper in all five locations. Among the natural enemies green mirid bug, spider, lady bird beetle, carabid beetle and ground beetle were most prevalent. The highest population of green mirid bug was observed in Gazipur.

Rice planthopper incidence started from 2nd week of September 2014. Peak incidence was found on 29 October to 5 November at Kasta, Sirajganj.

The increasing trend, in the GLH, LBB and SPIDER abundance series between 1996 and 2005 has flattened out and is decreasing from 2006 to 2012. This indicates a periodic, slowly varying population abundance characteristic. Two different sampling methods showed different association with climatic variables particularly GLH population.

The highest natural enemies, percent parasitism by *Trichogramma zahiri* were observed in rice field nearby nectar-rich flowering plants. Moreover, there was no yield reduction observed in rice field surrounded by flowering plants compared with insecticide application.

It was found that continuous use of insecticide had no effect on yield and yield contributing characters of rice when insect infestation below the ETL. So, farmers should avoid continuous/ indiscriminate use of insecticide which ultimately save production cost and save the environment from insecticidal pollution.

One percent (1%) damage of tillers by GM at mid-tillering stage caused 1.08 and 1.02 % yield loss of BRRI dhan52 and BRRI dhan49 respectively at field condition.

A total of 108 commercial formulations of insecticides were evaluated against brown planthopper (BPH) and yellow stemborer (YSB). Among those 83 were found effective (81 against BPH and two against YSB). Effective commercial formulations were recommended to PTAC for registration and commercial use.

Out of 79 entries, 19 were found moderately resistant against BPH. Among the 49 entries 12 were selected as moderately resistant against WBPH. Among the 68 entries tested against GLH, two entries were found moderately resistant. Out of seven F_2 materials two were confirmed as moderately resistant to GM.

Among 63 rice germplasms, Muktahar (Acc # 156) and Koha Binni (Acc# 208) were recorded as moderately resistant (MR) (6-10% OS) to resistant (0-1% OS) against GM.

Fumigation with Phostoxin tablet and zinc phosphide (<2%) bait mixed with wheat @ 5g bait caused 45% reduction of rats.

SURVEY AND MONITORING OF RICE ARTHROPODS

Pest and natural enemy incidence at BRRI farm, Gazipur

Incidence of rice insect pests and their natural enemies along with their damage intensities was monitored weekly at BRRI farm, Gazipur. Figures 1, 2 and 3 present the data collected from five different habitats (seed bed, grass fallow, upland and irrigated rice, rice-ratoon) in Aus, T. Aman and Boro seasons 2014-15. In Aus 2014, green leafhopper dominated in seed bed followed by grass fallow, upland and irrigated rice environment. Rice bug was most abundant in ratoon. In this season spider dominated in all five habitats. In T. Aman season, the highest population of grass hopper was observed in seed bed followed by rice-ratoon and grass fallow habitats. Green leafhopper was dominant in irrigated rice. Among the natural enemies lady bird beetle (LBB), spider, carabid beetle and damselfly dominated in all the habitats. In Boro 2015 season, grass hopper was most abundant in seed bed, rice-ratoon, grass fallow and irrigated rice. Predator LBB and spider dominated in seed bed followed by rice-ratoon, grass fallow and irrigated rice.

Pest and natural enemy incidence in light trap

Rice insect pests and their natural enemies were

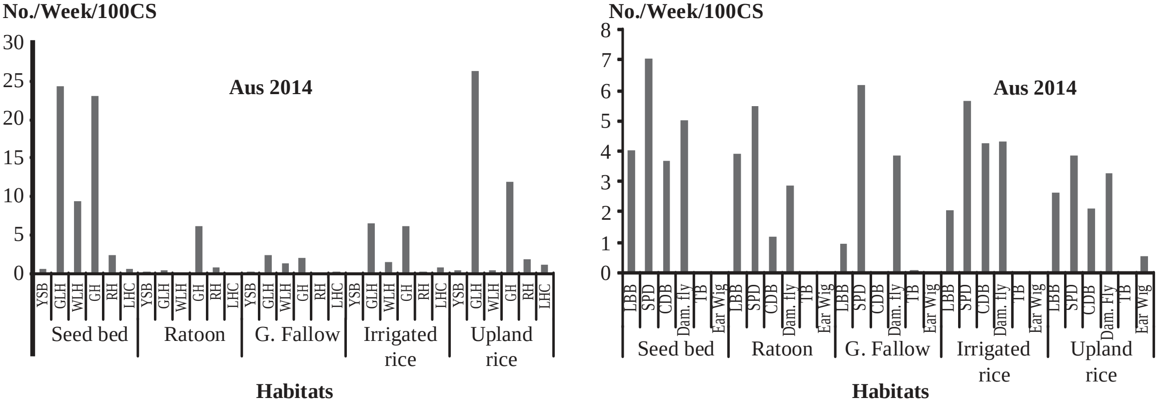


Fig. 1. Incidence of insect pests and natural enemies in rice and non-rice habitats during Aus 2014 at BRRI farm, Gazipur.

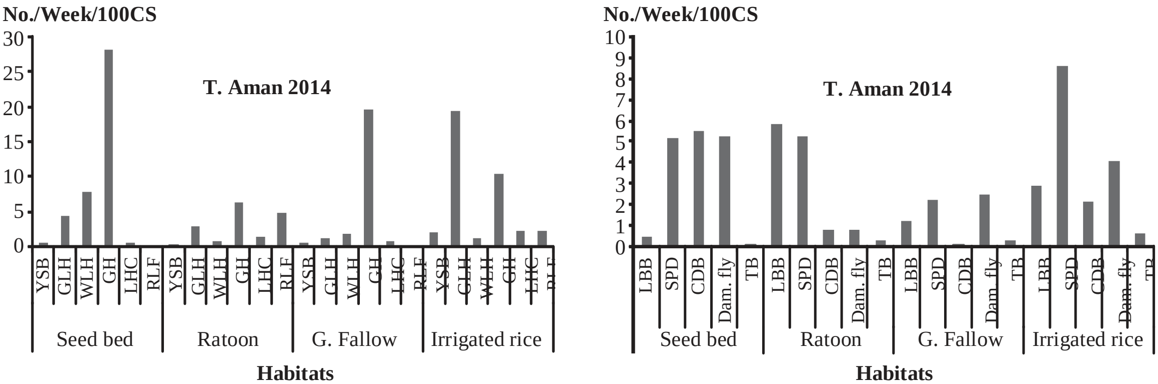


Fig. 2. Incidence of insect pests and natural enemies in rice and non-rice habitats during T. Aman 2014 at BRRI farm, Gazipur.

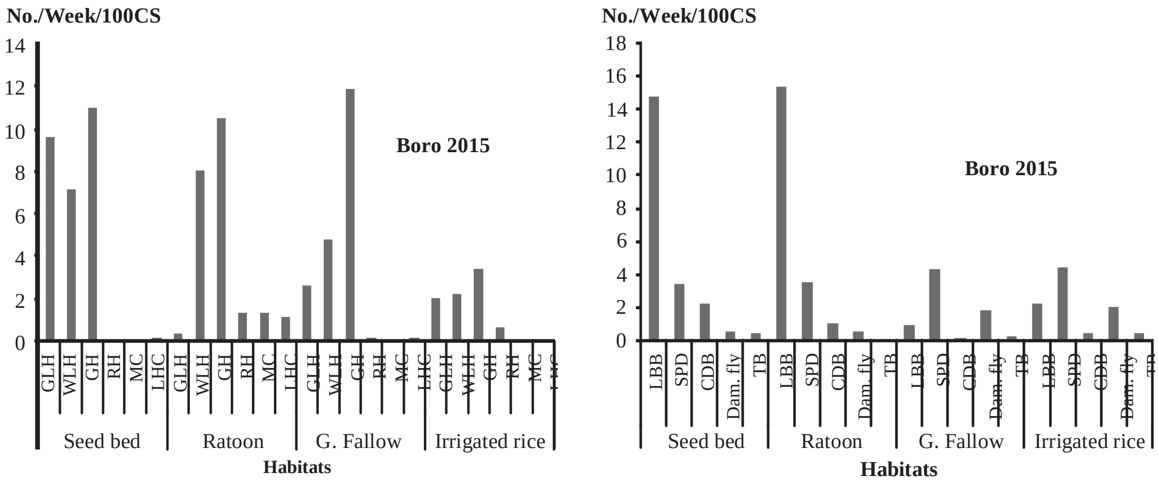


Fig. 3. Incidence of Insect pests and natural enemies in rice and non-rice habitats during T. Aman 2015 at BRRI farm, Gazipur.

monitored by using light traps during July 2014 to June 2015 at BRRI farms in Gazipur, Barisal, Rajshahi, Comilla and Sonagazi. Figures 4, 5 and 6 present the data of insect pests and their natural enemies. Brown planthopper population were higher (94,917) followed by green leafhopper

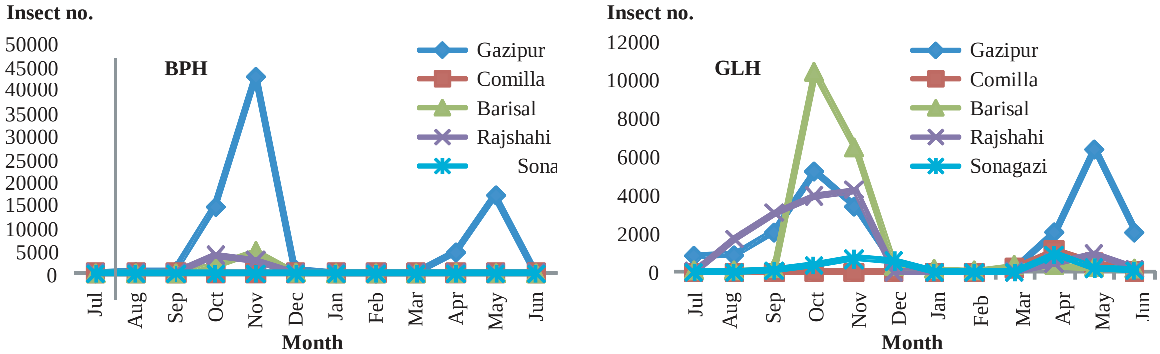


Fig. 4. Incidence pattern of BPH and GLH in light trap at BRRI HQ and regional stations during July 2014- June 2015.

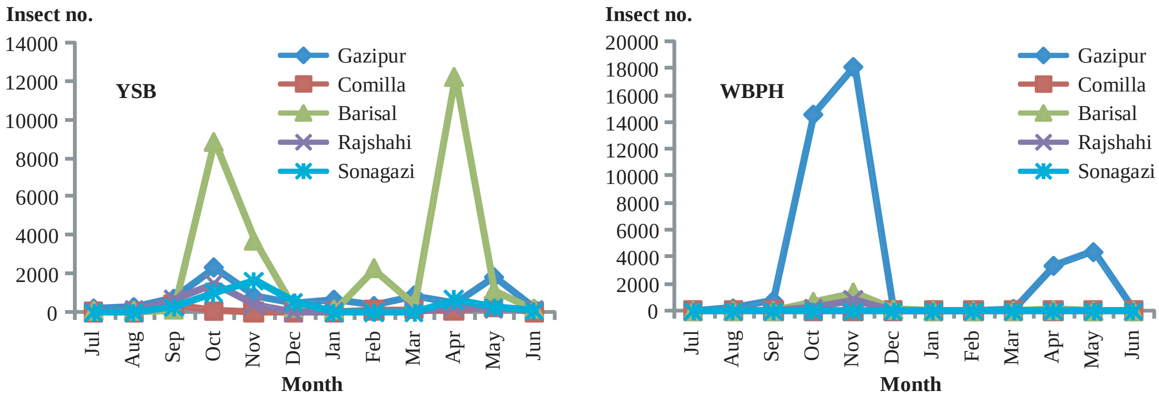


Fig. 5. Incidence pattern of YSB and WBPH in light trap, BRRI HQ and regional stations during July 2014- June 2015.

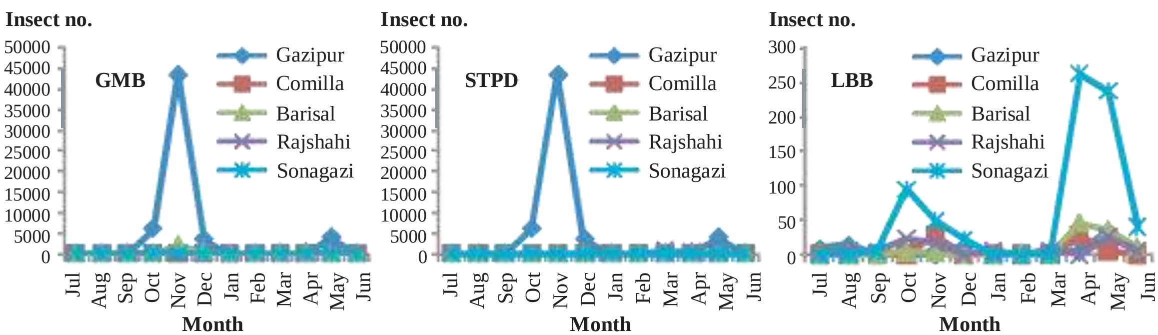


Fig. 6. Incidence pattern of GMB, STPD and LBB in light trap, BRRI HQ and regional stations during July 2014- June 2015.

(62,222), yellow stemborer (47,816) and white-backed planthopper (45,182 no.) in all five locations. Brown planthopper dominated (80,940) in Gazipur, yellow stemborer (29,333) in Barisal and green leafhopper (14,513) in Rajshahi. Among the natural enemies, green mirid bug, spider, lady bird beetle, carabid beetle and ground beetle were most prevalent. The highest population of green mirid bug (57,172) was observed in Gazipur.

Light trap attracted considerable number of winged adult BPH than WBPH from the 3rd week of October to the end of November 2014 both at BRRI HQ, Gazipur and BRRI RS, Barisal. The peak incidence of BPH was recorded in the 2nd week of November 2014 in both the locations. Population of WBPH was comparatively lower than BPH during this period. However, peak numbers were recorded in November 2014 and

May 2015. Among the natural enemies, green mired bug population was considerably higher in BRRI HQ, Gazipur than Barisal indicating their density related BPH population build-up.

Construction of epidemiology information interchange system for migratory disease and insect pests in Asia region

Monitoring of planthoppers with yellow sticky trap (YST). Monitoring by YST during T. Aman 2014 indicates that the rice planthopper incidence started from 2nd week of September 2014. Peak incidence was found at Kanchaneswar on 29 October and that was from 29 October to 5 November at Kasta, and again the highest on 29 October at Aurangail then decreased until harvest of the crop. Among the natural enemies, green mirid bug population was higher in Kasta on 5 November than the other locations, and the population was comparatively lower in kanchaneswar than Aurangail. Spider population was almost similar during the observation period. In Boro 2015, BPH and WBPH population tended to increase at Dobila, Hamkuria and Washin from the 1st week of April and the peak population was in the end of April. Natural enemies were also observed all the year round.

Monitoring of planthoppers with aerial YST. RPH (BPH, WBPH and SBPH) and natural enemy (GMB and spider) were more active in the Boro seedbed, and higher number of insects was caught at 4.88 m height traps than the other one (2.44 m). Aerial movement of RPH in space do exist and it was higher in Dobila followed by Hamkuria and Washin.

STUDIES ON RICE INSECT PEST AND NATURAL ENEMY ECOLOGY

Global warming is expected to increase/decrease frequency of rainfall/precipitation, drought intensity and solar radiation, which may affect rice ecosystems particularly arthropods eg, pests and their natural enemies. This study discusses influences of climatic variations from almost two decades, on yellow stem borer (YSB), brown planthopper (BPH), green leafhopper (GLH) and their natural enemies (spider, lady bird beetle-LBB, green mirid bug-GMB). Light trap and sweep net catches of arthropods from different rice habitats shows a strong bi-annual periodicity for BPH, YSB and GMB. The increasing trend, in the GLH, LBB and SPIDER abundance series between 1996 and 2005 has flattened out and is decreasing from 2006 to 2012. This indicates a periodic, slowly varying population abundance characteristic. Two different sampling methods showed different association with climatic variables particularly GLH population.

INTEGRATED PEST MANAGEMENT

Conservation of natural enemies through ecological engineering approaches

The highest natural enemies, percent parasitism by *Trichogramma zahiri* were observed in rice field nearby nectar-rich flowering plants. However, least natural enemies and parasitism were found in rice field where four times (continuous/ prophylactic) insecticides were applied (Figs. 7, 8 and 9). Moreover, there was no yield reduction observed in rice field surrounding by flowering plants compared with insecticide application. So, farmers should avoid the toxic and hazardous insecticides to control the insect pests by growing nectar-rice flowering plants on the bunds of surrounding rice crops.

Validation of BRRI recommended practices for insect pest management

During the experimental period (Boro 2014-15) insect infestation remained below the economic threshold level (ETL). Green leafhopper (GLH), white leafhopper (WLH) grasshopper (GH), yellow stem borer (YSB), white stem borer (WSB), leaf roller (LR), rice hispa (RH), field cricket (FC), rice bug (RB), caseworm (CW), long horned cricket (LHC), dead heart (DH) and onion shoot (OS) were found in fortnightly sweeping and hill counting. No significant differences were observed for insect number and infestation among the treatments. More or less same insect pests were also observed in Barisal region. The highest number of RH was found in Barisal region (0.38/20 hill) followed by LHC, YSB and GLH. Very small

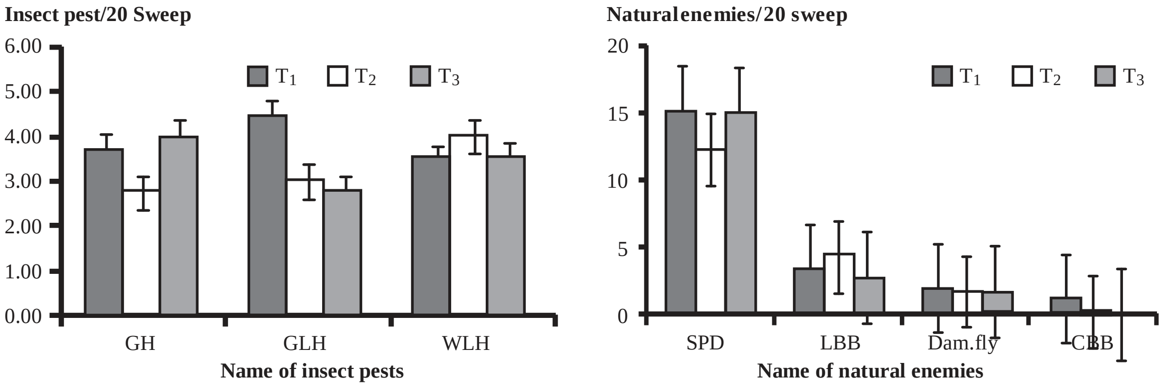


Fig 7. Incidence of insect pest and natural enemies in Gazipur during Boro 2014-15.

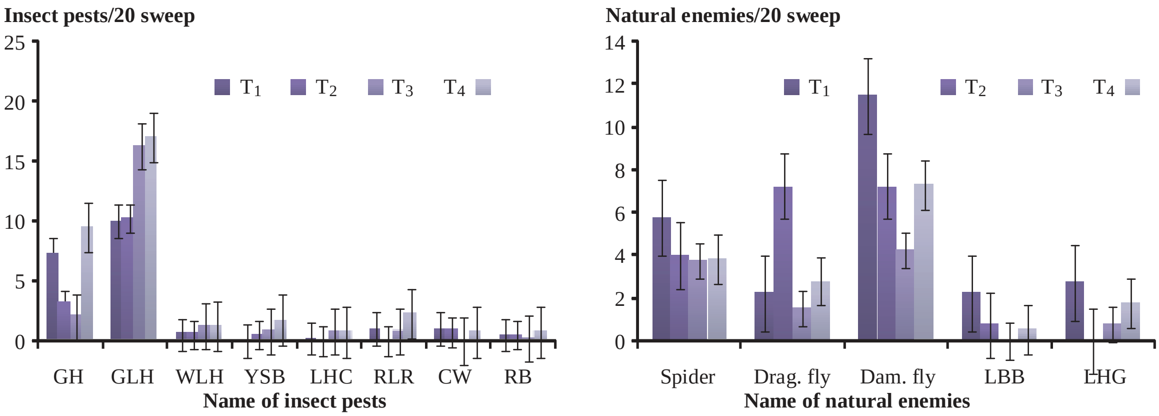


Fig. 8. Incidence of insect pest and natural enemies in Rajshahi (T. Aman 2014).

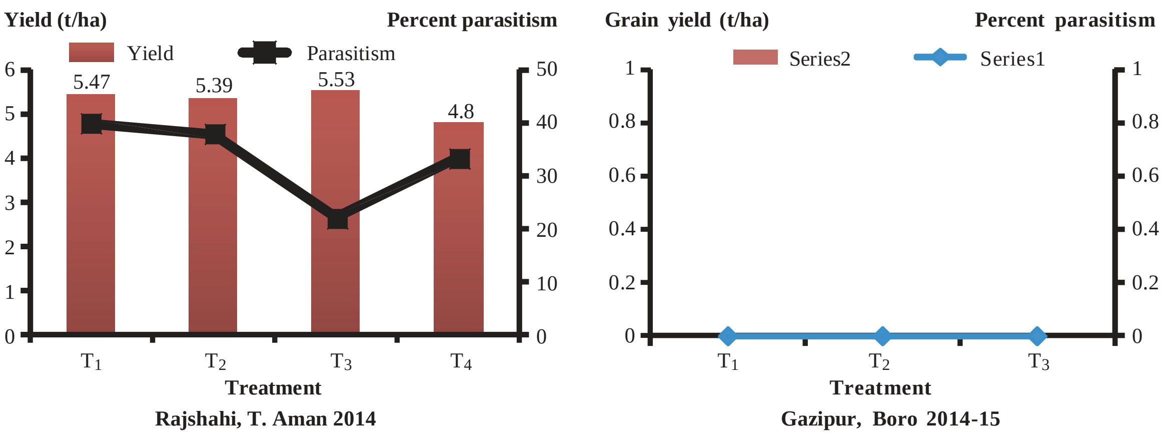


Fig.9. Percent parasitism by *Trichogramma zahiri* and yield in different treatments at Rajshahi during T. Aman 2014 and Gazipur during Boro 2014-15.

number of BPH and WBPH were also observed at Barisal region.

Among the natural enemies spider (SPD), damsel fly (Dam fly), and dragon fly (Drag. fly), ladybird beetle (LBB), carabid beetle (CBB) and long horned grasshopper (LHG) were found in sweeping. Damsel fly, CBB and LHG were not found in T_1 during sweeping where insecticide was used fortnightly. Except LBB, other natural enemies were found lowest in T_1 (insecticide treated plots) during 20 hill counting. During 20 hill counting no LBB and the lowest number of CBB were observed in T_1 at Barisal region. Thus, it indicates that continuous use of insecticide has the detrimental effect on the population of natural enemies. Initially, treatments T_2 (perching + sweeping + need based insecticide application) and T_3 (perching) were refrained from insecticide used at the early crop stages (30-40 DAT) in all the locations. As a result natural enemy populations increased (though definite trend was found) both in T_2 and T_3, which might have reduced pest population below the ETL. Therefore, no insecticide was used in T_2 and T_3. So, continuous/indiscriminate use of insecticide at early crop stage (30-40 DAT) should be avoided to conserve natural enemy in the rice field.

No significant difference in yield was observed in other three treatments (T_1, T_2 and T_3) for both the locations. In T_1 insecticides (Carbofuran 5G @ 10.0 kg/ha) were applied four times but no yield advantage was observed over the treatment T_2 and T_3 where perching and sweeping were done without any insecticide use. Therefore, it was found that continuous use of insecticide had no effect on yield and yield contributing characters of rice when insect infestation was below the ETL. So, farmers should avoid continuous/ indiscriminate use of insecticide, which ultimately save production cost and save the environment from insecticidal pollution.

Validation of BRRI recommended practices for insect pest management, T. Aman 2014

During the experimental period insect infestation in both Rangpur and Barisal region was below the economic threshold level (ETL). Yellow stemborer (YSB), dead heart (DH), rice leaf roller (RLR), caseworm (CW), long horned cricket (LHC), grasshopper (GH), green leafhopper (GLH), brown planthopper (BPH) and rice bug (RB) were found in Pirganj and Taraganj in fortnightly sweeping and hill counting. Caseworm (CW), LHC, GLH and BPH were not found in Taraganj and RB was not appeared in Pirganj during hill counting. The highest number of YSB was found in both the locations of Pirganj and Taraganj followed by RLR during sweeping. Rice leaf roller population was found as the highest in both the locations during sweeping. Similar insect infestation was observed at Barisal region during hill counting. Rice hispa adult (RHA) and rice hispa grub (RHG) and their damages were also observed at Barisal region, which normally not found at Rangpur region.

Among the natural enemies spider (SPD), LBB, STB, CBB and Dam fly were noticed both in Pirganj and Taraganj. In 20 hill count study STB was not found in T_1 of both the locations of Pirganj and Taraganj where continuously insecticide was used. Again, the lowest CBB and dam. fly was found at Pirganj and Taraganj respectively in the same treated plot. Similar detrimental effect of insecticide on natural enemies was also observed at Barisal region during hill counting. Thus, the findings indicate that insecticide use has the detrimental effects on natural enemies in the rice field.

No significant differences in yield were observed in other treatments (T_1, T_2 and T_3) in both the locations (Tables 1 and 2). In T_1 insecticide (Carbofuran 5G@ 10.0kg/ha) was applied five times but no yield advantage was observed. In T_2 and T_3 only perching and sweeping were done fortnightly or when necessary without using any insecticide but no yield reduction was observed. More or less same finding was also observed at Barisal region. Therefore, it was concluded that continuous use of insecticide had no effect on yield and yield contributing characters of rice when insect infestation below the ETL. So, farmers should avoid continuous/ indiscriminate use of insecticide, which ultimately saves production cost and saves the environment from insecticidal pollution.

CROP LOSS ASSESSMENT

Relationship between rice gall midge damage and yield loss

Yield loss occurred in gall midge infested hills compared to control hills. The highest yield loss occurred in BRRI dhan52 (18.08%) where 16.70% onion shoot observed (ranged 7.69 to 25%) followed by BRRI dhan49 (15.19%) where 14.94% onion shoots appeared (ranged 6.67 to 23.08%; Table 3). The results indicated that 1% damage of

Table 1. Plant characteristics, yield component and yield of different treatments in Pirganj and Taraganj in T. Aman 2014.

Treatment	Tiller/ hill (Mean ±SE)	Leaf/ hill (Mean ±SE)	Panicle/ hill (Mean ±SE)	Plant ht (cm) (Mean ±SE)	Yield (t/ha) (Mean ±SE)
			Pirganj		
T_1	12.91 ± 0.23 n=240	61.38 ± 1.23 n=240	11.87 ± 0.15 n=80	120.03 ± 0.59 n=80	5.84 ± 0.26a n=3
T_2	12.61 ± 0.21 n=240	60.56 ± 1.08 n=240	11.83 ± 0.15 n=80	118.19 ± 0.5 n=80	5.72 ± 0.28ab n=3
T_3	12.73 ± 0.24 n=240	61.00 ± 1.15 n=240	11.92 ± 0.15 n=80	119.75 ± 0.61 n=80	5.68 ± 0.27ab n=3
T4	12.47 ± 0.23 n=240	60.58 ± 1.12 n=240	11.73 ± 0.14 n=80	119.35 ±0.60 n=80	4.66 ± 0.20b n=3
	F-value:4.61				
F-value	*0.675 (NS)*	*0.116 (NS)*	*0.327 (NS)*	*1.834 (NS)*	*p<0.05*
			Taraganj		
T_1	16.90 ±0.17a n=360	72.35 ± 1.09a n=360	11.89 ± 0.16a n=80	116.15 ± 0.58a n=80	5.66 ± 0.35a n=3
T_2	16.67 ± 0.16a n=360	71.75 ± 1.10a n=360	11.83 ± 0.26a n=80	115.24 ± 0.24a n=80	5.45 ± 0.37a n=3
T_3	16.49 ± 0.16a n=360	70.11 ± 1.11a n=360	11.84 ± 0.25a n=80	114.83± 0.69a n=80	5.35 ± 0.32a n=3
T4	15.81 ± 0.15b n=360	64.82± 1.30b n=360	10.88 ± 0.21b n=80	110.18 ± 1.08b n=80	4.34 ± 0.22b n=3
	F-value:3.38				
F-value	*9.817*	*10.93*	*4.78*	*11.59*	*p<0.05*

Data were analyzed using one-way ANOVA; NS: not significantly different at the 5% level (Tukey's post hoc test). T_1 =Prophylactic use of insecticide, T_2 = Perching+ sweeping+need based insecticide application, T_3 = Perching, T_4 = Farmers' practice.

Table 2. Plant characteristics, yield component and yield of different treatments in Barisal region during T. Aman 2014.

Treatment	Tiller/ hill (Mean ±SE)	Leaf/ hill (Mean ±SE)	Panicle/ hill (Mean ±SE)	Plant ht (cm) (Mean ±SE)	Yield (t/ha) (Mean ±SE)
T_1	13.37 ± 0.30 n=60	41.37 ± 0.99 n=120	11.26 ± 0.31 n=60	127.37 ± 0.36 n=60	4.76 ± 0.12ab n=3
T_2	12.18 ± 0.27 n=60	41.79 ± 1.01 n=120	11.45 ± 0.31 n=60	127.45 ± 0.35 n=60	5.21 ± 0.10a n=3
T_3	11.95 ± 0.38 n=60	41.59 ± 0.96 n=120	11.21 ± 0.29 n=60	126.66 ± 0.38 n=60	4.60 ± 0.05ab n=3
T_4	12.08 ± 0.35 n=60	41.97 ± 0.97 n=120	11.13 ± 0.27 n=60	127.29 ± 0.42 n=60	4.23 ± 0.23b n=3
					F-value:8.332
F-value	*0.487 (NS)*	*0.116 (NS)*	*0.808 (NS)*	*0.031(NS)*	*p<0.05*

Data were analyzed using one-way ANOVA. NS: not significantly different at the 5% level (Tukey's post hoc test). T_1=Prophylactic use of insecticide, T_2=Perching+ sweeping+need based insecticide application, T_3=Perching, T_4=Farmers' practice.

Table 3. Plant and yield contributing characteristics of gall midge damage hills and control hills, BRRI RS farm, Rajshahi, T. Aman 2014.

Hill status	Tiller/hill (no.) (Mean± SE)	Panicle/hill (no.) (Mean± SE)	Percent onion shoot/ hill (Mean± SE)	Plant ht (cm) (Mean± SE)	Panicle length (cm) (Mean± SE)	Filled grain wt./hill (g) (Mean± SE)	% yield loss/ hill
				BRRI dhan49			
Infested	15.10±1.04a	9.30±0.30	14.94 ± 1.55	125.50±1.01b	28.70±0.37	26.80±0.80b	15.19
Control	14.0±0.42b	9.90±0.43	-	130.40±1.00a	28.90±0.31	31.60±1.85a	
				BRRI dhan52			
Infested	13.60±0.50a	9.20±0.71	16.70 ± 1.44	128.70 ±1.42b	28.10±0.28	20.94±1.55b	18.08
Control	12.70±0.56b	9.00±0.79	-	129.50±0.82b	28.20±1.62	25.56±1.62a	
F-value	*2.18*	*0.43*	-	*3.85*	*1.04*	*8.46*	
Significance	*P<0.05*	*NS*	-	*P<0.05*	*NS*	*P<0.05*	

tillers at mid-tillering stage caused 1.08 and 1.02 % yield loss of BRRI dhan52 and BRRI dhan49 respectively at field condition.

EVALUATION OF CHEMICALS AND BOTANICALS

A total of 108 commercial formulations of insecticides were evaluated against BPH and YSB. Among them, 83 were found effective (81 against BPH and two against YSB). Effective commercial formulations were recommended to PTAC for registration and commercial use.

HOST PLANT RESISTANCE

Screening of elite breeding lines, rice germplasm and rice varieties

A total of 79 entries were tested under controlled conditions in green house against BPH, 49 against WBPH, 68 against GLH and three against GM during the reporting period. In addition, seven F_2 materials also tested against BPH.

Out of 79 entries 19 were found moderately resistant against BPH. Among the 49 entries 12 were selected as moderately resistant against WBPH. Among the 68 entries tested against GLH two were found moderately resistant. Among three AYT materials, none were found resistant against GM. Out of seven F_2 materials, two were confirmed as moderately resistant (Table 4).

Screening of elite breeding lines, germplasm and rice varieties against gall midge (GM)

A total of 63 rice germplasm collected from GRS Division were screened against GM during the reporting period from July 2014 to June 2015. Among 63 rice germplasms, Muktahar (Acc # 156) and Koha Binni (Acc # 208) were recorded as moderately resistant (MR) (6-10% OS) to resistant (0-1% OS) against GM at glasshouse condition.

VERTEBRATE PEST MANAGEMENT

Evaluation of different control measures against field rat. The experiments were conducted during transplanting of Boro 2015 rice. Four treatments were executed in 20 replicates individually with different management options. Live/dead rats were observed for 10 consecutive nights. Fumigation

Table 4. Resistant reactions of rice entries against BPH, WBPH, GLH and GM at BRRI greenhouse, 2014-15.

Seed source	Entries tested (no.)	Target pest	Resistant entry	Reaction
Advanced line	79	BPH	BR7881-62-2-3-7-P_3 (RYT), IR83142-B-71-B-B, BR7683-30-3-3-4, BR7671-37-2-2-3-7, IR77734-93-2-3-2, BR 8096-55-1-9-1, BR7372-18-3-3-HR3 (COM), HHZ15-SAL13-Y1, HHZ23-DT16-DT1-DT1, HHZ15-DT4-DT1-Y1, HHZ11-DT7-SAL1-SAL1, CN-6, BR7669-11-1-2-8-2-1, BR 8334-18-7-5, BR 8335-10-6-3-5, BR8337-6-4-7-7, BR 8337-9-3-2-5, BR 8337-9-3-2-1, BR8339-3-4-2-1	MR (5)
	49	WBPH	IR83140-B-36-B-B, IR 77734-93-2-3-2, BR 8079-52-2-2-2 BR7369-10-5-2-3, BR7369-52-3-2-1-1, HHZ23-DT16-DT1-DT1, BR7800-63-1-7-3, BR7840-54-3-2-1, BR8257-37-1-2-2 BR7669-11-1-2-8-2-1. BR7718-55-1-3, BR7718-55-1-3	MR (5)
Advanced line	68	GLH	HHZ6-SAL3-Y1-SUB2, BR7718-55-1-3	MR (5)
AYT materials	3	GM	-	-
F_2 materials	7	BPH	BINA dhan10/ASD-7 BRRI dhan55/ASD-7	MR (3) MR (5)
Germplasm	63	GM	Muktahar (Acc # 156) Koha binni (Acc# 208)	MR (6-10% OS) R (0-1% OS)

Susceptible check: BR3 (for all), Resistant ck: T27A, IR64 and Ptb18 for BPH, WBPH and GLH respectively. Scores were made according to SES. BPH= brown planthopper, WBPH= white-backed planthopper, GLH= green leafhopper, R= resistant (score 0-1), MR= moderately resistant (3-5), S=susceptible (7-9).

with phostoxin tablet caused the death of nine rats out of 20 active burrows indicating 45% reduction of active rats. However, similar results were recorded from zinc phosphide (<2%) bait mixed with wheat @ 5g bait in each burrow. Single capture live trap with lucrative bait (coconut oil + dried paddy wrapped by nylon net) caught the highest number (15) of rat resulting 7.5% trap success in 10 consecutive nights.

Plant Pathology Division

SUMMARY

Survey on rice diseases incidence in different rice ecosystems suggested that in T. Aman 2014 season, bacterial blight was most prevalent in Rangpur region. Brown spot was also most frequently encountered in Rangpur and Rajshahi. Incidence of sheath blight was highest in Rajshahi. Incidence of false smut in different surveyed areas ranged from 1-10% with severity index 1-5 which were almost identical in different locations. Tungro was observed only in Comilla on BR 11, BRRI dhan56 and BRRI dhan57. In Boro 2014-15 seasons, incidence of seedling blight ranged from 25-30% in Gopalganj and Rajshahi regions. Neck blast was most prevalent in Rangpur region on BRRI dhan28. Brown spot was most frequently encountered in Gopalgonj region. Leaf scald was observed only in Barisal on BRRI dhan29 and BRRI dhan47. On the other hand, incidence of bacterial blight was highest in Gopalgonj on BRRI hybrid dhan3, Khatobhojon and SL8. A rapid model (FLYER) was developed to assess the yield loss caused by false smut disease. A differential set (12 isolates) of blast isolates was confirmed in T. Aman 2014 season for the development of standard differential set for Bangladesh. These isolates were able to detect most of the known blast resistance genes except *Pia*, *Pik-s* and *Pi20* (t). Parasexual study on rice blast and crabgrass blast isolates indicated no recombination occurred among the tested blast isolates. For the first time, *Fusarium* spp. was identified as the causal agents of seedling blight. Under the resistance breeding, estimation of blast resistance genes in 320 land races and 50 HYV have already started with the collaboration of JIRCAS, Japan. Genotyping of these germplasms using 74 SSR markers distributed over the 12 chromosoms was done and found two major groups Japonica and Indica. Again, Indica group was divided in to Aus, Aman and Boro with some exceptions. Blast resistant genes *Pi, Pi40, Pita2* and *Pish* were introgressed in the background of premium quality rice BR63 and Nyanmoni as well as IR64, BRRI dhan28 and BRRI dhan29. BC_2F_1 seeds of BRRI dhan29 introgressed with *Pi9, Pi40* and *Pita2* were also produced. Pathogenicity result showed that some progenies of BC_3F_1 or BC_4F_1 developed from the crosses between BRRI dhan28, BRRI dhan29 and a local improved variety with IRBB60 or IRRBB65 were resistant against bacterial blight (BB). The pure line, HRP (Mala) 7-10 was found to be the best considering agronomic and yield characteristics. Again in Boro season, a total of 26 hills were selected based on phenotypic characters. Among the tested blast resistant multiline varieties of IR49830, IRBLsh-T produced the highest yield (5.0 t/ha). This line is also suitable for tidal non-saline sub-ecosystem. Out of 64 INGER materials, only one IRBL 9-W/RL showed resistant reaction (R) (disease severity scale 1) against blast. Again, Among the 61 INGER materials, 03 materials (IRBB 21, IRBB 65 and IRBB 66) showed resistant reaction (R) (disease severity scale 1) against BB. Out of 52 advanced breeding lines, only one material IRBB 21 showed resistant reaction while six materials showed moderately resistant reaction against BB. Again only 02 materials showed moderately tolerant reaction against ShB pathogen. Seedling blight was effectively controlled with seed treatment or spraying of fungicides (0.3%) (Difeconazole+Azoxystrobin 20%, Pyraclostrobin and Azoxystrobin 25%) in tray seedlings. A complete protocol for raising healthy rice seedling in trays was developed considering agronomic and disease management. A complete protocol for raising healthy rice seedling in trays was developed considering agronomic characters and disease management. Five fungicides such as Palki 75WG, Indofil's Baan, Mactivo 75WG, Navita 75WG and Trigger 75WP were successfully controlled rice blast incidence (above 80%) and recommended for registration. In addition, a total of 35 demonstrations were conducted in farmers' field under PGB and IAPP projects. In general, the BRRI recommended management practices against sheath blight and/or blast disease(s) were found to be more effective compared to the farmers' practices. A total of 347 farmers acquired knowledge about rice diseases and the disease management from training program under PGB project.

TRANSFERABLE TECHNOLOGY

Management of seedling blight and tray seedling raising (TSR) protocol. Raising rice seedlings in trays has not been successful in Boro season because of seedling blight disease. *Fusarium* spp. was identified as the causal agent of seedling blight both in trays and seed bed in Bangladesh. The pathogen was identified from the infected seedlings grown in trays at Gazipur and seed beds at Gopalganj (Tungipara) and Rajshahi. Seed treatment or spraying in seedlings with Fungicide-5 (Difeconazole+Azoxystrobin 20%), Fungicide-8 (Pyraclostrobin) and Fungicide-9 (Azoxystrobin 25%) effectively controlled the seedling blight of rice in the tray. A complete protocol for raising healthy rice seedling in trays has been developed based on the agronomic characters and disease management. This was mentioned as TSR-protocol for raising tray seedling of rice. Validation of the TSR protocol at field level in different cold regions during Boro season is under implementation.

Fungicides for blast disease control. Five fungicides like Palki 75WG, Indofil's Baan, Mactivo 75WG, Navita 75WG and Trigger 75WP successfully controlled rice blast incidence and recommended for registration.

EPIDEMIOLOGY OF RICE DISEASES

Survey and monitoring at farmers' field

Survey and monitoring on rice diseases were conducted to know the current status of different rice diseases in different climatic environments. Different rice diseases were surveyed in both T. Aman and Boro seasons at different districts. In T. Aman, survey was carried out in different upazilas of Rangpur and Satkhira districts. In surveyed areas BB, brown spot, false smut and sheath blight diseases were prominent in both the districts. Incidence of other diseases was insignificant. In different upazilas of Barisal and Jhalokathi districts, incidence of brown spot, blast, narrow brown spot and bacterial leaf blight disease was recorded as 38-66, 10-16, 8-17 and 18-29% respectively. Brown spot seemed to be predominant in T. Aman season followed by blast and other diseases.

In Boro season, survey was conducted in Khulna, Bagerhat, Gopalganj, Pirojpur and Rajshahi districts. In the surveyed areas seedling blight, bacterial blight (BB), neck blast, brown spot (BS), sheath blight and sheath rot diseases were observed. In the early season, around 25-30% seedlings of 50% seedbed were found infected with seedling blight in Gopalganj and Rajshahi. Incidence of seedling blight in the trays was severe wherever it was grown. Among the major diseases neck blast, BB and BS were found severe. Neck blast was found prominent in BRRI dhan28 in Bagerhat district (incidence 32% and severity 4), whereas, BB was observed in local and hybrid varieties in Gopalgonj sadar (incidence 70%, severity 5). Brown spot was severe in Gopalganj district (incidence 82%, severity 6) next to Bagerhat district (incidence 40%, severity 3). In Rangpur region, survey was conducted in Lalmonirhat and Rangpur sadar upazila. Blast incidence was epidemic in nature in BRRI dhan28. Most of the early planted variety, which flowered at the time of drizzle raining, was affected much with blast (5-90% panicle, severity 3-9). Other varieties like BRRI dhan29, few hybrid varieties were also affected with blast (leaf infection 10%, panicle infected 5-10%, severity 3). In Barisal region, BB showed the highest incidence along with greater severity scale (7) followed by blast, brown spot, and leaf scald recorded as 22-48, 8-19, 23-37 and 7-13% respectively. Survey was carried out in three upazilas Habiganj, Baniachang and Nabiganj of Habiganj district. Irrespective of location, overall incidence of narrow brown leaf spot was observed as the highest (44% leaf, severity 2), which was followed by brown spot (43%, severity 3) and bacterial blight (10% leaf, severity 3). The incidence of sheath blight and neck blast was 1.3% (severity 3.6) and 2.0% (severity 3). Bacterial blight and narrow brown leaf spot were found less.

FLYER: A simple yet robust model for estimating yield loss from rice false smut disease (*Ustilaginoidea virens*)

The model FLYER (False smut induced yield loss estimator in rice) which estimates the yield loss in rice due to false smut disease in a field scale was developed. The model was run by two inputs: (i) fraction of productive but diseased tillers in a field, and (ii) average number of smut balls present in the diseased panicles.

The driving algorithm of the model, the yield reduction in a diseased panicle as a function of number of smut balls present in the panicle, was validated with additional data from Bangladesh, India and Japan. When tested with independent data from fields infected naturally by rice false smut (RFSm), FLYER closely estimated the yield loss. This model could contribute to rapid assessment of regional and variety-specific yield loss, and strategic management of the disease on a field-by-field basis (Fig. 1).

PATHOGEN POPULATION STRUCTURES AND BIOLOGY

Confirmation of the standard differential set of blast isolates

Twenty five isolates were selected preliminary as differential from our previous study. Those were re-cultured from stock and tested their pathogenicity using monogenic lines following the standard method at Plant Pathology Laboratory, BRRI, Bangladesh. Disease was scored following 0-5 scale. Depending on their consistency in reaction pattern to DVs, rate of sporulation and differentiating ability, isolates were selected from the diverse group. Among the preserved 25 isolates, 12 were selected from the diverse groups of reaction pattern depending on the consistency in reaction to DVs, rate of sporulation and differentiating ability. The diverse groups of selected pathogen are existed. The reaction patterns of selected differential isolates were able to detect most of the known blast resistance genes except *Pia*, *Pik-s* and *Pi20* (t).

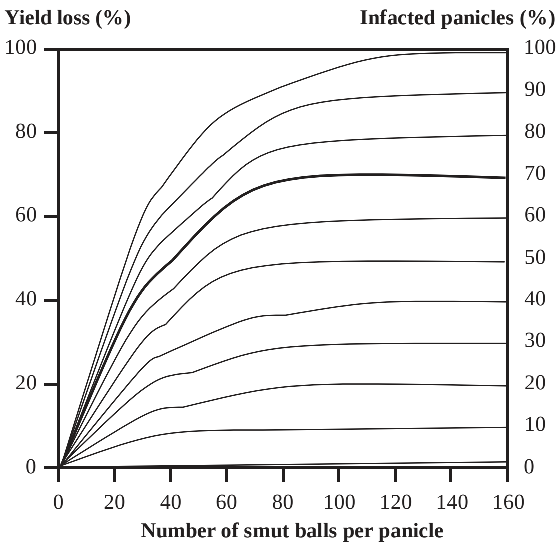


Fig. 1. Classification of rice accessions on the basis of polymorphism of DNA markers.

Parasexual recombination between blast fungi *Pyricularia oryzae* and *P. grisea* on double inoculated lesion

The study was conducted at Saga University, Japan to investigate the parasexual ability of *Pyricularia* spp. Two rice isolates TP106 and TP022 (*Pyricularia oryzae)*, and one crab grass isolate SA13-1ME (*P. grisea)* were used in this experiment. SA13-1ME was used for the first inoculation and TP106 or TP022 was used for the second inoculation.

A total of 520 isolates collected from the double inoculated lesions were subjected to PCR-RFLP analysis of the ITS region to identify subcultures of the inoculated rice blast isolates (Table 1). As a result, four isolates from the double inoculated lesions with SA13-1ME and TP106 were identified as subcultures of TP106. The 319 isolates from the 48 double inoculated lesions with SA13-1ME and TP106, four isolates Ca32-1, Ca32-7, Ca42-4 and Ca44-4 had the PCR product that could be digested with *Dra*I (Fig. 2). SA13-1ME and TP106 differed in mycelial colour, ie, SA13-1ME produced colony with black, while TP106 produced white colour. The four isolates had colonies with the same colour as that of colony of TP106. The other 315 isolates had colonies with black. These results indicate that the four isolates were derived from TP106. In other words, TP106 succeeded in colonization in the three lesions, Ca32, Ca42 and Ca44. On the contrary, in the 201 isolates from the 28 double inoculated lesions with SA13-1ME and TP022,

Table 1. Summary of *Pyricularia* isolates from double inoculated lesions on crabgrass.

Combination	Number of isolates		Number of lesions tested[c]
	P. oryzae[a]	*P. grisea*[b]	
SA13-1ME/TP106	4	315	48 (3)
SA13-1ME/TP 022	0	201	28 (0)

[a]Number of isolates having *P. oryzae* ITS type. [b]Number of isolates having *P. griseae* ITS type. [c]Number of lesions where isolates having *P. oryzae* ITS type is in parenthesises.

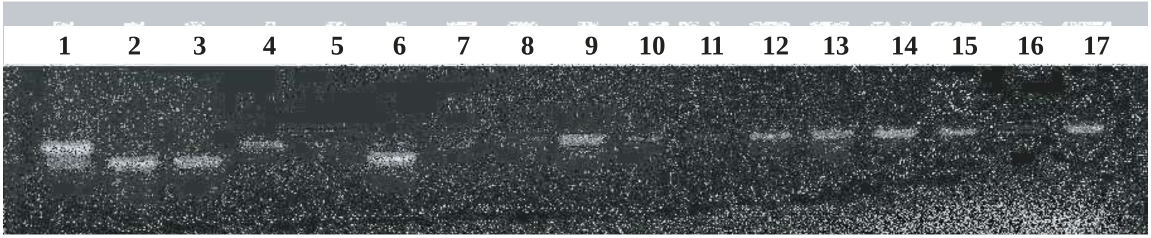


Fig. 2. ITS-RFLP profiles of *Pyricularia* isolates from double inoculated leaves of crab grass with *P. grisea* and *P. oryzae*. ITS regions of isolates tested were amplified with PCR primers ITS5 and ITS4. Amplicons were digested with *Dra*I and fractionated in 1.5% agarose gel. Lanes: 1, SA13-1ME; 2, TP106; 3,Ca42-4; 4, Ca44-2; 5, Ca44-3; 6, Ca44-4; 7, Ca44-5; 8, Ca45-1; 9, Ca45-2; 10, Ca45-3; 11, Ca45-4; 12, Ca45-5; 13, Ca45-6; 14, Ca46-1; 15, Ca46-2; 16, Ca46-3; 17, Ca46-4.

isolates were not derived from TP022. All of the 201 isolates had PCR product that could not be digested with *Dra*I (Fig. 2).

To access the recombination genotypes, 17 isolates from three double inoculated lesions were subjected to MAGGY- DNA fingerprint analysis. However, unfortunately, recombinant DNA fingerprint patterns between TP106 and SA13-1ME were not detected among the 17 isolates. Although TP022 was not recovered from the double inoculated lesions, TP106, recovered from the double inoculated lesion, indicates that rice blast fungus could invade and colonized in blast lesions on crab grass. Therefore, it can be expected that the recombinant event occurs in nature only when the rice blast pathogen opportunistically infects a blast lesions on crab grass in which the crab grass pathogen preexists.

Identification of the causal agent of seedling blight

Efforts on raising rice seedling in trays have been failed due to severe infection of seedling blight disease. Further, recent observation shows the significant increase of this disease incidence in the field during cold environment. Therefore, isolation and identification of the causal pathogen of rice seedling blight occurred in the trays and field was investigated. The infected samples were collected from Gopalganj (Tungipara), Rajshahi and Gazipur. Pure culture of the fungi and its morphological and microscopic studies confirmed that all the tested samples were infected with *Fusarium* spp. This is the first report of *Fusarium* seedling blight of rice in Bangladesh.

DISEASE RESISTANCE AND MARKER ASSISTED SELECTION STUDIES

Identification of major blast resistant genes in land races of Bangladesh using molecular marker and pathogenicity

Estimation of blast resistance genes in land races and HYV were done using both molecular marker and differential isolates. In molecular analysis, 74 SSR markers distributed over the 12 chromosoms were used for grouping the test meterials depending their genetic constituents. In pathogenicity test, twenty differential isolates (12 from Bangladesh, seven from Japan and one from Kenya) covering almost all the known blast resistance genes were used for varietal differentiation.

Estimation of blast resistance genes in 320 land races and 50 HYV have already started with the collaboration of JIRCAS, Japan. Genotyping of these germplasms using 74 SSR markers distributed over the 12 chromosoms was done and found two major groups Japonica and Indica (Fig. 3). Again, Indica group was divided into Aus, Aman and Boro with some exceptions. Nipponbare was in Japonica while Kasalath in Indica group (*Aus* sub speces). It indicates that highly blast resistant materials were in Aus sub group. Because Kasalath was a typical Aus variety that contained blast resistant genes, comprised in Aus sub-group. Pathogenicity tests using differential isolates are now going on.

Development of BB resistant variety

To develop BB resistant rice varieties, BRRI dhan28, BRRI dhan29 and a local improved varieties were used as recipient parents. IRBB60 and IRBB65 were used as donor parents. BRRI dhan28 and BRRI dhan29 were the two mega varieties for Boro season and local improved variety is one of the popular varieties in south-west region of Bangladesh during T. Aman season. IRBB60 and IRBB65 are the BB resistant pyramid lines of IR24. Phenotyping and genotyping were applied for suitable plant selection. Table 2 presents the result. Pathogenicity result showed that some progenies of BC3F1 or BC4F1 developed from the crosses were resistant to most virulent isolate BXO9.

Pyramiding blast resistant genes

The experiment was conducted to develop blast resistant lines. Monogenic blast resistant genes *Pi*, *Pi40*, *Pita2* and *Pish* were introgressed in the background of premium quality rice BRRI dhan63 and Noyanmoni and also in the back ground of IR64, BRRI dhan28 and BRRI dhan29. In another attempt, BC_2F_1 seeds of BRRI dhan29 introgressed with *Pi9*, *Pi40* and *Pita2* were also produced. Table 3 shows the number of seeds produced from the crosses. Confirmation of the F_1s will be done through MAS.

Purification of locally improved Aus cultivar Mala through pure line selection

Panicles of widely adapted Aus variety Mala was collected from Bakerganj, Barisal during last Aus 2013 season. From the collected panicles, 10 panicles were selected for growing in Boro 2013-14 season at BRRI HQ, Gazipur following head to row system. Fertilizers and other cultural practices were done as per BRRI recommendation and farmer's Mala as well as BR2 (Mala) were used as check varieties in all cases. HRP (Mala)-7-10 was performed better compared to local check in T. Aus, 2014. But, in Boro season 2014-15 when the desired lines were grown for seed multiplication programme. It showed some degree of segregation.

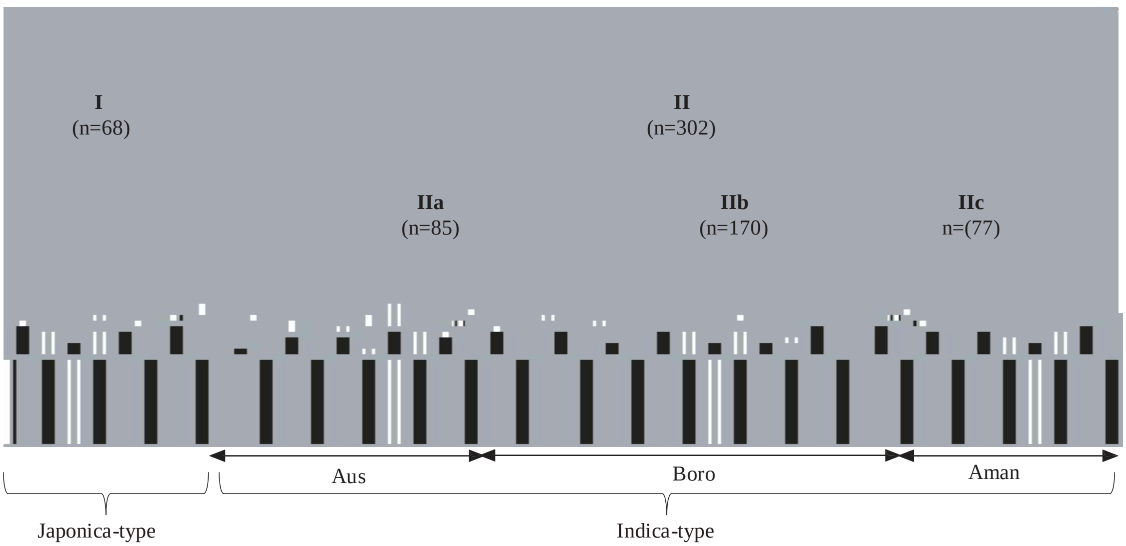


Fig. 3. Classification of rice accessions on the basis of polymorphism of DNA markers.

Table 2. Development of BB resistant materials from the crosses of BRRI dhan28, BRRI dhan29 and local improved variety and bacterial blight resistant pyramid lines of IR24.

Recipient/Recurrent	Donor		Present status
	Designation	Target *R* gene	
BRRI dhan28	IRBB60	*Xa4, xa5, xa13, Xa21*	45 seeds of BC3F1
BRRI dhan29	IRBB60	*Xa4, xa5, xa13, Xa21*	30 seeds of BC3F1
Local Improved	IRBB60	*Xa4, xa5, xa13, Xa21*	35 seeds of BC4F1
Local Improved	IRBB65	*xa5, Xa7, xa13, Xa21*	30 seeds of BC4F1

Table 3. No. of F_1 seeds produced from the crosses between monogenic blast resistant line(s) and recurrent parent.

Recurrent parent	Donor	Gene	No. of F_1 seed
	Aman 2014-15		
IR64	IRBL9W	Pi9	62
	IR65482-4-136-2-2	Pi40	86
	IR93325	Pita2	27
Nyonmoni	IRBL9W	Pi9	62
	IR93322	Pish	93
	IR93324	Pita	103
	IR93325	Pita2	24
	Boro 2014-15		
BRRI dhan28	IRBL9W	Pi9	87
	IR65482-4-136-2-2	Pi40	37
BRRI dhan63	IR65482-4-136-2-2	Pi40	34
	IR93325	Pita2	37
BRRI dhan29	IR93325	Pita2	66 (BC2F1)
	IR65482-4-136-2-2	Pi40	20 (BC2F1)
	IRBL9W	Pi9	8 (BC2F1)

Distinct morphological characteristics were observed between the selected lines compared with local Mala and BR2. Among the tested pure lines, HRP (Mala)-7-10 was found best based on phenotypic observation. Again in Boro season, 26 hills were selected based on phenotypic characters.

Evaluation of blast resistant multiline variety of IR49830 suitable for tidal non-saline sub-ecosystem

An investigation was carried out to develop suitable blast resistant rice variety for tidal non-saline sub-ecosystem. NILs of IR49830 harboring blast resistant genes *Pish*, *Pi9* and *Pita-2* were selected as suitable materials from the last year T. Aman season at BRRI RS, Barisal. Sadamota or other popular varieties practiced by local farmers were used as check variety. Fertilizers and other cultural practices were done as per BRRI recommendation.

Considering the disease reaction and agronomic performance three lines such as IRBL9-W, IRBLta2Pi and IRBLsh-T (containing both blast and submergence resistant gene along with taller seedling height) were found suitable for tidal non-saline eco-system. Among them IRBLsh-T line produced the highest yield of 5.01 and 4.88 t/ha in BRRI, Barisal and farmers field at Bakerganj, Barisal respectively (Figs. 4 and 5).

Screening INGER materials and advanced breeding lines against blast, BB and ShB

An investigation was carried out to detect the disease reaction of advanced breeding lines against bacterial leaf blight and sheath blight disease of rice. Advanced materials were tested against virulent isolates of the respective pathogen. Blast resistant materials were screened only at seedling stage while BB were screened at both seedling and maximum tillering stages. ShB was screened only at maximum tillering stage under natural condition.

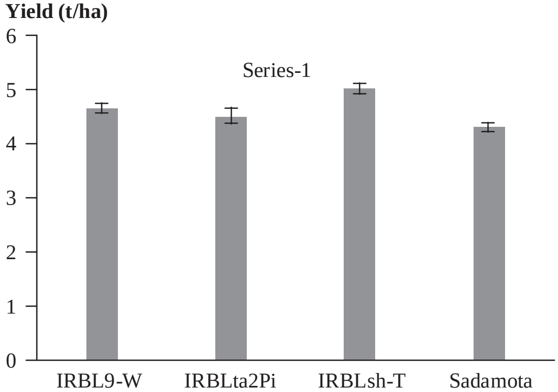


Fig. 4. Yield performance of multilines at BRRI RS, Barisal.

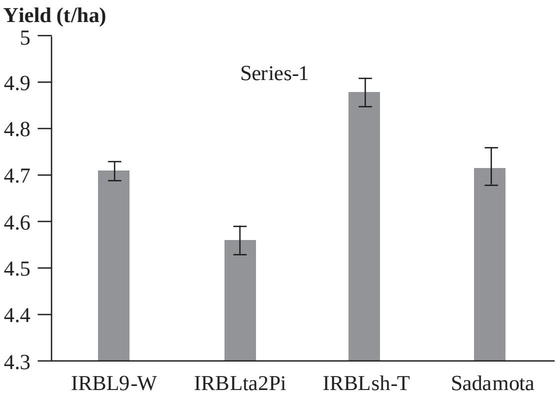


Fig. 5. Yield performance of multilines at Bakerganj, Barisal (Farmers' field).

Seedlings for blast screening were grown in seedling cell tray. For other diseases, seeds were sown in the seedbed and transplanted in the main field with BRRI recommended practices following appropriate design with three replications. In each case, resistant and susceptible checks were maintained.

Out of 64 INGER materials, only one IRBL 9-W/RL showed resistant reaction (R) (disease severity scale 1) against blast while 21 materials showed moderately resistant reaction, 31 entries showed moderately susceptible reaction; whereas five entries showed susceptible reaction and six showed highly susceptible reaction against rice blast pathogen. Again, among the 61 INGER materials, three (IRBB 21, IRBB 65 and IRBB 66) showed resistant reaction (R) (disease severity scale 1) against BB while 17 showed moderately resistant reaction (MR) (disease severity scale 3), 21 showed moderately susceptible reaction (disease severity scale 5), 11 showed susceptible reaction (disease severity scale 7) and nine showed highly susceptible (disease severity scale 9) to BB pathogen.

In T. Aman 2014 season, out of 52 advanced breeding lines, only one material IRBB 21 showed resistant reaction while six materials (OM1490, IRBB65, IR77542-551-1-1-1-1-2, BR7965-6-1-4-9, BR829-16-2, and BR7941-41-2-2-2-4) showed moderately resistant reaction against BB. Again only two materials (BR 7472-16-2-1-2-1, and IR78761-B-SATB1-28-3-26) showed moderately tolerant reaction against ShB pathogen; and 03 materials (BR6848-3B-12, IR73055-8-1-1-3-1, and IR78761-B-SAB1-28-3-26) showed moderately resistant reaction to blast (according to JIRCAS evaluation standard). Again, in Boro 2014-15 season, out of 71 materials; 14 materials (BR7783-AC12-3, BR7783-AC6-3-2-2-1, BR8079-52-2-2-2, BR8096-48-2-2-4, BR7369-10-5-2-3, BR7372-18-2-1-HR1-HR6, HHZ15-SAL13-Y1, HHZ11-DT7-SAL1-SAL1, BR7840-54-3-2-1, BR7840-54-3-4-1 and BR7879-17-2-4-HR3-P1) showed moderately resistant reaction against BB; while five materials (IR77734-93-2-3-2, BR7369-10-5-2-3, BR7372-35-3-3-HR9, HHZ6-SAL3-Y1-SUB2 and IR77092-2R-B-10) showed moderately resistant reaction against blast.

DISEASE MANAGEMENT

Efficacy of phylloplane *Pseudomonas* strains against rice sheath blight

The study was conducted as a part of PhD research. The aim was to determine the efficiency of bacterial strains on sheath blight suppression. Virulent isolate of *R. solani* KLRs16 and two promising *Pseudomonas* bacterial strains UMB20 and BMB42 were used. Bacterial isolates were immobilized in peat materials as per methodologies. Plants were inoculated by *R. solani*. Data were recorded on Area Under Diseases Progress Curve (AUDPC), percent tiller infection, disease progression rate, 100-grain weight.

Application of bacterial strains either individual or mixture significantly reduced the total AUDPC of sheath blight and tiller infection (%) compared to untreated plants upon challenge inoculation with *R. solani* (Table 4). The total AUDPC obtained from all the treatments ranged from 700.67 to 1042.57. Significantly the highest (1042.57) AUDPC was recorded in untreated plants and the lowest (700.67) was in plants treated with mixture strains. Sheath blight suppression over the control was 32.79, 32.58 and 21.19% respectively in mixture strains of UMB20 and BMB42, UMB20 and BMB42. Combined application of bacterial strains also significantly increased 100-grain weight (TGW) compared to the control.

Management of seedling blight and tray seedling raising protocol

The disease incidence was the highest in the control treatment (Table 5). Fungicide- 5, 8 and 9 (code names) were found effective (zero incidence of disease) against the seedling blight when treated the seeds at 0.3% solution before seed soaking. Further, spraying of the above mentioned fungicides was also effective (zero incidence) when sprayed after the emergence of seedling from the soil. Other fungicides tested in the experiment whether as seed treatment or seedling spray were ineffective. Application of MOP or ash was also ineffective. The disease incidence corresponding to the fungicides suggested that Fungicides-5, Fungicide-8 and Fungicide-9 were effective in controlling the disease.

The seedling height was the highest both in Fungicide-8 and Fungicide-9 followed by Fungicide-5 when seed treatment method was followed (data not presented). Similar results were also observed in case of fungicide spraying. Root mat formation was also found better in these treatments that were rolled easily when the whole seedling-mat was separated from the trays. These

Table 4. Effect of bacterial consortium on sheath blight disease development in rice.

Treatment	AUDPC (affected unit area)	Progression rate (unit /day)	(%) ShB suppression over control	% tiller infection	% reduction of TI over control	TGW (g)
UMB20	702.88c	0.016b	32.57	83.19b	16.31	1.57ab
BMB42	821.57b	0.014bc	21.18	96.14a	3.28	1.52ab
UMB20+BMB42	700.67c	0.011c	32.54	87.12b	12.36	1.65a
Control	1042.57a	0.028a	-	99.41a	-	1.49b

AUDPC=Area under diseases progress curve, ShB=Sheath blight, TI=Tiller infection,Each data represents the mean of four replications. Mean values within a column followed by the same letters are not significantly different at P 0.05 by Lsd.

Table 5. Effect of fungicides and soil amendments on seedling blight incidence in tray seedlings in Boro, 2015.

Treatment*	Group	% diseased area/tray	
		Seed treatment	Seedling spray
Fungicide-1	Trifloxystrobin+Tebuconazole	53.3 cd	41.7 ab
Fungicide-2	Carbendazim	60 c	40.0 abc
Fungicide-3	Cu-oxycloride	30.0 fg	23.3 cde
Fungicide-4	Triciclozole	41.7 def	20.0 de
Fungicide-5	Difeconazole+Azoxystrobin	00.0 h	00.0 f
Fungicide-6	Propiconazole	38.3 ef	12.5 ef
Fungicide-7	Cyproconazole+Azoxystrobin	18.3 g	31.7 bcd
Fungicide-8	Pyraclostrobin	00.0 h	0.00 f
Fungicide-9	Azoxystrobin	00.0 h	0.00 f
Fungicide-10	Trifloxystrobin+Propiconazole	16.7 g	32.5 bcd
Fungicide-11	Difeconazole+Propiconazole	16.7 g	8.33 ef
Fungicide-12	Validamycin	50.0 cde	33.3 bcd
MOP (10g/tray)		80.0 ab	-
Ash:Soil (v/v: 1/1)		76.7 b	-
Control (no treatment)		92. 7 a	53.3 a
CV		21.0%	45.7%
Lsd (5%)		13.4	17.6

Fungicides treated/sprayed at 0.3% solution; Each figure is average of three replications. -=Treatment not considered.

results suggested that, Fungicide-5, 8 and 9 (seed treatment or spraying seedling in trays) could be used in mechanical transplanter because of optimum seedling height, proper root mat formation and no disease incidence. Therefore, the tested protocol (TSR-protocol) is suggested for raising healthy seedling for mechanical/manual transplanting.

Effect of organic amendment to minimize blast in rice

This experiment was carried out to find out the effectiveness of rice husk to control blast disease of rice. Seven treatments including a disease and a healthy control were evaluated (Table 6). The soil was amended with the organic amendments prior to seven days of transplanting. Spore suspension of 14-day-old pure culture of virulent *Pyricularia grisea* was sprayed at maximum tillering stage. Data were recorded on node (%) and neck (%) infection and yield (g/hill). Significant difference was not found in neck blast incidence and yield among the treatments. The highest node blast incidence was observed in rice husk@2t/ha and the lowest in rice husk ash@2t/ha+Nativo (Single spray) (Table 6). Both node and neck blast incidences were found lower in rice husk ash+Nativo, Nativo and in healthy control. Although no significant difference in grain yield was observed but the highest yield was recorded with Nativo (two spray) and Nativo (single spray) with husk ash@2t/ha application. Disease incidence was also comparatively lower in these two treatments.

Evaluation of new chemicals against sheath blight and blast diseases

An investigation was carried out to find out effective chemicals against sheath blight and blast diseases of rice at BRRI HQ, Gazipur. The plants were inoculated artificially. Among the 24 fungicides, six ie Avtar, Palki 75 WG, Mactivo 75 WG, Navera, Bravo and Seltima successfully controlled rice sheath blight disease (above 80%) in the year 2014 (Table 7). These six fungicides will undergo in next season for further confirmation. Whereas, out of 28 fungicides, only five ie Palki 75 WG, Indofil’s Baan, Mactivo 75 WG, Navita 75 WG and Trigger 75 WP successfully controlled the disease (above 80%) in the year 2013 and 2014 and recommended for registration.

TECHNOLOGY DISSEMINATION

Demonstration on integrated rice disease management at farmers’ field

An investigation was carried out to demonstrate rice disease management practices at farmers’ field condition. BRRI recommended disease management practices were demonstrated at farmer’s field of Barisal and Rangpur region. Mostly integrated disease management practices of sheath blight and blast were demonstrated. Area of each demonstration is around 33 decimal, 75% of demonstration plot was occupied by BRRI recommendation practice and 25% farmers’ practice.

In T. Aman 2014 season, the highest blast disease incidence (91%) was observed in BRRI dhan34 with farmer’s practice, while the least disease incidence was recorded as 17% in the same variety at BRRI managed plot in Barisal region. Again, the highest yield of 3.64 t/ha was obtained in BRRI dhan34 at BRRI managed plot, while the lowest yield was recorded as 2.23 t/ha in popular local variety Sakkorkhora under farmer’s

Table 6. Disease incidence and yield performance in different treatments used for blast disease management.

Treatment and dose	Node blast incidence (%)	Neck blast incidence (%)	Yield (t/ha)
Rice husk @ 2.5 t/ha	6.36 a*	3.03	7.448
Rice husk ash @ 2 t/ha	4.66 ab	1.74	7.718
Nativo (2 spray)	2.97 ab	1.33	8.60
Na_2SiO_3 @300 kg/ha	2.54 ab	5.38	6.748
Rice husk ash 2.0 t/ha + Nativo (1 spray)	1.70 b	1.24	8.90
Disease control	5.09 ab	5.00	6.974
Healthy control	2.13 ab	0.90	7.206
Lsd (5%)	4.63	5.26 ns	2.54 ns

*Same letter in a column does not differ significantly.

Table 7. Effect of different fungicides on rice sheath blight and blast disease.

Fungicide	% disease reduction	Fungicide	% disease reduction
Sheath blight		Blast	
Avtar	80.16	Palki 75WG	80.2
Palki 75 WG	80.12	Indofil`s Baan	80.6
Mactivo 75 WG	80.08	Mactivo 75WG	84.0
Navera	80.21	Navita 75WG	80.9
Bravo	80.17	Trigger 75WP	81.7
Seltima	80.21		

management. Again, in Rangpur region, the highest sheath blight disease incidence 85% was recorded in Swarna at farmer’s practice, while the least disease incidence was obtained as 15% in BRRI dhan52 at BRRI managed plot. Again, the highest yield of 5.44 t/ha was obtained in BRRI dhan52 under BRRI management, while the lowest yield was recorded as 4.67 t/ha in BRRI dhan51 in farmer’s practice.

In Boro 2014-15 season, the highest blast disease incidence (42.16%) was obtained in BRRI dhan29 at farmer’s practice, while the least disease incidence was recorded as 8.29% in the same variety at BRRI managed plot in Barisal region. Again, the highest yield of 7.98 t/ha was obtained in BRRI dhan29, while the lowest yield was recorded as 5.51 t/ha in BRRI dhan29 at farmer’s managed plot. In Rangpur region, the highest blast disease incidence 44.27% was recorded in BRRI dhan29 at BRRI managed plot while the least disease incidence was obtained as 6.47% in the same variety at farmer’s managed plot. Again, the highest yield of 7.12 t/ha was obtained in BRRI dhan52 under BRRI management while the lowest yield (6.52 t/ha) was obtained in BRRI dhan52 at farmer’s practice.

Enhancing rice production through integrated blast disease management (PGB project)

BRRI recommended practice for blast disease management was demonstrated in the farmers’ field in Gopalganj area. Two practices were followed: A) BRRI recommended practice: all cultural (water, weed and fertilizers) and chemical (Nativo spray) management practices were followed as BRRI guidelines and B) Farmers’ practice (FP). No maintaining of spacing distance, no use of clean cultivation, using low fertilizer dose rather than BRRI recommendation and no idea about disease and how to manage disease). Fungicide (Nativo) was sprayed (1^{st}) as soon as leaf blast was observed and second spray was done after 8-12 days after 1^{st} spray in plots where BRRI recommended practices were followed. After two weeks of second spray, disease severity and incidence were recorded and finally, neck blast, node blast and yield data were recorded.

In case of disease incidence, significant variation was observed between BRRI recommended practices and farmers’ practices. The highest panicle blast incidence was observed in farmers’ practices compared to BRRI recommended practices in all test locations (Table 8). In case of yield, significant variations were observed in different locations as well as in different practices. The highest yield was observed in Gopalganj sadar (9.23t/ha) but the highest yield increase was found in Tungipara (11.55%) (Table 8). Although higher node blast incidence was observed in Tungipara, it was not reflected on yield in BRRI recommended practices.

Enhancing rice yield through capacity building training for farmers

Training was conducted in six upazilas- Gopalganj sadar, Tungipara, Kotalipara, Nazirpur, Mollarhat and Fakirhat. In each upazila two batches of training were performed on identification of major rice diseases and their management. Diseased plant samples and preserved samples were shown visually and helped them to identify the disease symptoms and mention the disease names. A total of 347 farmers gained knowledge on rice diseases and their management. From this training, the farmers clearly identified disease symptoms. Farmers were also able to understand about major rice diseases and learned about the causal pathogens of the major diseases.

Table 8. Yield performance in BRRI recommended practice and Farmers' practice at different locations.

Location	Variety	Yield (t/ha)		Increase (%) in BRRI
		BRRI	FP	
Gopalganj sadar	Hira-6	9.23	8.87	4.16
Tungipara	BRRI dhan29	6.26	5.61	11.55
Kotalipara	BRRI dhan29	8.37	8.31	0.71
Nazirpur	BRRI dhan29	5.30	5.06	4.69
Fakirhat	Hira-4	8.9	8.28	6.23
Mollarhat	BRRI dhan29	8.45	8.25	2.40
Lsd 5% (BRRI*FP)	0.731			

BRRI recommended practices, FP: Farmers' practice.

Rice Farming Systems

SUMMARY

From different cropping patterns for their water requirement in medium highland ecosystems the tested patterns gave significantly higher REY as well as higher gross margin and higher water productivity than check pattern. Tomato-Mugbean-T. Aman produced 277% higher rice equivalent yield (36.5 t/ha) than the check pattern of two rice system (9.68 t/ha).

In long-term effect of three cropped cropping patterns on the agro-economic productivity and soil health, the Potato-Boro-T. Aman cropping pattern produced the highest REY of 17.8 t/ha and 16.7 t/ha in Rangpur and Gazipur, respectively followed by Boro-T. Aus-T. Aman (12.9 t/ha and 14.9 t/ha).

In maize intercropping technologies to develop suitable cropping pattern packages for maize based cropping pattern in Chuadanga, the total productivity of intercropping system was compared in terms of maize equivalent yield (MEY), which differed significantly among the treatments. Significantly the highest MEY was obtained from CP_3 (31.0 t/ha) followed by CP_1 (25.6 t/ha). High value vegetable crop produced as intercrop with maize contributed significant difference among the tested patterns. Significantly lower MEY were obtained from sole maize plot.

In the high intensity Cropping Pattern for greater Kushtia, the highest REY was found from Maize+Potato/Pumpkin-T. Aus-T. Aman cropping pattern (25.69 t/ha) followed by Maize+Spinach-T. Aus-Aman cropping pattern (17.93 t/ha) and Maize -T. Aman (16.26) cropping pattern. And lowest REY was found from Mustard-Mungbean-Aus-Aman (15.15 t/ha) cropping pattern.

From the improved cropping systems for greater Kushtia, the REY of improved cropping patterns Mustard-Boro-T. Aman (12.27-13.93 t/ha), Maize-Mungbean-T. Aman (13.67- 13.86 t/ha), Maize-Til-T. Aman (15.60 t/ha) and Potato-Mukhikachu-T. Aman (40.06 t/ha) were significantly higher than the existing Boro-Fallow-T. Aman (10.22-11.65 t/ha), Maize-Fallow-T. Aman (11.00-14.42 t/ha) Maize-Jute-T. Aman (14.01 t/ha) and Boro-Mukhikachu-Fallow (30.23 t/ha) cropping pattern, respectively. Irrespective of location, all of the improved cropping patterns gave higher gross margin than the local check.

The highest grain yield was obtained with the T_4 treatment (4.90 t/ha) followed by the T_5, T_6 and T_2 treatments, and minimum under T_1 (3.83 t/ha) treatments. In Boro season, the grain yield of rice was significantly affected by different treatments (p 0.05). The highest grain yield was obtained from T_5 (8.55 t/ha) treatment followed by the T_4 and T_2 treatments.

In Boro season, higher grain yield was obtained from the N_3 treatment (7.10 t/ha) followed by the N_2 (6.88 t/ha), N_4 (6.78 t/ha) and N_1 (6.70 t/ha) treatments and lower was in the N_6 (3.23 t/ha) treatment in BRRI dahn28. In BRRI dhan29, significantly higher grain yield was observed in N_4 (7.80 t/ha) treatment compared to all other treatments and lower was found in the N_6 (3.15 t/ha) treatment. BRRI dhan29 achieved higher grain yield compared to BRRI dhan28 irrespective of N treatment.

From the evaluation of BRRI prilled urea applicator in Boro and T. Aman rice in Boro-Fallow-T. Aman cropping system, the output of the study, the significantly higher grain yield was obtained from T_1 (5.66 t/ha) followed by T_3 (5.60 t/ha) and T_2 (5.53 t/ha) treatments. The lowest yield was observed in T_5 (4.16 t/ha). In Boro season, the highest grain yield was obtained from T_3 (6.73 t/ha) followed by T_1 (6.22 t/ha) treatments in BRRI dhan28.

Irrespective of spacing, the hybrid variety of sunflower, Hysun33 produced higher seed yield in low, medium and high salinity level. Hysun33 produced higher seed yield at the spacing of 60 cm × 45 cm in low (2.85 t ha^{-1}), medium (2.73 t ha^{-1}) and high salinity (2.00 t ha^{-1}) level.

In the rice-based cropping pattern in partially irrigated ecosystem, the REY among the tested patterns ranged from 23 to 28.13 t ha^{-1} and apparently the higher REY was observed in CP_3 followed by CP_4 and CP_2. Higher gross return, gross margin and benefit cost ratio (BCR) were also obtained from CP_3 (Tomato-Mungbean-BRRI dhan62) followed by CP_4 (Tomato-Mungbean-BRRI dhan39) and CP_2 (Tomato-Mungbean-BRRI dhan56) and the lower was found in CP_1.

In the three crop systems for medium high tide wetland non-saline ecosystem, the three crop system produced significantly higher REY of 42% to 162% than two crop system of Fallow-Jute-T.Aman cropping pattern (8.57 t/ha). Potato-Jute-T. Aman cropping pattern gave higher REY of 22.47 t/ha among the tested patterns. The gross margin of potato and lentil based three crop system was 488% and 204% higher than Fallow-Jute-T. Aman system (23,746 Tk/ha).

From the study of USG applicator, it was found that the highest REY of 27 t/ha was observed in Potato (Diamont)-Maize (NK-40)-T. Aman (BRRI dhan57) cropping pattern followed by potato based cropping pattern. Inclusion of sunflower and mungbean gave about 211% and 96% higher REY respectively than two rice system (7.17 t/ha). Fallow-T. Aus-T. Aman, Mungbean-Fallow-T. Aman, Fallow-Fallow-T. Aman/Grass pea was also trialed at Patuakhali, Jhalkathi and Barisal district respectively. The REY of Fallow-T. Aus-T. Aman, Mungbean-Fallow-T. Aman and Fallow-Fallow-T. Aman/Grass was 151%, 55% and 91% higher than single T. Aman cropping pattern (3.19 t/ha).

Evaluation of different cropping patterns for their water requirement in medium highland ecosystem

Six cropping patterns were evaluated to find out the most water efficient profitable cropping pattern for sustainable food production. The experiment was conducted at East Byde, BRRI farm, Gazipur during, Kharif II-2014, Rabi 2014-15 and Kharif I-2015 season. Cropping patterns viz, Tomato (BARI hybrid tomato-5)-Mungbean (BARI mug-6)-T. Aman (BRRI dhan49), Wheat (BARI gom-26)-Mungbean (BARI mug-6)-T. Aman (BRRI dhan49), Potato (BARI alu-7)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan49), Lentil (BARI masur-7)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan49) and Chickpea (BARI chola-9)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan49) were evaluated along with the check, Boro (BRRI dhan29)-Fallow-T. Aman (BRRI dhan49) in RCB design with three replications. Recommended management practices were followed for rice and non-rice crops. Irrigation water applied in each plot with bucket and data were recorded. Water productivity was measured with the following formula:

$$\text{Water productivity (kg/mm/ha)} = \frac{\text{Total yield of crop (kg/ha)}}{\text{Water requirement of crop in mm (Rainfall + irrigation)}}$$

All the tested patterns gave significantly higher REY as well as higher gross margin and higher water productivity than the check pattern. Tomato-Mugbean-T. Aman produced 277% higher rice equivalent yield (36.5 t/ha) than the check pattern of two rice system (9.68 t/ha) (Table 1). This cropping pattern also gave more than 1600% higher gross margin and higher water productivity (20.9 kg/mm/ha). All other tested patterns also showed the better performance in respect of REY, gross margin and water productivity than two rice cropping pattern (check).

Long-term effect of three cropped cropping patterns on the agro-economic productivity and soil health

A study was designed to determine the long-term implications of Potato-Boro-T. Aman, Maize-Mungbean-T. Aman and Boro-T. Aus-T. Aman cropping patterns on the system productivity, economics and soil fertility. The experiment was conducted during 2011-12 at the BRRI farm, Gazipur and BRRI regional station farm, Rangpur. The tested cropping patterns were, Potato-Boro-T. Aman, Maize-Mungbean-T. Aman, Boro-T. Aus-T. Aman and Boro-Fallow-T. Aman (check). The experiment was laid out in a RCB design with three replications. Recommended management practices were followed. Table presents yield, REY and economic performance. Potato-Boro-T. Aman cropping pattern produced the highest REY of 17.8 t/ha and 16.7 t/ha in Rangpur and Gazipur respectively followed by Boro-T. Aus-T. Aman (12.9 t/ha and 14.9 t/ha).

Evaluation of maize intercropping technologies to develop suitable cropping pattern packages for maize based cropping pattern in Chuadanga

This study was undertaken to assess the suitability of growing different short duration Rabi vegetables with hybrid maize in Maize-Sweet gourd-T. Aman cropping system. The study was conducted at farmer's field of Chuadanga sadar, Kharif I-2014,

Table 1. Yield of tomato, wheat, potato, lentil, chickpea, mungbean, rice and REY of different cropping patterns, BRRI, Gazipur, 2014-15.

Cropping pattern	Yield t ha^{-1}			
	Rabi/ Boro	Mug/ T. Aus	T. Aman	REY
Tomato-Mugbean-T. Aman (CP_1)	67.23	1.02	4.61	36.50
Wheat- Mugbean-T. Aman (CP_2)	4.17	1.09	4.68	14.89
Potato-T. Aus-T. Aman (CP_3)	16.50	4.17	4.55	17.52
Lentil- T. Aus-T. Aman (CP_4)	1.80	4.15	4.83	16.45
Chickpea- T. Aus-T. Aman (CP_5)	2.04	4.16	4.58	14.59
Boro-Fallow-T. Aman (CP_6)	5.10	-	4.98	9.68
CV (%)	-	-	-	5.9
F for treatment	-	-	-	**
$LSD_{0.05}$ for treatment	-	-	-	1.96

Price (Tk/kg)- Tomato: 8, Wheat: 30, Potato: 10, Lentil: 80, Chickpea: 50, Mungbean: 52, Paddy: 18.

Kharif II-2014 and Rabi 2014-15 seasons. Three cropping patterns viz, Maize+Spinach-Sweet gourd-T. Aman, Maize+Potato-Sweet gourd-T. Aman and Maize+Carrot-Sweet gourd-T. Aman were evaluated along with the check, Maize-Sweet gourd-T. Aman in RCB design with three replications. Recommended management practices were followed for rice and non-rice crops.

The total productivity of intercropping system was compared in terms of maize equivalent yield (MEY), which differed significantly among the treatments. Significantly the highest MEY was obtained from CP_3 (31.0 t/ha) followed by CP_1 (25.6 t/ha) (Table 2). High value vegetable crop produced as intercrop with maize contributed significant differences among the tested patterns. Significantly lower MEY were obtained from sole maize plot.

From the economic analysis, the highest gross margin was obtained from CP_3 (2,54,000 Tk/ha) followed by CP_1. The CP_3, CP_1, CP_5 and CP_4 gave about 69, 46, 27 and 20% higher gross margin (GM) than the check pattern (Table 3).

Development of high intensity cropping pattern for greater Kushtia

The experiment was conducted at the farmer's field from April 2014 to June 2015. Three cropping patterns viz, Mustard (BARI sarisha-14)-Mungbean (BARI mug-6)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan57), Maize (BARI hybrid bhutta-7/Indian hybrid varity)+Spinach (Local)-Sweet gourd (BARI misti kumra-2)-T. Aman (BRRI dhan57) and Maize (BARI hybrid bhutta-7/Indian hybrid varity)+Potato (Cardinal)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan57) were evaluated along with the check Maize (BARI hybrid bhutta-7/Indian hybrid varity)-Fallow-T. Aman (BRRI dhan57/BRRI dhan49) in RCB design with three replications. Recommended management practices were followed for rice and non-rice crops. A simple economic analysis was done to evaluate the total productivity of these cropping patterns.

The highest REY was found from Maize+Potato/Pumpkin-T. Aus-T. Aman cropping pattern (25.69 t/ha) followed by Maize+Spinach-T.

Table 2. Yield and maize equivalent yield (MEY) of different cropping patterns, Chuadanga, 2014-15.

Treatment	Yield (t/ha)				MEY (t/ha)
	Maize	Vegetable	Sweet gourd	T. Aman	
Maize+Bushbean-Sweet gourd-T. Aman (CP_1)	12.56	5.27	17.16	4.07	25.55
Maize+Spinach-Sweet gourd-T. Aman (CP_2)	11.33	9.51	17.31	3.91	21.78
Maize+Potato-Sweet gourd-T. Aman (CP_3)	11.37	17.38	17.22	3.87	31.00
Maize+Red amaranth-Sweet gourd-T. Aman (CP_4)	11.93	5.33	18.17	3.82	23.38
Maize+Coriander- Sweet gourd-T. Aman (CP_5)	12.63	2.22	16.44	4.56	23.94
Sole Maize-Sweet gourd-T. Aman (CP_6)	12.93	-	17.36	3.94	21.19
CV (%)					6.0
F for treatment					**
$LSD_{0.05}$ for treatment					2.67

Price (Tk/ kg)- Tomato: 8, Potato: 10, Bushbean: 15, Spinach: 4, Red amaranth: 10, Coriander: 20, Sweet gourd: 4, Paddy: 18.

Table 3. Economic performance of different cropping patterns, Chuadanga, 2014-15.

Cropping pattern	TVC (000 Tk/ha)	GR (000 Tk/ha)	GM (000 Tk/ha)	GM (%) over FP
Maize+bushbean-Sweet gourd-T. Aman (CP_1)	215	434	219	(+) 46
Maize+Spinach-Sweet gourd-T. Aman (CP_2)	217	370	153	(+) 2
Maize+Potato-Sweet gourd-T. Aman (CP_3)	273	527	254	(+) 69
Maize+Red amaranth-Sweet gourd-T. Aman (CP_4)	218	398	180	(+) 20
Maize+coriander-Sweet gourd-T. Aman (CP_5)	216	407	191	(+) 27
Sole Maize-Sweet gourd-T. Aman (CP_6)	210	360	150	-

Aus-Aman cropping pattern (17.93 t/ha) and Maize-T. Aman (16.26) cropping pattern. And the lowest REY was found from Mustard-Mungbean-Aus-Aman (15.15 t/ha) cropping pattern (Table 4).

Validation of improved cropping systems for greater Kushtia

Different ecosystems were selected by the joint effort of researcher and extension personnel in Chuadanga, Meherpur and Kushtia districts. Seven farmers in each block were selected for the improved cropping system demonstration to show the technological advantage of the improved systems over the existing system. In each trial, an improved cropping pattern was tested against the existing cropping pattern. REY of improved cropping patterns Mustard-Boro-T. Aman (12.27-13.93 t/ha), Maize-Mungbean-T. Aman (13.67-13.86 t/ha), Maize-Til-T. Aman (15.60 t/ha) and Potato-Mukhikachu-T. Aman (40.06 t/ha) were significantly higher than the existing Boro-Fallow-T. Aman (10.22-11.65 t/ha), Maize-Fallow-T. Aman (11.00-14.42 t/ha) Maize-Jute-T. Aman (14.01 t/ha) and Boro-Mukhikachu-Fallow (30.23 t/ha) cropping pattern respectively. Irrespective of location, all the improved cropping patterns gave higher gross margin than the local check.

Effect of fertilizer management on yield of double transplanted Aman and Boro rice in T. Aman-Boro cropping systems

In this study in late situation double transplanting of Aman and Boro with fertilizer treatments were evaluated. The experiment was conducted during T. Aman 2014 and Boro 2014-15 seasons at BRRI farm, Gazipur. In this experiment six planting methods along with three fertilizer application methods for double transplanting were applied (Table 5). The design of the experiment was RCB with three replications. Nitrogen, P, K, S and Zn were applied as per recommendation. In T. Aman season, the grain yield ranged from 3.83 to 4.90 t/ha among the treatments. The treatment effect on grain yield was significant ($p \leq 0.05$). The highest grain yield was obtained with the T_4 treatment (4.90 t/ha), followed by the T_5, T_6 and T_2 treatments, and minimum under T_1 (3.83 t/ha) treatments (Table 5). In Boro season, the grain yield of rice was significantly affected by different treatments ($p \leq 0.05$). The highest grain yield was obtained from T_5 (8.55 t/ha) treatment, followed by the T_4 and T_2 treatments. The lower and statistically similar grain yields were observed from T_7 (6.07 t/ha) and T_1 (6.82 t/ha) treatments (Table 6).

Table 4. Yield performance for different cropping patterns in Meherpur, 2014-15.

Cropping pattern	Yield (t/ha)				REY (t/ha)
	T. Aus	T. Aman	Mustard/Maize	Mungbean/Potato/ Spinach/Pumpkin	
Mustard-Mungbean-T. Aus-T. Aman	4.35	4.1	1.3	0.7	15.15
Maize+Spinach-T. Aus-T. Aman	4.59	4.12	9.36	5.7	17.93
Maize+Potato/Pumpkin-T. Aus-T. Aman	4.21	4.58	9.16	14.5+7.47	25.69
Maize-T. Aman	-	5.27	12.78	-	16.26
$LSD_{(0.05)}$	-	-	-	-	2.21
CV (%)	-	-	-	-	5.90

Price (Tk/kg)- Mustard: 60, Mungbean: 80, Potato: 10, Spinach: 4, Maize: 17, Pumpkin: 5, Paddy: 20.

Table 5. Grain yield of DT Aman Rice in Boro-Fallow-T. Aman cropping pattern, BRRI Gazipur, 2014.

Treatment	Grain yield (t/ha)
T_1=Normal transplanting with 60 DOS (TP: 25 Sep; Sowing: 25 Jul.)	3.83
T_2=Normal transplanting with 45 DOS (TP: 25 Sep.; Sowing: 10 Aug.)	4.05
T_3=Normal transplanting with 30 DOS (TP: 25 Sep.; Sowing: 25 Aug.)	-
T_4=Double transplanting with removed seedling (100%) and no fertilizer in 1st transplanted plot	4.90
T_5=Double transplanting with removed seedling (100%) and 1st split urea in 1st transplanted plot	4.63
T_6=Double transplanting with removed seedling (75%) and full fertilizer in 1st transplanted plot	4.50
T_7=Remaining 25% seedling in fully fertilized 1st transplanted plot	3.89
CV (%)	9.3
$LSD_{0.05 \text{ for treatment}}$	0.73

Table 6. Grain yield of DT Boro Rice in Boro-Fallow-T. Aman cropping pattern, BRRI Gazipur, 2014-15.

Treatment	Grain yield (t/ha)
T_1=Normal transplanting with 80 DOS (TP: 25 Feb; Sowing: 05 Dec)	6.82
T_2=Normal transplanting with 60 DOS (TP: 25 Feb; Sowing: 25 Dec)	8.19
T_3=Normal transplanting with 40 DOS (TP: 25 Feb; Sowing: 15 Jan)	8.09
T_4=Double transplanting with removed seedling (100%) and no fertilizer in 1st transplanted plot	8.31
T_5=Double transplanting with removed seedling (100%) and 1st split urea in 1st transplanted plot	8.55
T_6=Double transplanting with removed seedling (75%) and full fertilizer in 1st transplanted plot	7.76
T_7=Remaining 25% seedling in fully fertilized 1st transplanted plot	6.07
CV (%)	9.8
$LSD_{0.05\% \text{ for treatment}}$	1.33

Evaluation of fertilizer management options in major crops in Kushtia region

Ten farmers of Hanurbaradi and Shuvorajpur block in Chuadanga and Meherpur district were selected for this trial during Kharif-II 2014 and Rabi 2014-15 seasons to compare the different fertilizer management options during T. Aman and Boro season. Each farmer's field was divided into three parts to imply the treatments viz, BRRI recommended fertilizer dose, soil test based fertilizer dose and farmer's usual fertilizer dose.

In Chuadanga, BRRI recommended fertilizer management and farmer's practice gave similar grain yield. Whereas soil test based fertilizer treatment resulted significantly lower grain yield compared to other treatments in T. Aman season. In Boro season, all the options gave similar grain yield.

In Meherpur, BRRI recommended fertilizer management and farmer's practice gave similar grain yield in T. Aman season. Soil test based fertilizer treatment gave significantly lower grain yield compared to other treatments. In Boro season, BRRI recommended treatment gave significantly higher grain yield. Soil test based fertilizer treatment and farmer's practice gave the similar grain yield.

Nitrogen management options in Boro and T. Aman rice under Boro-Fallow-T. Aman cropping system

This study was undertaken to determine appropriate timing of split application of N for making accurate N fertilizer recommendations for rice. The treatments were: i) One third of N was applied at IT stage + one third at AT stage + one-third at PI stage (N_1); ii) One-half at IT stage + another-half at PI stage (N_2); iii) One third at IT stage + two-third at PI stage (N_3); (iv) One-fourth at IT stage + one-fourth at AT stage+ half at PI stage (N_4); v) Half at IT stage + another half at AT stage (N_5) and vi) N-control (N_6). BRRI dhan44 in T. Aman season and BRRI dhan28 and BRRI dhan29 in Boro season were grown. In T. Aman, each treatment received 70 kg N/ha as urea and in Boro, 119 kg N/ha and 136 kg N/ha as urea for BRRI dhan28 and BRRI dhan29 respectively. In T. Aman, timing of N application treatments had significant effect ($p<0.01$) on grain yield. Significantly higher grain yield (5.50 t/ha) was observed in N_4 treatment followed by N_3 (5.47 t/ha), N_2 (5.33 t/ha) and N_1 (5.13 t/ha) treatments. In Boro, higher grain yield was obtained from the N_3 treatment (7.10 t/ha) followed by the N_2 (6.88 t/ha), N_4 (6.78 t/ha) and N_1 (6.70 t/ha) treatments and lower was in the N_6 (3.23 t/ha) treatment in

BRRI dahn28. In BRRI dhan29, significantly higher grain yield was observed in N_4 (7.80 t/ha) treatment compared to all other treatments and lower was in the N_6 (3.15 t/ha) treatment. BRRI dhan29 achieved higher grain yield compared to BRRI dhan28 irrespective of N treatment.

Evaluation of BRRI prilled urea applicator in Boro and T. Aman rice in Boro-Fallow-T. Aman cropping system

The experiment was conducted in T. Aman and Boro seasons of 2014-15 to compare the yield under varying methods of N application. There were five treatments: (i) Hand broadcasting of prilled urea as per BRRI recommendation (T_1), (ii) USG application by applicator (2.7 g/4 hills) (T_2), (iii) Prilled urea application by applicator (70% of the recommended urea in broadcasting) (T_3), (iv) Hand broadcasting of prilled urea as per T_3 dose (T_4) and (v) N-control (T_5). BRRI dhan44 and BRRI dhan28 were grown in T. Aman and Boro season respectively. The significantly higher grain yield was obtained from T_1 (5.66 t/ha) treatment followed by T_3 (5.60 t/ha) and T_2 (5.53 t/ha) treatments. The lowest yield was observed in T_5 (4.16 t/ha) treatment. In Boro season, the highest grain yield was obtained from T_3 (6.73 t/ha) followed by T_1 (6.22 t/ha) treatments in BRRI dhan28. The lowest yield was observed in T_5 treatment (3.65 t/ha).

Evaluation of different cropping patterns in saline area

The study was conducted to validate different cropping patterns in saline soils during 2014-15 with six different cropping patterns. The cropping patterns were: CP_1= T. Aman-Dibbled sunflower; CP_2=T. Aman-Zero tilled wheat (strip tilled); CP_3=T. Aman-Zero tilled wheat (line sown), CP_4=T. Aman-Spinach (broadcast, line sown); CP_5= T. Aman-dibbled Okra; CP_6= Fallow-Fallow-T. Aman (Check) following RCB design with six replications. On average, transplanted Aman rice produced 4.15, 4.48 and 4.66 t ha^{-1} grain yield in low, moderate and high saline area respectively. BRRI dhan53 yield range was 4.06 to 4.23 t ha^{-1}. The medium and high saline sites, farmers cultivated BRRI dhan54, which produced grain yield of 4.37-4.50 t ha^{-1} and 4.72-5.54 t ha^{-1} respectively. Wheat yield was reduced more than 50% in high saline area compared to the yield of low and medium saline area. Indian spinach sown in line without tillage and by dibbling method produced a yield of about 30 and 26 t ha^{-1} which was slightly reduced in medium saline area and reduced by about 15% in high saline area. The study showed the feasibility of sunflower in different gradient of salinity, wheat and spinach in low and medium saline area.

Evaluation of sunflower varieties and spacing under different gradient of salinity

This study was undertaken to evaluate the suitable variety and optimum plant population for better productivity of dibbled sunflower in the saline soils. The treatments were: Variety V_1= BARI Surjomukhi-2, V_2= Hysun33, V_3= Advanced line and spacing: S_1= 75 × 45 cm: S_2= 60 × 45 cm and S_3= 45 ×30 cm following RCB design with six replications. Irrespective of spacing, the hybrid variety of sunflower, Hysun33 produced higher seed yield in low, medium and high salinity level.Hysun33 produced higher seed yield at the spacing of 60 × 45 cm in low (2.85 t ha^{-1}), medium (2.73 t ha^{-1}) and high salinity (2.00 t ha^{-1}) level.

Evaluation of fertilizer recommendation in rice-dibbled sunflower cropping sequence under different gradients of salinity

The experiment was conducted to enhance the productivity of rice-sunflower cropping system in the saline soils. Five different fertilizer management were F_1=Full recommended fertilizer in rice in rice and sunflower (RR); F_2=Full recommended P and K fertilizer in rice and sunflower (N omission); F_3=Full recommended N and K fertilizer in rice and sunflower (P omission) F_4=Full recommended P and N fertilizer in rice and sunflower (K omission); F_5=Farmers' practice in rice and sunflower (FP) following RCB design with three replications.

The highest grain yield was recorded in the treatment of recommended dose of N, P, K fertilizer (4.62 t ha^{-1}), which was statistically similar to farmers practice (4.59 t ha^{-1}) and without K fertilizer (4.26 t ha^{-1}).

Agricultural Economics Division

SUMMARY

BRRI dhan28 and BRRI dhan29 were the most popular varieties covering 69% of area in Boro season, whereas in T. Aman season, BR11 and BRRI dhan49 were the dominant varieties that covered 23% area. In Aus season, the area coverage of BRRI dhan28 was the highest (21%) followed by BR26 (9%). Among BRRI varieties, BRRI dhan29 was the top yielder in Boro (5.81t/ha) followed by BRRI dhan28 (5.30 t/ha). In T. Aman season, BRRI dhan49 ranked the top position in terms of per unit yield (4.81 t/ha) followed by BR11 (4.77 t/ha) and BRRI dhan44 (4.77t/ha). In Aus season, BRRI dhan29 also produced higher yield (4.04 t/ha) followed by BRRI dhan48 (3.93 t/ha). Hybrids are being adopted as replacement of other MVs in Boro and Aus seasons due to higher yield performance. Farmers faced constraints like higher wage and irrigation cost, non-availability of quality seeds and lower market price of their product.

Rice farmers are still using more seeds and urea fertilizer than the recommended rate irrespective of cropping season; but applied comparatively lower amount of MoP. Although, Boro growers obtained higher yield, T. Aman growers gained higher gross return due to lower cost of production and higher market price. Factor and income share revealed that the human labour contributed the highest effort to the production process; and, on the other hand, farmers earned the highest income share among all other production participants. We have opportunities in rice production but that is not risk or threat free.

Due to lack of sufficient suitable domestic Aman varieties farmers of the border region used to cultivate Indian varieties in this season. Unless and until development of suitable domestic varieties for Aman season, cultivation of Indian varieties would continue. Breeders should consider the agro-climatic conditions and socio-economic demand of farmers' in the variety development process. In this regard, short to medium growth duration, stress tolerant varieties associated with higher milling out-turn and market demand should be given its due consideration.

Variety, area and farmers selection was not appropriate for the demonstration trial; as most of the farmers were acquainted with the demonstrated varieties earlier. Farmers did not show further interest to grow BRRI dhan55 as it was not good in terms of yield and amylose content. The grain of BRRI dhan48 is coarse; so it is difficult to popularize where Aus rice is not widely cultivated.

Most of the garment workers belong to farming community (78%) and majority (58 percent) of them were migrated in search of job for extreme poverty. Cereals, notably rice, constitute the most important food item consumed by the garment workers, which essentially dominated daily food intake at 443 gm/person; thrice a day, and it also being used as snacks in different forms as well.

FARM LEVEL ADOPTION AND EVALUATION OF MODERN RICE CULTIVATION IN BANGLADESH

BRRI Agricultural Economics Division is carrying out study to observe the farm level adoption and yield performance of different modern and indigenous rice varieties in Aus, T. Aman and Boro seasons throughout the country with the following objective:

Determine the region-wise adoption rate of different rice varieties in different seasons; and Estimate the yield of different modern and local rice varieties.

Multistage random sampling technique was adopted in selecting the sample farmers. A total of 4,034 sample farmers under Aus, T. Aman, and Boro seasons were selected and surveyed from ten agricultural regions of Bangladesh.

Adoption of modern rice varieties

BRRI dhan28 and BRRI dhan29 were the dominant varieties in Boro season in Bangladesh. These two varieties covered 69% of the total Boro area harvested (Table 1). There were other promising hybrid and modern rice varieties, which covered 11% and 3% of the Boro area respectively. The overall adoption rate of BRRI varieties was about 78% in Boro season.

Table 1. Adoption (%) of different Boro rice varieties by agricultural regions of Bangladesh, 2014-15.

Variety	Barisal	Chittagong	Comilla	Dhaka	Jessore	Mymensingh	Rajshahi	Rangamati	Rangpur	Sylhet	Av. (%)
BR14	1.14	0.00	0.54	1.79	0.00	0.87	0.01	0.26	0.34	1.89	0.68
BR16	0.21	6.88	7.87	0.28	0.00	0.69	1.21	3.32	7.53	0.64	2.86
BR26	0.08	0.00	0.03	0.04	2.12	5.96	0.12	0.74	0.00	0.74	0.98
BRRI dhan28	29.72	45.90	39.62	48.29	45.53	45.34	33.72	36.39	42.61	34.30	40.14
BRRI dhan29	22.26	33.55	40.20	42.06	5.99	34.82	24.33	19.56	22.75	39.55	28.51
BRRI dhan47	8.20	1.16	0.07	0.00	0.03	0.07	0.02	1.10	0.01	0.00	1.07
BRRI dhan50	1.81	0.33	0.81	0.38	4.72	0.26	0.49	2.30	0.26	0.29	1.16
Other BRRI v arieties	5.30	2.16	2.23	0.39	2.57	0.97	2.33	9.92	1.19	2.79	2.99
All BRRI varieties	68.72	89.98	91.37	93.22	60.95	88.98	62.24	73.59	74.69	80.22	78.40
SL-8	2.37	0.00	1.99	1.43	4.50	2.52	0.93	0.69	1.01	0.98	1.64
Hira	2.32	2.89	2.69	2.30	3.54	2.33	2.34	8.42	5.09	9.58	4.15
Other hybrid	5.76	3.03	3.57	2.40	5.25	5.08	5.29	8.69	8.20	8.33	5.56
All hybrid	10.45	5.93	8.24	6.13	13.29	9.92	8.56	17.80	14.30	18.89	11.35
Miniket	0.00	0.00	0.00	0.00	14.84	0.00	12.32	0.00	1.98	0.00	2.91
Zira sail	0.00	0.00	0.00	0.00	0.00	0.00	9.09	0.00	0.00	0.00	0.91
Other Indian varieties	8.14	0.77	0.00	0.06	9.54	0.32	4.11	0.00	1.16	0.00	2.41
All Indian varieties	8.14	0.77	0.00	0.06	24.38	0.32	25.51	0.00	3.14	0.00	6.23
Other MVs	5.36	3.32	0.31	0.30	1.31	0.36	2.74	4.68	7.86	0.18	2.64
All MVs	92.67	100.00	99.93	99.71	99.93	99.59	99.05	96.07	99.99	99.29	98.62
All LVs	7.33	0.00	0.07	0.29	0.07	0.41	0.95	3.93	0.01	0.71	1.38
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Nevertheless, the coverage of modern varieties in Boro season was about 99%.

BR11 and and BRRI dhan49 appeared as the prominent rice varieties covering 23% (12% and 11%) areas in T. Aman season. The area covered by BRRI varieties was about 57% whereas the coverage of Indian varieties was 19% (Table 2). The overall coverage of modern varieties was about 81% in this season. The adoption rate of modern rice varieties in Aus season was about 78% of which the coverage of BRRI developed varieties was about 58%. Among all BRRI varieties, BRRI dhan28 ranked the top position (21%) followed by BR26 (9%) and BRRI dhan48 (8%). In this season, coverage of other MVs, Indian and hybrids were about 8, 8 and 3% respectively (Table 3). Results also indicated that, area coverage of traditional varieties was about 22%.

Table 2. Adoption (%) of different T. Aman rice varieties by agricultural regions of Bangladesh, 2014-15.

Variety	Barisal	Chittagong	Comilla	Dhaka	Jessore	Mymensingh	Rajshahi	Rangamati	Rangpur	Sylhet	Av. (%)
BR10	0.08	1.50	0.53	0.44	4.73	0.13	0.09	4.06	0.00	2.88	1.44
BR11	4.33	18.44	3.45	23.80	4.82	6.62	7.55	20.60	4.06	22.31	11.60
BR22	1.56	17.11	32.78	1.24	1.33	0.39	0.66	5.91	0.00	11.60	7.26
BR23	2.36	6.14	1.75	0.00	1.45	0.25	0.07	0.00	0.00	3.38	1.54
BRRI dhan28	0.08	0.01	1.16	0.00	0.38	0.00	0.04	1.21	0.00	0.30	0.32
BRRI dhan32	0.84	3.73	9.11	0.93	0.51	10.95	2.50	3.40	0.12	9.25	4.13
BRRI dhan33	6.60	0.00	0.15	0.32	5.49	1.79	2.05	6.71	0.39	0.14	2.36
BRRI dhan34	0.15	0.01	0.36	0.40	0.00	0.84	5.06	0.21	7.70	0.56	1.53
BRRI dhan39	5.49	0.44	1.38	0.52	14.46	0.72	2.56	6.70	0.02	1.02	3.33
BRRI dhan40	2.40	3.40	0.85	1.66	0.06	2.65	0.15	4.46	0.00	1.20	1.68
BRRI dhan41	2.55	5.44	2.05	3.60	0.74	3.77	0.26	4.17	0.08	2.63	2.53
BRRI dhan44	1.84	4.24	1.34	0.00	0.09	0.38	0.00	0.47	0.00	2.04	1.04
BRRI dhan46	0.28	6.22	5.38	2.18	0.00	0.93	0.03	0.41	0.00	7.47	2.29
BRRI dhan49	2.63	6.16	10.54	20.47	8.03	10.89	13.75	11.82	11.35	15.01	11.07
BRRI dhan51	0.96	0.82	1.01	1.22	0.77	3.40	0.85	0.00	2.55	1.57	1.31
BRRI dhan52	1.51	1.73	0.97	1.94	1.34	4.33	0.82	0.18	2.23	1.34	1.64
Other BRRI varieties	0.99	1.44	0.91	0.53	6.05	0.83	0.46	5.41	0.00	1.74	1.83
All BRRI varieties	34.65	76.84	73.72	59.25	50.25	48.88	36.90	75.73	28.51	84.43	56.92
All hybrid	0.13	0.00	0.00	0.02	1.24	0.73	0.81	0.00	1.50	0.00	0.44
Pajam	0.05	4.96	0.30	10.30	0.39	8.60	9.13	8.36	0.33	0.31	4.27

Table 2. Continued.

Variety	Barisal	Chittagong	Comilla	Dhaka	Jessore	Mymensingh	Rajshahi	Rangamati	Rangpur	Sylhet	Av. (%)
Ranjit	0.04	0.00	0.00	3.27	0.21	0.00	5.87	0.00	2.98	1.48	1.39
Swarna	0.52	7.41	0.80	1.72	32.36	0.00	30.97	0.62	58.81	2.08	13.53
Other Indian varieties	0.27	0.00	0.00	0.00	0.71	0.00	0.55	0.00	0.21	0.00	0.17
All Indian varieties	0.88	12.36	1.11	15.29	33.67	8.60	46.52	8.97	62.33	3.87	19.36
Bina dhan7	1.75	0.16	1.00	3.42	9.58	4.75	9.94	0.49	2.89	0.70	3.47
Others	0.67	0.00	0.20	2.26	0.17	5.76	1.16	1.28	0.72	1.63	1.38
All other MVs	2.42	0.16	1.20	5.68	9.75	10.51	11.10	1.77	3.61	2.34	4.85
All MVs	38.08	89.36	76.03	80.24	94.91	68.71	95.34	86.48	95.96	90.63	81.57
All LVs	61.91	10.64	23.97	19.76	5.10	31.29	4.66	13.52	4.05	9.37	18.43
Grand total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 3. Adoption (%) of different Aus rice varieties by agricultural regions of Bangladesh, 2014-15.

Variety	Barisal	Chittagong	Comilla	Dhaka	Jessore	Mymensingh	Rajshahi	Rangamati	Rangpur	Sylhet	Av. (%)
BR1	0.04	2.43	0.00	0.41	0.00	6.33	0.41	1.74	0.00	14.41	2.58
BR2	9.13	3.40	2.15	7.85	0.00	5.35	0.00	0.47	0.00	0.18	2.85
BR3	3.96	1.47	0.61	0.00	0.00	0.38	0.58	1.47	0.00	5.20	1.37
BR14	3.05	0.00	1.06	0.14	0.22	0.57	0.28	1.04	2.37	4.14	1.29
BR16	2.07	3.97	1.48	17.19	0.48	0.00	2.44	0.34	6.84	2.29	3.71
BR20	0.00	0.00	16.48	0.00	0.00	0.00	0.00	1.60	0.00	0.01	1.81
BR26	1.28	4.25	5.99	18.87	21.30	17.61	5.85	3.67	0.57	8.14	8.75
BRRI dhan27	9.51	7.57	3.42	0.27	1.00	0.00	1.34	2.14	0.00	0.22	2.55
BRRI dhan28	3.38	19.85	33.88	16.96	24.75	3.98	23.78	8.10	41.20	30.52	20.64
BRRI dhan43	1.44	0.75	2.51	1.02	0.57	4.63	0.46	2.17	0.00	3.27	1.68
BRRI dhan48	2.62	8.38	9.28	3.45	7.32	15.97	7.06	0.59	2.91	20.85	7.84
Other BRRI varieties	3.38	0.43	2.55	0.08	0.22	3.08	3.52	8.83	4.63	3.86	3.06
All BRRI varieties	39.87	52.49	79.42	66.24	55.85	57.90	45.72	32.16	58.53	93.11	58.13
All hybrid	0.96	3.23	6.15	0.00	2.57	0.31	7.81	0.00	13.57	0.11	3.47
Zira sail	0.00	0.00	0.00	0.00	0.00	0.00	10.23	0.00	0.00	0.00	1.02
Parija	0.00	0.00	0.00	0.00	0.00	0.00	15.49	0.00	25.60	0.00	4.11
Other Indian varieties	3.14	2.00	0.00	0.00	20.08	0.42	4.40	0.00	0.01	0.00	3.01
All Indian varieties	3.14	2.00	0.00	0.00	20.08	0.42	30.11	0.00	25.61	0.00	8.14
Bau-63	5.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55
Gota IRRI	17.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79
IR-50	0.00	0.46	4.63	0.00	3.60	0.00	0.21	0.00	0.00	1.58	1.05
Others	3.94	9.12	5.14	2.17	5.63	3.56	10.31	7.66	1.76	0.35	4.96
All other MVs	27.39	9.58	9.78	2.17	9.23	3.56	10.51	7.66	1.76	1.93	8.36
All MVs	71.37	67.30	95.35	68.40	87.73	62.18	94.15	39.82	99.47	95.15	78.09
All LVs	28.63	32.70	4.65	31.60	12.27	37.82	5.85	60.18	0.53	4.85	21.91
Grand total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Yield of modern rice varieties

In Boro season, among BRRI varieties, BRRI dhan29 was the top yielder (5. 81 t/ha) followed by BRRI dhan28 (5.3 t/ha). Average yield of BRRI varieties was 5.38 t/ha. The yield of hybrid rice was 6.2 t/ha (Table 4). Among the BRRI varieties in T. Aman season, BRRI dhan49 was the top yielder (4.81 t/ha) followed by BR11 (4.77 t/ha) and BRRI dhan44 (4.77 t/ha). Overall yield rate of modern varieties was 4.6 t/ha whereas the average yield of BRRI varieties was 4.41 t/ha (Table 5). In Aus season, BRRI dhan28 produced the highest yield (4.04 t/ha) followed by BRRI dhan48 (3.93 t/ha) (Table 6). The yield of hybrid rice was also higher (4.83 t/ha).

Trend of changes in adoption and yield level

The overall adoption of modern varieties in Aus season increased from 25.57% to 78.09 % (ie, 52.52 % during the period from 1990-91 to 2014-15) and, on the other hand T. Aman adoption rate increased in 47.57% (Table 7). In case of modern Boro varieties, the adoption rate was 88.93% in 1990-91which reached to 98.62% in 2014-15 resulting to 9.69% increase. The increase of yield was much higher in Aus

Table 4. Yield (t/ha) of different Boro rice varieties by agricultural regions of Bangladesh, 2014-15.

Variety	Barisal	Chittagong	Comilla	Dhaka	Jessore	Mymensingh	Rajshahi	Rangamati	Rangpur	Sylhet	Av. (%)
BR14	5.47		5.29	5.43		5.29	5.76	4.32	5.46	4.93	5.24
BR16	4.83	5.12	5.59	5.27		5.43	5.97	4.42	5.52	4.40	5.17
BR26	5.32		5.04	4.77	5.63	5.41	5.74	4.40		4.92	5.15
BRRI dhan28	5.35	5.11	5.44	5.33	5.66	5.27	5.52	5.01	5.36	4.87	5.30
BRRI dhan29	5.69	5.72	5.97	5.94	5.63	5.99	5.86	5.98	5.63	5.85	5.81
BRRI dhan47	5.55	5.19	5.48			5.82	5.25	4.11	5.04		5.22
BRRI dhan50	5.46	5.03	5.54	5.46	5.67	5.17	5.55	5.05	5.26	4.88	5.28
Other BRRI varieties	5.51	5.15	5.38	5.37	5.55	5.14	5.61	4.49	5.33	4.89	5.24
BRRI varieties	5.53	5.22	5.54	5.51	5.65	5.40	5.70	4.87	5.45	5.06	5.38
Hira	6.14	6.14	6.23	6.19	6.37	6.03	6.45	6.18	6.02	6.39	6.23
SL-8H	6.27		6.20	6.12	6.49	6.22	6.62	5.93	5.80	6.40	6.23
Other hybrid	6.28	6.17	6.03	6.13	6.34	6.27	6.24	6.29	6.07	5.38	6.15
Hybrid	6.24	6.16	6.19	6.14	6.35	6.21	6.29	6.13	5.97	6.18	6.20
Miniket					5.20		5.53		5.97		5.57
Zira sail							5.49				5.49
Other Indian varieties	4.94	4.70		4.29	5.26	4.07	5.12		5.00		4.67
Indian varieties	4.94	4.70		4.29	5.25	4.07	5.35		4.81		4.67
Other MVs	5.05	4.68	5.05	4.90	5.54	5.06	5.44	4.41	5.14	4.54	4.94
All MVs	5.62	5.23	5.81	5.83	5.90	5.63	6.00	5.08	5.58	5.22	5.60
All LVs	2.50		2.51	2.46	2.60	2.47	2.36	2.51	2.59	2.52	2.52
Grand total	5.22	5.23	5.71	5.61	5.89	5.00	5.87	5.16	5.56	4.94	5.43

Table 5. Yield (t/ha) of different T. Aman rice varieties by agricultural regions of Bangladesh, 2014-15.

Variety	Barisal	Chittagong	Comilla	Dhaka	Jessore	Mymensingh	Rajshahi	Rangamati	Rangpur	Sylhet	Av. (%)
BR10	4.48	5.54	4.68	3.97	4.21	4.52	4.08	4.56		4.31	4.48
BR11	4.65	5.53	4.75	4.64	4.65	4.61	4.63	4.80	4.61	4.81	4.77
BR22	4.09	3.20	3.50	4.16	4.02	4.09	2.97	4.27	4.07	4.45	3.88
BR23	4.65	5.22	4.49		4.56	4.21	4.64		4.29	4.52	4.57
BRRI dhan28	5.36	5.23	4.60		4.29		3.02	4.95		4.68	4.59
BRRI dhan32	4.07	5.08	4.63	3.92	4.78	4.60	4.56	4.68	3.80	4.28	4.44
BRRI dhan33	4.05		3.36	3.82	4.04	4.02	4.11	4.04	3.53	4.06	3.89
BRRI dhan34	4.25	4.29	4.23	3.51		3.74	3.67	3.84	3.70	3.97	3.91
BRRI dhan39	4.63	4.46	4.63	4.09	4.58	3.87	4.45	4.56	4.38	4.52	4.42
BRRI dhan40	4.18	3.32	4.01	4.05	4.33	4.30	3.84	4.39		3.47	3.99
BRRI dhan41	4.73	5.23	4.67	4.40	4.59	4.65	4.89	4.72	0.00	4.53	4.24
BRRI dhan44	4.77	4.68	4.73		4.95	4.69		4.91		4.73	4.77
BRRI dhan46	4.66	5.40	4.85	4.33		4.46	3.27	4.79		4.83	4.58
BRRI dhan49	4.79	5.39	5.01	4.38	4.84	4.67	4.58	4.92	4.66	4.86	4.81
BRRI dhan51	4.75	5.36	4.28	4.40	4.76	4.61	4.89		4.67	4.60	4.70
BRRI dhan52	4.89	5.27	4.60	4.53	4.78	4.63	5.13	4.25	4.75	4.64	4.75
Other BRRI varieties	3.61	3.92	4.13	4.22	3.79	4.29	3.82	3.99	4.29	4.16	4.02
All BRRI varieties	4.51	4.88	4.42	4.17	4.48	4.37	4.16	4.51	3.90	4.44	4.41
All Hybrid	5.21		5.15	5.24	5.07	5.24	5.10		5.10		5.16
Pajam	3.63	4.15	4.14	3.80	5.20	3.72	4.17	4.40	3.34	4.43	4.10
Ranjit	4.51			4.21	4.50		4.76		4.62	4.42	4.50
Swarna	4.25	4.63	4.11	4.06	4.64		5.09	3.19	4.70	4.47	4.35
Other Indian varieties	4.60				3.35	0.00			4.12		3.02
All Indian varieties	4.38	4.39	4.11	4.13	4.57	3.72	4.92	3.19	4.66	4.44	4.43
Bina dhan7	3.54	3.42	3.61	18.47	3.53	3.40	3.46	3.55	4.45	3.16	5.06
Other MV	2.68		3.00	3.01	3.35	3.23	2.92	3.20	2.76	2.02	2.91
All Other MVs	3.11	3.42	3.31	10.74	3.44	3.32	3.19	3.38	3.61	2.59	3.98
All MVs	4.52	5.11	4.44	5.38	4.65	4.25	4.38	4.56	4.45	4.22	4.60
All LVs	2.65	2.06	2.34	2.75	2.63	2.70	2.79	2.11	2.16	2.83	2.50
Grand total	3.58	4.09	3.73	4.05	4.13	3.70	4.12	4.19	4.11	3.89	3.96

Table 6. Yield (t/ha) of different Aus rice varieties by agricultural regions of Bangladesh, 2014-15.

Variety	Barisal	Chittagong	Comilla	Dhaka	Jessore	Mymensingh	Rajshahi	Rangamati	Rangpur	Sylhet	Av. (%)
BR1	4.93	3.34		3.62		3.43	3.87	3.59		3.90	3.76
BR2	3.68	3.33	3.68	3.47		3.41		3.77		3.64	3.62
BR3	3.62	3.45	3.93			3.10	4.34	3.84		4.32	3.86
BR14	3.54		3.93	3.57	3.72	3.10	3.75	3.56	4.11	4.01	3.73
BR16	3.71	3.71	4.04	3.74	3.75		3.95	3.62	3.79	3.96	3.84
BR20			3.98					3.58		3.10	3.83
BR26	3.57	3.41	3.95	3.54	3.92	3.42	3.76	3.64	3.91	3.74	3.70
BR3	3.62	3.45	3.93			3.10	4.34	3.84		4.32	3.86
BRRI dhan27	3.82	3.71	3.98	3.88	3.96		3.67	3.59		3.72	3.78
BRRI dhan28	3.89	3.83	4.26	4.10	4.13	3.54	3.88	3.84	4.12	4.32	4.04
BRRI dhan43	3.60	4.27	4.02	3.45	3.95	3.44	3.60	3.68		4.05	3.73
BRRI dhan48	3.72	3.57	4.22	3.48	4.00	3.43	4.03	3.88	4.59	4.38	3.93
Other BRRI varieties	3.70	3.57	3.89	4.13	3.89	3.42	3.88	3.53	4.86	3.97	3.80
All BRRI varieties	3.69	3.59	4.04	3.59	3.96	3.42	3.86	3.65	4.08	4.05	3.83
All hybrid	4.79	5.46	5.12		5.01	2.54	4.57		4.86	4.67	4.83
Parija							3.70		3.26		3.53
Zira sail							3.77				3.77
Other Indian varieties	3.39				3.57	2.42	3.90		4.56		3.58
All Indian varieties	3.39				3.57	2.42	3.77		3.39		3.60
Bau-63	3.67										3.67
Gota IRRI	3.98										3.98
IR-50		2.97	3.37		3.47		3.10			3.25	3.26
Others	2.99	2.81	3.24	3.48	3.25	3.07	4.04	3.11	3.49	3.70	3.39
All Other MVs	3.20	2.82	3.28	3.48	3.26	3.07	3.95	3.11	3.49	3.59	3.41
All MVs	3.67	3.44	4.13	3.59	4.07	3.34	3.99	3.59	4.15	4.01	3.89
All LVs	2.32	2.62	2.87	2.81	2.82	2.50	2.93	2.82	3.40	3.03	2.65
Grand total	3.23	3.32	4.04	3.28	3.87	3.10	3.86	3.22	4.14	3.93	3.62

Table 7. Changes in the level of adoption and yield level of modern rice varieties over the years.

Item	Period		Difference
	1990-91*	2014-15	
	Aus		
Adoption (%)	25.57	78.09	52.52
Yield(kg/ha)	1770	3890	2120 (119.77)
	T. Aman		
Adoption (%)	34.00	81.57	47.57
Yield (kg/ha)	3290	4600	1320 (40.12)
	Boro		
Adoption (%)	88.93	98.62	9.69
Yield (kg/ha)	4410	5600	1190 (26.98)

Figures in parentheses indicate the percent. *National average.

(119.77%) and T. Aman season (40.12%) compared to Boro (26.98%).

ESTIMATION OF COST-RETURN FOR MV RICE CULTIVATION AT FARM LEVEL

Economic decisions are primarily concerned with the most profitable level of input use in production process. It is, therefore, important to verify cost and return of rice cultivation, which will help the farmers, researchers and planners to take decision. Hence, a macro level study was undertaken to:

- Determine the level of inputs used in MV Aus, T. Aman and Boro rice cultivation
- Estimate the cost of MV rice cultivation in different seasons
- Evaluate the profitability, factor and income shares of MV Aus, T. Aman and Boro rice cultivation at the farm level

Multistage random sampling technique was adopted to select the rice farmers from 10 agricultural regions of Bangladesh. To carry out the cost-return analysis, we used a sample size of 120 Aus, 120 T. Aman and 120 Boro rice growing farmers.

Level of inputs used

It revealed from the findings that the highest amount of human labour (98 man-day/ha) was used for MV T. Aman followed by MV Aus and MV Boro (88 man-days/ha and 80 man-day/ha) rice cultivation respectively (Table 8).

Table 8. Per hectare input used for MV rice cultivation in different seasons of Bangladesh, 2014-15.

Input item	Season		
	Aus	Aman	Boro
Human labour (man-day/ha):	88	98	80
Hired	42	43	42
Family	46	55	38
Seed (kg/ha)	37	39	41
Fertilizer (kg/ha):			
Urea	155	191	259
TSP	55	65	101
MP	60	54	78
DAP	-	15	10
Gypsum	10	22	51
$ZnSO_4$	-	1	4

As major activities were accomplished on contractual basis in Boro season labour requirement was lower. The seed rate used by the rice farmers for Aus, T. Aman and Boro rice cultivation were 37, 39 and 41 kg/ha respectively; showed a decreasing trend compared to the previous years. It might be due that the farmers are now a days using quality seeds purchasing from different sources. Famers applied comparatively higher doses of urea and TSP; although, they are far behind the required doses of MoP fertilizer.

Costs of cultivation

Per hectare human labour costs were found Tk 35,090, 36,261 and 43,140 for Aus, T. Aman and Boro rice cultivation respectively (Table 9). Costs of fertilizer for Boro was higher (Tk 10,465/ha) compared to that of MV T. Aman (Tk 6,873/ha) and Aus (Tk 5,222/ha) rice cultivation. Irrigation cost was much higher (13.52% of total costs) for MV Boro rice cultivation than the other crops, since this crop is completely dependent on irrigation.

Profitability

The yield received by the rice farmers in Aus, T. Aman and Boro seasons were 3,879, 4,320 and 5,587 kg/ha respectively. Boro rice growers received higher gross return (Tk 94,925/ha) compared to T. Aman (Tk 76,032/ha) and Aus (Tk 57,409/ha) due to higher yield but T. Aman growers accumulated higher gross margin due to lower unit cost of production and higher market prices; while, the net return of all the seasons were negative on full costs basis (Table 10).

Table 9. Per hectare cost of MV rice cultivation in different seasons of Bangladesh, 2014-15.

Cost item	Season		
	Aus	Aman	Boro
Seedbed preparation (Tk/ha)	1,852	2,188	2,487
Seed (Tk/ha)	1,554	1,463	1,742
Human labour	35,090	36,261	43,140
	(48.51)	(47.68)	(41.39)
Family labour	14,260	12,628	12,180
Hired labour	13,020	17,340	11,860
Contract	7,810	6,293	19,100
Land prep cost (Tk/ha)	7,782	7,459	8,095
	(10.75)	(9.81)	(7.77)
Fertilizer (Tk/ha)	5,222	6,873	10,465
	(7.21)	(9.14)	(10.04)
Urea	2,790	3,606	4,222
TSP	1,313	1,616	2,222
MP	1,019	876	1,170
DAP		405	260
Gypsum	100	220	510
$ZnSO_4$		150	600
Cowdung (Tk/ha)			1,481
Irrigation (Tk/ha)	1,850	748	14,089
	(2.55)	(0.98)	(13.52)
Herbicide (Tk/ha)	165	380	308
Insecticide (Tk/ha)	1,490	2,268	2,198
Variable cost (Tk/ha)	55,005	57,640	82,524
Interest on operating capital @10 for five months	815	900	1,799
Land rent (Tk/ha)	16,512	17,515	19,895
	(22.82)	(23.03)	(19.09)
Total Cost (Tk/ha)	72,332	76,055	104,218

Note: Figure in the parentheses indicate percent of total.

Table 10. Comparative costs and return of MV rice cultivation in different seasons of Bangladesh, 2014-15.

Item	Season		
	Aus	Aman	Boro
Yield (kg/ha)	3,879	4,320	5,587
Paddy price (Tk/kg)	14.00	15.00	14.98
Return from paddy (Tk/ha)	54,306	64,800	82,195
Return from straw (Tk/ha)	3,103	11,232	12,730
Gross return (Tk/ha)	57,409	76,032	94,925
Variable cost (Tk/ha)	55,005	57,640	82,524
Total cost (Tk/ha)	72,332	76,055	10,4218
Gross margin (Tk/ha)	2,404	18,392	12,101
Net return (Tk/ha)	-14,923	-23	-9,293
Unit cost of production (Tk/kg)	18.64	17.61	18.65
BCR on cash cost basis	1.04	1.32	1.15
BCR on full cost basis	0.79	0.99	0.91

Factor and income share analysis

Factor sharing the output included current inputs, human labour, power tiller and land. Human labour itself earned the highest share of outputs, which were 61, 48, and 45% of Aus, Aman and Boro respectively. Land rent earned second highest share, which were 29, 23, and 21 % of Aus, Aman and Boro, respectively. The residuals, which goes to the operator, was found as the highest (7%) in Boro season and negative (-21%) in Aus season (Table 11).

Production participants sharing the income included the farmer, the hired labour and the power tiller. In Aus season, the farmer earned 39% of the total income of which 35% was generated by land, 30% by family labour and -26% as residuals and it was 51% in T. Aman season and 28% was generated by land, 20% by family labour and 3% as residual respectively. In Boro season, the farmer earned 50% of the total income of which 26% was generated by land, 16% by family labour and 8% as residual (Table 12).

Rice farmers are still using more seeds and urea fertilizer than the recommended rate irrespective of cropping season; although, they apply comparatively very lower amount of MP. Boro growers obtained higher yield due to better cropping environment, good management practices and use of better genotypes. T. Aman growers obtained higher gross margin due to lower production cost and higher market price. Factor and income share analysis revealed that the human labour contributed the highest effort to the production process; and on the other hand, farmers earned the highest income share among all other production participants.

DOMESTIC VS INDIAN AMAN VARIETY CULTIVATION IN BORDER REGION OF BANGLADESH: A FIELD LEVEL INVESTIGATION

Around 49% rice area is under Aman season, which provided around 38% of total rice production. Before the inception of BRRI, there was no HYV for Aman season in Bangladesh. BRRI has developed so far 34 Aman rice varieties including one hybrid. Out of them, BR11 was the most popular throughout the country. Indian variety has been started to be cultivated in the border areas since 1995 and gained popularity. The study was undertaken to find out the adoption level and causes of adoption of Indian Aman varieties in border areas of Bangladesh.

Table 11. Comparative factor share of Aus, Aman, and Boro rice cultivation in Bangladesh.

Factor share	Factor payment						Factor shares (%)		
	Value (Tk/ha)			Paddy equivalent* (kg/ha)					
	Aus	Aman	Boro	Aus	Aman	Boro	Aus	Aman	Boro
Current input[a]	10,283	13,172	17,200	735	878	1,148	18	17	18
Human labour	35,090	36,261	43,140	2,506	2,417	2,880	61	48	45
Power tiller	7,782	7,459	8,095	556	497	540	14	10	9
Land[b]	16,512	17,515	19,895	1,179	1,168	1,328	29	23	21
Residual[c]	-12,258	1,625	6,595	-876	108	440	-21	2	7
Total	57,409	76,032	94,925	4,101	5,069	6,337	100	100	100

*=Paddy equivalent (kg/ha)=Value (Tk/ha)/Paddy price (Tk/kg). [a]Includes costs of fertilizer, pesticides, insecticides and seed/seedlings, [b]Average land rent for the season, [c]Residual=(Total value product or physical product) - (Share paid to current inputs, human labour, power tiller and land).

Table 12. Comparative income shares of different production participants in Bangladesh.

Production participants	Total value (Tk/ha)			Paddy equivalent (kg/ha)			% of share		
and value added	Aus	Aman	Boro	Aus	Aman	Boro	Aus	Aman	Boro
Value added[a]	47,126	62,860	77,725	3,366	4,191	5,189	100	100	100
Farmer[b]	18,514	31,768	38,670	1322	2118	2581	39	51	50
Land	(16,512)	(17,515)	(19,895)	(1,179)	(1,168)	(1,328)	(35)	(28)	(26)
Family labour	(14,260)	(12,628)	(12,180)	(1,019)	(842)	(813)	(30)	(20)	(16)
Residual	(-12,258)	(1,625)	(6,595)	(-876)	(108)	(440)	(-26)	(3)	(8)
Hired labour	20,830	23,633	30,960	1488	1576	2067	44	38	40
Power tiller	7782	7459	8095	556	497	540	17	12	10

[a]Value added=Total value of output – current inputs costs, [b]Farmer=Value added- Hired (Human labour+ Animal labour/Power tiller).

The study was conducted in the border region of Bangladesh (Panchagar, Thakurgaon, Dinajpur, Rangpur, Naogaon, Chapia Nawabganj, Rajshahi, Kushtia, Chuadanga, Jessore and Satkhira) to find out the coverage and causes of Indian Aman varieties cultivated by the farmers. Intensive field surveys followed by several FGDs were conducted during-2014-15. The stakeholders of FGD were farmers, local representatives, school teachers and NGO personnel. Besides, district level information about area coverage and yield of domestic and Indian Aman varieties were collected from DAE. Simple statistical tools like percentage, mean were used to analyze the data.

Domestic and Indian variety and its area coverage in Aman season

Table 13 shows district wise cultivated Aman varieties and its coverage (%) in the border region of Bangladesh. According to the information from DAE, farmers' started to cultivate Indian varieties in the name of 'Ratna' and 'Varotio Swarna' in the border region during 1995-96. Later on, Lal Swarna, Guti Swarna and other Indian varieties gaining popularity at farm level. At present, 4/5 types of Swarna and other Indian varieties (Ranjit, Zirasail, Minikit, Jamaibabu etc) are being cultivated in the border region. During 2014-15 about 55% Aman area was under Indian variety (ranged 11% to 77%) and the rest 45% was domestic variety in that areas. Consumer Unity and Trust Society (CUTS) International and Unnayan Shamannay reported that 70% area was covered by Indian varieties (Swarna, Minikit, Ranjit, Parijat etc) in the border region during 2015. Last three years average of Indian HYV coverage was 56% (ranged 10% to 81%) (Table 14).

On the other hand, Bangladeshi varieties such as BR11, BR12, BRRI dhan28, BRRI dhan29 and hybrid-HIRA are being cultivated in eastern states

Table 13. Scenario of domestic and Indian varieties grown in Aman season 2014-15.

District	Domestic HYV	Indian HYV
Panchagar	BINA dhan-7 (11%), BRRI dhan52 (4%), BRRI dhan51 (3%), BRRI dhan49 (2%) and Others (3%). Total 23%.	Swarna (69%), Ranjit (4%), Nepali Swarna (3%) and Mamun Swarna (1%). Total 77%.
Thakurgaon	BRRI dhan49 (4%), BR11 (3%), BINA-7 (7%), BRRI dhan52 (2%) BRRI dhan34 (2%) and others (14%). Total 34%.	Swarna (63%), Nepali Swarna (1%), Ranjit (1%) and Suman Swarna (1%). Total 66%.
Dinajpur	BRRI dhan34 (16%), BRRI dhan49 (7%) BINA-7 (3%), BRRI dhan52 (2%), BR11 (2%), BRRI dhan51 (1%) and others (2%). Total 33%.	Swarna (33%), Guti Swarna (18%), Nepali Swarna (5%), Swarna-5 (3%), Ranjit (3%), Mamun Swarna (2%), Suman Swarna (1%) and others (2%). Total 67%
Rangpur	BR11 (35%), BINA-7 (8%), BRRI dhan52 (6%), BRRI dhan33 (2%), BRRI dhan49 (2%) and others (1%). Total 58%.	Swarna (39%), Ranjit (%) and others (1%). Total 42%.
Naogaon	BRRI dhan49 (13%), BRRI dhan34 (6%), Pajam (6%), BINA-7 (4%), BR11 (3%), BRRI dhan32 (1%) and others (1%). Total 34%.	Swarna (60%), Ranjit (4%), Zirasail (1%) and others (1%). Total 66%.
Chapainababganj	BRRI dhan34 (11%), BINA-7 (5%), BRRI dhan51 (2%), BRRI dhan49 (1%) and others (3%). Total 23%.	Swarna (70%), Zirasail (2%) and others (1%). Total 77%.
Rajshahi	BINA-7 (11%), BRRI dhan33 (5%), BRRI dhan49 (4%), BRRI dhan39 (4%), BR11 ((2%), BRRI dhan51 (1%) and others (6%). Total 33%.	Swarna (64%), Guti Swarna (2%) and others (1%). Total 67%.
Kushtia	BRRI dhan39 (29%), BRRI dhan33 (11%), BRRI dhan49 (9%), BINA-7 (9%), BR11 (6%), BR10 (4%), BR23 (3%), BRRI dhan30 (3%) and others (10%). Total 84%.	Swarna (15%) and others (1%). Total 16%.
Chowadanga	BRRI dhan39 (13%), BRRI dhan49 (6%), BINA-7 (4%), BRRI dhan51 (3%), BRRI dhan33 (3%) and others (5%). Total 34%.	Swarna (57%), Ranjit (8%) and others (1%). Total 66%.
Jessore	BINA-7 (13%), BRRI dhan30 (10%), BRRI dhan39 (9%), BR10 (6%), BR11 (4%) and Others (11%). Total 53%.	Swarna (26%), Guti Swarna (10%), Minikit (10%) and others (1%). Total 47%.
Satkhira	BR10 (16%), BR23 (16%), BRRI dhan30 (16%), BINA-7 (12%), BRRI dhan49 (11%), BR11 (9%), BRRI dhan39 (2%), BRRI dhan33 (1%) and others (4%). Total 89%.	Swarna (6%), Jamaibabu (3%) others (2%). Total 11%.
	Average of domestic HYV 45%	Average of Indian HYV 55%

Table 14. District-wise domestic and Indian HYV coverage (%) in Aman season.

District	2012-13		2013-14		2014-15		Average	
	Domestic HYV	Indian HYV	Domestic HYV	Indian HYV	Domestic HYV	Indian HYV	Domestic HYV	Indian HYV
Panchagar	16	84	19	81	23	77	19	81
Thakurgaon	22	78	20	80	34	66	25	75
Dinajpur	36	64	33	67	33	67	34	66
Rangpur	57	43	68	32	58	42	61	39
Naogaon	27	63	34	66	35	65	32	68
Chapainababganj	15	85	18	82	23	77	19	81
Rajshahi	38	62	41	59	33	67	37	63
Kushtia	84	15	86	14	84	16	85	15
Chowadanga	41	59	28	72	34	66	34	66
Jessore	42	58	53	47	53	47	49	51
Satkhira	90	10	92	08	89	11	90	10
Average	43	57	45	55	45	55	44	56

of India like Assam, Bihar, Jharkhand, Odisha and West Bengal (Tazlina Zamila Khan, 2015.

Reasons for cultivating Indian varieties

The respective DAE office and the respondent farmers opined that there are some reasons for cultivating Indian varieties in Aman season. Although, there are some domestic Aman varieties like, BR10, BR11, BRRI dhan33, BRRI dhan39, BRRI dhan51 and BRRI dhan52, which is still popular to farmers due to early maturity, easy to threshing and better market price but most of the varieties are very old and susceptible to different stresses, diseases and pests. Moreover, grain size of the varieties is bold, so yield and market price is also low. On the other hand, Indian variety is comparatively stress tolerant; yield is better, slender grain, good taste and higher market price. So, the farmers are inclined to cultivate Indian varieties.

FOOD HABIT AND DIETARY INTAKE PATTERN OF GARMENT WORKERS AT GAZIPUR AREA

Once, the economy of Bangladesh was largely dependent on agriculture, but the situation has been changed and the ready-made garments (RMG) sector has emerged as the biggest contributor of the economy. This sector has experienced an exponential growth and contributes significantly; about 15 percent to the GDP. It provides around 4.2 million people's employment (BBS, 2011) and uplifted the neglected section of the population; especially women, through empowerment and transforming their socio-economic condition (Ali R N *et al.*, 2008). Like other Bangladeshi consumers, rice is the most dominant food item and primary source of energy and nutrients of the factory workers. Thus it is important to investigate the food habit and determine the amount of the different nutrients that an individual garment worker can derive from average daily per capita food intake.

The study was conducted purposively in selected semi-urban areas of Gazipur district. Fifty respondents were selected and interviewed with structured questionnaire to generate required data. Simple statistical tools like percentage, mean, variation, etc were used to analyze the data.

Socio-economic characteristics and background of garment workers

About 12 percent of the respondents reported that he/she is the only earning member of the family. Average family size of the respondents was seven, whereas number of dependent family member on his/her income was three (on average). Most of the respondents belong to farming community (78%) either landless tenant or marginal farming family (Table 15). The third and fourth community belongings identified were non-agricultural labourer and non-migrated local poor respectively.

Causes of migration

Majority (58%) of the respondents were migrated

Table 15. Family background of the garment workers.

Community	Respondents (no.)	Percentages
Landless tenant farming family	25	50
Marginal farming family	14	28
Non-agricultural labourer	7	14
Non-migrated local poor	4	8
Total	50	100

Source: Field survey (2015).

looking for better life under extreme poverty. The second important factor was job search. About 18 percent of the respondents migrated for this reason. The third and fourth important causes identified by the migrants were to accompany husbands at workplace and personal problems, respectively.

Budget for food and access to commodity market

Budget for food. Majority of the respondents (44%) allocated Tk 41-50 for daily meals per person and only 8% respondents spent above Tk 60 for per day for their food purpose (Table 16).

Access to commodity market. In the study area, cent percent respondent reported that they preferred to buy day-to-day commodities from the evening markets while coming back home. The respondents also liked evening markets for other reasons such as availability of preferred commodities, freshness etc.

Table 16. Garment workers' daily budget for food.

Daily budget per person	Respondents (no.)	Percentages
Less than Tk 40	9	18
Tk 41-50	22	44
Tk 51-60	15	30
Above Tk 60	4	8

Source: Field survey (2015).

Food habit and dietary intake

Rice consumption behaviour. Notably rice constitutes the most important food item of garment workers. Among the respondents, 36% took rice thrice a day. Boiling rice in excess water and discarding the gruel was found common practices and reported by 72 percent respondents. Varietal preference of rice was found dependent on respondent's budget constraints and per unit retail price. Cooking quality and taste of rice was preferred than grain shape and appearance. Rice is also being consumed as snacks in different forms like *Moori* (puffed rice), *Chira* (flattened rice), *Khoi*, *Chal-vaja*, *Khud* (broken rice) and *Pitha* (cakes made of rice flour) (Table 17).

Food consumption pattern

Average per capita cereal (rice) intake was 443 gm per day followed by little quantity of vegetables (19.14%), tubers (6.52%) and nominal amount of other food items. Milk and milk products, egg and meat were consumed only occasionally in a small amount. Fruit intake was mainly seasonal and includes banana, mango, jackfruit, guava, black berry and other locally produced less-expensive ones (Table 18**)**. The least consumed food groups were vegetables, fish, pulse, sugar, edible oil etc.

Table 17. Consumption pattern of different rice items.

Rice item	Percentage of respondent	
	Regular consumption	Occasional consumption
Parboiled rice	96	-
Un-parboiled rice	4	64
Moori (puffed rice)	100	-
Chira (flattened rice)	40	60
Khoi	-	76
Rooti (bread of rice flour)	14	100
Chal-vaja and *Khud* (broken rice)	10	90
Gruel	-	10
Panta/Left-over rice	-	30
Pitha (cakes made of rice flour)	-	100

Source: Field survey (2015).

Table 18. Average per capita per day food intake of garment workers.

Item	Average per capita per day food intake (grams)	Percentages of total consumption
Rice and rice products	443.6	52.37
Wheat and other cereals	27.1	3.20
Potato, starchy root and tubers	55.2	6.52
Pulse	24.9	2.94
Sugar/ Gur	7.5	0.89
Edible Oil	17.2	2.03
Vegetables	162.1	19.14
Fruits	13.5	1.59
Fish, dried fish and meat	40.05	4.73
Eggs	6.04	0.71
Milk and milk products	23	2.72
Spices and condiments	10.9	1.29
Miscellaneous (tea, soft drinks, snacks, betel leaf etc)	15.9	1.88
Total food consumed	847	100

Source: Field survey (2015).

Comparing the average per capita per day food intake of garment workers with the daily requirement (as per BAN-HDRB 2007) it is clear that they are consuming food items; except rice; in a lesser amount than required (Fig. 1). Rice is being consumed in a higher rate (26.74 percent) than the daily requirement of 350 gm. This pattern of imbalanced consumption may lead to serious malnutrition and health hazards.

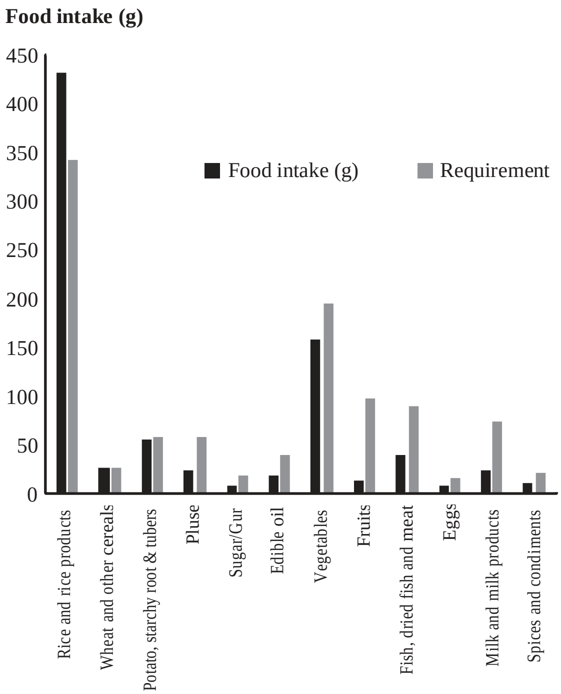


Fig. 1. Comparision of daily food intake with the requirements.

Changes in overall livelihood pattern

Sixty-four percent of the respondents said that their socio-economic conditions had improved due to involving in garment factory, while 36 percent reported no change in their overall socioeconomic condition. Rising inflation, repaying loan and increasing family expectation were the main reasons reported by the respondents who had the negative responses.

The study revealed that average family size of the respondents was seven and dependent family member on his/her income was three and 12 percent of the respondent was only the earning member of the family. Most of the respondents belong to farming community (78%). Majority (58 percent) of them were migrated for extreme poverty and insolvency. Rice was consumed by hundred percent of the garment workers, which essentially dominated daily food intake per person at 443 gm making up 52.37% of total food consumption. Varietal preference of rice was found dependent on respondent's budget allocation and per unit retail price.

Current condition of the garment workers would not improve if their earning couldn't be balanced with the living cost. Price of daily necessities need to be controlled. Government should supply subsidized daily needs at the industrial areas of Bangladesh. Enriching rice varieties with micro nutrients like vitamins, minerals would be a potential solution to ensuring food as well as nutritional security of the garment workers.

Agricultural Statistics Division

Personnel
Md Ismail Hossain, *PhD*
Principal Scientific Officer and Head
Niaz Md Farhat Rahman, *MS*
Senior Scientific Officer

ICT Cell
S M Mostafizur Rahman
System Analyst
Ful Miah
Cartographer (Senior IT Officer)
Md Mahfuz Bin Wahab
Programmer
Kabita
Assistant Programmer

SUMMARY

In the reporting period BR11, BRRI dhan49, BRRI dhan51 and BRRI dhan52 were found as the most stable in T. Aman season while BR3, BR4 and BRRI dhan23 appeared to be below average stable among the non-aromatic rice. In case of aromatic rice BR5, BRRI dhan34, BRRI dhan37 and BRRI dhan38 also appeared to be average stable varieties.

BRRI dhan28 and BRRI dhan29 was the only most stable variety and BR1, BR2, BR6, BR7, BR8, BR18, BR19, BR26, BRRI dhan27, BRRI dhan35, BRRI dhan55, BRRI dhan58 and BRRI dhan59 appeared to be below average stable in Boro season. In case of fine rice BRRI dhan50 also appeared to be average stable in Boro season.

Model analysis indicates that BR11, BR22, BRRI dhan32, BRRI hybrid dhan4 were more preferable and cultivable varieties in T. Aman season; BRRI dhan28, BRRI dhan29, BRRI dhan50, BRRI hybrid dhan3 in Boro season and BR9, BR16, BRRI dhan48 in Aus season due to higher yield among the producers and producer cum consumers. Pure consumers were found to prefer rice varieties on the basis of taste, finess and availability of the varieties. Although, BRRI variety contributes about 90% of total production, it does not reflect in field level as the BRRI varieties are sold in different brand names. As for example, BRRI dhan28 sales as Nizersail and BRRI dhan29 as Jhingasail and Miniket etc.

Three mathematical models have been developed for consumers' and producers' and producer-cum-consumers' preference to rice varieties by using four locations/districts farmers' data of Bangladesh in terms of rice deficit and rice surplus area. These three models are used to determine factors affecting producers' decision on varieties for rice cultivation and can provide an indication of the factors affecting consumers' preference to rice varieties.

Farmer-specific technical efficiencies are estimated using rice growing farmers' survey data, which includes DEA models, applying the linear programming method. The technical inefficiency effects are modeled as a function of farmer-specific information about farmers, the farmer's experience in Boro rice cultivation, the linkages of agriculture extension personnel, the condition of soil in cultivated land, extra labour and knowledge of rice production. From the result, the cultivation experience of farmer and the linkage of the extension personnel in this cultivation affect the efficiency level of the farmers. This study finds the necessity of improving the quality of seed, the irrigation method and maintained the amount of fertilizer, which has a significant effect on Boro rice production in selected area of Manikganj district. Here we found that most of the farmers of Boro rice cultivation are efficient. Policies leading to improve the of irrigation method, the quality of seed and reduction of using pesticides could be beneficial in decreasing inefficiency of farmers in Bangladesh.

The climatic factors of maximum temperature and humidity showed statistically significant influences in Aus rice and the contributions have been found positive for both the parameters. The contribution of climatic factors has no significant effect on Aman rice. For Boro rice minimum temperature displayed statistically significant but negative correlation with the yield. Maximum temperature and humidity has significantly affected the yield. The year to year variation due to climate change had an impact on the Aus, Aman and Boro rice yield. Therefore, to the issue of climate change and ensuring food security, the concerned authorities should provide policy recommendations and action plans to adapt and to cope properly with the changing nature of climate factors.

Dry season Boro rice mainly depends on supplementary irrigation from groundwater, results in severe groundwater depletion. Main source of recharging of groundwater aquifer in this area is rainfall, but rainfall is also dropping here. Hydrographs are analyzed and groundwater level contour maps are prepared by Arc GIS version10 software from the monitoring wells data of Bangladesh Water Development (BWDB). For aquifer geometry a subsurface geological cross section made by RockWorks software from bore log data of Department of Public Health Engineering (DPHE) and Bangladesh Water Development (BWDB). Only two aquifers exist and in north-west (NW) area shows effective

aquifer thickness is shorter than south-east (SE) portion. Average rates of maximum depth (dry season) and minimum depth (wet season) groundwater depilation are 0.23 meter/year and 0.38 meter/year respectively in Rajshahi district. In some upazilas these rates are much higher than that of average. Groundwater recharge condition is very poor in Tanore, Godagari, Mohanpur and Baghmara upazilas and vulnerable for Boro rice ie irrigated rice. A crucial relationship remains between Boro production and groundwater depletion. So crop diversification or less water consuming crops can be an option for the study area.

The scientists of this division were also engaged in helping scientists of other disciplines in planning experiments, statistical data analysis and interpretation of results. A total of 60 different types of analyses were performed during the reporting year. A number of maps were prepared using GIS and supplied to the scientists of other divisions whenever required. Besides, ICT cell of Agricultural Statistics Division provides ICT related support services to other divisions such as hardware, software and troubleshooting related problem etc.

STABILITY ANALYSIS OF BRRI VARIETIES

The newly developed stability model takes into account the performance of the genotypes across the geographical locations differing in land, soil and other biotic and abiotic factors and over the years characterizing fluctuation of weather variable, floods and drought etc.

Experiments are being conducted in the T. Aman and Boro seasons with BRRI released rice varieties since T. Aman 2014 and Boro 2014-15 in Gazipur and different regional stations. The collaborative regional stations in the T. Aman season are Rajshahi, Rangpur, Comilla, Sonagazi, Barisal, Satkhira and Kushtia and in the Boro season Rajshahi, Rangpur, Comilla, Habiganj, Barisal, Bhanga, Satkhira, Kushtia and Sonagazi.

The number of varieties is 27 and 25 in T. Aman and Boro season respectively. The design used is RCB with three replications and the effective plot size (harvest area) is 5×2 m^2 leaving the boarder. Recommended crop management practices are followed. The newly developed stability model was used to analyse the data.

The value of G_i (stability index of the ith genotypes) ranges from -1 to +3 ie, $-1 \leq Gi \leq 3$. The higher the value of G_i more is the stability of the genotype across the environments. Stability of a variety is characterized as follows:

Value of G_i	Nature of stability
≤ 0	Unstable
$0 < \mathbf{G_i} \leq 1$	Below average stability
$1 < G_i \leq 2$	Average stability
$2 < G_i \leq 3$	Stable

Tables 1 and 2 present the results. Among the non-aromatic T. Aman varieties, BR11, BRRI dhan49, BRRI dhan51 and BRRI dhan52 were found stable and their stability ranks were 4, 2, 1 and 3 respectively, while BR3, BR4 and BRRI dhan23 appeared to be below average stable. BR10, BR22, BRRI dhan25, BRRI dhan30, BRRI dhan31, BRRI dhan32, BRRI dhan33, BRRI dhan39, BRRI dhan40, BRRI dhan41, BRRI dhan44, BRRI dhan46, BRRI dhan53, BRRI dhan54 and BRRI dhan56 were found to have average stability among non-aromatic T. Aman varieties. Among the aromatic T. Aman rice BR5, BRRI dhan34, BRRI dhan37 and BRRI dhan38 appeared to be average stable.

In Boro season, the only stable variety was BRRI dhan28 and BRRI dhan29 in each year. BR3, BR9, BR12, BR14, BR15, BR16, BR17, BRRI dhan36, BRRI dhan45, BRRI dhan47 and BRRI dhan50 appeared to have average stability. All other Boro varieties appeared to have average stability.

DEVELOPMENT AND VALIDATION OF PRODUCER, CONSUMER AND PRODUCER CUM CONSUMER PREFERENCE MODEL FOR RICE VARIETIES

This study is an attempt to evaluate the factors affecting producers', consumers' and producer-cum-consumers' preference for rice varieties, because no systematic study has been conducted in

Table 1. Stability parameters of new model for grain yield for T. Aman.

Variety	Stability parameter			Stability index (G_i)	Stability rank (R_i)
	2002-14			2002-14	2002-14
	S_i	D_i	P_i	G_i	R_i
		Non-aromatic rice			
BR3	8.86	25.14	4	0.81	12
BR4	8.42	28.69	10	0.99	11
BR10	8.15	31.42	13	1.13	5
BR11	8.56	30.51	12	2.06	1
BR22	7.64	30.09	12	1.13	5
BR23	8.20	28.01	9	0.99	11
BR25	7.76	27.88	8	1.03	10
BRRI dhan30	8.40	29.78	11	1.04	9
BRRI dhan31	8.38	29.37	11	1.03	10
BRRI dhan32	8.11	31.52	13	1.14	4
BRRI dhan33	8.59	23.69	3	1.77	2
BRRI dhan39	7.80	25.23	5	1.91	2
BRRI dhan40	8.09	30.61	12	1.11	7
BRRI dhan41	8.03	29.94	11	1.08	8
BRRI dhan44	8.44	28.54	10	1.99	2
BRRI dhan46	8.73	27.32	9	1.91	2
BRRI dhan49	7.84	31.14	15	2.16	1
BRRI dhan51	6.61	30.36	13	2.28	1
BRRI dhan52	8.24	31.46	15	2.13	1
BRRI dhan53	7.85	23.42	6	1.83	2
BRRI dhan54	8.10	26.26	10	1.92	2
BRRI dhan56	8.21	14.89	3	1.50	3
BRRI dhan57	7.90	25.25	10	1.92	2
BRRI dhan62	8.10	15.92	3	1.50	3
BRRI hybrid dhan4	8.12	30.12	12	1.11	5
		Aromatic rice			
BR5	8.18	20.61	2	1.08	8(4)
BRRI dhan34	8.74	20.41	2	1.12	6(3)
BRRI dhan37	8.22	22.89	2	1.77	2(1)
BRRI dhan38	8.46	22.80	2	1.74	2(2)

Table 2. Stability parameters of new model for grain yield for Boro.

Variety	Stability parameter			Stability index (G_i)	Stability rank (R_i)
	2002-15			2002-15	2002-15
	S_i	D_i	P_i	G_i	R_i
		Non-aromatic rice			
BR1	8.40	0.22	21	0.33	13
BR2	7.48	-4.81	18	0.18	14
BR3	9.44	4.75	23	1.56	3
BR6	9.05	-6.55	18	0.05	15
BR7	4.06	0.80	21	0.70	10
BR8	2.66	-0.29	21	0.99	8
BR9	3.30	13.23	28	1.59	3
BR12	7.89	-2.43	20	1.25	5
BR14	4.48	11.41	27	1.27	5
BR15	2.97	10.05	26	1.49	4
BR16	7.50	10.10	26	1.96	2
BR17	2.83	8.66	25	1.46	4
BR18	22.20	0.57	21	0.15	14
BR19	6.31	3.18	23	0.61	11
BR26	5.65	4.65	23	0.75	10

Table 2. Continued.

Variety	Stability parameter			Stability index (G_i)	Stability rank (R_i)
	2002-15			2002-15	2002-15
	S_i	D_i	P_i	G_i	R_i
BRRI dhan27	5.57	3.88	23	0.71	10
BRRI dhan28	2.83	9.68	26	2.51	1
BRRI dhan29	5.75	20.73	32	2.70	1
BRRI dhan35	7.59	3.51	23	0.56	12
BRRI dhan36	5.29	8.65	25	1.02	7
BRRI dhan45	9.11	-1.94	20	1.22	6
BRRI dhan47	18.48	-8.48	17	1.17	6
BRRI dhan55	19.34	-20.48	11	0.62	11
BRRI dhan58	28.39	-24.67	9	0.82	9
BRRI dhan59	27.83	-9.68	10	0.61	9
BRRI dhan60	5.65	20.23	31	1.49	2
BRRI dhan61	2.79	8.98	25	1.31	2
BRRI dhan64	5.35	19.93	30	151	2
BRRI hybrid dhan1	9.11	-5.25	17	0.03	13
BRRI hybrid dhan2	7.37	-4.62	19	0.15	11
BRRI hybrid dhan3	5.65	4.65	23	0.75	5
		Aromatic rice			
BRRI dhan50	13.58	-8.88	15	1.13	6 (1)

identifying the factors that could influence or affect the preference to rice variety.

For this study four locations/districts ie Panchagarh, Lalmonirhat, Kurigram and Thakurgaon were selected. Panchagarh and Lalmonirhat were selected as ‘Rice deficit’ area. Kurigram and Thakurgaon were selected as ‘Rice surplus’ area. Fifty farmers were selected from producer, consumer and producer-cum-consumer from each location and the selected farmers were categorized into three groups such as producers’, pure consumers’ (consume rice from market) and producer-cum-consumers.

The pure consumers were selected from the urban areas of Panchagarh, Lalmonirhat, Kurigram and Thakurgaon districts (Table 3). Information was collected on the choice of varieties for production and consumption using a pre-designed questionnaire.

On the basis of newly developed three models for producers’ preference, consumers’ preference and producer-cum-consumer preference for rice varieties were used to achieve the objectives. From the validation of models, producer, consumer and producer cum consumers preferred rice varieties for their higher yield at Panchagarh, Lalmonirhat, Kurigram and Thakurgaon. On the other hand, the pure consumers preferred varieties based on their tastes.

BR11, BR22 and BRRI dhan32, BRRI hybrid dhan4 for T. Aman, BRRI dhan28, BRRI dhan29, BRRI dhan50 and BRRI hybrid dhan3 for Boro and BR9, BR16 and BRRI dhan48 for Aus were found to be more preferable and cultivable varieties due to higher yield among the producers and producer cum consumers. Pure consumers were found to prefer rice varieties on the basis of taste, fineness and availability of the varieties.

Although, BRRI variety contributes about 90% of total rice production, it does not reflect in field level as it sales in different brand names, like BRRI

Table 3. Reasons for liking varieties by the pure consumers in different location (%).

Reason	Panchagarh	Lalmonirhat	Kurigram	Thakurgaon
Tasty	28(56%)	25(50%)	27(54%)	25(50%)
Fine rice	7(14%)	10(20%)	9(18%)	8(16%)
Fine rice + tasty	8(16%)	9(18%)	6(12%)	10(20%)
Fine rice + non-sticky	7(14%)	6(12%)	8(16%)	7(14%)
Total	50	50	50	50

dhan28 sales as Nizersail and BRRI dhan29 as Jhingasail and Miniket etc.

Three mathematical models have been developed for consumer and producer preference to rice varieties in four locations/districts in terms of rice deficit and rice surplus area. These three models uses to determine factors affecting producers' decision on varieties for rice cultivation and can provide an indication of the factors affecting consumers' preference to rice varieties.

STOCHASTIC FRONTIER ANALYSIS AND DATA ENVELOPMENT ANALYSIS FOR EFFICIENCY OF RICE GROWING FARMERS IN BANGLADESH

Efficiency measurement has been the concern of researchers with an aim to look into the efficiency levels of rice growing farmers engaged in production activities. Identifying determinants of technical efficiency levels is a major concern in efficiency analysis. This study takes an attempt to provide estimates of technical efficiency and to compare technical efficiency among the rice growing farmers in Bangladesh using data envelopment analysis (DEA). Through the use of DEA tools to estimate the technical efficiency of 420 rice growing farmers in selected areas of Bangladesh, several conclusions are drawn. First, the DEA results showed the technical efficiency scores of all observed rice growing farmers.

To calculate the technical efficiency (TE), we must define some notations first, and assume that there is a set of selected input variables (called m) and output (namely k) for each of the households (N).

Consider *n* paddy farmers with m inputs and k outputs each one producing different output (y) and using different inputs (x).

The efficiency of farmers (Constant Return to Scale): $Max_{\theta,\lambda}\ \theta,$

Subject to
$$\theta y_r - \sum_{j=1}^{n} \lambda_j y_{rj} \geq 0,$$
$$-x_i + \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0,$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda_j \geq 0, \quad j = 1...n, \quad i = 1...m, \quad r = 1...k$$

The linear programming problem must be solved N times, once for each household in the sample and a value of θ is then obtained for each one (Coelli *et al.*, 1998).

In case of variable returns to scale, the constant return to scale (CRS) model can be modified to account for the variable return to scale (VRS) by adding the convexity constraint: $\sum_{j=1}^{n} \lambda_j = 1$ to the CRS model.

The efficiency (Variable Return to Scale):
$$Max_{\theta,\lambda}\ \theta,$$

Subject to
$$\theta y_r - \sum_{j=1}^{n} \lambda_j y_{rj} \geq 0,$$
$$-x_i + \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0,$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda_j \geq 0, \quad j = 1...n, \quad i = 1...m, \quad r = 1...k$$

Where, $\theta \geq 1$ is the efficiency score, x_{ij} the i-th input of the j-th farmers, y_{rj} the r-th output of the j-th farmers, λ_j the weight of the j-th farmers.

Thus, the technical efficient score under the VRS is always equal to or greater than the technical efficient score under the CRS. Therefore, both the CRS and the VRS methods are used in this paper to estimate the TE, because the CRS assumption is only appropriate when all households are operating at an optimal scale. However not all households may operate optimally due to imperfect competition, financial constraints, and other factors (Collie *et al.*, 1998).

Table 4 shows the result of output-oriented technical efficiency indexes of the rice growing sample farmers. For Manikganj sadar upazila the average overall technical efficiency (CRS-TE) is 64% with a minimum level of 36% and maximum level of 98%. Then, the pure technical efficiency (VRS-TE) results the mean index of 100%. It is evident from the results that the majority of the sample farmers' overall technical efficiency indexes and the pure technical efficiency indexes fall within the range of 0.03 and 0.90. For Manikganj Ghior upazila the average overall technical efficiency (CRS-TE) is 65% with a minimum level of 1% and maximum level of 99%. Then, the pure technical efficiency (VRS-

Table 4. Distribution of technical efficiency ratings of rice growing farmers in Manikganj district.

Efficiency index	Sadar upazila		Ghior upazila		Singair upazila	
	Number of farms					
	CRS	VRS	CRS	VRS	CRS	VRS
<0.40	1(0.71)	0(0.00)	35 (25.00)	13(9.28)	40(28.00)	10(7.14)
0.40 - 0.49	2(1.43)	0(0.00)	17 (12.14)	7(5.00)	7(5.00)	4(2.86)
0.50 - 0.59	1(0.71)	0(0.00)	15(10.71)	7(5.00)	3(2.14)	2(1.43)
0.60 - 0.69	0(0.00)	0(0.00)	8(5.71)	8(5.71)	11(7.86)	2(1.43)
0.70 - 0.79	7(5.00)	0(0.00)	7(5.00)	5(3.57)	5(3.57)	3(2.14)
0.80 - 0.89	21(15.00)	0(0.00)	4(2.86)	1(.071)	15(10.71)	7(5.00)
0.90 - 1.0	108(77.14)	140(100)	54(38.57)	99(70.71)	59(42.14)	112(80.00)
Total	140	140	140	140	140	140
Mean efficiency	0.64	1.0	0.65	0.85	0.69	0.89
Minimum efficiency	0.36	1.0	.014	0.07	0.03	0.03
Maximum efficiency	0.98	1.0	0.99	0.41	1.0	1.0

TE) results the mean index of 85% with a range of 7% up to 100%. It is evident from the results that the majority of the sample farmers' overall technical efficiency indexes and the pure technical efficiency indexes fall within the range of 0.07 and 0.90. For Manikganj Singair upazila the average overall technical efficiency is 69% with a minimum level of 3% and maximum level of 100%. Then, the pure technical efficiency results the mean index of 89% with a range of 3 up to 100%. It is evident from the results that the majority of the sample farmers' overall technical efficiency indexes and the pure technical efficiency indexes fall within the range of 0.01 and 0.70.

Farmer-specipic technical efficiencies are estimated using rice growing farmers' survey data by DEA model. This study finds the necessity of improving the quality of seed, the irrigation method and maintained the amount of fertilizer, reduction of using pesticides, the linkages of agriculture extension personnel, the condition of soil in cultivated land, extra labour and knowledge of rice production could be beneficial in decreasing inefficiency of farmers in selected areas of Manikganj district, Bangladesh.

EFFECTS OF CLIMATE CHANGE ON RICE YIELD

This study has been undertaken to investigate the impacts of climate change (viz changing in maximum temperature, minimum temperature, rainfall, humidity and sunshine) on the yield of three rice seasons (viz Aus Aman and Boro rice) in Bangladesh. Using annual data of rice yield and climatic factors spanning from 1974 to 2014, a time-series multivariate regression model and spatial analysis were employed to assess the impact. Heteroskedasticity of national level time series data has been converted to normal data using transformation method. Spatial analysis showed the spatially changing the climatic variables and their changing pattern and directions.

Descriptive statistics

Table 5 shows the descriptive statistics, which delineates the basic properties of all the variables under study. In case of yield, it is found that, among the three rice crops, the mean yield of Boro rice is the highest (2.80 t/ha). The observed mean yield of three rice crops under study according to the descending order is as follows: Boro >Aman >Aus. In case of climatic variables, the highest maximum temperature is noticed in the Aus (32.19 °C) growing season and the lowest minimum temperature were monitored in the Boro (18.28 °C) growing season. In case of rainfall, the highest total rainfall observed in the Aman (60,903 mm) rice growing season followed by Aus (57,785 mm) rice season. In view of humidity, the highest percentage of humidity (84.19%) is detected in the Aman season and the lowest value in the Boro (74.65%) season. Finally, highest sunshine (7.60 hour/day) is observed in the Boro season and lowest (5.44 hour/day) in the Aman season.

Table 5. Descriptive statistics, 1981-2011.

Variable	Rice seasons	Statistics					
		Mean	Std dev	Min	Max	Skewness	Kurtosis
Yield (t/ha)	Aus	1.29	0.39	0.90	2.50	1.35	1.33
	Aman	1.64	0.37	1.10	2.36	0.43	-1.01
	Boro	2.80	0.66	1.80	3.97	0.44	-0.94
Maximum temperature (°C)	Aus	32.19	0.55	30.78	33.35	-0.13	-0.05
	Aman	31.34	0.42	30.47	32.17	0.16	-0.57
	Boro	29.66	0.53	28.53	30.90	-0.06	-0.15
Minimum temperature (°C)	Aus	24.14	0.38	23.42	25.23	0.11	0.57
	Aman	24.24	0.30	23.69	25.18	0.72	1.48
	Boro	18.28	0.43	17.48	19.13	0.19	-0.61
Rainfall (mm/year)	Aus	57785	9870	31709	75015	-0.62	0.02
	Aman	60903	10903	38138	78835	-0.39	-0.74
	Boro	14954	4478	4582	25436	0.21	0.00
Humidity (%)	Aus	80.36	1.33	76.28	82.66	-0.75	0.74
	Aman	84.19	0.99	80.83	85.78	-1.13	2.25
	Boro	74.65	2.31	68.01	78.33	-0.80	0.34
Sunshine (hour/day)	Aus	5.97	0.42	5.22	7.21	1.08	1.49
	Aman	5.44	0.37	4.52	6.51	0.50	1.22
	Boro	7.60	0.71	6.42	9.40	1.00	0.68

Trend graph

In addition to explaining descriptive statistics and analyzing linear trend between time and climate variables, graphs are also constructed with time (t) as an explanatory variable to observe the spectacular impression about the variations and changes in trend (upward or downward) among the five climatic variables over the whole period (1974-2014) (Figures 1-5). Maximum temperature fluctuated gradually, but the overall trend is observed to increase for all the seasons (Fig. 1). Small variations are noticed in minimum temperature. However, the trend still appeared to be increasing for Boro season but slightly decreasing trend for Aus and Aman seasons (Fig. 2). Rainfall in Aus and Boro rice growing seasons

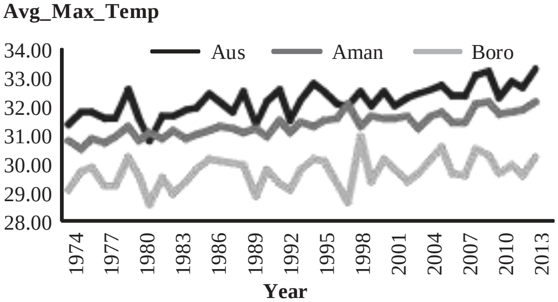


Fig. 1. Trends and variation of average maxium temperature for Aus, Aman and Boro from 1974-2014 in Bangladesh.

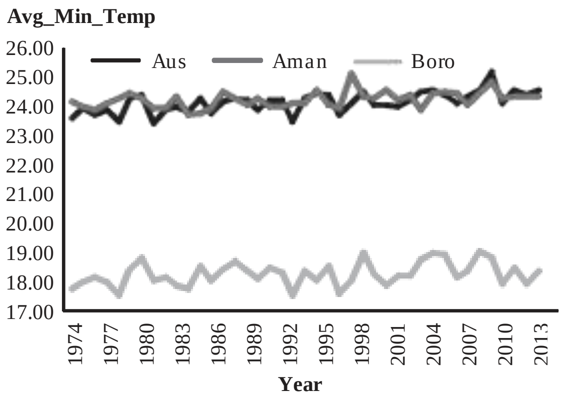


Fig. 2. Trends and variation of average minium temperature for Aus, Aman and Boro from 1974-2014 in Bangladesh.

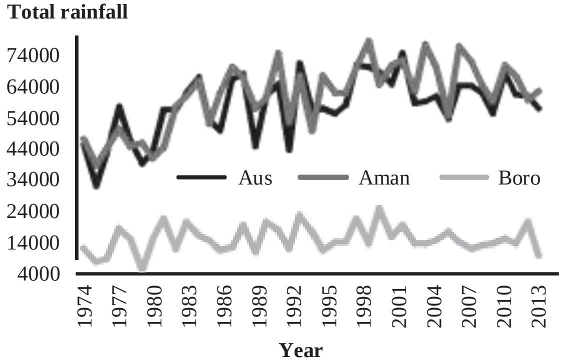


Fig. 3. Trends and variation of toatal rainfall for Aus, Aman and Boro from 1974-2014 in Bangladesh.

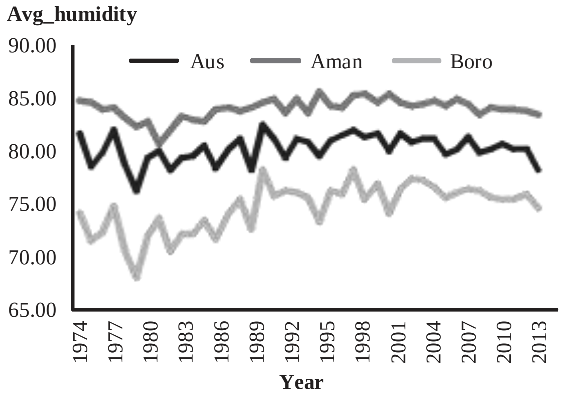


Fig. 4. Trends and variation of average humidity for Aus, Aman and Boro from 1974-2014 in Bangladesh.

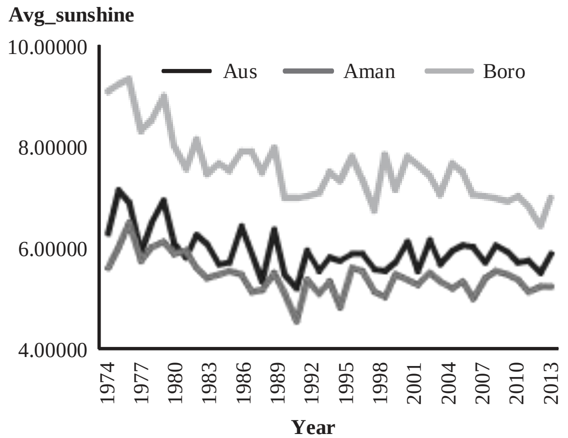


Fig. 5. Trends and variation of average sunshine for Aus, Aman and Boro from 1974-2014 in Bangladesh.

showed downward trends with distinct and greater fluctuations. The Aman season shows upward trend over time with greater fluctuations, which seriously affects the Aman rice crop (Fig. 3). Humidity demonstrates a decreasing trend with minor deviations in Aus and Aman seasons but greater fluctuations in Boro season (Fig. 4). Interestingly, sunshine exhibits a slow increasing (upward) trend for Aus and Boro seasons with greater fluctuations but in case of Aman season slow decreasing trend with low fluctuation (Fig. 5). However, investigation is done to confirm whether these climatic trends and fluctuations affect crops yield in the later section.

Climatic condition of Bangladesh in 2014

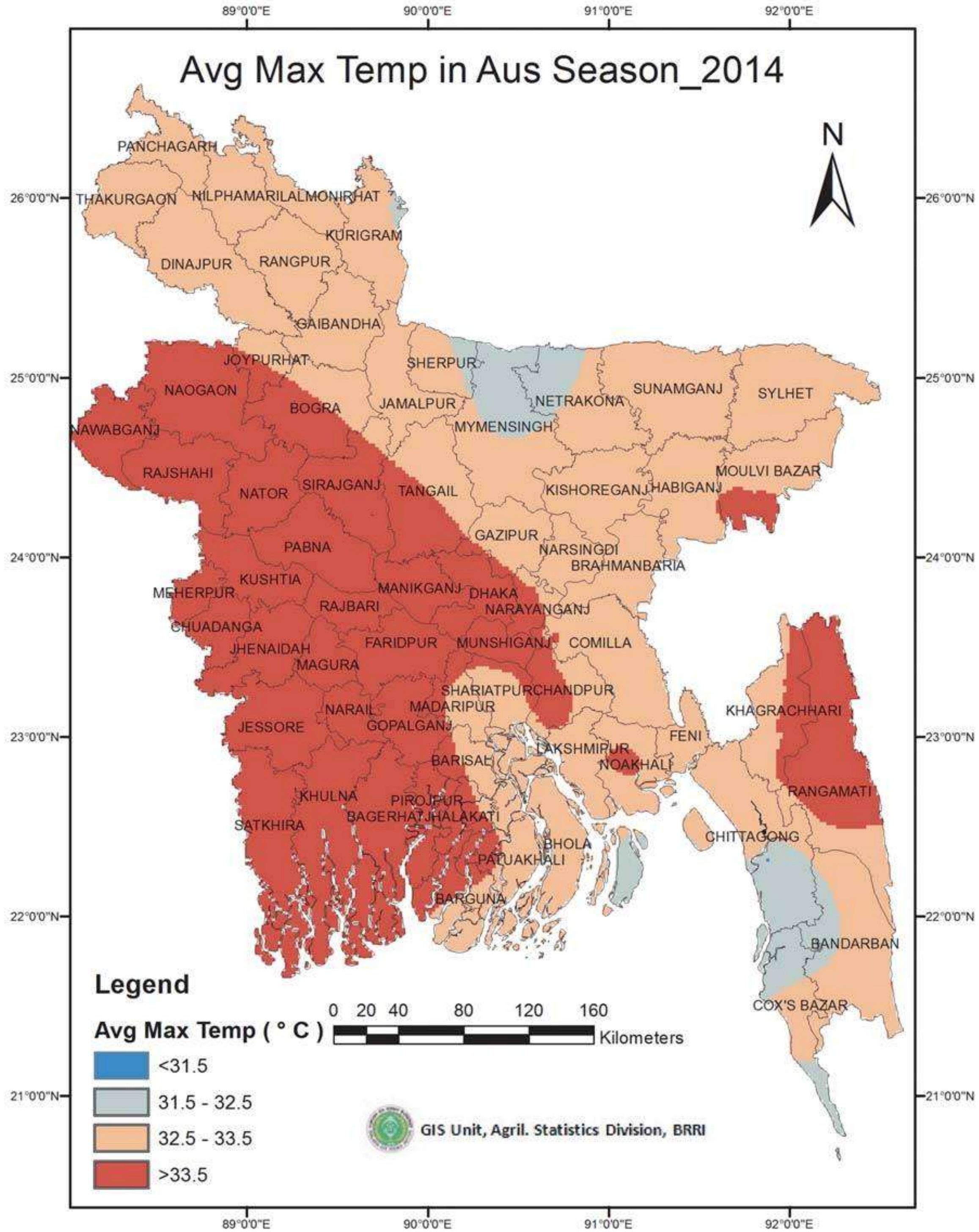
Aus. In Aus season maps 1-4 shows maximum temperature is decreasing west to east direction on the other hand minimum temperature decreasing south to north direction. From the total rainfall map most of the area covered by low rainfall (<1500mm) only eastern side shows high rainfall area but this area is very limited. Humidity maps implies that most area covered by intermediate humidity (75%-80%), high in southern area but some pocket areas are found with low humidity (<75%) in central and north-west region.

Aman. In Aman season maps 5-8 shows maximum temperature is high in all over Bangladesh. Minimum temperature is increasing north-west to south-east direction but north-east is also low. From the total rainfall map most of the areas are covered by low rainfall (<1500mm) and is increasing west to east. A humidity map implies that humidity is increasing north to south direction but most of the area is low humidity area.

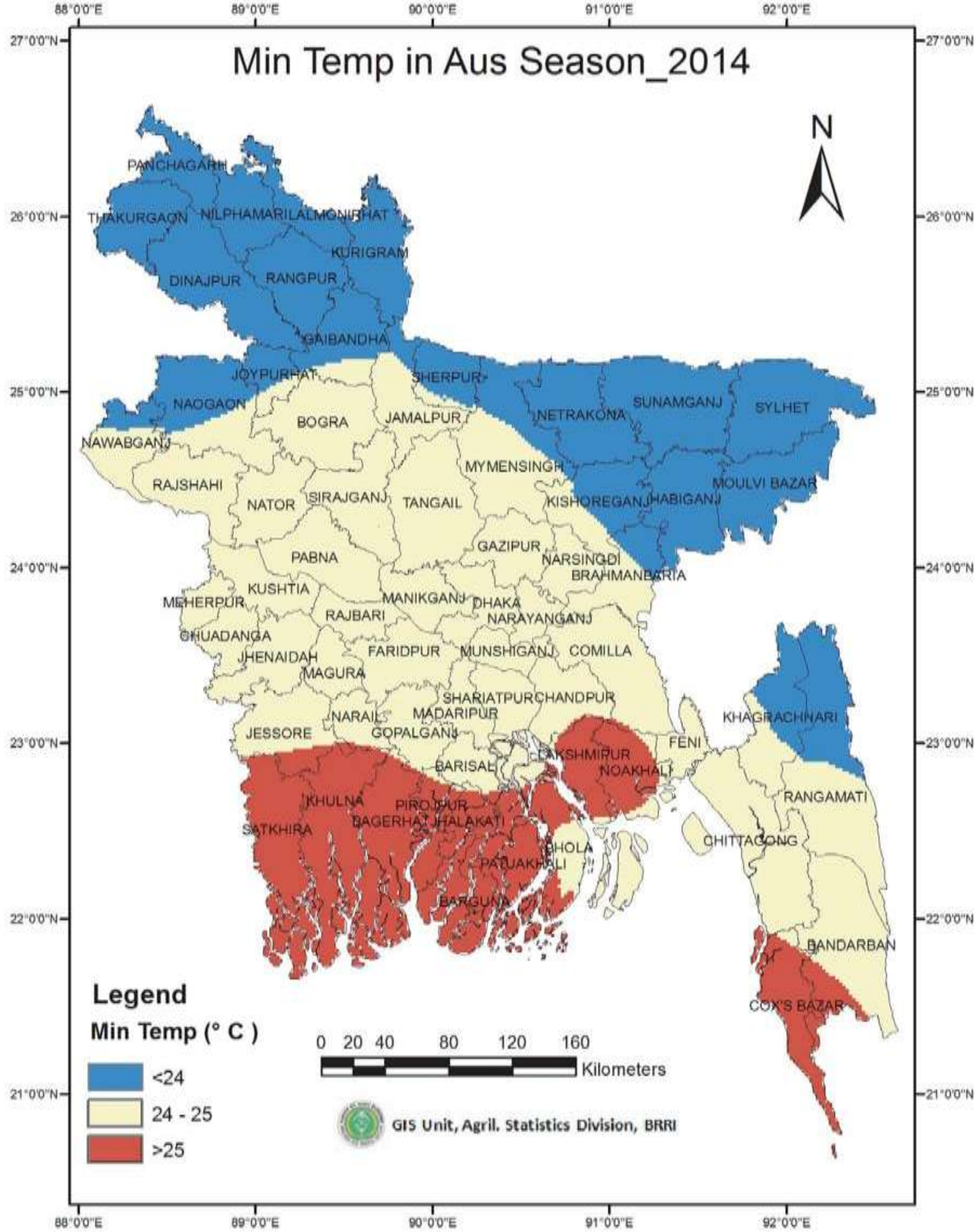
Boro. In Boro season maps 9-12, the maximum temperature shows increasing trend from north to south direction where most of the area is covered by high temperature (>31) and minimum temperature is also increasing from north to south direction. The total rainfall map shows increasing trend from west to east direction. A humidity map implies that humidity is increasing north to south direction.

The regression results for Aus rice

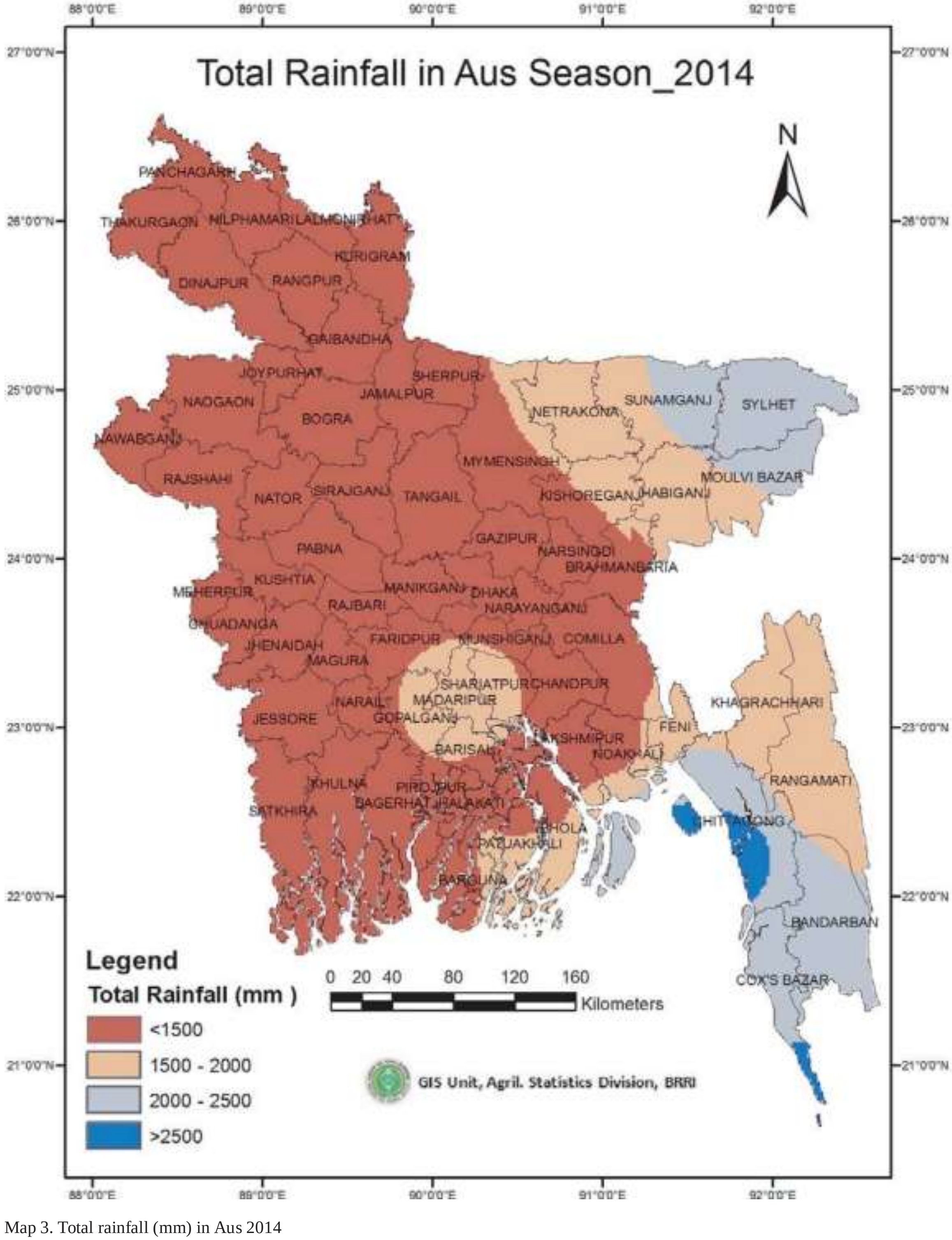
The regression trend line method is used to identify the climate change and time impacts on the yield. Table 6 presents the findings, which revealed that climate variables and time (year) affected the yield. The results further indicated that the effects of climate change on yield of Aus rice. Maximum temperature and humidity showed statistically significant influences on Aus rice yield and the contributions are found positive for both the parameters. Minimum temperature and rainfall displayed positive contribution but statistically insignificant effects on yield. In contrast, sunshine contribution is negative and insignificantly affected the yield. Year to year variation of temperature due to climate change had an impact on the Aus rice yield. The R^2 value implied that 96% of the yield



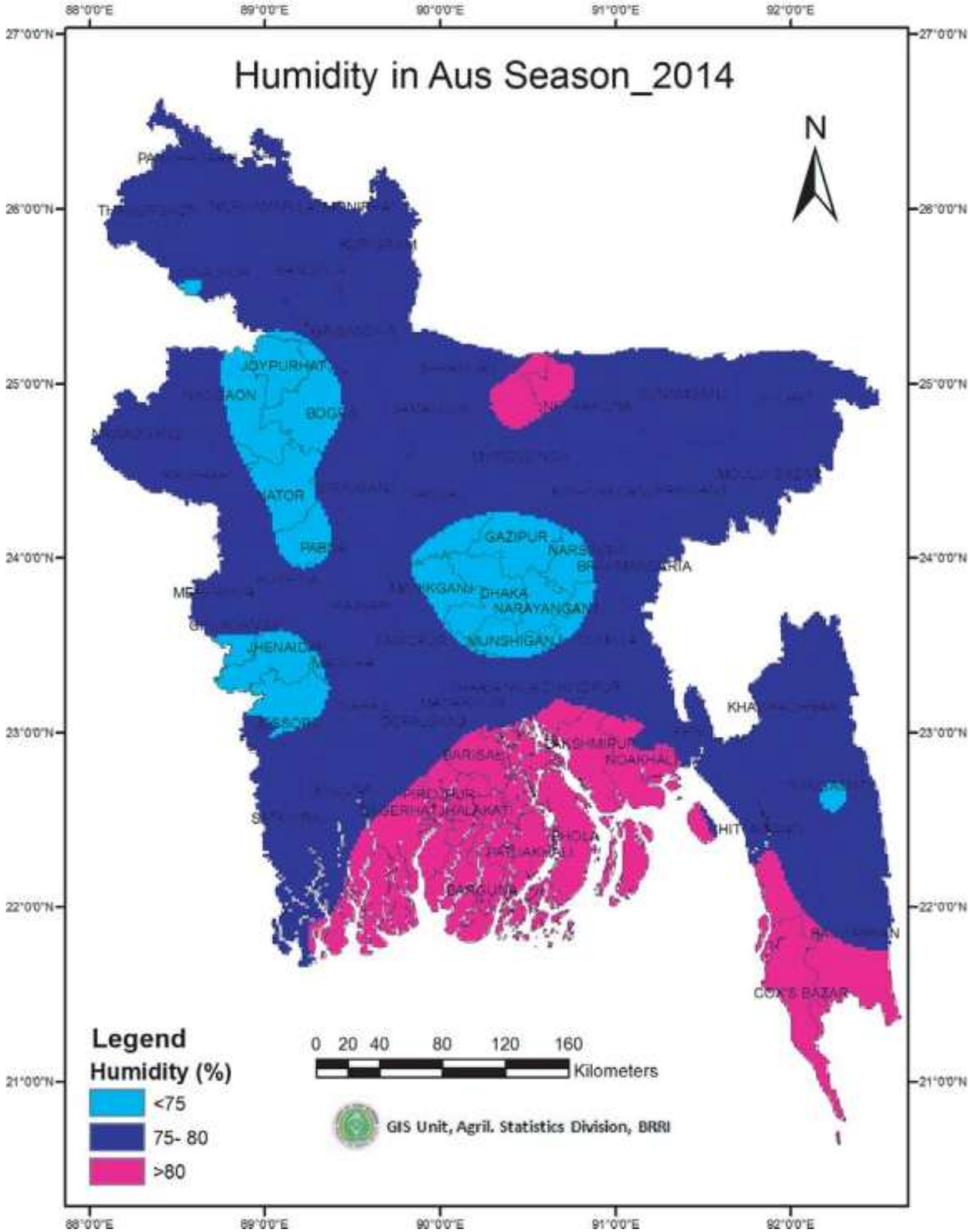
Map 1. Average max temp (°C) in Aus 2014.



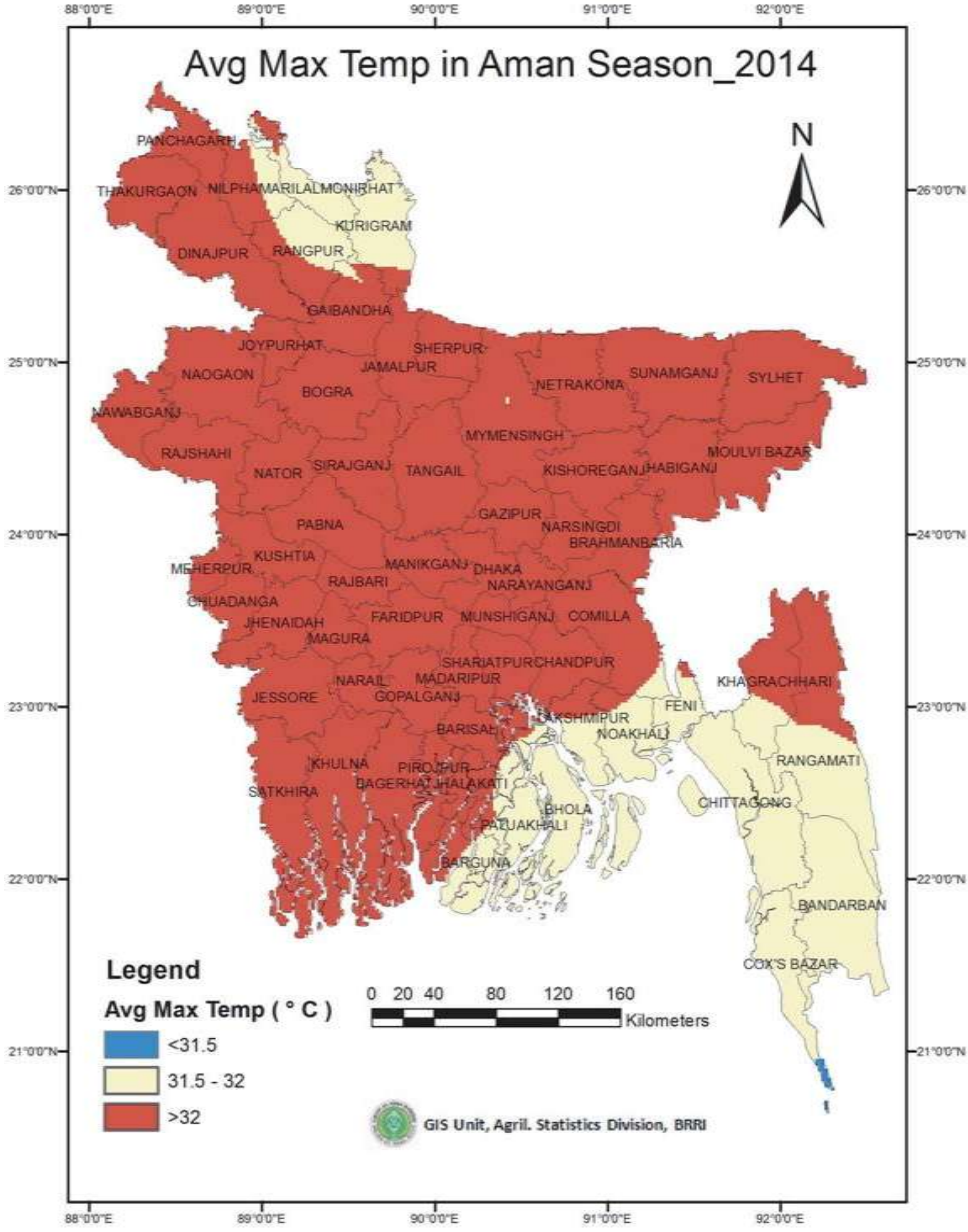
Map 2. Average max temp (°C) in Aus 2014.



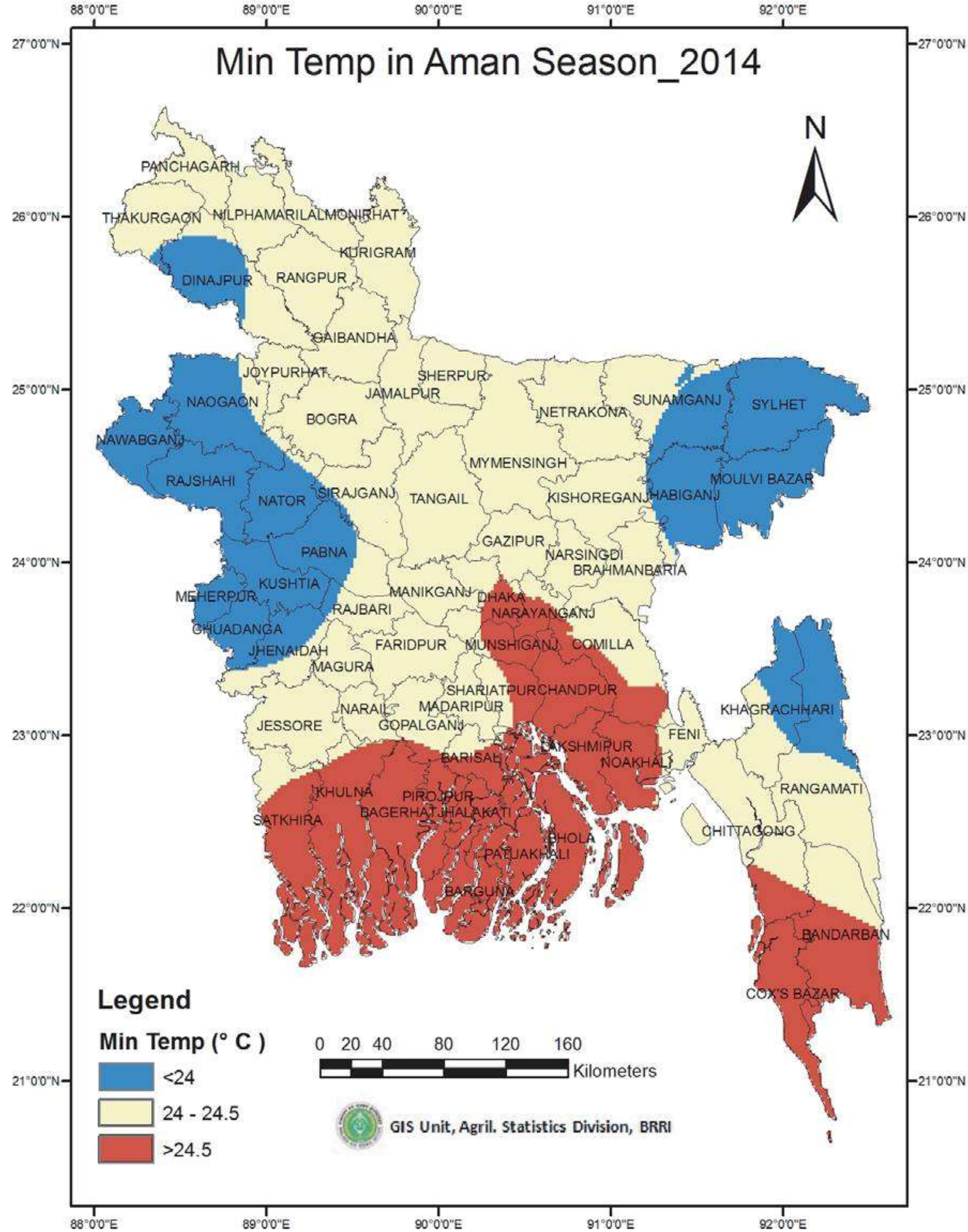
Map 3. Total rainfall (mm) in Aus 2014



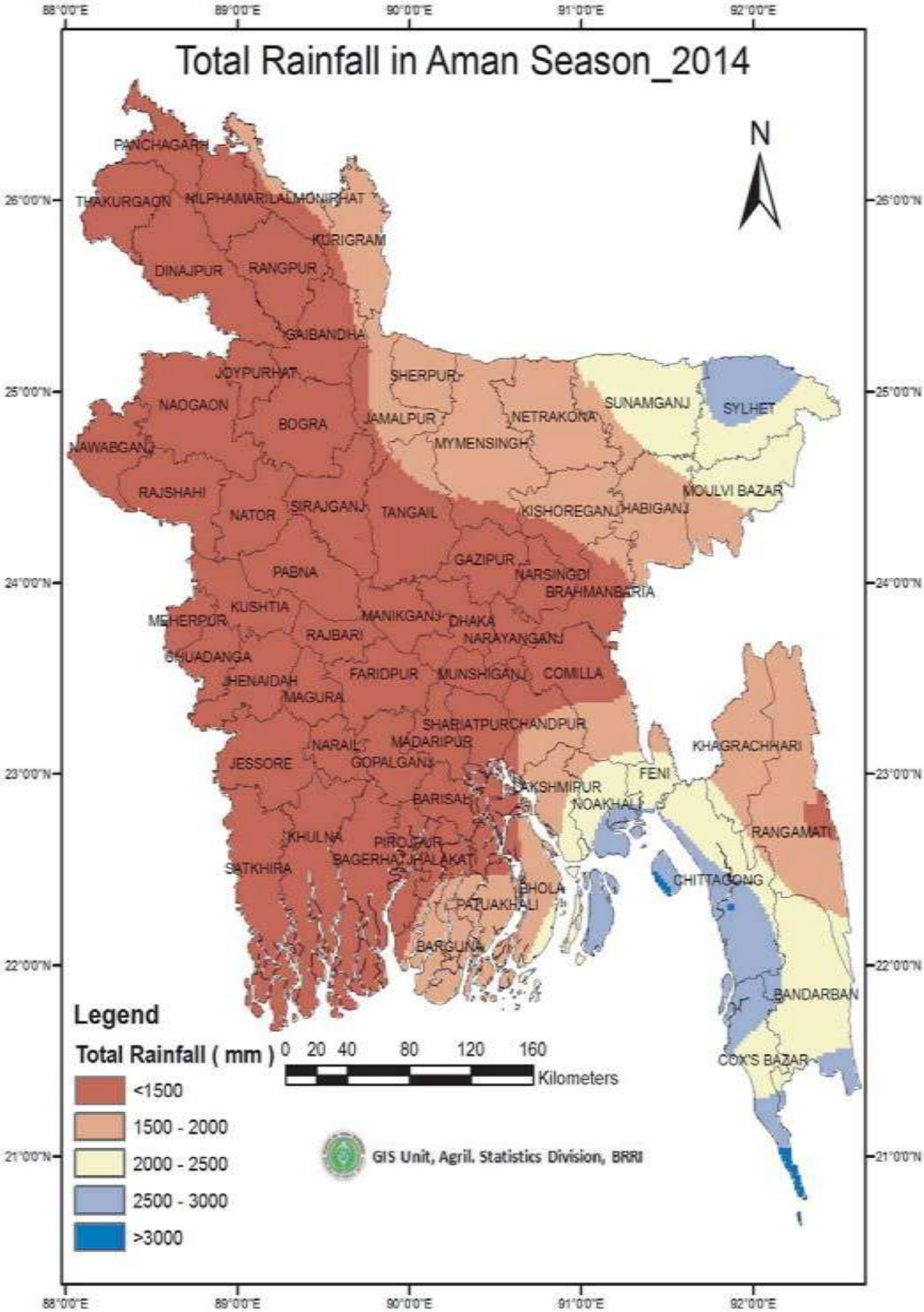
Map 4. Average humidity (%) in Aus 2014.



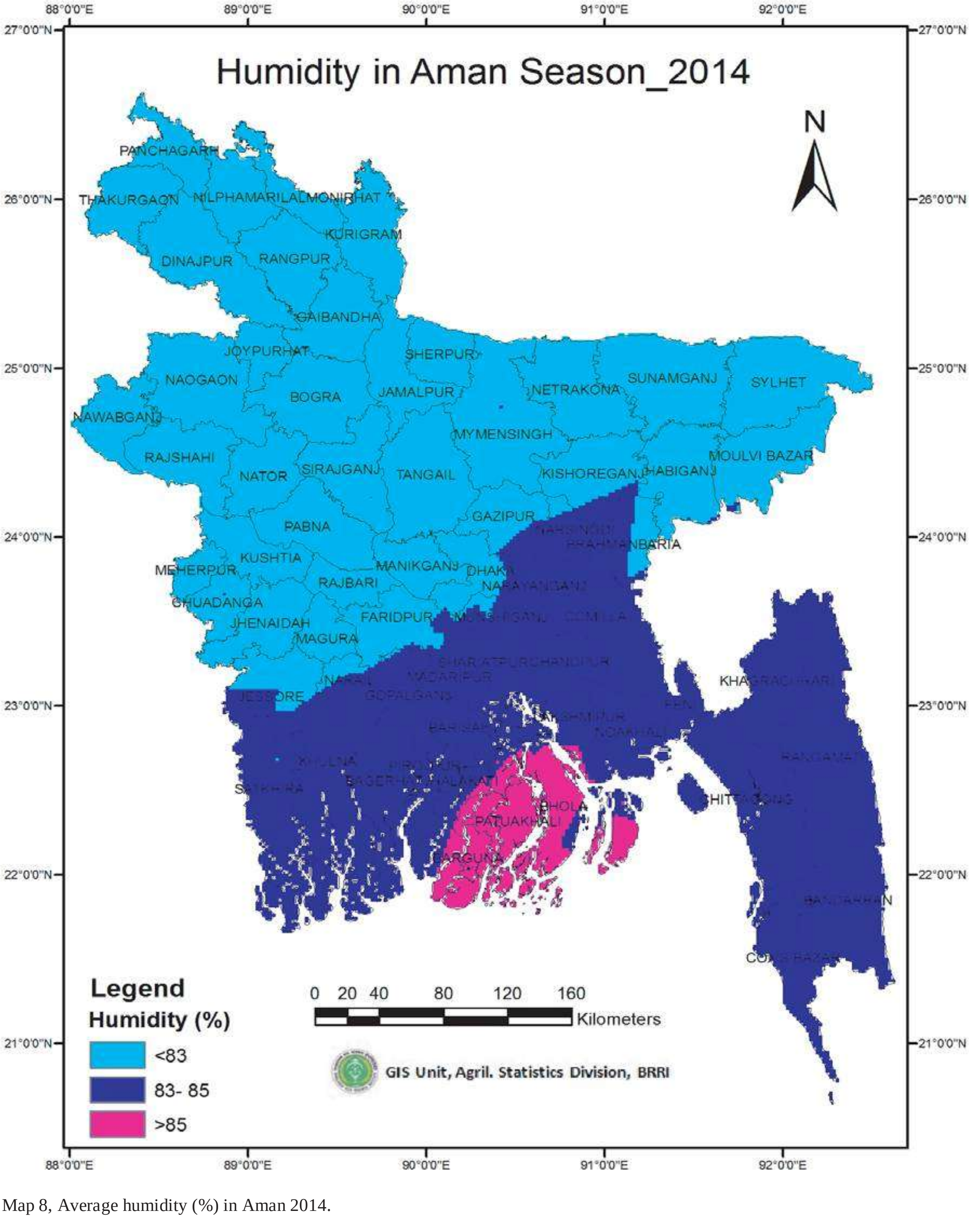
Map 5. Average max temp (°C) in Aman 2014 .



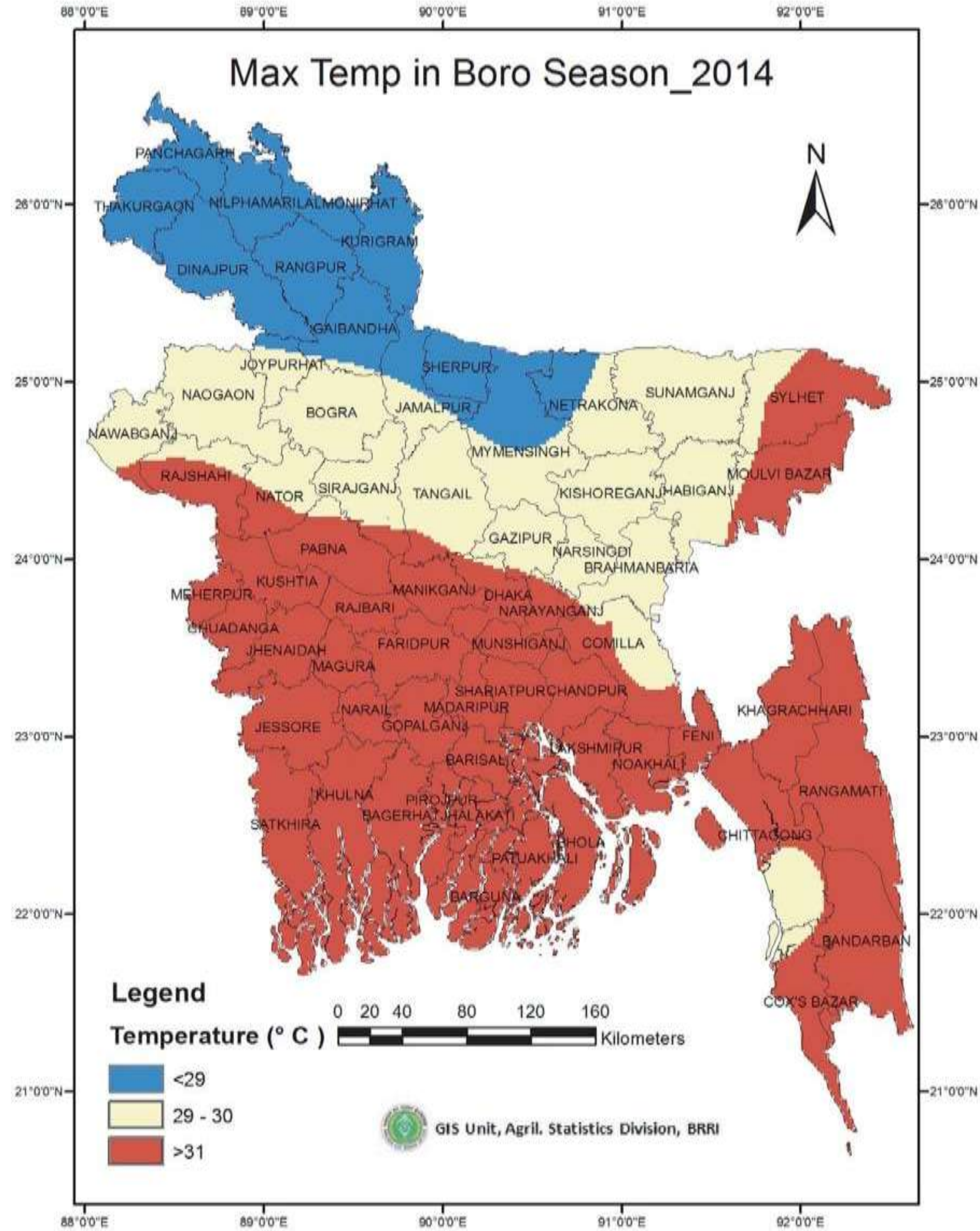
Map 6. Average max temp (°C) in Aman 2014.



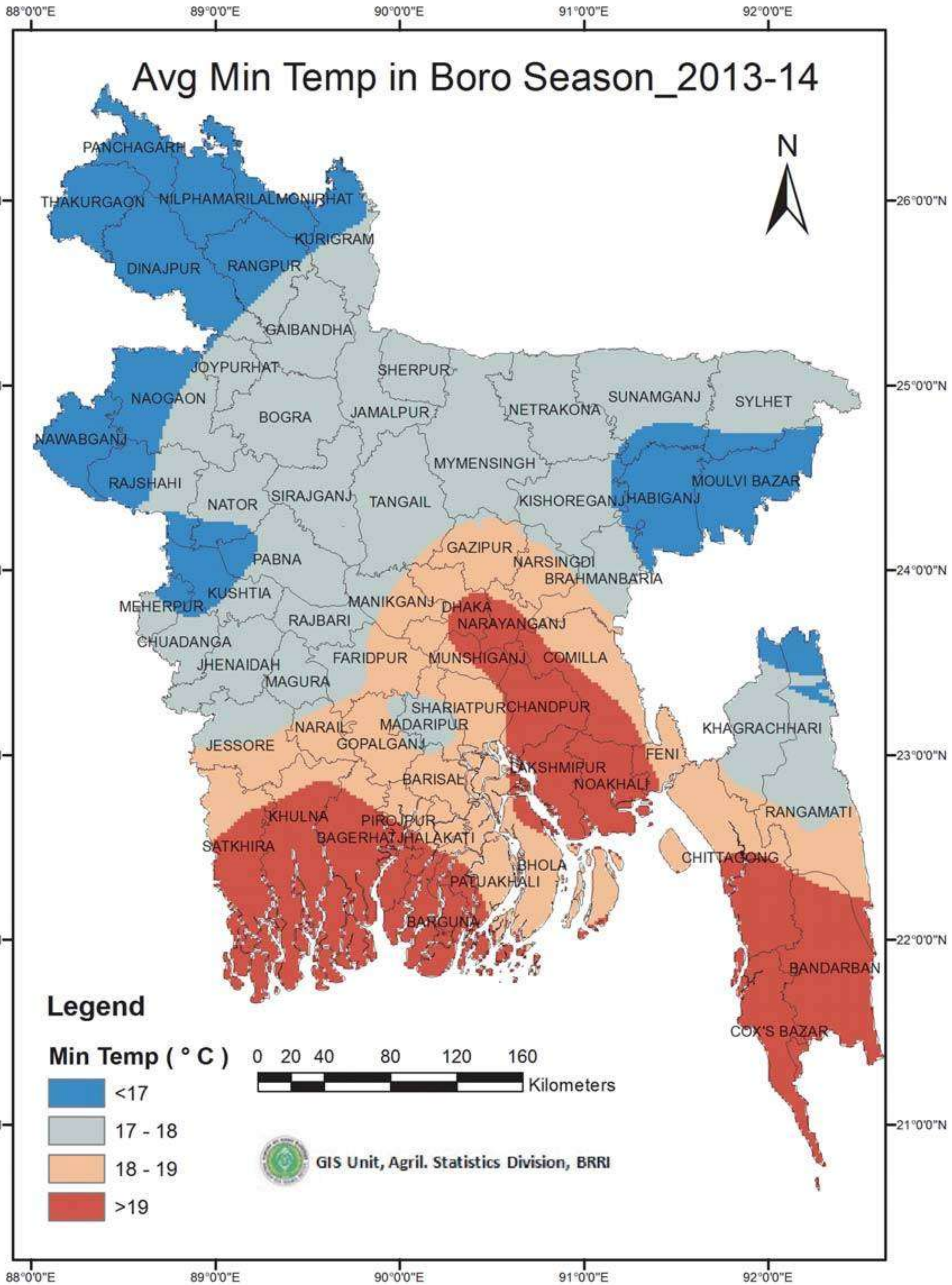
Map 7. Total rainfall (mm) in Aman 2014.



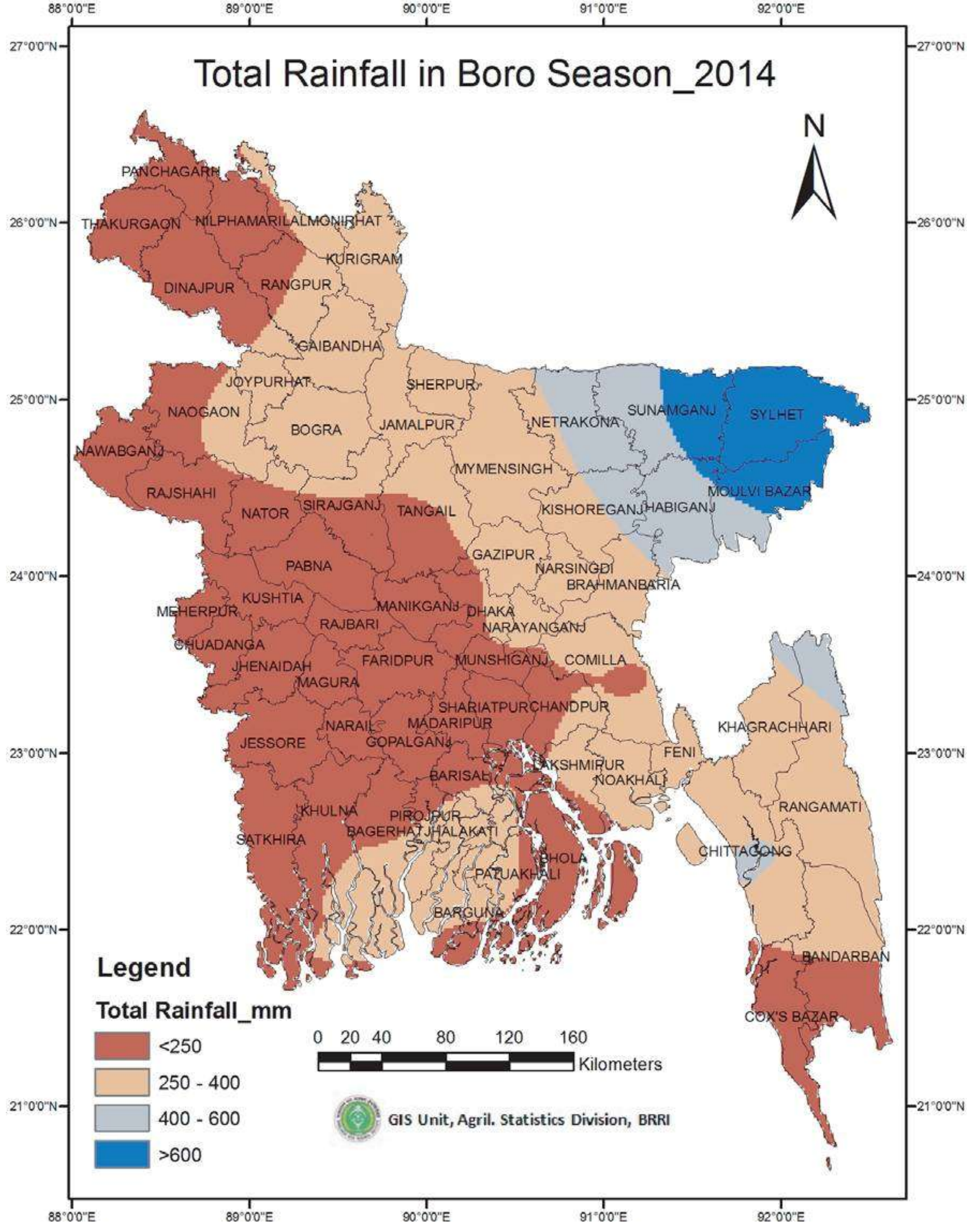
Map 8, Average humidity (%) in Aman 2014.



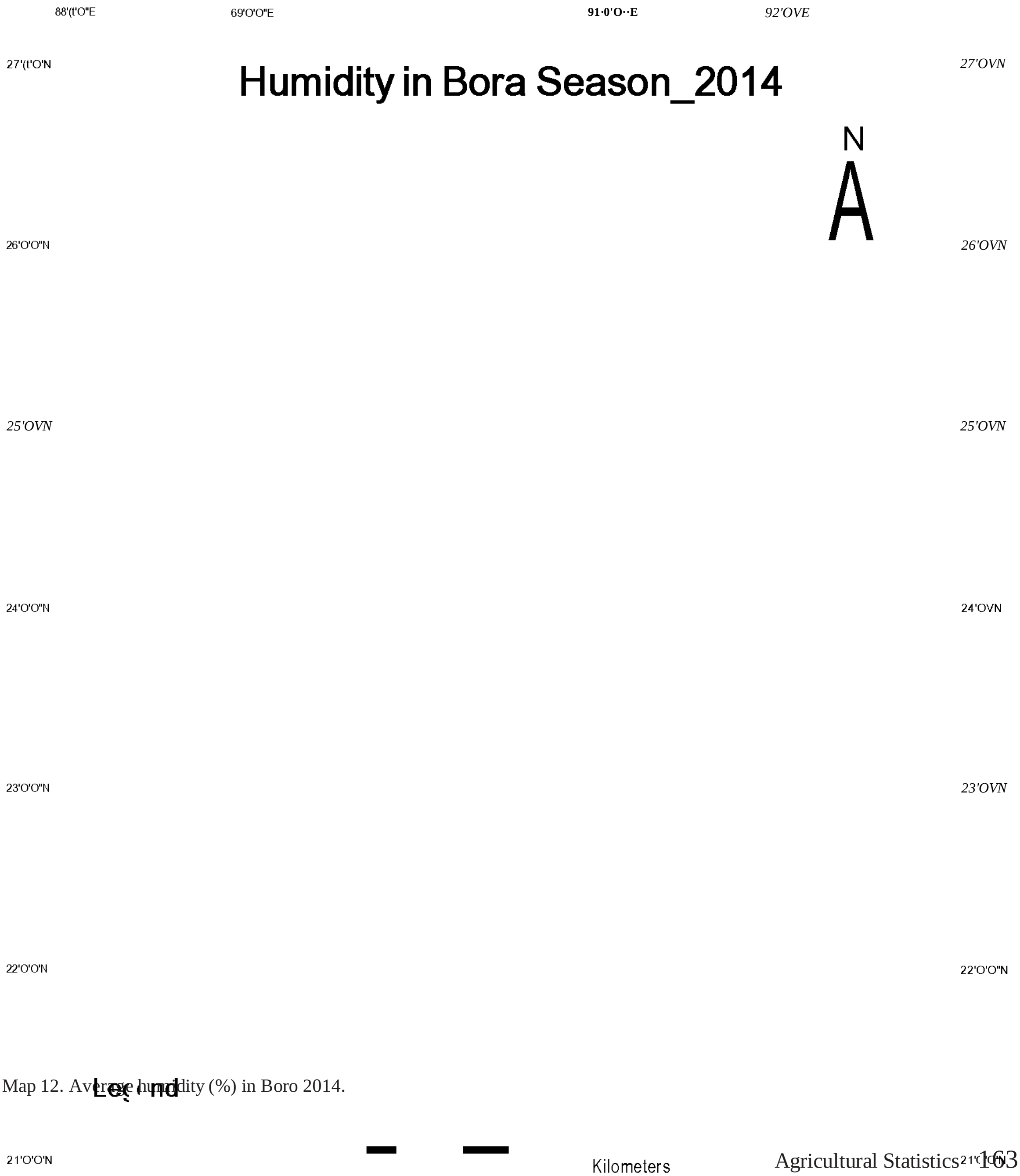
Map 9. Average max temp (°C) in Boro 2014.



Map 10. Average max temp (°C) in Boro 2014.



Map 11. Total rainfall (mm) in Boro 2014.



Map 12. Average humidity (%) in Boro 2014.

Humidity (%)

0 20 40 80 120 160

"<73

.. 73-75

GIS UClit, Agril. StatistiC$ Division, BRRI

Table 6. The regression results of Aus, Aman and Boro rice crops yield.

Climatic factor	Aus			Aman			Boro		
	Coefficient	SE	t-value	Coefficient	SE	t-value	Coefficient	SE	t-value
Intercept	-5.483	2.773	-1.977*	0.819	1.472	0.556	0.474	0.242	1.960*
Maxt	0.127	0.066	1.930*	0.024	0.062	0.384	0.017	0.010	1.714*
Mint	0.031	0.070	0.438	-0.058	0.048	-1.216	-0.018	0.009	-1.981*
Rainfall	0.000	0.000	-1.473	0.000	0.000	-1.463	0.000	0.000	-1.291
Humidity	0.039	0.017	2.364**	0.000	0.000	0.322	0.000	0.000	2.139**
Sunshine	0.474	0.393	-1.205	0.005	0.040	-0.124	0.450	1.842	0.244
Year	-0.037	0.003	-14.002***	0.019	0.002	8.922***	-0.006	0.001	-11.753***
Model R^2		0.96			0.95			0.96	
Adjusted R^2		0.95			0.94			0.95	
D-W test		1.88			1.53			1.27	
F-statistics		119.10***			98.64***			121.30***	

Note: *, ** and *** represents the 10, 5 and 1% level of significance respectively.

variation of Aus rice is influenced by the climatic variability and change. The remaining proportion of variation may be due to others relevant factors of Aus rice that are not included in this model. Durbin Watson test indicates that the chosen model is free of autocorrelation which is vital condition for any time series model. Overall (F-test) regression coefficients were statistically significant.

The regression results for Aman rice

Table 6 presents the result which demonstrated that the effects of all the climatic parameters. The weather parameters are not significantly affected the Aman rice yield. The contributions of minimum temperature and sunshine are found negative. Rainfall and humidity have no effect and maximum temperature has little positive effect on yield. Yearly variation due to climate change had an impact on the Aman rice yield at the 1% level of significance. R^2 for Aman rice yield is 0.95 implies that about 95% variation of Aus rice yield is being explained by the selected multiple regression model. The remaining proportion of variation may be due to other relevant factors of Aus rice that are not included in this model. Durbin Watson test indicates that the chosen model is free of autocorrelation, which is vital condition for any time series model. Overall (F-test) regression coefficients were statistically significant.

The regression results for Boro rice

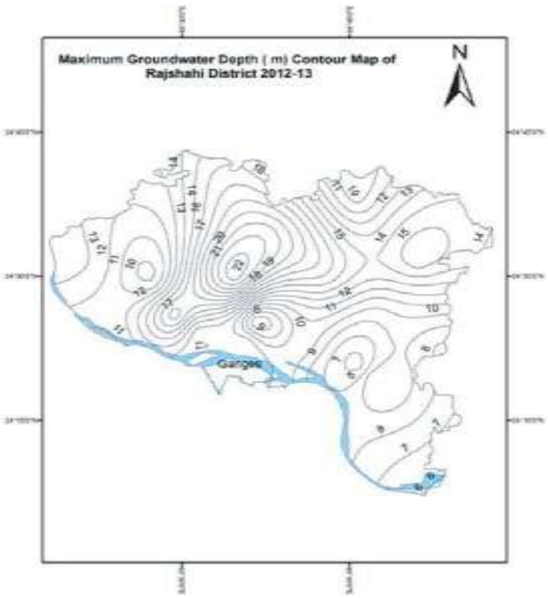
Boro rice is cultivated in Bangladesh using irrigation facilities during the dry season. The regression trend line method is performed to determine the climate-Boro rice relationship and Table 6 presents the result. It showed that, maximum and minimum temperature and humidity displayed statistically significant relation with the yield of Boro rice. The contributions of maximum temperature is found positive and it is negative for minimum temperature. There is no effect of rainfall and humidity on Boro rice yield. In contrast, sunshine contribution is positive and insignificantly affected the yield. The year to year variation due to climate change had an impact on the Boro rice yield. The R^2 value indicated that 96% variation in Boro rice yield is explained by the climatic parameters. Durbin Watson test indicates that the chosen model is free of autocorrelation, which is vital condition for any time series model. Overall (F-test) regression coefficients were statistically significant.

Finally, the yield of Aus rice was influenced greatly by the maximum temperature and humidity. Any climatic variables for Aman rice yield have no significant effect. The influence of minimum temperature was observed to be detrimental for Boro rice. However, maximum temperature and humidity exposed positive inter-relation in respect to yield with statistically significant contribution.

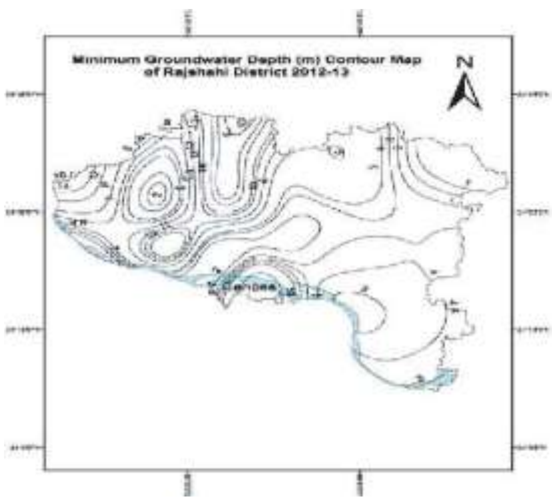
GROUNDWATER DEPLETION WITH EXPANSION OF IRRIGATION IN BARIND TRACT: A CASE STUDY

The study has described continuous declination of groundwater level with increase of groundwater irrigation in Barind Tract from mid 2000 to 2013 in the perspective of Rajshahi district, which is located in severely drought prone area at north-western part of Bangladesh. Dry season Boro rice mainly depends on supplementary irrigation from groundwater, results in severe groundwater depletion. Main source of recharging of groundwater aquifer in this area is rainfall, but rainfall is also dropping here. Hydrographs are analyzed and groundwater level contour maps are prepared by Arc GIS version 10 software from the monitoring wells data of Bangladesh Water Development (BWDB). For aquifer geometry a subsurface geological cross section made by RockWorks software from bore log data of Department of Public Health Engineering (DPHE) and Bangladesh Water Development (BWDB). Only two aquifers exist and in NW area shows effective aquifer thickness is shorter than SE portion.

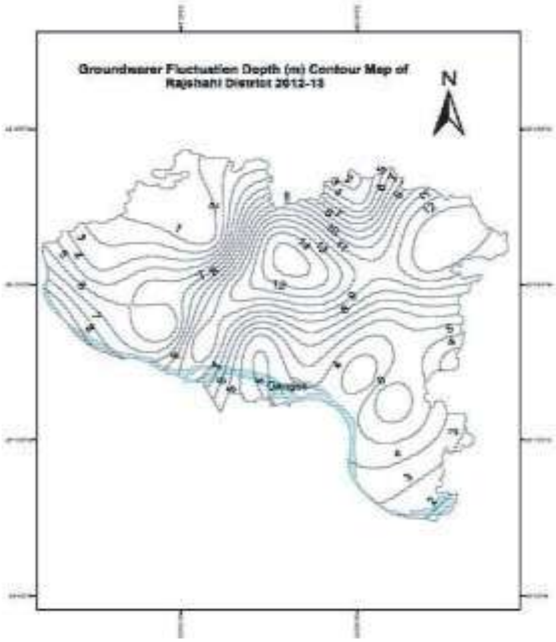
In this study it is found that groundwater is depleting due to huge withdrawal all over Rajshahi and some areas are very critical especially the northern part. Main source of recharging of groundwater in this area is rainfall, which is also reducing. Average rates of maximum depth (dry season) and minimum depth (wet season) groundwater depilation are 0.23 meter/year and 0.38 meter/year respectively. Rate of declination of minimum depth is higher than that of maximum, which implies groundwater recharge coming down due to withdrawal of excessive groundwater. A significant change of minimum water depth observed after 2009. Among the upazilas, condition of Godagari and Tanore are very critical, in Godagari minimum depth depleted 17m and Tanore 8.1 m since the year 2000 to 2013. Moreover, recently these two upazilas maximum and minimum depths have got very closer. So it can be said that there have some problems, in aquifer recharge thus the situation is very alarming and the area has lost suitability for Boro production. As it is shown in the contour maps (maximum, minimum, fluctuation depth), groundwater level, condition of Baghmara, Mohanpur and Tanore is very vulnerable and that of the upazilas of Puthia, Charghat and Bagha so far is not in vulnerable position (Maps 13-15). Cross section of bore log data along the direction of NW to SE up to depth 250 m only two aquifers exist and in NW area shows effective aquifer



Map 13. Maximum groundwater depth contour cap of Rajshahi district (2012-13).



Map 14. Minimum groundwater depth contour map of Rajshahi district (2012-13).



Map 15. Groundwater fluctuation depth contour map of Rajshahi district (2012-13).

thickness, which is shorter than SE portion that means areas of NW are very vulnerable to groundwater extraction (Fig. 6). So it is clear that upazilas of Tanore, Godagari, Mohanpur and Baghmara are very vulnerable for irrigation. There is a unblemished relation between Boro i.e. irrigated rice production and groundwater depletion. Thus future Boro production is threatened in the area even through it shows increasing treand. So, dependency of Boro of Barind area should be reduced. And groundwater depletion increased irrigation cost as water must be pumped farther to reach the surface, using more energy. In extreme cases, using such a well can be

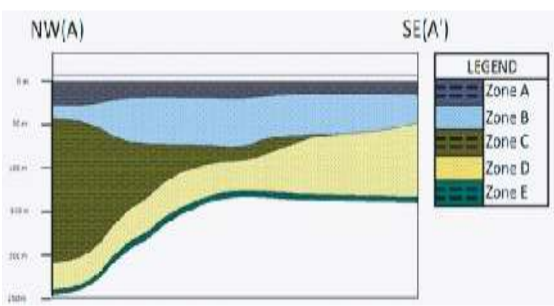


Fig. 6. Cross section from NW(A) to NE(A').

cost prohibitive. Moreover, some environmental negative effect may arise like reduction of surface water supplies, land subsidence, deterioration of water quality etc. Crop variation from water consuming crop (paddy) to less water consuming crops (vegetables, fruits etc), artificial recharging, increasing dependency on surface water, increasing irrigation efficiency including application of alternate wetting and drying (AWD) method, rainwater harvesting etc can be option for the study area.

MAINTENANCE OF RICE AND RICE RELATED VARIABLE DATABASE

The purpose of this activity is to maintain up-to-date information on rice and related crops and inputs and also to provide rice and related information to other research divisions and interested persons. Secondary data on rice and other important crops are collected periodically from **ĉĨĵĪijĨīĬĺç ĉļĹĬĨļç Ķĭç ĚĻĨĻİĺĻİĨĺç ïĉĉĚð**, Agricultural Marketing Directorate (AMD), Bangladesh Meteorological Department (BMD), Bangladesh Water Development Board (BWDB), Bangladesh Agriculture Development Corporation (BADC) and other sources periodically and computerized.

Existing databases have been updated. Also to make an agricultural database we want to initiate a database system where we can use updated software and database programme. Besides to make this database, we will use SQL Server 2005 express edition/2008/2010/2012 version. We will also use Oracle 9i/10g/11i version.

SUPPORT SERVICES

The scientists of this division were also engaged in helping scientists of other disciplines in planning experiments, statistical data analysis and interpretation of results. A total of 110 different types of analyses were performed during the reporting year. A number of maps were prepared using GIS and supplied to the scientists of other divisions whenever required. ICT cell of

Agricultural Statistics Division has taken initiative in government perspectives but “BRRI Networks” group is first introduced amongst all National Agricultural Research System (NARS) and also first among all research institute. It is regular monitoring and updating with new information from any national and international newspaper or other sources. It is continuous process. ICT cell of Agricultural Statistics Division will provides antivirus related support services to other divisions such as setup antivirus software, clean virus, update antivirus database related problem etc.

OTHER ACTIVITIES

The division is also engaged in management of BRRI web portal, BRRI network and internet connectivity, information system, personal data sheet, digital signature system, web mail, group mail and facebook group as well as BRRI heritage etc.

Farm Management Division

SUMMARY

The experiment was conducted at the west byde of BRRI farm, Gazipur in T. Aman 2014 to investigate the seed quality of rice that are affected by rainfed during reproductive and ripening phases. The treatments included two planting dates (D_1=16 August and D_2=12 September) and three rice varieties (V_1=BRRI dhan40, V_2=BRRI dhan41 and V_3=BRRI dhan46). The treatments were arranged in a randomized complete block (RCB) design with three replications. The interaction between planting dates and variety was not significant in all the parameters of yield and yield components. The germination percentage (GM %), seedling vigour index (SVI), high density grain (HDG %), shoot dry weight (SDW) and root dry weight (RDW) were also not significantly affected by the interaction between planting dates and variety. Planting in 16 August produced higher number of tillers m^{-2}, panicles m^{-2}, grain panicle^{-1}, 1000-grain weight (TGW), grain and straw yield. Only the TGW was significantly affected by variety. BRRI dhan46 produced the highest TGW and grain yield followed by BRRI dhan41 and the lowest in BRRI dhan40. The GM%, SVI, HDG%, SDW and RDW were significantly affected by planting dates. All of these parameters performed better in 16 August planting than 12 September planting. The highest GM% and HDG% was obtained from BRRI dhan46 followed by BRRI dhan41 and the lowest in BRRI dhan40 but the SVI was the highest in BRRI dhan41 and the lowest in BRRI dhan40. The SDW was the highest in BRRI dhan40, which was statistically identical to BRRI dhan46 but significantly decreased in BRRI dhan41.

The experiment was conducted at the west byde of BRRI farm, Gazipur during T. Aman 2014 to determine the tillering pattern, growth, yield and yield components of rice as affected by seedling age. The treatments included six different seedling ages, such as 15, 20, 25, 30, 35, and 40 days. The treatments were arranged in a RCB design with three replications. The unit plot size was 4 m × 4 m. One seedling per hill at 20 cm × 20 cm spacing was transplanted. Irrespective of seedling age, the stem dry weight of all sampling dates increased slightly at PI stage then sharply increased at FS. After that decreased and reached minimum level at the maturity stage. The leaf dry weight also followed the same trend as stem dry weight. The panicle dry weight in all the treatments sharply increased from flowering to maturity stage. Irrespective of seedling age, the tiller number gradually increased with the DAT and reached maximum at 45 DAT then gradually decreased and reached minimum at ripening and maturity stage. Fifteen-day-old seedling produced the highest number of tiller per hill from 15 to 120 DAT. The lowest number of tillers was recorded in 40-day-old seedling in all the sampling dates. The panicle number m^{-2} also increased with decreasing seedling age. It was the highest in 15-day-old seedling and the lowest in 40-day-old seedling. Fifteen to 30-day-old seedling produced identical and higher number of grain panicle^{-1} and 40-day-old seedling gave the lowest number of grain panicle^{-1}. The highest grain yield was obtained from 15-day-old seedling transplanted plot followed by 20, 25, 30, 35 and the lowest from 40-day-old seedling transplanted plot.

The experiment was conducted to know effect of fungicide and water stress on the natural incidence of neck blast (*Pyricularia oryzae*) in Boro rice at the BRRI farm, Gazipur in Boro season 2014-15 following a RCB design with five replications.

Treatments were as follows- T_1=Nativo 75WG (2 sprays at 10 days interval at flowering stage) + no water stress; T_2=Nativo 75WG (2 sprays at 10 days interval at flowering stage) + no water stress; T_3=Trooper 75WG (2 sprays at 10 days interval at flowering stage) + no water stress; T_4=Trooper 75WG (2 sprays at 10 days interval at flowering stage) + post-flowering water stress; T_5=No fungicide + no water stress and T_6=Control (No fungicide + post-flowering water stress). No significant natural incidence of neck blast was observed during Boro 2014-15 season in the West Byde research area of BRRI. Therefore, the overall treatment effect on the natural incidence and severity of neck blast was found to be insignificant. Grain yield was also unaffected by the treatments. However, the highest grain yield (7.6 t/ha) was recorded with T_1 (Nativo 75WG, 2 sprays at 10 days interval at flowering stage + No water stress).

Another experiment was conducted to find out the effect of foliar spray of MOP and elemental S for spot free seed production at the west byde of BRRI farm, Gazipur during Boro 2014-15 following a RCB design with three replications. Six treatments viz, T_1=Recommended fertilizer (RF) + MOP (60 g/10L H_2O) spray at complete panicle emergence of milking stage and 2nd spray 15 days after 1st spray, T_2=RF + Elemental S (Thiovit) at 60 g/10L H_2O same as above, T_3=RF + 60 g MOP + 60 g Thiovit in 10 L water, T_4=RF + Folicur spray, T_5=RF + BRRI recommended practice and T_6=RF + No spray + No MOP were tested in this experiment. BR3 variety was used in the experimental purpose. Incidence of grain spot was found to be unaffected by the treatments. However, the lowest incidence (17.33%) of grain spot was observed with T_3 (RF + 60 g MOP + 60 g Thiovit in 10 L water). Again, no significant effect of the treatments was observed on the grain yield of BR3.

Survey and monitoring of labourers' wage rate at different locations around BRRI HQ, such as Joydebpur, Chowrasta, Salna, Board Bazar, Konabari, Tongi, were conducted throughout the year. The average wage rate day^{-1} varies from Tk 335 to 350. The wage rate day^{-1}during the peak periods of the year Tk 470 to 480 in May, Tk 285 to 340 in July-August and Tk 330 to 420 in December-January were existed.

The wage rate varied between Tk 200-300, 200-300, 200-300, 250-300, 250-300, 300-400, 300-400 and 350-400 at Habiganj, Rangpur, Rajshahi, Barisal, Sonagazi, Comilla Satkhira and Khulna respectively.

This division produced about 12,158 kg rice of which 8,275 kg, 1,180 kg and 2,703 kg seed, non-seed and mixed rice respectively. This rice seed was deposited to BRRI general store. This division also produced 11,781 kg breeder seed in collaboration with the GRS division.

During the reporting year, BRRI had 734 labourers of which 525 regular, 107 irregular. In the HQ, the number of total labour was 447 of which 340 regular and 74 irregular. The institute has 274 ha of land of which 163 ha was cultivable. Total labour utilization in different divisions was 1,71,936 man days of which 58.46, 36.81 and 4.72% were for research, support service and holidays respectively. A total of Tk 4,91,88,635 was paid as labour wages of which Tk 2,87,56,881.70; 1,81,09,299.94 and 23,22,453.35 were paid to the labourers for research work, support service works and leaves respectively. About 73.82 ha of land was used by different divisions in different season of which 6.53 ha in Aus, 32.62 ha in Aman and 34.66 ha in Boro seasons. This division manages the BRRI flower garden to maintain the aesthetic view of the campus, which is visible during the summer and winter season.

RESEARCH

Seed quality of different T. Aman rice as affected by drought in ripening phase

An experiment was conducted at the west byde of BRRI farm, Gazipur during T. Aman 2014 to investigate the seed quality of rice that are affected by rainfed during reproductive and ripening phases. The treatments included dates (D_1=16 August and D_2=12 September) and three rice varieties (V_1=BRRI dhan40, V_2=BRRI dhan41 and V_3=BRRI dhan46). The treatments were arranged in a randomized complete block (RCB) design with three replications. The unit plot size was 4 m × 3 m. Yield and yield component data were taken. The germination percentage (GM%), seedling vigor index (SVI), high density grain (HDG%), shoot dry weight (SDW), and root dry weight (RDW) of seeds of harvested crop were also taken for observing the performance of seed quality. The collected data were analyzed using Crop Stat Software programme.

The interaction between planting dates and variety was insignificant in all the parameters of yield and yield components. Therefore, only the main effect has been described and discussed below:

Effect of planting dates on yield and yield components. The planting dates had significant effect on yield and yield components (Table 1). Sixteen August planting produced higher number tillers m^{-2}, panicles m^{-2}, grain panicle^{-1} and TGW. The maximum grain and straw yield was also recorded in 16 August planting and yield decreased

Table 1. Yield and yield components of rice as affected by the planting date and variety in T. Aman 2014.

Treatment	Tiller m^{-2} (no.)	Panicle m^{-2} (no.)	Grain $panicle^{-1}$ (no.)	1000-grain wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
			Planting date			
16 Aug	223	201	100	23.77	4.48	6.02
12 Sep	210	187	94	22.58	3.56	5.47
LSD at 5% level	*2.0*	*3.0*	*5.09*	*1.10*	*0.48*	*0.63*
			Variety			
BRRI dhan40	218	194	101	22.23b	3.96	5.67
BRRI dhan41	216	195	96	23.53ab	3.97	5.65
BRRI dhan46	217	194	95	23.76a	4.13	5.90
LSD at 5% level	*ns*	*ns*	*ns*	*1.35*	*ns*	*ns*

In a column, different small letters indicate the differences among treatments, ns=Not significant.

significantly in 12 September planting might be due to decrease in rainfall, temperature and solar radiation during ripening phase (Figs. 1 and 2).

Effect of variety on yield and yield components. Only the TGW was significantly affected by variety (Table 1). BRRI dhan46 produced the highest TGW followed by BRRI dhan41 and BRRI dhan40 produced the lowest. The highest tiller number m^{-2} was recorded in BRRI dhan40 followed by BRRI dhan46 and the lowest was in BRRI dhan41. BRRI dhan41 gave the highest number of panicle m^{-2} but BRRI dhan40 produced the maximum number of grain $panicle^{-1}$. BRRI dhan46 produced the maximum grain yield followed by BRRI dhan41 and BRRI dhan40 produced the lowest. The straw yield was not significantly affected by variety.

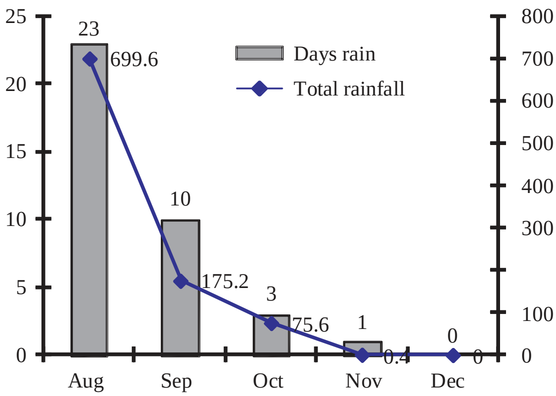


Fig. 1. Monthly number of rainy days and monthly total rainfall, T. Aman 2014. (Vertical bar represents the number of rainy days)

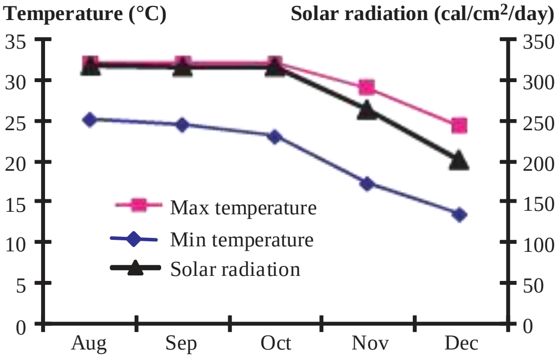


Fig. 2. Maximum and minimum temperature and solar radiation, T. Aman 2014.

The interaction between planting dates and variety was not significant on seed quality such as germination percentage (GM%), seedling vigour index (SVI), high density grain (HDG%), shoot dry weight (SDW) and root dry weight (RDW) (Table 2).

Effect of planting dates on seed quality, root and shoot dry weight. The GM%, SVI, HDG%, SDW and RDW were significantly affected by planting dates. All of these parameters performed better in 16 August planting than 12 September planting.

Effect of variety on seed quality and root and shoot dry weight. Variety had significant effect on all the parameters except RDW. The highest GM% (95.0) was recorded in BRRI dhan46 followed by BRRI dhan41 and the lowest was in BRRI dhan40 (88.83) but the SVI was the highest in BRRI dhan41 (5.63) and the lowest was in BRRI dhan40 (3.59). The HDG% significantly increased in BRRI dhan46 (87.13) and the lowest was in BRRI dhan40 (82.23) as the same trend also observed in GM%. The SDW was the highest in

Table 2. Seed quality of rice as affected by the planting date and variety T. Aman 2014.

Treatment	GM %	SVI	HDG %	Shoot dwt of 10 seedling (mg) at 10-day-old	Root dwt of 10 seedling (mg) at 10-day-old
			Planting date		
16 Aug	93.00	4.86	86.26	42.46	41.78
12 Sep	91.00	4.50	82.97	40.47	40.04
LSD at 5% level	*1.7*	*0.25*	*2.56*	*1.56*	*1.35*
			Variety		
BRRI dhan40	88.83c	3.59c	82.23c	42.58a	40.92
BRRI dhan41	92.17b	5.63a	84.48b	39.93b	41.89
BRRI dhan46	95.00a	4.82b	87.13a	42.25a	41.42
LSD at 5% level	*2.11*	*0.31*	*3.15*	*1.91*	*ns*

In a column, different small letters indicate the differences among treatments, ns=Not significant. (GM%=Germination percentage, SVI=Seedling vigour index, HDG%=High density grain)

BRRI dhan40 (42.58 mg), which was statistically identical to BRRI dhan46 and significantly decreased in BRRI dhan41 (39.93 mg). The variety had no significant effect on RDW but it was the highest in BRRI dhan41 (41.89 mg) and the lowest was in BRRI dhan40 (40.92 mg).

Thus it was concluded that 16 August planting gave higher grain yield than 12 September planting. Among the varieties, BRRI dhan46 was the highest yielder than BRRI dhan40 and BRRI dhan41. Considering seed quality, 16 August performed better than 12 September planting. In case of varieties, BRRI dhan46 was the best in terms of GM%, SVI, HDG% and SDW.

Effect of seedling age on the growth, yield and yield components of rice

The experiment was conducted at the west byde of BRRI farm, Gazipur during T. Aman 2014 to determine the tillering pattern, growth, yield and yield components of rice as affected by seedling age. The treatments included six different ages of seedling, such as 15, 20, 25, 30, 35, and 40 days. The treatments were arranged in RCB design with three replications. The unit plot size was 4 m × 4 m. One seedling per hill at 20 cm × 20 cm spacing was transplanted. Tillers were counted from transplanting to maturity with 15 days intervals. Dry weight of leaf, stem and panicle were taken at different growth stages such as tillering, panicle initiation, flowering, dough and maturity stages. Yield and yield components data were also taken. The collected data were analyzed using Crop Stat Software programme.

Tiller production. The number of tillers produced at different days after transplanting (DAT) was significantly affected by seedling ages (Fig. 3). Regardless of seedling age, the tiller number gradually increased with the DAT and reached maximum at 45 DAT then gradually decreased and reached minimum at ripening and maturity stage ie 105 to 120 DAT. Fifteen-day-old seedling produced the highest number of tiller per hill from 15 to 120 DAT, which was statistically identical with the tiller number produced from 20 and 25 days old seedling. The lowest number of tillers was recorded in 40-day-old seedling in all the sampling dates which was statistically similar to the tiller number produced from 35 days old seedling.

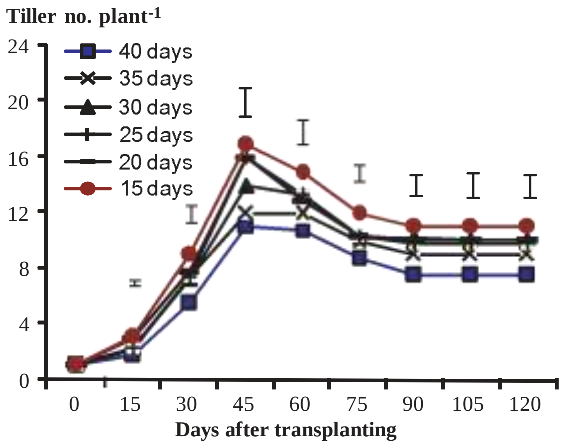


Fig. 3. Tiller number at different days after transplanting (DAT) as affected by seedling ages. (Vertical bar represent the Lsd (0.05) value indicates the differences between different seedling ages under same sampling date)

Dry matter production. The dry matter data of leaves, stems and panicles were recorded at different growth stages (TS=Tillering stage, PI=Panicle initiation stage FS=Flowering stage, DS=Dough stage and MS= Maturity stage*)* and affected by seedling ages (Fig. 4). Irrespective of seedling age, the stem dry weight of all increased slightly at PI stage then sharply increased at FS. After that it decreased and reached minimum at maturity stage. The leaf dry weight also followed the same trend as stem dry weight. The panicle dry weight in all the treatments sharply increased from flowering to maturity stage. In this experiment it has been observed that stem and leaf dry weight increased up to flowering stage after that decreased but panicle dry weight increased from flowering to maturity indicating that dry matter moved from stem and leaf to the panicles.

The tiller number m^{-2}, panicle number m^{-2}, grain $panicle^{-1}$ and grain yield were significantly affected by seedling age but TGW and straw yield were not significantly affected (Table 3).

Tiller number. The 15-day-old seedling produced the highest number of tiller. The tiller number m^{-2} decreased gradually with increasing seedling age and the lowest number of tiller was recorded in 40-day-old seedling. Twenty to 30-day-old seedling gave statistically similar number of tiller m^{-2}.

Panicle number. The panicle number m^{-2} also increased with decreasing seedling age. It was the

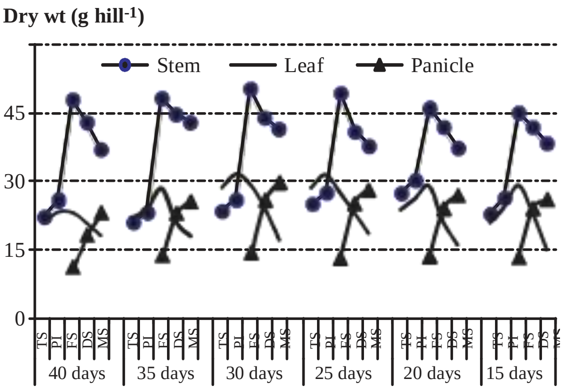


Fig. 4. Dry matter changes in leaves, stems and panicles at different growth stages of rice as affected by different seedling ages. (TS=Tillering stage,PI=Panicle initiation satge FS=Flowering stage, DS=Dough stage and MS= Maturity stage)

highest in 15-day-old seedling, which was statistically identical with the number of panicle produced from 20 to 25-day-old seedling. Again 20 to 35-day-old seedling produced statistically similar panicle number and 40-day-old seedling produced the lowest.

Grain number. Twenty-five- and 30-day-old seedling produced the highest number grain $panicle^{-1}$, which was statistically identical with grain $panicle^{-1}$ produced from 15 and 20-day-old seedling. Forty-day-old seedling gave the lowest number of grain $panicle^{-1}$.

Grain yield. The highest grain yield obtained from 15-day-old seedling transplanted plot followed by 20, 25, 30, 35 and the lowest was in 40-day-old seedling but there was no significant difference between 15 to 25-day-old seedling and between 20 to 30-day-old seedling and also between 30 to 35-day-old seedling.

Thus yield and yield components was higher in younger seedling used plot as it produced more tillers and panicles. The plants those are produced from younger seedlings translocated more carbohydrate from source to sink might be the reason of higher yield in younger seedling used plot.

Effect of fungicide and water stress on the natural incidence of neck blast (*Pyricularia oryzae*) in Boro rice

The experiment was conducted at the BRRI farm, Gazipur during Boro season 2014-15 following an event of post-flowering water stress. The treatments were: T_1=Nativo 75WG (2 sprays at

stress; T_2=Nativo 75WG (2 sprays at 10 days interval at flowering stage) + post-flowering water stress; T_3=Trooper 75WG (2 sprays at 10 days interval at flowering stage) + no water stress; T_4= Trooper 75WG (2 sprays at 10 days interval at flowering stage) + post-flowering water stress; T_5=No fungicide + no water stress

water stress). The treatments were arranged in a RCB design with five replications. Thirty-day-old seedlings of BRRI dhan29 were transplanted (one seedling per hill) maintaining a spacing of 20 cm × 20 cm. Fertilizers were applied and other

Table 3. Yield and yield components of rice as affected by different seedling ages.

Seedling age	Tiller m^{-2} (no.)	Panicle m^{-2} (no.)	Grain $panicle^{-1}$ (no.)	1000-grain wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
			Seedling age			
40 days	196d	187c	92c	23.65	3.50d	5.14
35 days	253c	250b	94bc	24.19	4.31c	4.80
30 days	264b	250b	98a	23.54	4.70bc	5.45
25 days	267b	253ab	98a	24.22	4.80ab	5.58
20 days	268b	254ab	96a	23.54	4.89ab	5.80
15 days	280a	256a	97a	23.59	5.27a	5.63
LSD at 5% level	*4.8*	*5.3*	*3.0*	*ns*	*0.53*	*ns*

In a column, different small letters indicate the differences between treatments, ns=Not significant.

intercultural operations were conducted as per BRRI recommendations. Water stress was implemented at post-flowering stage by draining out the standing water. Fungicides (Nativo 75WG and Trooper 75WG) were sprayed twice (at 10 days interval) at flowering stage using hand sprayer following recommended doses as indicated on the product labels. Data on disease incidence and severity were collected following Standard Evaluation System (IRRI 1996). Yield (t/ha) data were also recorded with different treatments.

This experiment was based on the natural incidence of neck blast disease and no deliberate inoculation was conducted. However, no significant natural incidence of neck blast was observed during Boro 2014-15 season in the west byde research area of BRRI. Therefore, the overall treatment effect on the natural incidence and severity of neck blast was found to be insignificant. Grain yield was also unaffected by the treatments. However, the highest grain yield (7.6 t ha^{-1}) was recorded with T_1 (Nativo 75WG, 2 sprays at 10 days interval at flowering stage + No water stress) (Fig. 5).

Thus, no significant difference was observed among the treatments in terms of blast incidence and grain yield.

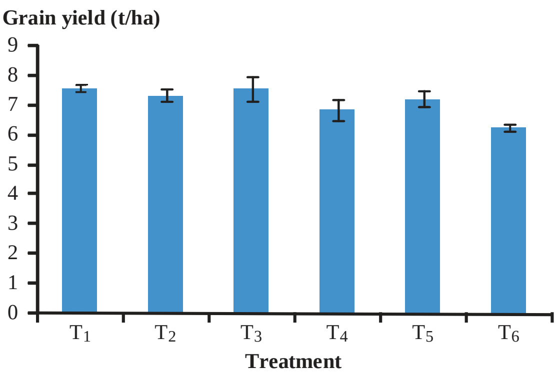


Fig. 5. Effect of different treatments on yield of BRRI dhan29. (Each small vertical bar represents the standard error of each treatment)

Effect of foliar spray of MOP and elemental S for spot free seed production

The experiment was conducted to find out the effect of foliar spray of MOP and elemental S for spot free seed production at the west byde of BRRI farm, Gazipur during Boro 2014-15 to evaluate the effectiveness of foliar spray of MOP and elemental S against grain spotting to produce spot free seed. Six treatments viz, T_1=RF + MOP (60 g/10L H_2O) spray at complete panicle emergence of milking stage and 2nd spray 15 days after 1st spray, T_2=RF + Elemental S (Thiovit) at 60 g/10L H_2O same as above, T_3=RF + 60 g MOP + 60 g Thiovit in 10 L water, T_4=RF + Folicur spray, T_5=RF + BRRI recommended practice and T_6=RF + No spray + No MOP were tested in this experiment. The treatments were arranged in a RCB design with three replications. BR3 variety was used in the experimental purpose. The plot size was 3 m × 3 m. Thirty-five-day-old seedlings of BR3 were transplanted at the spacing of 20 cm × 20 cm. Fertilizers were applied in the experimental plot as urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate at the rate of 270-130-120-70 and 10 kg ha^{-1}. Whole amount of triple super phosphate, muriate of potash, gypsum and zinc suphate were applied prior to final land preparation. Urea was top dressed in three equal splits at 15, 45 and 55 days after transplanting (DAT). All other intercultural operations were done as and when necessary. Data were collected on grain spot incidence and grain yield from an area of 5 m^2 at maturity stage of the crop. Collected data were statistically analyzed using a standard statistical procedure and only mean differences among treatments were adjudged.

Incidence of grain spot was found to be unaffected by the treatments. However, the lowest incidence (17.33%) of grain spot was observed with T_3 (RF + 60 g MOP + 60 g Thiovit in 10 L water). Again, no significant effect of the treatments was observed on the grain yield of BR3 (Fig. 6).

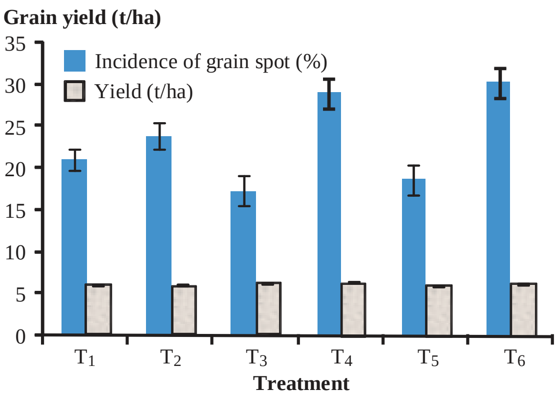


Fig. 6. Effect of different treatments on grain spot incidence and yield. (Each small vertical bar represents the standard error of each treatment)

Thus, the he lowest incidence (17.33%) of grain spot was observed when BRRI recommended fertilizer was applied in combination with 60 g MOP and 60 g Thiovit in 10 L water.

Monitoring labour wage rate at different locations

A survey was conducted to find out the labourers' wage rate at different locations around BRRI HQ such as Joydebpur, Chowrasta, Salna, Board Bazar, Tongi, Konabari etc (Table 4). It was observed that the average wage rate per day was Tk 375-415. The highest wage rate of labourers was in May (Tk 385-440 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 385-420 per day) due to harvesting and post-harvest operations of Aus and transplanting of Aman rice and the third higher wage rate was observed during December-January (Tk 440-495 per day) due to the peak period for harvesting and post-harvest operation of Aman rice and transplanting of Boro rice. In another survey, it was observed that the wage rate varied from place to place and ranged between Tk 250-300, 275-300, 275-300, 250-300, 250-300, 325-350, 325-350 and 300-350 at Habiganj, Rangpur, Rajshahi, Barisal, Sonagazi, Comilla, Satkhira and Khulna repectively (Table 5).

RICE SEED PRODUCTION

In different seasons, this division produced 12,158 kg rice of which 8,275 kg seed, 1,180 kg non-seed and 2,703 kg mixed rice. These rice seeds were deposited to BRRI general store.

Breeder seed. As a part of the project programme of GRS Division, this division produced about 11,781 kg breeder seed. These seeds were deposited to GRS Division.

SUPPORT SERVICES FOR RESEARCH MANAGEMENT

Land and labour management. Including regional stations, BRRI had about 734 labourers of which 525 regular and 107 irregular during the reporting year. In BRRI HQ, total number of labour was 447 of which 340 regular and 74 irregular labourers. BRRI has 274 ha of land of which 163 ha is cultivable (Table 6).

Labour use. Total labour used in different divisions for research purpose, research works, support services and leaves was 1,71,936 man days of which 58.46, 36.81 and 4.72% were used for research, support service and holiday purpose respectively.

Labour wages. It was observed that total labour wages was Tk 4,91,88,635 of which Tk 2,87,56,881.7; 1,81,09,299.94 and 23,22,453.35 were paid to the labourers for research work, support service works and leaves respectively.

Land use. A total of 73.82 ha of land were used by different divisions in different season of

Table 4. Labourer's wage rate without stuff at different places around BRRI, Gazipur during 2014-15.

Month	Wage rate (Tk)	Remark
April	330-385	Normal period
May	385-440	Peak period. Harvesting and post-harvest operation of boro rice and transplanting of Aus rice.
Jun	330-385	Normal period
Jul	385-440	Peak period. Harvesting and post-harvest operation of aus rice and transplanting of Aman rice.
Aug	395-420	
Sep	375-385	Normal period
Oct	360-385	
Nov	330-360	
Dec	440-495	Peak period. Harvesting and post-harvest operation of aman rice and transplanting of Boro rice.
Jan	440-495	
Feb	330-385	
Mar	363-385	Normal period
Average	375-415	

*Wage rate of each month is the average rate of different places such as Joydebpur, Chowrasta, salna, Board Bazar, Konabari etc.

Table 5. Labourer's wage rate without stuff at different locations of Bangladesh, 2014-15.

Location	Wage rate (Tk)
Habiganj	250-300
Rangpur	275-300
Rajshahi	275-300
Barisal	250-300
Sonagazi	250-300
Comilla	325-350
Satkhira	325-350
Khulna	300-350

which 6.53 ha in Aus, 32.62 ha in Aman and 34.66 ha in Boro season.

Garden management. This division always manages a flower garden to maintain an aesthetic view of the office area, some parts of the campus during summer and winter seasons by planting of different flowers such as Marigold (hybrid and local), Cosmos (hybrid), Dianthus, Salvia, Astar, Jenia, Chrysanthemum, Dahlia, Petunia, Lily flower, Flux, Time flower, Nayantara, Dupati, Rose, Bottom flower, Gladiolus etc.

Table 6. Land and labour strength of BRRI, 2014-15.

Station	Total land (ha)	Cultivable land		Labour (no.)		
		Area (ha)	Total land (%)	Muster roll		Total
				Regular	Irregular	
HQ at Gazipur	76.83	44.45	57.9	340	107	447
Comilla	24.68	16.03	65.0	28	21	39
Habiganj	35.03	25.90	73.9	30	10	40
Sonagazi	45.77	35.90	78.4	27	17	44
Barisal	41.10	10.74	26.1	21	12	33
Rajshahi	13.24	8.92	67.4	22	10	32
Bhanga	11.46	9.55	83.3	15	5	20
Rangpur	6.07	4.05	66.7	26	9	35
Kushtia	0	0	0	10	3	13
Satkhira	20.00	8.10	40.5	6	15	21
Total	274.18	163.64	59.7	525	209	734

Farm Machinery and Postharvest Technology Division

SUMMARY

A push-pull type single row conical weeder was fabricated in the FMPHT divisional research workshop. Float angle of the skid was considered as 25°, which helps to make slippage of the rotor. Six smooth and six serrated blades were mounted on the periphery alternately on the rotor to uproot and buried weeds with traction and shear force.

A manual rice transplanter was fabricated at FMPHT research workshop. The performance test was conducted during Boro 2015 season at BRRI HQ research plot using 30-day-old (3-4 leaf) seedling of BRRI dhan28. The field capacity was found 0.033 ha/h at an operating speed 0.421 km/h. The transplanter successfully transplanted seedlings on average hill-to-hill spacing 21 cm and six cm depth with 5-7 seedlings/hill. The missing, floating and buried hills were observed 7.19%, 5.93% and 1.33/m^2 respectively.

A prototype of mini combine harvester was fabricated at the Janata Engineering workshop, Chuadanga under Public Private Partnership approach. BRRI provides design, drawing, technical and financial support to the workshop. The preliminary test was conducted during wheat and Boro 2015 season and some mechanical faults were identified. Rectification of these faults is under process.

A power chopper was developed to chop straw for cattle feed, mushroom bed and briquette materials in specific size. The performance test was conducted in FMPHT research workshop of BRRI and five other places- BLRI Savar, Shajadpur of Sirajganj, Chuadanga, Jessore and Rangpur.

A de-husking machine was developed to improve the performance of existing engelberg huller. The capacity of developed de-husker was 500 kg/h and hulling efficiency was more than 90% in one pass. The head rice recovery was increased by 1-2% due to use of de-husker. In addition, bran and husk can be used for extracting bran oil and making briquette respectively.

A total of 12 air blow type rice mills were fabricated at local manufacturing workshop Jamtoly, Ashulia, Savar, Dhaka. Seven of them were distributed and installed at farmers house under the supervision of BRRI and five were installed at NGO site under direct supervision of KOICA Bangladesh office. The supplied mill was not found commercially profitable. It can be used only for household purpose.

In 2014-15, in total 130 day-long demonstration cum informal training programmes were conducted at different places of the project areas. About 5,200 participants including farmers, machine operators and Sub-Assistant Agricultural Officer (SAAO) attended the demonstration cum informal training programmes. BRRI weeder, BRRI rice-wheat reaper, BRRI rice-wheat thresher (TH-7), BRRI open drum thresher, BRRI winnower, BRRI USG applicator and BRRI prilled urea applicator were also exhibited. As a result awareness was created among the farmers on the benefit of using of BRRI farm machinery and they also wanted to purchase the machine with subsidiesed prices.

Six day-long and 48 two-day-long training programmes were conducted during Aman and Boro seasons 2014-15 in different locations within the project areas. Altogether 132 and 960 participants mostly farm machinery operators attended respectively in formal training programmes as trainee. A basic idea (how to operate new engine; when need to change air, oil and fuel filter etc) on operation, repair and maintenance of diesel engine was shared with the participants. Trained operator was able to repair minor defects of the machine themselves. After the training, the operators operated all machinery successfully.

One manufacturers training programme was conducted during 2014-15. Fifteen participants from different farm machinery manufacturing workshops attended the five day-long trainings. The training programmes included both the theoretical lecture and the practical sessionss.

AGRICULTURAL MACHINERY DEVELOPMENT AND TESTING

Design and development of a Single Row Conical Weeder

A manually operated conical weeder was designed considering 14-16 cm width of operation for uprooting weeds and mulching of soil. An engineering design was done with the help of AutoCAD programming and prototypes were fabricated using locally available materials GI pipe, GI sheet, MS sheet, MS flat bar and MS shaft at the FMPHT divisional workshop. First version, second version and final version was fabricated in the divisional research workshop for single row operation in rice field. Some problems were found in the first version during field test. Those problems had been overcome in the second prototype and also found some mechanical error. For making easier and adjustable of the conical weeder, third version was fabricated in the research workshop. The skid and main frame is the basement of the conical weeder. The main frame holds the two conical rotors, which help to rotate the rotors on the soil surface. All force (push and pull) exerted on the conical rotors by the main frame. Float angle of the skid was considered as 25°, which helps to make slippage of the body. A float of 36 cm in length and 12 cm in width had been designed in front portion that prevents the penetration into soil. Float was designed two mm thickness with two cm MS flat bar attached with thin metal sheet. Handle was attached upon the main frame for exerted push and pull type of force to operate the conical weeder. The BRRI conical weeder has two cone shaped rotors mounted in tandem with opposite orientation. Smooth and serrated blades were mounted alternately on the rotor to uproot and burry weeds when the rotors create a back and forth movement in the top three centimeter of soil. Thorough test and performance evaluation of the final version of single row conical weeder is going under process.

During design, the following criteria were considered:

- Easy weeding and simple operation and maintenance
- Distance between row to row
- Minimum force would be required to operate in the field
- It should have simple and easy adjustment
- Locally available materials should be used to minimize the fabrication cost
- Light weight for easy handling
- It would be easy to repair and maintain
- It would be suitable for operation by a single person

Performance evaluation of BRRI Manually Operated Rice Transplanter

BRRI manually operated (six-row) rice transplanter was fabricated at FMPHT divisional research workshop. The machine consists of two floats, a main frame assembly, picker bar assembly and handle. The row-to-row spacing is 20 cm, whereas plant-to-plant spacing can be adjusted as per the requirement. The machine is backward pull-type and it needs mat-type seedlings for transplanting. Two floats facilitate the transplanter to slide over the puddled soil surface. Fixed opening type pickers are attached with the transplanting arm of the machine. Flat bar, BI sheet, angle bar, wall pipe, SS sheet, SS rod, chain and sprocket, spring, wood, nuts and bolts were used to manufacture this machine.

A preliminary performance test was conducted during Boro 2015 season at BRRI HQ research plot using 30-day-old (3-4 leaf) seedling of BRRI dhan28. The field capacity was found 0.033 ha/h at an operating speed 0.421 km/h. The transplanter successfully transplanted seedlings on average hill-to-hill spacing 21 cm and six cm depth with 5-7 seedlings per hill. The missing, floating and buried hills were observed 7.19%, 5.93% and 1.33/m^2 respectively. It has been observed that hill-to-hill spacing was wider at some places and narrower at others resulting in deviation from the desired spacing. It may happen due to the operator speed variation.

Design and development of a Mini Combine Harvester

The combine harvester or "combine" is a machine that combining three separate operations comprising harvesting/reaping, threshing, and winnowing - into a single process. Combine harvesters have been a very significant part of the global industrial revolution and make a substantial contribution to food production worldwide - virtually no other invention has had the kind of impact on world food production that this workhorse has had. In case of Bangladesh the most common practice is still the traditional manual methods. Harvesting is done by using hand sickle (called kachi). Combine harvester are gradually being introduced in Bangladesh.

Government and non-government organization imported combine harvester (head feed and whole feed) which are not affordable for the farmers due to high cost. Moreover the imported combine harvesters are big in size, tough to handle in small and fragmented land. The most of the farms land have no road for easy accessibility of machines. Considering the above point, BRRI took initiatives to fabricate a Mini Combine Harvester at the Janata Engineering workshop, Chuadanga under Public Private Partnership (PPP) approach. BRRI provides design, drawing, technical and financial support to the workshop. Locally available materials such as MS sheet, bar, rod, nut bolt, power transmission system, feeding, threshing and cleaning mechanism, wheel, base and frame, steering, hydraulics system (collected), were used to fabricate the combine. First prototype was developed and tested in wheat and Boro 2015 season to find out the performance, efficiency and operation fault. Following mechanical faults were identified and taken initiative to remove it.

Development of a Power Chopper Machine

Power chopper machine was developed to chop straw for cattle feed, mushroom bed and briquette materials, that needs specific sizes (length) of rice straw. Traditionally, chopping straw by sharpen cutting blade is time consuming and laborious. Existing manual chopper has not yet been popular in Bangladesh due to low cutting efficiency, excessive sliding tendency of the blade etc. Under this circumstance, FMPHT division of BRRI developed power chopper, which can chop dry, wet (fresh) rice straw in defined sizes. Besides this, maize trunk, all kinds of fodder, small branches of tree etc is also possible to chop.

The machine operated by 4 hp diesel engine or 2 hp electric motor by two labourers. It can be chopped at least 1.5cm length of straw or other materials. The machine was manufactured with locally available materials ie MS sheet, engle bars, casting iron, SS cutting blade. The main parts of the machine are frame, feeding tray, feeding cylinder, driver gear, cutting blade and output channel.

The performance test was conducted in FMPHT research workshop and five other places,

Problem	Comments/Initiative will be taken
Cutter part weight was too much	The cutting efficiency was satisfactory and weight will be reduced.
Conveying length was too large	Conveyer length will be reduced.
Threshing drum length was small (61cm) and some un-threshed grain remained.	The threshing drum length will be increased up to (86cm) and the height of the thresher will be reduced.
The blower and cleaning sieve was large for cleaning the threshed grain.	The cleaning part will be deducted
The inclination angle of grain conveyer channel is not justified and length of screw conveyer is short	The grain conveyer channel inclination will be deducted (25°) and screw conveyer length will be enlarged (50 cm).
The combine working speed was not up to the mark and tyre wheel was not suitable in wet field.	The tyre wheel will be replaced by crawler type and speed will be adjusted
The overall dimension of frame was un-used	The body dimension will be fixed up (152×152 cm)

BLRI Savar, Shajadpur of Sirajganj, Chuadanga, Jessore and Rangpur (Table 1). Manufacturing cost of this machine is Tk 25,000-30,000.

MILLING AND PROCESSING TECHNOLOGY

Modification and improvement of dehusking machine

A 4kW 3 phase motor of 1,440 rpm was used to operate rubber roll husker to separate husk from paddy and 38 cm diameter exhaust blower with 1.5kW motor of 2840 rpm used for removing husk. The dehusked paddy from dehusker used in existing engelberg huller mill for polishing. The capacity of developed dehusker was 500 kg/h and hulling efficiency was more than 90% in one pass. The head rice recovery was increased by 1-2% due to use of dehusker. In addition, bran and husk can be used for extracting bran oil and making briquette respectively.

Fabrication and distribution of improved Air Blow Type Rice Mill

A total of 12 air blow type rice mill was fabricated at local manufacturing workshop Jamtoly, Ashulia, Savar, Dhaka. Out of them seven mills were distributed and installed at farmers' level under supervision of BRRI and five of them were installed at NGO site under direct supervision of KOICA Bangladesh office. The milling capacity of supplied mill was found 180-200 kg/ha. If someone wants to use the supplied mill commercial basis then No. 2 huller should be replaced by No. 8 huller and other accessories will be unchanged.

INDUSTRIAL AND FARM LEVEL EXTENSION OF AGRICULTURAL MACHINERY

Demonstration cum training of BRRI developed machinery at farmer's field

In the year of 2014-2015, a total 130 day-long demonstration cum informal training programmes were conducted at different places of FMTD project areas. About 5,200 participants including farmers, machine operators and Sub-Assistant Agricultural Officers (SAAO) attended the demonstration cum informal training programmes. As a result, awareness was created among the farmers on the benefit of using of BRRI farm machinery and they also wanted to purchase the machine with subsidised prices. Drum seeder, BRRI weeder, BRRI rice-wheat reaper, BRRI rice-wheat thresher (TH-7), BRRI open drum thresher, BRRI winnower, BRRI USG applicator and BRRI chula were also displayed during the entire period of the fairs. Functions of these machines, advantages and disadvantages were displayed to the spectators by posters, display cards and leaflets. Awareness about the benefit of using machinery in farm operation was created among the farmers and other stakeholders.

Training on operation, repair and maintenance of BRRI farm machinery

Forty-eight two-day long training programmes were conducted during Aman and Boro seasons 2014-15 in different locations within the project areas. Altogether 960 participants mostly farm machinery operators attended in formal training programmes as trainee. A basic idea (how to operate new engine; when need to change air, oil and fuel filter etc) on operation, repair and maintenance of diesel engine was shared with the participants. Trained operator was able to repair minor defects of the machine themselves. After training, the operators operated all machinery successfully.

Total six day-long training programmes were conducted during Aus, Aman and Boro seasons 2014-15 in different upzila office within the project areas. Altogether 132 participants sub-assistant agriculture officer attended in formal training programmes as trainee. Trained officers were able to repair minor defects of the machine themselves. After training, the operators operated all machinery successfully.

Table 1. The field performance of BRRI Power Chopper.

Chopper	Dry straw (kg/ha)	Wet straw (kg/ha)	Maize (kg/ha)	Fodder (kg/ha)	Small branch of tree (kg/ha)
Motor operated	240	750	455	550	540
Engine operated	280	1000	485	675	600

Training on manufacturing processes of BRRI farm machinery

One manufacturer's training programme was conducted during 2014-15. The training programme consists of 15 participants from different farm machinery manufacturing workshops for five days long training. Training programmes included both the theoretical lecture and the practical sessions.

Workshop Machinery and Maintenance Division

SUMMARY

The power unit of a self-propelled reaper was developed and fabricated in research workshop of BRRI. The problem of this gearbox was identified through performance evaluation of power transmission systems in paddy and wheat field. The performance of the reaper was found satisfactory. The gear box of the power transmission systems was functionally well but it is little bit heavy. So, a new type of gearbox with compact size and reduced weight has been designed with the help of AutoCAD tools and developed at BRRI research workshop. In this machine for easy power transmission, a gearbox with mechanism of two forward and a backward speed have been introduced. Fabrication of power transmission system of the reaper is in progress and it will be tested in the next season.

WMM Division of BRRI has developed a self-propelled reaper for harvesting rice and wheat and the performance of this reaper is good in fragmented land as well as dry-land condition but it has a problem in wet-land condition. There is no suitable reaper in our country for wet-land condition. It does not move forward in wet-land during harvesting because its wheel goes down the soil and rotates in the same place. The self-propelled reaper wheel for wet-land condition has been designed with the help of AutoCAD tools. Fabrication of the reaper wheel has been completed using the locally available materials at BRRI research workshop. It has been tested in BRRI farm.

Experiments were conducted at Harinakundu upazila of Jhenidah district in Boro and Aman 2014 seasons and BRRI farm, Gazipur in Boro 2015 season to determine paddy yield as influenced by different tillage depths. There were three tillage depths such as: 4-5, 5-6 and 6-7 inches in Jhenidah district and 4-5 and 6-7 inches in BRRI farm. The tillage depths were maintained by a power tiller. Tillage depths significantly affected the yield of BRRI dhan28 in Boro 2014, BRRI dhan56 in Aman 2014 and Boro 2015 season. The highest grain yield of BRRI dhan28 was found 7.50 t/ha in the tillage depth up to 6-7 inches and the lowest yield was found 6.88 t/ha in the tillage depth up to 4-5 inches in Boro season. On the other hand, in Aman 2014 season, the highest grain yield of BRRI dhan56 was found 5.40 t/ha in 6-7 inches tillage depth and the lowest yield was found 4.40 t/ha in 4-5 inches tillage depth. The highest grain yield of BRRI hybrid dhan2 was found 1.60 t/ha in 6-7 inches tillage depth and the lowest yield was found 1.35 t/ha in 4-5 inches tillage depth in Boro 2015 season. The highest yields of both the seasons were found under the higher tillage depths up to 6-7 inches and the lowest yields were obtained in the tillage depth up to 4-5 inches.

There are different kinds of transport/vehicles and farm machinery at BRRI. Repair and maintenance works of these were done by WMM Division. Repair works and change of spare parts of these vehicles and farm machinery were also done under major and moderate/minor repair and maintenance work. The total cost of major and moderate/minor repair and maintenance was Tk 66,33,650.00 from July 2014 to June 2015. Among these major repair and maintenance cost was Tk 60,59,523 and moderate/minor cost was Tk 5,74,127.

DEVELOPMENT OF AGRICULTURAL MACHINERY

Design and development of power transmission system of a power unit

This Division of BRRI has developed a self-propelled reaper for harvesting rice and wheat. The gear box of self-propelled power unit was developed and fabricated in the BRRI research workshop (Fig. 1). Power transmission unit of the reaper was tested in paddy field at BRRI farm, Gazipur, BRRI RS farm Rajshahi, Rangpur and also in paddy and wheat field at Jhenidah District. The problem of this gearbox was identified through performance evaluation of power transmission systems. The performance of the self-propelled reaper was found satisfactory. The existing gear box has a provision of two forward speeds with a backward speed. When engine is started, all gears in the gear box move either engaging or disengaging clutch. Backward gear always moves but keeps idle when the reaper is in forward

Fig. 1. Actual view of BRRI developed self-propelled reaper.

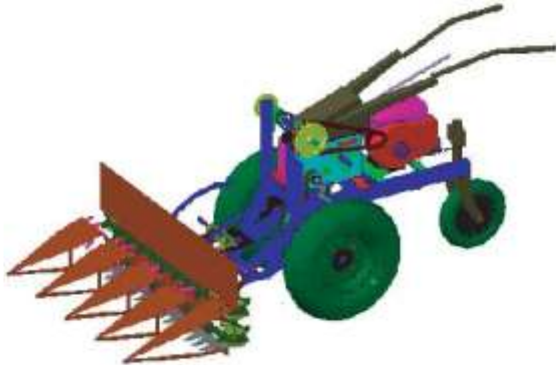


Fig. 2. AutoCAD drawing of power transmission unit of BRRI developed reaper.

motion. Power is transmitted in reduced form from gear box to axle through chain and sprocket. This gear box is functionally well but it is little bit heavy. So, it is necessary to design a new type of gearbox with compact size and reduced weight.

Design consideration

The self-propelled reaper has been designed considering the following criteria:

- Simple, lightweight, and sturdy in design
- Functionally perfect for harvesting crops for which it has been designed
- Locally available materials have been used for construction of the different parts of the reaper due to avoid facing difficulties of unavailability of raw material
- The machine has been designed for a specific crop as well as multipurpose type without sacrificing its merits
- Small in size due to compact design
- The light duty low cost diesel engine has been used as a prime mover for the reaper
- The cost of machine per unit length is low, and thus the cost of harvesting operation is also low
- Harvesting losses have been controlled within acceptable limit
- Trouble free machine.

Power transmitting unit

Compact size with reduced weight power transmission unit of self-propelled reaper has been designed with the help of AutoCAD tools (Fig. 2) and developed at BRRI research workshop. Fabrication of reaper will be completed very soon and this will be used in the next season. Major components of self-propelled reaper have also been designed and these are as follows:

- Power transmission System
- Chassis of the power unit
- Prime mover
- Control accessories etc.

Chassis of self-propelled reaper unit

The chassis of the self-propelled reaper unit consists of the following items:

Mainframe

The main frame was made of 3.0 mm thickness 50.8 × 50.8 mm m/s angle bar. It was fitted horizontally to the ground. The driving handle was fitted to the upper end of the mainframe by electric arc welding. The tail wheel was also fitted to the back engine base frame by the arc welding. The main power transmission shaft was placed the upper end of the frame. Two ball bearings along with casing were used for connecting the shaft to the main frame. The gearbox along with the shaft was placed below the main power transmission shaft by the ball bearings with casings. Figure 3 shown the details.

Gearbox

The gearbox is a power-transmitting unit. It is simple in construction with forward and backward speed and a neutral gear position (Fig. 4). In this gearbox, for forward speed of the reaper, gears are moving along with shaft carrying with load. The gearbox consists of different parts as listed below:

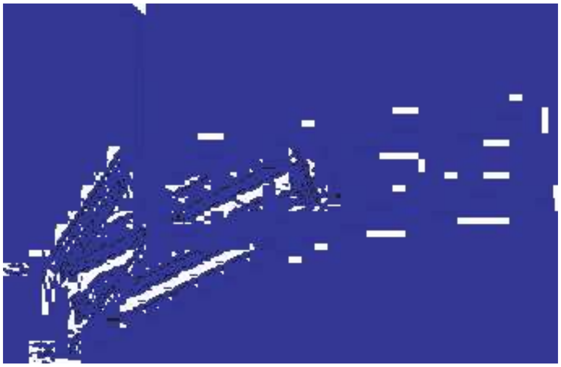


Fig. 3. AutoCAD drawing of mainframe of BRRI developed reaper.

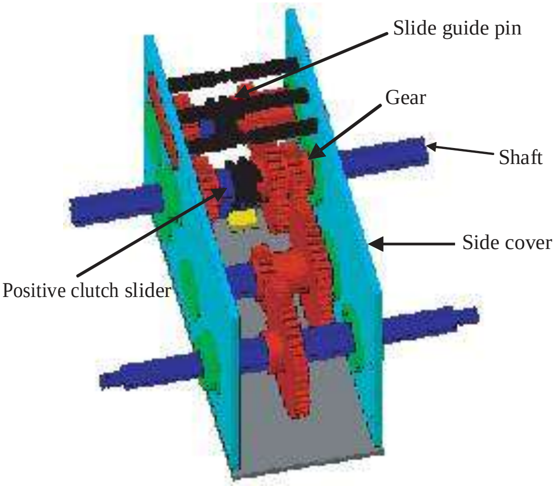


Fig. 4. AutoCAD drawing of gearbox of BRRI developed reaper.

Gearbox casing Gear
shaft with key Gear
pinion and clutch
Ball bearing and journal bearing
Positive clutch slider
Slider guide pin
Gear liver mechanism etc.

Ball bearing and journal bearing

Five shafts were mounted to the sidewall of the gearbox by four pairs of ball bearing. A pair of ball bearing was also used at the partition in the gear box. Another two pairs of ball bearing were used at the wheel axle and one pair of ball bearing was used with power transmission shaft so that they move around the shaft independently.

Positive clutch slider

Two common forms of clutches are the square–jaw clutch and the spiral–jaw clutch. One of the members must always slide axially on feather keys or spines to engage and disengage the clutch. The square–jaw clutch is the simplest form and can theoretically transmit torque in either direction without introducing a component of force. The spiral–jaw clutch can be engaged at somewhat higher speeds without serious clashing, but it can transmit torque in only one direction without requiring an external axial force to maintain the engagement. Straight spines are also widely used to give positive engagement with no tendency to develop an axial force.

Driving wheels with axle

The diameter of wheel was 69.4 cm. One pair of 45 mm diameter m/s shaft was used for driving wheel axle. Two pair's ball bearings with pillow type casing were used to fit the wheel axle to the inclined trusses. A pair of 21.9 cm diameter sprocket was used in this axle to transmit power from the gearbox by a roller chain.

Driving handles with tail wheel

The driving handles were made of 20 mm diameter m/s pipe. It is fitted to the upper end of the main frame by electric arc welding. Two m/s rods were used to connect the other ends of the engine base frame to driving handles by electric arc welding.

Gear shifting lever along with accessories

Clutches are used to connect or disconnect shafts as required by the gear shifting lever. Two common forms of clutches are the square-jaw clutch and the spiral-jaw clutch. In this study, the positive spiral jaw clutches was used.

Main power transmission shaft along with pulley and sprocket

Continuous mechanical power is usually transmitted along and between rotating shafts. The transfer between shafts was accomplished by gears, belts, chains or other similar means for matching the torque/speed characteristics of the interconnected shafts (Fig. 5). Shafts were supported in two bearings (sliding or rolling),

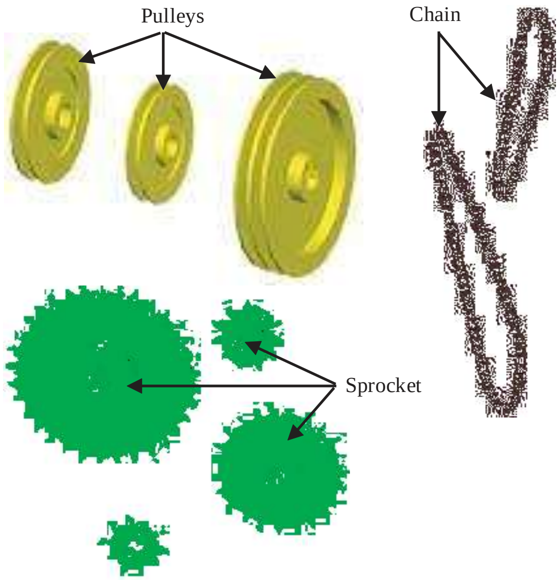


Fig. 5. AutoCAD drawing of pulleys, chain and sprocket.

which allowed the shafts to turn freely. There was no appreciable torque exerted by the bearings. A sliding bearing was needed for a lubricant film in the clearance space between shaft and bearing bush and in the fully hydrodynamic bearing illustrated the oil dragged into the wedge-shaped gap causing a pressure build-up (similar to that in hydroplaning), which supported the shaft without metal-to-metal contact and little friction.

Modification of reaper travelling wheel for wet-land condition

Harvesting of cereal grains by machines is an important part of mechanized agriculture. It is the first and major post-harvest operation for separation, processing and storage of grains. Delayed harvesting due to shortage of labour and bad weather conditions often causes yield loss, which can be minimized by use of reaper/harvester. Paddy is grown all round the year whereas wheat is grown only in the winter season (Rabi) in Bangladesh. These crops are harvested traditionally by using sickle, which is very tedious and time consuming. Due to fragmented land, self-propelled reaper is more suitable for harvesting rice and wheat in our land condition. A low cost self-propelled reaper has been developed by WMM Division of BRRI using locally available material for harvesting rice and wheat. The performance of this reaper is good in fragmented land as well as dry-land condition. However, it has a problem in wet-land condition. At present, there is no suitable reaper in our country for wet-land condition. During harvesting in wet-land, it does not move forward because its wheel goes down the soil and rotates in the same place. So, there is a scope to modify a reaper-wheel for wet-land condition for harvesting rice and wheat. For this reason, this experiment has been undertaken at research workshop BRRI, Gazipur during 2013-14 to modify a self-propelled reaper wheel using locally available materials.

The complete design of self-propelled reaper wheel has been done with the help of AutoCAD tools (Fig. 6). Fabrication of the reaper wheel has been completed according to the design using the locally available materials at BRRI research workshop (Fig. 7). It will be tested in the next season.

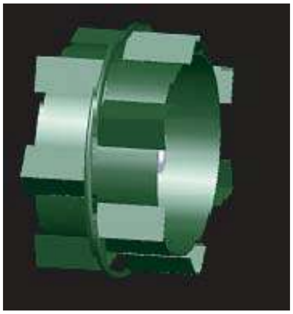


Fig. 6. AutoCAD drawing of reaper travelling wheel.

Fig. 7. Actual view of reaper travelling wheel for wet-land condition.

Determination of tilling efficiency of power

This experiment was conducted at BRRI farm Gazipur in Boro 2015 season. The tillage depths were 4-5 inch and 6-7 inch where BRRI hybrid dhan2 was cultivated in Boro 2015 season. Other experiments were conducted at Harinakundu upazila under Jhenidah district in Boro 2014 and Aman 2014 seasons. There were three tillage depths such as: 4-5, 5-6 and 6-7 inches in Jhenidah district. BRRI dhan28 was cultivated in Boro 2014 season and BRRI dhan56 was cultivated in Aman 2014 season. The tillage depths were maintained by a power tiller. The paddy was irrigated and weeding as well as other intercultural operations were done as and when necessary. Paddy was harvested at full maturity. The weights of paddy were recorded plot-wise.

The effects of tillage depths on grain yield of BRRI hybrid dhan2 in Boro 2015, BRRI dhan28 in Boro 2014 and BRRI dhan56 in Aman 2014 seasons were varied from different tillage depths. The highest grain yield of BRRI hybrid dhan2 (breeder seed) in Boro 2015 season was found 1.60 t/ha in the tillage depth up to 6-7 inch and the lowest yield was found 1.35 t/ha in the tillage depth up to 4-5 inches (Table 1). Table 1 shows the highest grain yield of BRRI dhan28 was found 7.50 t/ha in the tillage depth up to 6-7 inches and the lowest yield was obtained 6.88 t/ha in the tillage depth up to 4-5 inches in Boro 2014 season. Table 1 also shows the highest grain yield of BRRI dhan56 in Aman 2014 season which was 5.40 t/ha in the tillage depth up to 6-7 inches and the lowest yield was found 4.40 t/ha in the tillage depth up to 4-5 inches. The highest yields of all the seasons were found under the higher tillage depths up to 6-7 inches and the lowest yields were obtained in the tillage depth up to 4-5 inches (Table 1). The deep tillage (6-7 inches) might have favoured the roots to proliferate down into the deeper layers of the soil profile to extract more nutrients and moisture that has led to higher growth and yield of both the seasons. Higher tillage depth favourably influenced the soil-water-plant ecosystem, thereby improved crop yields.

Table 1. Yield of paddy with different tillage depths.

Season	Paddy	Tilling depth (inch)	Paddy yield (t/ha)
Boro 2014	BRRI dhan28	4-5	6.88
		5-6	6.96
		6-7	7.50
Aman 2014	BRRI dhan56	4-5	4.40
		5-6	4.84
		6-7	5.40
Boro 2015	BRRI hybrid dhan2	4-5	1.35
	(breeder seed)	6-7	1.60

Adaptive Research Division

SUMMARY

In the reporting period, 32 advanced breeding lines for different seasons were evaluated by conducting 10 advanced line adaptive research trials (ALART) in different agro ecological regions under varietal improvement programme. Considering some important characteristics like grain yield, shorter growth duration, grain size, good grain quality, stress tolerance, micronutrient enriched, non-shattering habit, phenotypic acceptability and farmers' opinion, nine advanced lines for different seasons were recommended for proposed variety trial (PVT). Among them, one was selected for B. Aus, six for T. Aman and two for Boro season. In B. Aman (DWR) 2014, none of the advanced lines was found to be more suitable than the local check varieties. In B. Aus 2014, BR6848-3B-12 was found suitable for PVT. In T. Aman 2014, BR7941-116-1-2-1 and BR7941-41-2-2-2-4 for tidal submergence, IR77092-B-2R-B-10 and BR9377-9-21-3B for salt tolerance, BR7638-7-2-5-2 for rainfed lowland rice ecosystem and BR7697-15-4-4-2-2 for premium quality rice were found suitable for PVT. During Boro 2015, BR7781-10-2-3-2 as premium quality rice and NERICA Mutant as short duration variety were selected for PVT.

During Aus 2014, Aman 2014 and Boro 2015, seed production and dissemination programme (SPDP)s were conducted by using different BRRI varieties and other technologies at different locations of Bangladesh under GOB and different projects like Integrated Agricultural Productivity Project (IAPP), Mujibnagar Integrated Agricultural Development Project (MIADP), Enhancing Quality Seed Supply Project (EQSS) etc. A total of 166 demonstrations were conducted in 90 upazilas of 42 districts, from which about 351 tons of paddy grains were produced and 54 tons were retained as seeds by the farmers for next year cultivation. About 44 thousand farmers shared knowledge and awareness about BRRI varieties through demonstrations following field days, field visit and other interactions. Among them, about 14 thousand farmers were motivated to adopt BRRI varieties.

In Aus 2014, Aman 2014 and Boro 2015, adaptive trials were conducted in different locations of Barisal and Rangpur regions under IAPP to indentify the most suitable varieties for those specific areas. For Barisal region, BRRI dhan48 for T. Aus and BRRI dhan41 and BRRI dhan44 for T. Aman were found most suitable. In Boro season, BRRI dhan47 and BRRI dhan58 were found most suitable for Barisal region. For Rangpur region, it was Swarna, BRRI dhan49 and BRRI dhan57 for T. Aman and BRRI dhan58 for Boro season. In the reporting period, ARD conducted 28 farmers' training at different locations in which 930 trainees (farmers and SAAOs of DAE) participated. The division also conducted 75 field days at different locations of the country. About 12,350 persons participated in those occasions. A total of 5.5 tons quality seeds of popular and recently released rice varieties were produced at BRRI farms, Gazipur under ARD for conducting adaptive trials in different locations of the country in Aus, Aman and Boro seasons.

TECHNOLOGY VALIDATION

Advanced line adaptive research trial (ALART)

B. Aus 2014. Four advanced lines: BR6855-3B-12, BR6855-3B-13, BR6848-3B-12 and BR6976-2B-11-1 along with BRRI dhan43 as check were tested at farmers' field in eight locations (Table 1). In terms of yield performance, all the tested advanced lines except BR6976-2B-11-1 performed better than the check variety BRRI dhan43. Among the lines, BR6848-3B-12 was found to be less infected by disease. In addition this line had about 1 t/ha yield advantage over the check variety BRRI dhan43. Considering the yield advantage, grain size, growth duration and phenotypic acceptance, BR6848-3B-12 was recommended for PVT.

T. Aman 2014 (Tidal submergence). Four advanced lines BR7941-1-1-2-1, BR7941-41-2-2-2-4, BR7941-30-1-1-1 and BR7941-116-1-2-1 along with BRRI dhan44, Sadamota and Dudkalam as checks were tested at farmers' field in eight locations (Table 2). Average seedling height of all the tested advanced lines ranged 64-74 cm, which was longer than the check variety BRRI dhan44 (54 cm). Considering seedling height, grain yield, grain size and growth duration, BR7941-116-1-2-1

Table 1. Grain yield (t/ha), growth duration, 1000-grain weight (TGW) and plant height of some advanced lines under ALART grown in different locations of Bangladesh during B. Aus 2014.

Genotype	Location									Growth duration (day)	TGW (g)	Plant ht (cm)
	Grain yield (t/ha)											
	L1	L2	L3	L4	L5	L6	L7	L8	Mean	Mean	Mean	Mean
BR6855-3B-12	2.84	2.90	3.32	4.29	3.31	2.74	4.08	2.18	3.21	109	28.2	109
BR6855-3B-13	3.05	3.32	3.46	4.31	3.47	2.90	4.56	2.10	3.40	108	28.5	108
BR6848-3B-12	3.37	3.60	3.34	4.88	3.94	2.96	4.81	2.26	3.64	104	24.3	112
BR6976-2B-11-1	2.23	2.65	2.68	3.83	2.25	2.45	3.34	1.58	2.62	106	23.2	91
BRRI dhan43 (ck)	2.68	2.57	2.78	3.22	3.11	2.34	3.10	1.64	2.68	105	23.0	108
LSD (5%)				0.53					0.19	0.7	0.2	0.9

L1-Gazipur (BRRI), L2-Gazipur (Kapasia), L3-Noakhali (Sadar), L4-Feni (Sonagazi), L5-Sylhet (Golapganj), L6-Faridpur (Modhukhali), L7-Magura (Sadar), L8-Kushtia (Doulatpur).

Table 2. Grain yield (t/ha), growth duration, TGW and seedling height of some advanced lines under ALART (Tidal submergence) grown in different locations of Bangladesh during T. Aman 2014.

Genotype	Location									Growth duration (day)	TGW (g)	Plant ht (cm)
	Grain yield (t/ha)											
	L1	L2	L3	L4	L5	L6	L7	L8	Mean	Mean	Mean	Mean
BR7941-1-1-2-1	3.36	3.65	3.40	3.33	3.30	3.92	1.79	3.63	3.30	148	25.41	64
BR7941-41-2-2-2-4	3.91	4.20	4.00	4.07	4.10	4.07	1.57	4.13	3.76	151	23.56	72
BR7941-30-1-1-1	3.40	3.90	3.83	3.53	3.90	4.47	1.90	3.75	3.59	147	26.10	74
BR7941-116-1-2-1	4.30	5.24	4.73	4.77	4.00	4.85	2.33	4.50	4.34	145	26.42	70
BRRI dhan44 ck	3.98	4.40	4.63	3.70	3.60	3.83	1.66	3.80	3.70	147	26.52	54
Sadamota ck	3.42	4.41	3.57	3.96	3.50	3.63	1.43	2.71	3.33	164	28.05	70
Dudkalam	3.19	3.51	3.93	3.57	3.70	3.87	2.01	3.25	3.38	139	26.93	73
LSD (5%)				0.63					0.22	0.69	0.24	

L1-Borguna (Betagi), L2-Jhalokathi (Sadar), L3-Jhalokathi (Nolchiti), L4-Patuakhali (Sadar), L5-Patuakhali (Dumki), L6-Barisal (Sadar), L7-Barisal (Bakerganj), L8-Pirojpur (Sadar).

and BR7941-41-2-2-2-4 were recommended for PVT.

T. Aman 2014 (Salinity). Six salt tolerant advanced lines: IR73055-8-1-1-3-1, IR83484-3-B-7-1-1-1, IR78761-B-SATBI-68-6, IR83440-4-B-11-2-1-1-AJYI-B, IR77092-B-2R-B-10 and BR9377-9-21-3B along with BRRI dhan41 and BRRI dhan54 as checks were tested at farmers' field in seven saline prone areas (Table 3). Based on grain yield, grain size, growth duration, salt tolerance and farmers' opinion, IR77092-B-2R-B-10 and BR9377-9-21-3B were recommended for PVT.

T. Aman 2014 (RLR). Three advanced lines BR7468-12-1-1-1-1, BR7472-16-2-1-2-1 and BR7638-7-2-5-2 along with BRRI dhan32 and BRRI dhan49 as checks were tested at farmers' field in 10 locations (Table 4). Considering the yield, growth duration similar with BRRI dhan49 and less infection of false smut disease and farmers' opinion, BR7638-7-2-5-2 was recommended for PVT.

T. Aman 2014 (PQR). Four premium quality advanced lines BR7697-15-4-4-2-1, BR7697-15-4-4-2-2, BR7697-16-2-2-1-1 and BR7369-52-3-2-1-1 along with BRRI dhan37 as check were tested at farmers' field in 10 locations (Table 5). On average, all the tested entries gave higher yield, ranging 4.24 to 4.63 t/ha, than the check variety BRRI dhan37 (3.59 t/ha). Based on grain yield, grain size, grain quality, growth duration, phenotypic acceptance and farmers' opinion, BR7697-15-4-4-2-2 was recommended for PVT.

B. Aman 2014 (DWR). Two advanced lines: BR224-2B-2-5 and BR5915-B-7 along with Gabura (ck) and existing local check of the respective area were tested at farmers' field in five locations (Table 6). But the trials at Habiganj (Baniachong) was abandoned due to some unavoidable situation. Yield performance of all the

Table 3. Grain yield (t/ha), growth duration, TGW and plant height of some advanced lines under ALART (Salinity) grown in different locations of Bangladesh during T. Aman 2014.

Genotype	Location								Growth duration (day)	TGW (g)	Plant ht (cm)
	Grain yield (t/ha)										
	L1	L2	L3	L4	L5	L6	L7	Mean	Mean	Mean	Mean
IR73055-8-1-1-3-1	4.03	3.60	3.75	2.95	3.53	4.23	4.49	3.80	125	23.5	106
IR83484-3-B-7-1-1-1	4.15	2.76	3.10	2.91	3.80	4.25	4.41	3.63	124	23.3	105
IR78761-B-SATBI-68-6	4.38	3.56	3.00	3.60	3.67	4.46	4.64	3.90	123	23.8	108
IR83440-4-B-11-2-1-1-AJYI-B	3.90	2.79	2.92	3.36	3.28	3.75	4.45	3.49	124	23.6	103
IR77092-B-2R-B-10	4.67	3.86	4.20	3.62	4.51	4.55	5.03	4.35	140	23.4	112
BR9377-9-21-3B	3.80	1.71	4.07	4.48	5.02	4.57	5.11	4.11	149	24.3	125
BRRI dhan41 (ck)	3.85	2.34	4.10	4.34	4.67	4.54	5.06	4.13	147	23.7	122
BRRI dhan54 (ck)	4.25	1.35	4.30	3.56	4.36	4.41	4.78	3.86	137	23.8	119
LSD (5%)				0.46				0.17	0.4	0.2	1.1

L1-Satkhira (Debhata), L2-Satkhira (Shymnagar), L3-Satkhira (Kaliganj), L4-Khulna (Batiaghata), L5-Khulna (Dumuria), L6-Bagerhat (Morelganj), L7-Patuakhali (Kalapara).

Table 4. Grain yield (t/ha), growth duration, TGW and plant height of some advanced lines under ALART (RLR) grown in different locations of Bangladesh during T. Aman 2014.

Genotype	Location											Growth uration (day)	TGW (g)	Plant ht (cm)
	Grain yield (t/ha)													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Mean	Mean	Mean	Mean
BR7468-12-1-1-1-1	5.70	5.48	4.60	3.40	5.38	3.94	4.30	3.74	4.11	5.12	4.58	130	20.80	109
BR7472-16-2-1-2-1	5.61	5.59	4.73	4.00	5.38	3.66	4.07	4.11	4.05	5.25	4.64	130	20.66	110
BR7638-7-2-5-2	5.71	5.67	5.35	3.67	5.23	3.59	5.57	4.16	5.42	5.39	4.98	136	21.72	110
BRRI dhan32 ck	5.00	4.45	5.00	4.60	5.78	4.24	5.34	4.23	4.80	5.31	4.88	132	21.03	121
BRRI dhan49 ck	5.53	5.06	5.96	5.00	5.47	4.00	5.54	4.41	4.90	5.34	5.11	136	19.80	102
LSD (5%)					0.44						0.13	0.41	0.22	0.68

L1-Jessore (Jhikorgacha), L2-Barisal (Sadar), L3-Chittagong (Hathazari), L4-Comilla (Muradnagar), L5-Kishoreganj (Pakundia), L6-Satkhira (Sadar), L7-Sylhet (Sadar), L8-Rajshahi (Godagari), L9-Gazipur (BRRI), L10-Kushtia (Sadar).

Table 5. Grain yield (t/ha), growth duration, TGW and plant height of some advanced lines under ALART (PQR) grown in different locations of Bangladesh in T. Aman 2014.

Genotype	Location											Growth uration (day)	TGW (g)	Plant ht (cm)
	Grain yield (t/ha)													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	Mean	Mean	Mean	Mean
BR7697-15-4-4-2-1	4.54	5.00	5.10	4.80	3.80	5.20	3.74	5.00	3.50	3.70	4.44	131	22.2	122
BR7697-15-4-4-2-2	4.33	5.40	5.27	4.60	4.50	5.10	4.67	4.90	3.60	3.90	4.63	131	21.5	121
BR7697-16-2-2-1-1	3.77	4.90	5.23	4.96	4.11	5.31	4.00	4.70	3.30	4.00	4.43	134	22.7	120
BR7369-52-3-2-1-1	4.03	5.00	5.00	4.50	4.00	4.82	4.00	4.30	3.10	3.69	4.24	131	23.8	122
BRRI dhan37 ck	4.00	4.60	3.74	2.90	3.31	3.68	4.48	3.50	3.00	2.66	3.59	148	16.7	130
LSD (5%)					04 7						0.15	0.43	0.23	4.55

L1-Chittagong (Hathazari), L2-Kushtia (Sadar), L3-Jessore (Jhikorgacha), L4-Satkhira (Sadar), L5-Rajshahi (Godagari), L6-Kishoreganj (Pakundia), L7-Sylhet (Sadar), L8-Barisal (Sadar), L9-Gazipur (BRRI), L10-Comilla (Muradnagar).

DW genotypes was very poor. In all locations except Tangail and Comilla, local check variety gave higher yield than the tested lines and check variety Gabura. At Tangail and Comilla, all the entries including checks gave statistically similar yield. Farmers did not prefer the advanced lines due to lower yield and longer duration. On the other hand, they preferred their respective local varieties. So, none of the advanced lines was recommended for PVT.

Table 6. Grain yield (t/ha), growth duration and TGW of some advanced lines under ALART (DWR) grown in different locations of Bangladesh during B. Aman 2014.

Genotype	Location						Growth duration (day)	TGW (g)
	Grain yield (t/ha)							
	L1	L2	L3	L4	L5	Mean	Mean	Mean
BR224-2B-2-5	1.91	2.02	1.98	1.98	1.99	1.98	179	24.43
BR5915-B-7	2.03	1.92	1.80	1.89	1.91	1.90	176	24.73
Gabura (ck)	1.10	1.99	1.70	1.83	1.99	1.92	174	25.08
Local (ck)	2.28	2.14	2.15	2.03	1.98	2.11	170	24.82
	Sarsaria	Dhaldigi	Horinchamra	Hijoldiga	Khama			
LSD (5%)			0.20			0.09	0.22	0.25

L1-Sirajganj (Tarash), L2- Pabna (Bera), L3- Manikganj (Shibaloy), L4-Comilla (Homna), L5-Tangail (Basail).

Boro 2015 (PQR). Three premium quality advanced lines: BR7781-10-2-3-2, BR7369-10-5-2-3 and BR7369-52-3-2-1-1 along with BRRI dhan50 and BRRI dhan63 as checks were tested at farmers' field in 12 locations (Table 7). Among the lines, BR7781-10-2-3-2 gave the highest mean yield (5.84 t/ha), ranged 5.32-6.66 t/ha. Considering grain yield (5.84 t/ha), growth duration (155 days), grain size, phenotypic acceptance and farmers' opinion, BR7781-10-2-3-2 was recommended for PVT.

Boro 2015 (MER). Two micronutrient enriched advanced lines: BR7833-11-1-1-3-4 and BR7830-16-1-5-9-9 along with BRRI dhan28 and BRRI dhan64 as checks were tested at farmers' field in 12 locations (Table 8). Considering all required characteristics, none of the advanced lines was found suitable for PVT.

Boro 2015 (Short duration). NERICA Mutant along with BRRI dhan28 and BRRI dhan45 as checks were evaluated at farmers' field in 12 locations (Table 9). Grain yield ranging from 5.06 to 7.10 t/ha in different locations, NERICA Mutant gave higher average yield (6.08 t/ha) than the check varieties BRRI dhan28 (5.87 t/ha) and BRRI dhan45 (5.61 t/ha). Average growth duration of NERICA Mutant was 148 days, which was four and six days longer than BRRI dhan28 (144 days) and BRRI dhan45 (142 days) respectively. Considering several aspects, NERICA Mutant was recommended for PVT.

Boro 2015 (Cold tolerant). Three cold tolerant rice genotypes: IR77496-31-2-1-3-1, BR7812-19-1-6-1-P4 and BR7813-1-1-3-1 along with BRRI dhan28 and BRRI dhan36 as checks were evaluated at farmers' field in 10 cold prone areas (Table 10). Farmers did not show so much interest about the advanced lines compared to BRRI dhan28, although some yield advantage was found in advanced lines. Considering grain yield,

Table 7. Grain yield (t/ha), growth duration, TGW and plant height of some advanced lines under ALART (PQR) grown in different locations of Bangladesh during Boro 2015.

Genotype	Location													Growth duration (day)	TGW (g)	Plant ht (cm)
	Grain yield (t/ha)															
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	Mean	Mean	Mean	Mean
BR7781-10-2-3-2	5.56	6.30	5.51	6.13	5.62	5.53	5.32	6.66	5.36	6.47	5.77	5.47	5.84	155	17.0	104
BR7369-10-5-2-3	5.21	6.20	4.63	5.62	5.16	5.02	4.74	6.26	5.41	6.05	5.72	5.42	5.45	160	23.6	106
BR7369-52-3-2-1-1	5.23	6.51	5.37	5.90	5.25	5.16	5.00	6.64	4.87	5.76	6.07	5.53	5.61	157	24.7	101
BRRI dhan50 (ck)	5.68	6.40	6.12	5.71	5.90	5.65	5.38	6.51	5.10	5.96	5.62	5.53	5.80	156	19.5	85
BRRI dhan63 (ck)	5.24	6.46	5.65	5.64	5.77	4.80	5.22	6.60	5.11	6.13	5.46	5.39	5.62	153	21.2	87
$LSD_{0.05}$						0.46							0.13	0.3	0.22	1.1

L1-Barisal (Sadar), L2-Chittagong (Hathazari), L3-Comilla (Muradnagar), L4-Gazipur (BRRI), L5-Habiganj (Sadar), L6-Khulna (Dumuria), L7-Kishoreganj (Pakundia), L8-Kushtia (Sadar), L9-Pabna (Sadar), L10-Rangpur (Sadar), L11-Satkhira (Sadar), L12-Nilphamari (Syedpur).

Table 8. Grain yield (t/ha), growth duration, TGW and plant height of some advanced lines under ALART (MER) grown in different locations of Bangladesh during Boro 2015.

Genotype	Location													Growth duration (day)	TGW (g)	Plant ht (cm)
	Grain yield (t/ha)															
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	Mean	Mean	Mean	Mean
BR7833-11-1-1-3-4	6.24	6.59	5.94	5.39	5.84	5.75	5.25	6.25	5.29	5.72	6.10	6.31	5.89	152	30.1	85
BR7830-16-1-5-9-9	5.80	6.44	6.35	6.06	5.58	5.74	5.95	6.80	5.94	6.53	5.65	6.68	6.12	153	27.1	99
BRRIdhan28 (ck)	6.30	6.41	5.84	5.22	5.60	6.09	5.94	6.20	5.80	6.71	5.89	5.97	6.00	143	22.9	96
BRRIdhan64 (ck)	5.65	5.52	5.29	5.45	6.20	5.42	5.55	6.32	5.89	6.20	5.52	6.12	5.76	152	25.5	102
$LSD_{0.05}$						0.69							0.20	0.79	0.31	0.95

L1-Barisal (Sadar), L2-Chittagong (Hathazari), L3-Comilla (Muradnagar), L4-Gazipur (BRRI), L5-Khulna (Durmuria), L6-Kishoreganj (Pakundia), L7-Kushtia (Sadar), L8-Pabna (Sadar), L9-Rangpur (Sadar), L10-Satkhira (Sadar), L11-Nilphamari (Syedpur), L12-Habiganj (Sadar).

Table 9. Grain yield (t/ha), growth duration, TGW and plant height of some advanced lines under ALART (Short duration) grown in different locations of Bangladesh during Boro 2015.

Genotype	Location													Growth duration (day)	TGW (g)	Plant ht (cm)
	Grain yield (t/ha)															
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	Mean	Mean	Mean	Mean
NERICA Mutant	6.95	6.26	6.23	5.50	6.20	5.76	6.45	5.22	7.10	5.81	6.37	5.06	6.08	148	24.7	100
BRRI dhan28 (ck)	5.91	5.76	5.84	6.11	5.96	5.82	5.80	5.15	6.56	6.04	6.16	5.28	5.87	144	23.0	95
BRRI dhan45 (ck)	5.76	5.93	5.58	5.92	5.66	5.55	5.62	5.01	6.10	5.55	5.93	4.69	5.61	142	28.2	94
$LSD_{0.05}$						0.57							0.17	0.5	0.18	1

L1-Barisal (Sadar), L2-Chittagong (Hathazari), L3-Comilla (Muradnagar), L4-Gazipur (BRRI), L5-Habiganj (Sadar), L6-Khulna (Dumuria), L7-Kishoreganj (Pakundia), L8-Kushtia (Sadar), L9-Pabna (Sadar), L10-Rangpur (Sadar), L11-Satkhira (Sadar), L12-Nilphamari (Syedpur).

Table 10. Grain yield (t/ha), growth duration, TGW and plant height of some advanced lines under ALART (Cold Tolerant) grown in different locations of Bangladesh during Boro 2015.

Genotype	Location									Growth uration (day)	TGW (g)	Plant ht (cm)
	Grain yield (t/ha)											
	L1	L2	L3	L4	L5	L6	L7	L8	L9	Mean	Mean	Mean	Mean
IR77496-31-2-1-3-1	6.90	6.71	5.65	5.76	6.79	5.44	6.63	5.75	5.93	6.17	158	25.13	84
BR7812-19-1-6-1-P4	6.52	6.80	6.37	6.15	7.05	5.80	5.93	6.72	6.59	6.44	160	27.60	95
BR7813-1-1-3-1	6.85	6.52	5.75	6.35	7.51	5.90	6.75	5.75	6.96	6.48	156	25.13	96
BRRIdhan28 (ck)	6.45	5.35	5.80	6.02	6.70	5.81	6.15	5.85	6.20	6.04	144	21.59	93
BRRIdhan36 (ck)	5.25	5.12	4.82	4.75	5.25	6.20	5.75	5.55	5.66	5.37	145	23.21	88
LSD (5%)						041				0.14	1.13	0.30	1.86

L1-Dinajpur (Sadar), L2-Gazipur (BRRI), L3-Chuadanga (Alamdanga), L4-Naogaon (Sadar), L5-Pabna (Sadar), L6-Panchagor (Sadar), L7-Rangpur (Sadar), L8-Nilphamari (Syedpur), L9-Moulovibazar (Srimongol).

growth duration, grain type, disease reaction, phenotypic acceptance and farmers'opinion, none was found suitable for PVT.

On-farm evaluation of different urea applicator machines on growth and yield of Boro rice

The experiment was conducted at five farmers' fields. There were three treatments of urea application like using USG applicator, prilled urea applicator and hand broadcasting. Urea application using prilled urea applicator and hand broadcasting of urea gave significantly about 0.8 t/ha higher yield than USG applicator (Table 11). Plant growth was found uneven using USG applicator where as almost uniform plant growth was found using prilled urea applicator. The overall performance of

Table 11. Effect of different methods of urea application on grain yield and yield components of BRRI dhan58 in Boro season.

Treatment	Grain yield ($t\ ha^{-1}$)	Panicle m^{-2} (no.)	Grain $panicle^{-1}$ (no.)	Growth duration (day)	Plant ht (cm)
USG applicator	6.00	308	105	153	86
Prilled urea applicator	6.78	365	111	155	98
Hand broadcasting	6.88	366	112	155	100
$LSD_{0.05}$	0.30	11	9	4	4

prilled urea applicator was found as the best in respect to plant growth, grain yield and urea saving (about 30% compared to hand broadcasting). However, it needs cost-benefit economic analysis.

TECHNOLOGY DISSEMINATION

Seed production and dissemination programme

For rapid dissemination of newly released BRRI varieties among the farmers, Adaptive Research Division (ARD) conducts seed production and dissemination programme (SPDP) in every season of the year. This is an effective programme for the adoption of BRRI varieties through quality seed production at farmers' level.

SPDP, T. Aus 2014. SPDPs were conducted in 57 upazilas of 23 districts (Rajbari, Khulna, Bagerhat, Jessore, Chapainawbganj, Dinajpur, Gazipur, Comilla, Sylhet, Rangamati, Chittagong, Cox''s Bazar, Barisal, Jhalokathi, Patuakhali, Borguna, Kurigram, Nilphamari, Lalmonirhat, Kushtia, Meherpur, Chuadanga and Jhinaidah). BRRI dhan48 and BRRI dhan55 were used. Total production of two varieties was about 102 tons and farmers retained 12.5 tons seeds from those varieties for next year cultivation. About 9,684 farmers gained awareness about the varieties through field visits, discussion and knowledge sharing. About 2,751 farmers were motivated to cultivate these varieties in next year.

SPDP with USG, T. Aman 2014. SPDPs with USG were conducted in 67 upazilas of 29 districts (Rajbari, Khulna, Bagerhat, Jessore, Chapainawbganj, Dinajpur, Gazipur, Comilla, Sylhet, Rangamati, Chittagong, Cox's Bazar, Barisal, Patuakhali, Jhalokathi, Barguna, Nilphamari, Lalmolnirhat, Kurigram, Kushtia, Meherpur, Chuadanga, Jhinaidah, Narshingdi, Sherpur, Tangail, Netrakona, Mymensingh and Kishoreganj). Twelve varieties were used depending on local situation. Total production of those varieties was about 138 tons, from which 23 tons quality seeds were retained by the farmers for next year use. About 17,492 farmers gained knowledge about those varieties and the beneficial effect of USG and more than 5,597 farmers were motivated to cultivate those varieties and USG.

SPDP with USG, Boro 2015. SPDPs with USG were conducted in 42 upazilas of 25 districts (Gopalganj, Rajbari, Khulna, Sherpur, Netrokona, Kishoreganj, Brahman Baria, Rangamati, Cox's Bazar, Patuakhali, Jhalokathi, Barguna, Nilphamari, Lalmolnirhat, Kurigram, Kushtia, Meherpur, Chuadanga, Jhinaidah, Narshingdi, Tangail, Kishoreganj, Gazipur and Comilla). 10 varieties (BR16, BRRI dhan47, BRRI dhan50, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan61, BRRI dhan63, BRRI hybrid dhan2 and BRRI hybrid dhan3) were used depending on local situation. Total production of those varieties was 81 tons and farmers retained 18 tons seeds of those varieties for next year use. A total of 16,426 farmers gained awareness and knowledge through field visits, discussion and knowledge sharing and 5,755 farmers were motivated to adopt those varieties and USG.

Adaptive trials under IAPP

Adaptive trial helped farmers to choose the appropriate variety for their local situation. In adaptive trial a combination of some varieties were cultivated together in the farmers' field with one or two local standard checks.

T. Aus 2014. Four adaptive trials were conducted in four districts of Barisal region (Barisal, Jhalokathi, Patuakhali and Borguna). BR24, BRRI dhan27, BRRI dhan48, BRRI dhan55 and local check (Mala, Surayamoni and Gota IRRI) were used. Considering overall performance, BRRI dhan48 was found to be the most suitable variety in T. Aus in Barisal region.

T. Aman 2014. Seven adaptive trials were conducted in seven districts (Barisal, Jhalokathi, Patuakhali, Borguna, Nilphamari, Lalmonirhat and Kurigram). BRRI dhan41, BRRI dhan44, BRRI dhan49, BRRI dhan52 and local check (Jafor IRRI, Sadamota, Dudkalam) were used in Barisal region while BRRI dhan49, BRRI dhan56, BRRI dhan57, BRRI dhan62 and local check (Swarna, Binadhan-7) were used in Rangpur region. Considering overall performance, modern varieties were found suitable to cultivate in Barisal region, while Swarna was found as the most popular variety and thereafter BRRI dhan49 and BRRI dhan62. Farmers especially in the Rangpur region preferred Swarna for its higher grain yield, low inputs requirements, mild drought tolerance and minimum take care. Some farmers preferred BRRI dhan57 and BRRI dhan62 due its shorter growth duration and fine grain.

Boro 2015. Sixteen adaptive trials were conducted in eight districts. BRRI dhan47, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan61 and Bhajan (local check) were used in Barisal region while BRRI dhan29, BRRI dhan50, BRRI dhan55, BRRI dhan58, BRRI dhan59 and farmers seed of BRRI dhan28 as local check were used in Rangpur region. Considering grain yield, growth duration and farmers' opinion, BRRI dhan58 and BRRI dhan47 were found suitable for Barisal region and BRRI dhan58 and BRRI dhan50 were for Rangpur region.

Farmers training and promotional activities

Farmers' training. A total of 28 farmers' training were conducted at different locations in which a total of 930 trainees (844 farmers and 86 SAAOs of DAE) participated.

Field day/Farmers' rally. Seventy-five field days were conducted at different locations under different projects (IAPP, MIADP, EQSS) and GOB during reporting period. A total of 12,350 persons participated in those occasions. These programmes also generated much enthusiasm about modern rice production technologies and BRRI varieties, which helped rapid dissemination of technologies.

Seed production at BRRI farm

A total of 5.5 tons quality seeds of different BRRI varieties were produced, which were used for follow up adaptive research trials.

Training Division

SUMMARY

The Training Division has conducted 74 training programmes in the reporting period with course duration from 3-day to one week. A total of 1,381 participants from different government and non-government organizations were trained through these courses. Need based course curriculum was developed for these courses. The highest number of participants were from the Department of Agricultural Extension (DAE). The overall improvement of knowledge for extension personnel in 1-week rice production training (RPT) varied widely and ranged from 235 to 304%. The improvement results show the importance of rice production training (RPT) for extension personnel. Effectiveness of imparted trainings was determined on the basis of feedback remarks on different aspects. Most of the trainees expressed positive views about the course content and method of training. However, participants of all the courses, specially the 1-week course, suggested for increasing duration of the course from 1-week to at least 2-3 weeks. Most of the BRRI's speakers' performance was very good to excellent.

TRAINING NEED ASSESSMENT

A need assessment session was conducted at the beginning of each batch of training to know the expectation of the trainees. A total of 1,881 responses on different issues were received from the trainees of which 583 from regular batches, 875 from Enhancement of Quality Seed Supply Project (EQSSP), 305 from Mujibnagar Integrated Agricultural Development Project (MIADP) and 38 from Integrated Agricultural Productivity Project (IAPP) (Table 1). Among the responses 1,798 was received from SAAOs and 83 from extension agents of NGO. Though the participants were different categories and from different regions and environments of the country, their expectations were very much similar. Specially the SAAOs showed high expectation about insect and disease management followed by variety related issues. On the other hand, NGO participants showed the highest interest about seed production followed by variety and fertilizer related issues.

CAPACITY BUILDING AND TECHNOLOGY TRANSFER

One-week rice production training
The main objectives of the course was to train the field level extension workers of DAE and the project staff (SA and scientists). The course curriculum was designed based on the priority of field problems related to rice production and rice based technologies. A total of 804 personnel were trained (170 SAAO from regular batches, 461 SAAO from EQSSP, 40 scientists, SAAO,SA and CF from IAPP and 123 SAAO and NGO personnel from MIADP Project (Table 2).

Knowledge improvement was assessed based on the marks obtained in benchmark and final evaluation of individual participants. Average improvement of the participants from regular, EQSSP, IAPP and MIADP was 235, 310, 295 and 304% respectively (Table 3). Table 4 presents the performance status of 1-week rice production for different categories of participants.

Quality rice seed production and storage
A total of 32 training programmes on seed production, processing and storage were conducted in 2014-15. The participants of these courses were Upazila Agriculture Officer (UAO) and Agriculture Extension Officer (AEO) of DAE, Assistant Director (AD) and Senior Assistant Director (SAD) of BADC, field level officers of BRAC, SAAO of DAE, Scientific Assistant (SA) of IAPP, BRRI and Community Facilitator (CF) of IAPP, DAE. For these courses funds of EQSSP and IAPP were used. Table 5 presents the details of the training course.

Training information of BRRI
During the reporting period, 72 training programmes have been conducted by the Training Division of BRRI (Table 6).

Table 1. Expectations by the trainees on different subjects in need during 2014-15.

Subject/issue	Expectation (%)							
	SAAO						NGO	Rank
	Regular	EQSSP	Mujibnagar	IAPP	All	Rank		
Disease	19	18	20	21	20	1	6	5
Insect	18	15	17	15	16	2	4	6
Variety	13	11	10	13	12	3	18	2
Rice growth	6	4	7	5	6	6	3	7
Fertilizer	7	10	6	4	7	5	10	3
Hybrid	8	7	6	5	7	5	5	5
Soil	3	6	5	6	5	7	3	7
Crop management	5	4	6	5	5	7	5	5
IWM	4	2	8	6	5	7	8	4
Seed	10	11	4	12	9	4	30	1
Weed	3	3	4	3	3	8	2	8
Others	4	9	7	8	7	5	13	
Total	100	100	100	100	100		100	
Response (no.)	583	875	305	35	1798		83	

Table 2. One week rice production training conducted by BRRI in 2014-15.

Project	Batch (no.)	Participants (no.)			Designation	Organization
		Total	Male	Female		
Regular (GOB)	9	170	162	8	SAAO	DAE
EQSSP	25	471	419	52	SAAO, NGO	DAE, PKSF
IAPP	2	40	34	6	Scientists, SAAO, SA	DAE, BRRI, IAPP
MIADP	6	123	115	8	SAAO, Dip. Agril.	DAE, NGO
Total	-	804	730	74		

Table 3. Knowledge gain and improvement through 1-week rice production training during 2014-15.

Project	Evaluation (average mark %)		Improvement (%)
	Benchmark	Final evaluation	
Regular	23.66	76.17	235
EQSSP	17.71	79.50	310
IAPP	24.32	75.76	295
MIADP	19.16	70.83	304
Average	21.21	75.56	286

Table 4. Performance status of 1-week rice production training in 2014-15.

Project	Category of results/certificates		
	Distinction	Satisfectory	Prticipatory
Regular	76	86	8
EQSSP	86	334	51
IAPP	26	10	4
MIADP	42	68	13
Average	58	125	76

Table 5. Particulars of quality rice seed production and storage training during 2013-14.

Project	Batch (no.)	Participants (no.)			Designation	Organization
		Total	Male	Female		
EQSSP	24	418	365	53	UAO, AEO, AD, SAD and NGO Off.	BADC, DAE, PKSF
IAAP	8	159	154	5	SAAO, CF	DAE, IAPP
Total	32	577	519	58		

Table 6. Total training conducted by Training Division in 2014-15.

Name	Training (no.)	Duration	Participants (no.)			Designation
			M	F	Total	
Rice production training (Regular)	9	1-week	162	8	170	SAAO/Officers
Integrated rice production (MIADP)	6	1-week	115	8	123	SAAO, NGO Officers
Integrated rice production training and data collection (IAPP)	1	5 days	20	0	20	SAAO/SA/CF
Experimental design and data analysis (IAPP)	1	5 days	20	14	6	Scientists
Rice production training (EQSSP)	25	1-week	419	52	471	SAAO
Quality rice seed production, processing and storage (IAPP)	8	3-day	154	5	159	SAAO/CF
Rice seed production, processing and storage (EQSSP)	24	3-day	365	53	418	UAO, AEO, AD, SAD, BRAC Officers
Total	74		1,249	132	1,381	

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 were compiled and analyzed. This study reveals that one week RPT course is very much helpful for the trainees to build up their capacity for modern rice production activities.

Performance of BRRI speakers

Ten batches of one week RPT were considered for this evaluation. At first, batch wise analysis was done on the basis of five criteria for each speakers. The five criteria were as follows: a. style of presentation; b. question handling; c. use of training materials; d. time management and e. quality and relevance of handout and its timely supply. Average of 5 criteria was used to determine the performance of individual speaker in each batch. The overall performances of BRRI's speakers' were very good (36.82%) to excellent (42.39%) in both long and short courses.

UPDATING BRKB

Training division is working to develop and update information on all BRRI released technologies in a digital form through Bangladesh Rice Knowledge Bank (BRKB). One of the objectives of this work is to redesign and make the BRKB user friendly with latest rice information. During the reporting period seven new fact sheets on newly released rice varieties were prepared and uploaded in BRKB website.

Publications and Public Relations Division

SUMMARY

The Publications and Public Relations Division is dedicated to documentation and dissemination of information regarding BRRI developed technologies and more so that good relations with the target people or stakeholders are maintained.

To achieve this goal in the reporting year the division has been engaged in different activities that included editorial services for publications and other communication materials, maintaining public relations through distribution of books, leaflets, folders, seasonal greeting cards, advertisements etc, attending different meetings, radio and TV programmes, writing and disseminating press releases, articles for the social and print media, participating in workshop, seminar, fairs, training programmes home and abroad.

In the reporting year, we produced 26,150 copies of 12 publications with 1,416 pages in Bangla and English and distributed 21,791 copies of different publications from the existing stock of 273 publications issued so far. We got 831 written requisitions for publications in the reporting year. The division supplied BRRI publications to 1, 381 participants of government and non-government organizations of 74 training programmes held in BRRI. In addition we provided publications to 566 visitors from home and abroad and issued dozens of press releases in national mass media. More than 50 news items and popular articles were published about BRRI in national dailies and periodicals in addition to radio and television coverage.

PUBLICATION

In the reporting year this division produced 26,150 copies of 12 publications (Table 1) with 1,416 pages in Bangla and English. That means we have had to edit and process on average four pages per day in addition to other activities. The forms of these publications include annual reports, newsletters, book, booklets, journals, diary and seasonal greeting cards. A trend change about BRRI publications can be mentioned here. From this year we started to print BRRI newsletter as a regular quarterly publication in Bangla and English. Our Director General's seasonal greeting cards have been given the shape of a regular publication adding latest technology information.

Annual Report (English, 1,050 copies). We published three volumes of BRRI Annual Reports in the reporting year. These were: BRRI Annual Report for 2011-12, BRRI Annual Report for 2012-13 and BRRI Annual Report for 2013-14. In total these 1,416-page publications report mainly on research findings and related activities of the Institute illustrated with tables and figures on a yearly basis. BRRI Annual Report also lists working scientists and officials and put forward achievements of the Institute in a Director General's note. This publication consists of a summary of research works carried out by 19 research divisions and nine regional stations of the institute in a financial year. The document contains significant portions of the research covering seven programme areas, such as crop-soil-water management, rice farming systems, pest management, socio-economics and policy, technology transfer and farm mechanization representing the broader conceptual frameworks of BRRI activities.

Dhan Gobeshana Samachar (Bilingual, 9,500 copies). In the reporting period, we printed three volumes of quarterly rice newsletters having 32 pages in total. In the past it was published in Bangla and primarily addressed to extension workers, educated farmers and other people who were especially interested to BRRI activities. But since January 2015 BRRI authority decided to publish it both in Bangla and English so that even our foreign partners can use it to be updated about BRRI research and other activities. It acts as an effective channel for the transfer of appropriate rice technology to farmers and extension agents who might confront manifold field problems and require instructions. It is distributed among agricultural extension officials up to the upazila level and to mass media and concerned organizations.

Adhunik Dhaner Chash (Bangla, 10,000 copies). It is one of the most important BRRI publications on BRRI developed technologies and modern rice cultivation practices. To the extension agents, farmers, agricultural scientists, students as well as policy makers, its demand is very high.

Table 1. BRRI publications printed in 2014-15.

Name	Language	Target audience	Copy (no.)
Annual Report 2011-12	English	Scientists, Administrator Policy makers	350
Annual Report 2012-13	English	Scientists, Administrator Policy makers	350
Annual Report 2013-14	English	Scientists, Administrator Policy makers	350
Dhan Gobeshana Samachar (Special Issue), Jun-Jul 2014	Bangla/English	Scientists, Extensionists Farmers, Policy makers	5,000
Dhan Gobeshana Samachar, Jan-Mar 2015	Bangla/English	Scientists, Extensionists Farmers, Policy makers	2,500
Dhan Gobeshana Samachar, Apr-Jun 2015	Bangla/English	Scientists, Extensionists Farmers, Policy makers	2,000
Adhunik Dhaner Chash, May 2015	Bangla	Scientists, Extensionists Farmers, Policy makers	10,000
About BRRI 2014	English	Scientists, Extensionists Policy makers	3,000
Bangladesh Rice Journal, Vol. 17	English	Scientists	300
Bangladesh Rice Journal, Vol. 18	English	Scientists	300
BRRI Diary 2015	Bangla	Scientists, Extensionists Farmers, Policy makers	500
Seasonal Greetings: Eid Card/ New Year Card	Bangla/English	Scientists, Extensionists Farmers, Policy makers	2,000
Total			26,150

Some people describe it as the bible of rice cultivation in this country. We published the 80-page booklet in four colours with glossy papers. The book contains almost all the essential information about BRRI developed rice varieties along with their management practices in the field level those are suitable to the 30 agri-ecological zones of the country.

About BRRI (English, 3000 copies). PPRD published About BRRI, a 52-page booklet in September 2014. It contains a brief introduction about BRRI focusing on its past, present and future plans as well as major achievements, current programmes and projects with colourful photos and descriptions. Its intended audience is the foreign partners and the local policy makers as well as the other stakeholders.

Bangladesh Rice Journal (English, 600 copies). In the reporting period, we published two volumes (17 and 18) of the Bangladesh Rice Journal, a scientific publication of BRRI. The journal is a peer reviewed publication based on original research findings dedicated to rice science.

BRRI Diary (Bangla, 500 copies). We started to publish BRRI Diary in a comparative new form in 2015. Earlier it was published as a simple telephone directory. In the reporting year its shape and size has been changed and has been given a complete diary form. Almost all the essential information to contact BRRI has been added to it. Detailed information regarding concerned ministries and partner organizations including phone numbers and email IDs of BRRI scientists and officials is also available in it.

Seasonal Greetings (Bangla and English, 2,000 copies). In recent times BRRI Director General's seasonal greetings have been given a shape of useful publication. In an experimental approach we put in it some information as like as BRRI developed new rice varieties and detailed contact addresses of the institute along with prints of art work and colourful photographs. Similarly, it is distributed to our target audience/readers with our regular publications on the occasion of two Eid festivals and two new years--Bangla and Christian.

DISTRIBUTION OF PUBLICATIONS

PPRD distributed 21,791 copies of different publications from the existing stock of 273 publications issued so far. Extension or agricultural officials constitute the major part of the target audiences of BRRI publications. They receive BRRI publications mainly through the Training Division. PPRD also directly supplies publications to different groups of people on request. Most of the requests come from farmers, students, researchers, agricultural institutes, GO-NGOs, schools, colleges and universities, visitors from home and abroad.

PUBLIC RELATIONS

The division maintained contact with the mass media and government and semi-government organizations and distributed publications and contributed in organizing annual research review workshop and cooperated with the management to deal with the visitors. PPRD people distributed 21,791 copies of different publications from the existing stock of 273 publications issued so far. We got 831 written requisitions for publications in the reporting year. In addition to that now and then we have had to answer queries about BRRI technologies of newsmen and other stakeholders over telephone and through personal communication. We have had to write rejoinders and clarifications to newspapers to dispel misleading information about BRRI as well as rice related issues. The division supplied BRRI publications to 1, 381 participants of government and non-government organizations of 74 training programmes held in BRRI. In addition we provided publications to hundreds of visitors from home and abroad and issued dozens of press releases in national mass media about BRRI activities. More than 50 news items and popular articles were published about BRRI in national dailies and periodicals in addition to regular radio and television coverage. As the voice of BRRI we also proposed 40 titles of radio programmes for the BRRI scientists and most of them were broadcast in the *krishi bishoiok kerjokram* of the Bangladesh Betar.

Most receivers included extension workers, researchers, educated farmers, students and visitors. They also distributed publications to listed organizations and individuals, including libraries. In addition, we have processed and distributed 34 display advertisements about BRRI in the reporting year that have been published in different newspapers and periodicals.

BRRI RS, Barisal

SUMMARY

A total of 1016 seeds were selected from the crosses. In F_1 population five out of 12 was selected and confirmed. A total of 90, 67 and 51 progenies were selected from F_2, F_3 and F_7 population, respectively.

In total, 15 lines were selected in observational trial (OT). On the basis of maximum yield production and seedling height, only six entries namely BR8452-5-4-1-1-1, BR8470-7-1-1-2-HR1, BR8470-14-2-2-2-HR2, BR8470-17-2-2-3-HR5, BR8469-6-1-3-1-1 and BR8462-18-1-2-1-HR4 were selected for further evaluation from PYT1.

On the basis of maximum yield production and seedling height, only two entries namely BR8472-21-1-1-1-HR2, BR8164-43-2-1-HR2 from PYT2; seven entries viz BR7941-41-2-2-2-4, BR7941-45-2-2-2-1, BR7941-45-2-2-2-1, BR7844-3-2-2-1-1, BR7847-47-3-3-2-2-2-2-1, BR7849-5-2-2-2-2-4, BR7943-53-1-2-1 from SYT and four entries such as BR7941-119-1-2-1, BR7941-30-1-1-1, BR7941-116-1-2-1, BR7941-41-2-2-4 from AYT were selected for further evaluation.

In the proposed variety trial, salt tolerant line IR7861-B-SATB1-28-3-24 produced higher yield than the check variety BRRI dhan53; Zn-rich line BR7528-2R-19-HR10 produced higher yield than the check variety BRRI dhan39; Rainfed lowland rice line BR7622-5-1-1-1 gave higher yield than both the checks and BR7472-16-2-1-2-3 gave higher yield than one check BRRI dhan39; PQR line BR7357-11-2-4-1-1 produced higher yield than the check variety BRRI dhan37. In Boro season, the highest grain yield was obtained by the proposed variety BR7671-37-2-2-3-7 followed by BR7833-11-1-1-2-1-2B5. However growth duration of both the advanced lines was 2 to 8 days earlier than the check variety BRRI dhan64.

Higher mean % DI and DS were observed in irrigated land (33.9% and 3.3 respectively) than that of rainfed land (16.2% and 1.7). Maximum 70% DI and seven DS on Kumragoir was recorded in Aman while maximum 90% DI and nine DS on BRRI dhan61 was recorded in Barisal region. Trooper 75WP and Nativo performed better in reducing leaf and neck blast disease incidence around 80% over control at farmers' field under natural field condition.

Based on the premium quality rice grain, higher yield, growth duration and farmers' opinion, BR7781-10-2-3-2, NERICA mutant and zinc enriched BR7833-11-1-1-3-4 may be considered for further research programme.

Between the two locations and among the six varieties, BRRI dhan58 performed the best and gave the highest mean grain yield (7.54 t/ha). The lowest yield (5.40 t/ha) was observed in BRRI dhan61.

BRRI RS, Barisal conducted 13 farmers' training in different locations of Barisal region during Boro 2015. In total 390 persons (303 males and 87 females) were trained to create awareness for adopting the BRRI rice production technologies and to accelerate the dissemination rate of BRRI varieties in those areas.

In total eight field days were conducted where around 1,400 audience of farmers, researchers, extension providers, NGO personnel, administrative people, public leaders participated. Many farmers of Barisal region expressed their contentment to the variety BRRI dhan62 in Aman and BRRI dhan64 in Boro due to short growth duration, zinc content and satisfactory grain yield.

The rainwater harvest technique is sufficient to stabilize T. Aman rice yield in drought prone scenarios. The mean grain yield increased by 5.09% under research management compared to farmer's management but ranged from 3.87 to 6.36%. Irrigation water could be saved 15.23 to 31.06% following the AWD method depending on the texture of the soil in Barisal region. AWD method requires about 22.68% less money compared to farmer's practice when using diesel operated LLP in Boro. Proper management with 3-4 supplemental irrigations at early stage could increased yield up to 1-18% compared to farmer's practice in Aus. Average water productivity also increased marginally from 0.42 to 0.43 by following research management practice.

The highest yield was observed in BRRI hybrid dhan2 (6.61 t ha^{-1}) followed by BRRI hybrid dhan3 (6.55 tha^{-1}). The lowest yield was found in BR17 (3.89 tha^{-1}) under stability analysis of BRRI released boro varieties.

Under IAPP programme the highest average yield was found in BRRI dhan48 (5.19 t/ha) followed by BRRI dhan43 (4.32 t/ha) in Aus. In Aman, BRRI dhan54 produced the highest yield on average of 5.31 t/ha followed by BRRI dhan44 (5.16 t/ha) and BRRI dhan53 (4.99 t/ha). In Boro, the highest average yield was found in BRRI dhan59 (7.39 t/ha) followed by BRRI dhan60 (7.33 t/ha).

The results of on-station adaptive trial of BRRI dhan44-Sub1 lines reveal that the two lines BR9158-19-9-6-9-17 (3) and BR9158-19-9-6-9-50 (4) gave the highest yield compared to the check however those are not statistically significant.

Under PGB-IADP programme, the highest yield of 5.074 t ha^{-1} was recorded from BRRI dhan48 in Aus. In Aman, the highest yield (5.97 t/ha) was recorded in BRRI dhan49. On the other hand, BRRI dhan64 (6.86 t/ha) was the highest grain yielder in Boro.

Under the programme of Harvest Plus Bangladesh, an average yield of 3.92 t/ha was recorded in BRRI dhan62 in Aman season. The average yield of BRRI dhan64 was 6.11 t/ha in Barisal region in Boro 2014-15.

Under the programme of EQSS project, maximum yield (7.36 t/ha) of BRRI dhan64 was obtained at Jhalakathi while minimum yield (5.35 t/ha) was recorded at Doulatkhan upzilla of Bhola District. The average yield of BRRI dhan64 was 6.64 t/ha in Barisal region in Boro 2014-15.

A total of 5.9 ton and 18.5 ton breeder seed was produced in T. Aman 2014 and Boro 2014-15 respectively. During the reporting year, around 50 plant samples from farmers' field have been diagnosed and necessary solutions have been advocated. In addition, several rice fields have been visited with the request of farmers, DAE personnel and local representatives.

VARIETAL DEVELOPMENT

Tidal submergence tolerant rice in T. Aman

Under these project, 10 experiments were conducted, which were hybridization, F_1 confirmation, selection of F_2 population, selection from F_3 generation at the pedigree nursery, selection from F_7 generation at the pedigree nursery, observational trial (OT), preliminary yield trial-1 (PYT-1), preliminary yield trial-2 (PYT-2), secondary yield trial (SYT) and advanced yield trial (AYT).

A total of 1016 seeds were selected from twelve crossing combination of tidal submergence tolerant rice. In F_1 confirmation, five lines namely BR7840-54-1-2-5/Dudkalam, BR7840-54-1-2-5/Lalswarna, BR7840-54-1-2-5/Sadamota, IR75862-208-B-B-HR1/Chikor and BR7830-16-1-5-3/Sadamota were selected and confirmed. Ten F_2 populations with approximately 2500-3000 progenies for each cross were grown in pedigree nursery. A total number of 90 progenies were selected from F_2 population. Out of 76 progenies from F_3 generations only 67 were selected. A total of 76 progenies from F_7 generations were grown from where 51 were selected. Out of 210 entries, 15 lines were selected in observational trial (OT) for tidal submergence tolerant rice in T. Aman 2014 at BRRI RS, Barisal.

Thirty genotypes in preliminary yield trial-1 (PYT-1) and 30 genotypes in preliminary yield trial-2 (PYT-2) were evaluated. On the basis of maximum yield production and seedling height, only six entries namely BR8452-5-4-1-1-1, BR8470-7-1-1-2-HR1, BR8470-14-2-2-2-HR2, BR8470-17-2-2-3-HR5, BR8469-6-1-3-1-1, BR8462-18-1-2-1-HR4 for PYT-1 and two entries-BR8472-21-1-1-1-HR2, BR8164-43-2-1-HR2 for PYT-2 were selected for further evaluation.

Eleven genotypes were evaluated in secondary yield trial (SYT) for tidal submergence tolerant rice in T. Aman 2014. Sadamota, Dudkalam and BRRI dhan44 were used as checks. On the basis of maximum yield production and seedling height, only seven entries namely BR7941-41-2-2-2-4, BR7941-45-2-2-2-1, BR7941-45-2-2-2-1, BR7844-3-2-2-1-1, BR7847-47-3-3-2-2-2-2-1, BR7849-5-2-2-2-2-4, BR7943-53-1-2-1 were selected for further evaluation.

In advanced yield trial (AYT) for tidal submergence tolerant rice, four genotypes were evaluated along with three checks as they were used in SYT. On the basis of maximum yield production and seedling height, only four entries namely BR7941-119-1-2-1, BR7941-30-1-1-1, BR7941-116-1-2-1, BR7941-41-2-2-4 were selected for further evaluation.

REGIONAL YIELD TRIAL (RYT)

Regional yield trial for T. Aman. Three advanced lines IR70213-10-CPA 4-2-2-2, B 10533 F-KN-12-2, BR8033-2-2-1-2 along with two checks BRRI dhan32 (ck), BRRI dhan49 (ck) were tested for rainfed low land rice. Both of the advanced lines produced lower yield than the standard check BRRI dhan32, but they were very similar to BRRI dhan49. Growth duration was also closer among the tested materials than BRRI dhan32. In another RYT for RLR (short duration), six advanced lines WAS122-IDSA 14-WAS B-FKR 1 (NERICA-L-8), WAS 122-INDSA 1-WAS-2-B-1-TGR132 (NERICA-L-16), WAS 161-B-6-B-1 (NERICA-L-36), WAS 161-B-4-B-1-TGR-51 (NERICA-L-32), WAS 191-4-10 (NERICA-L-54), NERICA Mutant along with two checks BRRI dhan49 (ck) and BRRI dhan56 (ck) were tested. All of the advanced lines produced lower yield than the standard check BRRI dhan49. Growth duration was lower among the tested materials than BRRI dhan49. Eight advanced lines BR8226-8-5-2-2, BR8226-11-4-4-3, BR8226-11-4-6-2, BR8294-1-3-2-2, BR8226-13-1-2, BR8226-17-1-2, BR8227-6-2-1, BR8515-23-6-3 along with two checks BRRI dhan34 (ck), BRRI dhan37 (ck) were tested for premium quality rice. All of the advanced lines except BR8226-11-4-6-2, and BR8515-23-6-3 produced higher yield than standard check BRRI dhan34 and BRRI dhan37. Out of seven advanced lines for micro nutrient enriched rice, only three (BR7879-17-2-4-HR3-P1, BR7671-37-2-2-3-7-3, BR8143-15-2-1) produced higher yield than the standard check BRRI dhan32 but except BR7840-54-3-2-2. The others were very similar to BRRI dhan39 in response to yield. Four advanced lines along with two checks BRRI dhan39, BRRI dhan56 were tested for Green Super Rice. Both of the advanced lines produced similar yield than the standard check BRRI dhan39 but very higher yield than BRRI dhan56.

Regional yield trial for Boro. Five advanced lines along with two checks BRRI dhan50, BRRI dhan63 were tested for premium quality rice. Advanced lines IR77734-93-2-3-2 and BR8079-52-2-2-2 gave 5.18 and 5.83 t/ha yield respectively, which was higher than standard checks. Based on the yield performance IR77734-93-2-3-2 and BR8079-52-2-2-2 may be recommended for further process. One advanced line along with two checks BRRI dhan28, BRRI dhan45 were tested for short duration rice. Advanced line NERICA mutant gave higher yield, which was higher than standard checks. Based on the yield performance NERICA mutant may be recommended for further process. Ten advanced lines along with two checks BRRI dhan28 and BRRI dhan29 as well as BRRI dhan60 were tested for favourable Boro rice. Advanced lines BR7783-AC12-3, BR7783-AC13-5, BR7783-AC14-5 and BR7783-AC6-3-2-2-1 gave 7.03, 6.45, 6.80 and 6.46 t/ha yield respectively, which was higher than standard checks. Based on the yield performance BR7783-AC12-3, BR7783-AC13-5, BR7783-AC14-5 and BR7783-AC6-3-2-2-1 may be recommended for further process. Nine advanced lines along with two checks BRRI dhan28, BRRI dhan29 were tested for micronutrient rice. All the advanced lines produced similar or higher yield than BRRI dhan28 but gave lower yield than BRRI29. Based on the yield performance BR7833-19-2-3-5 BR8261-19-1-1-3, BR7820-18-1-6-3-P4, BR7881-62-2-3-7-P3 and BR7879-17-2-4-HR3-P1 may be recommended for further process. Five advanced lines along with two checks BRRI dhan29, BRRI dhan60 were tested for green super rice. Based on the yield performance HHZ15-SAL13-Y1, HHZ23-DT16-DT1-DT1, HHZ15-DT4-DT1-Y1, HHZ11-DT7-SAL1-SAL1 and HHZ6-SAL3-Y1-SUB2 may be recommended for further process. Four advanced lines along with one check BRRI dhan28 was tested for short duration rice. Advanced lines BR8072-AC5-4-2-1-2-1, BR8072-AC7-4-1-2-2-1, BR8072-AC8-1-1-3-1-1 and BR8072-AC11-2-3-2-1-1 gave higher yield than standard check, which may be recommended for further process. One advanced lines BR6158RWBC2-2-1-1 along with two checks BRRI dhan58 and BRRI dhan29 were tested for high yielding rice. Advanced lines BR6158RWBC2-2-1-1 gave higher yield than the standard checks.

PROPOSED VARIETY TRIAL (PVT)

Proposed variety trial for T. Aman. Two lines were evaluated for salt tolerant Aman rice 2014 at

Barisal. The proposed variety IR7861-B-SATB1-28-3-24 produced higher yield than the check variety BRRI dhan53 at both the locations. One line was evaluated for zinc enriched Aman rice. The proposed variety BR7528-2R-19-HR10 produced higher yield than the check variety BRRI dhan53 at both the locations. Two lines were evaluated for rainfed low land Aman rice. The proposed variety BR7622-5-1-1-1 gave higher yield than both the checks and BR7472-16-2-1-2-3 gave higher yield than one check. One line was evaluated for premium quality Aman rice. The proposed variety BR7357-11-2-4-1-1 produced higher yield than the check variety BRRI dhan37.

Proposed variety trial for Boro. Two lines were evaluated for zinc enriched rice in Boro 2014-15 at Barisal. The highest grain yield was obtained from the proposed variety BR7671-37-2-2-3-7 followed by BR7833-11-1-1-2-1-2B5. However, growth duration of both the advanced lines was 2 to 8 days earlier than the check variety BRRI dhan64.

PEST MANAGEMENT

Survey and epidemiology of rice blast diseases in Barisal region

Survey on rice blast was conducted in farmers' fields of Barisal region (AEZ 13 of Tidal Floodplain and some parts of that regions covering AEZ 12 of Low Ganges River Floodplain) of Bangladesh representing Barisal sadar, Jhalakhati, Patuakhali, Borguna, Pirojpur and Bhola districts.

Maximum 70% disease incidence (DI) and seven disease severity (DS) on Kumragoir was recorded at Agailjhara of Barisal district, respectively followed by 55% and seven on the same cultivar at Taltoli of Barguna district. Other popular cultivars BRRI dhan34 and BRRI dhan44 were also infected by this disease across the location having 20-40% DI and 1-5 DS. Sakkorkhora was one of the popular local Aman cultivars in this region where maximum 25% DI and three DS were recorded at Charkhali of Pirojpur district. Out of 36 fields visited during Boro season, the disease was found in 27 fields under six districts. Maximum 90% DI and nine DS on BRRI dhan61 was recorded at Barisal, respectively followed by 70% and seven on BRRI dhan47 at the same district. At Jhalakathi district, BRRI dhan28 was observed with 70% DI and five DS. Another popular cultivar BRRI dhan29 was also infected by this disease across the location having 25-60% DI and 3-7 DS. Neck blast did not affect BRRI dhan55 and BRRI dhan58 across the locations. Higher mean % DI and DS were observed in irrigated land (Boro season) (33.9% and 3.3 respectively) than that of rainfed land (Transplanting Aman season) (16.2% and 1.7 respectively).

Management of rice blast diseases in Barisal region

The experiment was conducted at farmers' field of Barisal under natural field condition. Trooper 75 WP and Nativo performed better in reducing leaf blast disease incidence >80% over control (Table 1). Around 70% panicles of disease control plot were infected by neck blast where disease severity scale varied from 5-9. Trooper 75 WP and Nativo suppressed 76.5% and 80.5% neck blast incidence, respectively over control.

TECHNOLOGY TRANSFER

Advanced line adaptive research trial (ALART)

ALART, Boro 2014-15. Three premium quality advanced lines: BR7781-10-2-3-2, BR7369-10-5-2-3 and BR7369-52-3-2-1-1 along with BRRI dhan50 and BRRI dhan63 as checks were tested for PQR. Based on premium quality rice grain, higher yield, growth duration and farmers' opinion, BR7781-10-2-3-2 may be considered for further research programme. Two micronutrient dense advanced lines BR7833-11-1-1-3-4 and BR7830-16-1-5-9-9 along with BRRI dhan28 and BRRI dhan64 as checks were tested. Based on micronutrient (zinc) enriched, higher yield, grain type, growth duration and farmers' opinion, BR7833-11-1-1-3-4 may be considered for further research programme. One short duration advanced line NERICA mutant along with BRRI dhan28 and BRRI dhan45 as checks were tested. Based on higher yield, grain type, growth duration and farmers' opinion, NERICA mutant may be considered for further research programme.

Table 1. Efficacy of fungicides against leaf and neck blast disease.

Commercial name	Active ingradient (a.i.)	Rate	Leaf infection (%)	Neck blast reduction over control (%)
Trooper 75 WP	Tricyclazole	400 g/ha	11.5 (80.8*)	76.5
Nativo	Trifloxytrobin+ Tabuconazole	250 g/ha	10.0 (83.3*)	80.5
Untreated control		60.0		Around 70% panicles were infected by neck blast and disease severity scale varied from 5-9

*Percent reduction of leaf area infection over untreated control.

Adaptive trials of different BRRI released varieties during Boro 2014-15

Two adaptive trials were conducted in two upazilas of Barisal district (Barisal sadar and Agailjhara) under IAPP during Boro 2014-15. BRRI dhan47, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan61 and BR8 (Farmer's seed as local check) were used as cultivar in Barisal sadar while BRRI dhan47, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan61 and BRRI dhan29 (Farmer's seed as local check) were used. BRRI dhan58 was found suitable variety for both the location of Barisal district in Boro season. Most farmers preferred BRRI dhan58 for higher yield and good crop stand. Farmers prefered BRRI dhan47 for bold grain in Barisal.

CROP-SOIL-WATER MANAGEMENT

Demonstration of supplemental irrigation application to mitigate early drought effected during T. Aus 2014

Four demonstrations were executed at Amtoli, Barguna; Barguna sadar; Patuakhali sadar and Rajapur, Jhalokathi. Farmer's land was divided into two plots. One was selected as research plot and another plot was considered as farmer's plot. Research plot followed the research management and farmer's plot followed farmer's management. BRRI dhan48 was the test variety for the selected farmer's field. In Barisal region, yield performance of BRRI dhan48 is promising. At early stage it is required to establish the crop by supplemental irrigation which depends on rainfall.

Demonstration of water management technologies at farmer's field in T. Aman

Ten demonstrations were conducted at Amtoli, Barguna; Barguna sadar; Betagi, Barguna; Kalapara, Patuakhali and Jhalokathi sadar. Due to high tidal pressure no supplemental irrigation was applied at research plot whereas farmer's plot was considered as rain fed. In the rainwater harvesting demonstration, research plot adopted 15 cm. levee height for sufficient rainwater conservation under rainfed condition whereas farmer's plot followed farmer's practice. Rainfall was measured in the experimental site with a rain Gage. BRRI dhan52 was the test variety for the selected farmer's field. In Barisal region during T. Aman drought did not occurred, so supplemental irrigation was not essential. In levee management practice, preparation of higher levee than normal practice around the rice field conserves rainwater during rainy season. It can harvest rainwater, which is subjected to waste, serve rice water demand during T. Aman season.

Adoption and demonstration of water saving technologies at farmer's fields in Boro

The adoption and demonstration programme of water saving technology was conducted at five upazilas of Barisal region. Sadar and Betagi upazilas of Barguna, sadar and Kalapara upazilas of Patuakhali and Syedpur and Nolcity upazilas of Jhalokathi districts were selected in Boro 2014-15. All demonstration plots were selected as diesel operated LLP. AWD tools were installed in the research plots, whereas farmer's plots followed the farmer's practice. BRRI dhan28 and BRRI dhan47 were the test varieties during the demonstration.

Irrigation water could be saved 15.23% to 31.06% following the AWD method depending on the texture of the soil in Barisal region. About three to five of irrigations and about Tk 2,731 could be saved by adopting AWD method in this region. So, AWD method requires about 22.68% less money compared to farmer's practice when using diesel operated LLP. The highest water productivity was 0.85 kg/m^3 of BRRI dhan28 at Nolcity upazila of Jhalokati district and the lowest was 0.55 kg/m^3 of

BRRI dhan47 at Kalapara upazila of Patuakhali district under AWD method. The highest water productivity by farmer's practice was 0.62 kg/m^3 and the lowest was 0.43 kg/m^3 at Betagi upazila of Barguna and Nolcity upazila of Jhalokati district respectively. The average water productivity under AWD and farmer's practice were 0.69 kg/m^3 and 0.51 kg/m^3 respectively. But there was no significant yield difference between AWD and farmer's practice.

SOCIO-ECONOMICS AND POLICY

Stability analysis of BRRI released variety in T. Aman 2014 and Boro 2014-15

A study was accomplished at the Sagordi farm of BRRI RS, Barisal during Aman 14 and Boro 2014-15 seasons. Different BRRI released varieties were grown. Due to frequent tidal submergence, experiment in Aman season was fully damaged. The highest yield was observed in BRRI hybrid dhan2 (6.61 t ha^{-1}) followed by BRRI hybrid dhan3 (6.55 tha^{-1}). The lowest yield was found in BR17 (3.89 tha^{-1}). In most of the cases yield was low compared to standard yield because of higher seedling ages (62 days) than the recommended one.

INTEGRATED AGRICULTURAL PRODUCTIVITY PROJECT (IAPP)

Demonstration and validation trial of BRRI modern varieties in different locations

Twelve trials were conducted to demonstrate three modern Aus varieties viz BRRI dhan27, BRRI dhan48 and BRRI dhan43. The highest average yield (5.19 t/ha) was found in BRRI dhan48 followed by BRRI dhan43 (4.32 t/ha). The longest maturity days were found in BRRI dhan27 (114) followed by BRRI dhan48 (110). Maximum farmers were motivated to grow BRRI dhan48 in Aus season and they wished to store seed of BRRI dhan48 for next year cultivation.

In T. Aman 2014, twelve newly introgressed BRRI dhan44-Sub1 lines were evaluated at farmers' fields along with two standard checks. Two entries viz BR9158-19-9-6-9-93 (6) and BR9158-19-9-6-9-60 (5) gave higher yield though they did not differ significantly with the checks. One adaptive trial was conducted at BRRI RS, Barisal. The on-station adaptive trial results revealed that the two lines BR9158-19-9-6-9-17 (3) and BR9158-19-9-6-9-50 (4) gave significantly higher yield than the check BRRI dhan52.

Eleven demonstration trials were conducted in different upazilas of Barisal region to demonstrate five modern T. Aman varieties viz BRRI dhan44, BRRI dhan62, BRRI dhan53 and BRRI dhan54 in T. Aman 2014. BRRI dhan54 produced the highest yield on average of 5.31 t/ha followed by BRRI dhan44 (5.16 t/ha) and BRRI dhan53 (4.99 t/ha). Higher maturity date was found in BRRI dhan44 (148) and lower in BRRI dhan62 (99).

Six validation trials were conducted in Aguiljara, Barisal; Banaripara, Barisal; Nalcity, Jhalokathi; Kalaparah, Patuakhali; Betagi, Barguna and sadar, Barguna to evaluate five modern Boro rice varieties viz BRRI dhan59, BRRI dhan60, BRRI dhan61, BRRI dhan64 and BRRI dhan68 in Boro 2014-15 season. In the selected area the average yield of all the BRRI varieties were more than 7 t/ha. The highest average yield was found in BRRI dhan59 (7.39 t/ha) followed by BRRI dhan60 (7.33 t/ha). The longest maturity days was observed in BRRI dhan59 (149) followed by BRRI dhan60 (148) and BRRI dhan61 (148).

PIROJPUR-BAGERHAT-GOPALGANJ (PGB) INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT (IADP): BRRI COMPONENT

Demonstration of BRRI modern varieties in different locations of Barisal region

Aus varieties BRRI dhan27, BRRI dhan43 and BRRI dhan48 were grown at Najirpur upazila. BRRI dhan27 and BRRI dhan48 were grown at Mollahat upazila. The highest yield of 5.074 t ha^{-1} and 4.68 t ha^{-1} was produced by BRRI dhan48 in both the demonstration sites. The yield of BRRI dhan27 was 3.87 t ha^{-1}in Mollarhat upazila. Aman varieties BRRI dhan33, BRRI dhan39, BRRI dhan41, BRRI dhan44, BRRI dhan49, BRRI dhan52, BRRI dhan57 and BRRI dhan62 were grown under different locations of Bagerhat and Pirojpur districts. The highest yield (5.97 t/ha) was recorded in BRRI dhan49 at Najirpur, Pirojpur followed by the same variety in different locations of Najirpur. BRRI dhan44 produced 5.38 t/ha at Fakirhat, Bagerhat district. Newly introduced BRRI dhan62 gave 3.71-3.85 t/ha grain yield in different locations. The farmers' of that locality expressed their contentment to the variety BRRI dhan62 due to short growth duration, zinc content and satisfactory grain yield. In Boro varieties the highest grain yield of BRRI dhan64 (6.86 t/ha) was recorded at Mollahat and the lowest at Najirpur (6.71 t/ha). Average grain yield of BRRI dhan64 in these areas was 6.67 t/ha. The farmers' of that locality expressed their contentment to this variety due to zinc content and satisfactory grain yield.

HARVESTPLUS, BANGLADESH

Demonstration of BRRI dhan62 and BRRI dhan64. Eleven demonstrations of BRRI dhan62 and 25 demonstrations of BRRI dhan64 were conducted at different locations of Barisal and Bhola districts during Aman and Boro respectively. Interested farmers were selected with the help of DAE personnel. The highest yield (3.92 t/ha) was recorded at two spots of Najirpur, Pirojpur while the lowest yield was observed at the field of Debdas Buddo, Najirpur, Pirojpur. The average yield of BRRI dhan62 was 3.74 t/ha in Barisal region in T. Aman 2014 under harvest plus project.

The highest yield (7.85 t/ha) was recorded at Ujirpur, Barisal while the lowest was observed at Bhola sadar, Bhola. The average yield of BRRI dhan64 was 6.11 t/ha in Barisal region in Boro 2014-15. Some fields were heavily infected by leaf blast and neck blast as well. Grain yield was low in those fields.

FARMERS' TRAINING AND FIELD DAY

BRRI RS, Barisal conducted 13 farmers' training in different locations of Barisal region during Boro 2014-15. These training programmes were conducted at Borhanuddin, Bhola (02); Barguna sadar, Barguna (3); Nolcity, Jhalokati (2); Babuganj, Barisal (2) and at Baufal, Patuakhali (1) under EQSS project; at Nazirpur, Pirojpur (2) under PGB project and one at Baufal, Patuakhali under HarvestPlus project. Total 390 persons (303 males and 87 females) were trained. These programmes helped the farmers to create awareness for adopting the BRRI rice production technologies and to accelerate the dissemination rate of BRRI varieties in those areas. And they confidently increase the farmers' income as well as improve the livelihood through practicing the farming systems approach.

In total eight field days were conducted in collaboration with DAE under IAPP (Banaripara-1, Nolcity-1), EQSS (Bhola-2, Barguna sadar-1 and Babuganj-1), PGB (Nazirpur-1) and HarvestPlus (Barguna Sadar-1) project at Barisal region. Around 1400 audience of farmers, researchers, extension providers, NGO personnel, administrative people and public leaders were sincerely participated on these programmes.

BREEDER SEED PRODUCTION

During the year 2014-15 in both Aman and Boro, BRRI RS, Barisal produced the 5,922 kg of breeder seed in Aman season and 18,500 kg of breeder seed in Boro seson (Table 2).

Table 2. Breeder seed production in Aman 2014 and Boro 2014-15.

Variety	Quantity (kg)	Project
	Aman 2014	
BR 23	1040	EQSS
BRRI dhan41	522	EQSS
BRRI dhan44	400	EQSS
BRRI dhan52	2200	EQSS
BRRI dhan27	485	IAPP
BRRI dhan41	400	IAPP
BRRI dhan44	700	IAPP
BRRI dhan48	175	IAPP
Total	5,922	
	Boro 2014-15	
BR 26	4500	EQSS
BRRI dhan58	3000	EQSS
BRRI dhan61	2500	EQSS
BRRI dhan58	6000	IAPP
BRRI dhan61	2500	IAPP
Total	18,500	

BRRI RS, Bhanga

Varietal development

A total of 1,221 individual progenies were selected from segregating population. Thirty-four uniform entries were selected from observational trial of 265 genotypes considering yield advantage over check varieties having similar or less growth duration, amylose and grain zinc content for further evaluation in replicated trial. Seventeen promising lines were selected from SYT based on yield advantage and growth duration similar to or than the check varieties, amylose content and brown rice zinc content.

In Regional Yield Trial (RYT) for B. Aus, BR7699-2B-3-13-3 produced significantly 0.43 t higher grain yield (2.03 t/ha) with five days longer growth duration, followed by BR7587-2B-3 (1.85 t/ha) with three days longer growth duration than the check variety BRRI dhan43. In case of RYT for T. Aus, BR7708-62-1-1 produced 0.69 t significantly higher grain yield than the check variety BRRI dhan43 with four days earlier growth duration. In RYT of T. Aman, BR8143-15-2-1 produced 2.37 t higher grain yield than the check variety BRRI dhan32 with similar growth duration. While the line BR7840-54-3-2-2 produced 2.4 t higher yield than the check BRRI dhan39 with almost similar growth duration. For Boro season in RYT-FB, BR7988-10-4-1 produced the highest grain yield (7.85 t/ha) followed by BR7783-AC12-3 (7.80 t/ha), which was statistically non-significant than the check variety BRRI dhan29 but having significant earlier growth duration than the check. In RYT-PQR, BR8079-52-2-2-2 produced about 0.5 t higher yield than the check variety BRRI dhan50 with similar growth duration. In RYT-PQR(COM), BR7372-18-3-3-HR3(Com) produced the highest grain yield (6.63 t/ha), which was significantly higher than BRRI dhan50 with four days longer growth duration. In RYT-GSR, HHZ15-DT4-DT1-Y1 produced the highest grain yield (6.72 t/ha) followed by HHZ6-SAL3-Y1-SUB2 (6.44 t/ha), which were significantly higher than that of BRRI dhan60 with four days longer growth duration. In RYT-MER, the lines BR8261-19-1-1-3 (6.91 t/ha) and BR8257-37-1-2-2 (6.77 t/ha) over-yielded BRRI dhan28 by 1 t/ha with statistically similar growth duration. In RYT-SD, NERICA mutant produced 6.64 t/ha grain yield, which was statistically similar to that of the check varieties of BRRI dhan45 and BRRI dhan28 with 2-3 days longer growth duration. In RYT-SD (Bio), BR8072-AC8-1-1-3-1-1 produced the highest grain yield (5.44 t/ha) followed by BR8072AC11-2-3-2-1-1 (5.36 t/ha) which were statistically identical to that of BRRI dhan28 (5.29 t/ha) with almost similar growth duration. In case of RYT-Biotech, BR6158RWBC2-2-1-1 produced the highest grain yield (6.87 t/ha), which was statistically similar to that of check varieties BRRI dhan29 (6.55 t/ha) with almost similar growth duration.

In proposed variety trial (PVT) for T. Aman, the promising genotype BR7528-2R-19-HR10 produced 0.34 t/ha higher grain yield than the check variety BRRI dhan39 with eight days longer growth duration. In PVT for Boro, the promising line BR7671-37-2-2-3-7 significantly out-yielded the check variety BRRI dhan64 by about 1.5 t/ha with almost similar growth duration. In INGER trial, most of the materials were late maturing. No suitable entries could be selected for further trial or even as parents for future hybridization. In stability analysis of BRRI released Aman varieties, BR25 gave the highest grain yield (5.4 t/ha) followed by BRRI dhan52 (4.72 t/ha). In stability analysis of BRRI released modern rice varieties for Boro season, BRRI dhan60 and BRRI hybrid dhan1 gave the highest grain yield (8.3 t/ha) followed by BR8 (8.27 t/ha). BR17, BR18, BR19 and also BR8 lodged at maturity.

Agronomic management

From an experiment to determine seed rate in dry seed bed condition in T. Aman season, the interaction and seed bed management gave insignificant yield and panicle production. However, grain yield among the entries were significant. Therefore farmers of Faridpur region could practice the dry seed bed condition to grow seedlings instead of buying that from neighbouring districts.

Farm machinery and post harvest technology

There were some activities under FMTD (Farm Machinery Technology Development and Dissemination) Project under BRRI regional station, Bhanga, Faridpur during 2014-15. The main activities under the project at BRRI RS, Bhanga were to sell agricultural machinery to the farmers with 60% government subsidy and setting up demonstration trial in the farmers' field by the use of machines. The agricultural machinery sold under the project were BRRI Paddy-Wheat Thresher, BRRI Paddy Thresher, BRRI Winnower, BRRI Prilled Urea Applicator, BRRI Weeder and BRRI Rice-Wheat Reaper.

Technology transfer

Validation and adoption trial of BRRI dhan62 and BRRI dhan33 at Gopalganj district under PGB-IADP conducted in 22 farmers' plot showed slightly higher grain yield of BRRI dhan62 (4.75 t/ha) than BRRI dhan33 (4.67 t/ha) with 15-19 days early maturity. Farmers showed interest to grow BRRI dhan62 for its early maturing ability and slender grain type. BRRI released modern rice varieties viz BRRI dhan50, BRRI dhan58, BRRI dhan60, BRRI dhan63, BRRI dhan64 and BRRI dhan68 were distributed among 19 farmers in Gopalganj Sadar, Kashiani, Muksudpur, Tungipara and Kotalipara upazilas of Gopalganj district to validate the performance of the newly released Boro rice varieties. For slender grain type and high yield potential, farmers preferred BRRI dhan50, BRRI dhan58, BRRI dhan60 and BRRI dhan63.

Seed production at BRRI RS, Bhanga farm was about 36.5 tons during Boro season in 2014-15. Enhanced Quality Seed Supply Project provided support to produce about 16 tons of breeder seed of BRRI dhan28 and BRRI dhan29. Under Harvest Plus project support around 2.5 tons quality seed of the promising line BR7833-11-1-1-2-1-2B5 (as proposed variety) was produced. Also, around 18 tons of TLS of different varieties was produced in this farm using GOB fund. About nine tons of good quality seed of BRRI dhan50, BRRI dhan55, BRRI dhan58, BRRI dhan60, BRRI dhan63, BRRI dhan64 and BRRI dhan68 were produced in ten farmers' fields in greater Faridpur region under EQSS project. BRRI Bhanga organized 13 training programmes to educate 385 farmers.

BRRI RS, Comilla

SUMMARY

Altogether 37 crosses were made and 34 crosses were confirmed during T. Aman and Boro at BRRI regional station, Comilla. From F_2, F_3, F_4, F_5 and F_6 generations 992, 653, 1187, 257 and 107 plant progenies with desirable plant type and high yield potential were selected respectively. Eight homozygous lines were bulked under the varietal development programme. Three genotypes were selected from observational trial (OT) for uniformity in desirable characters and high yield potential. During T. Aman and Boro seasons 16 and 20 genotypes were selected from IRLON and IIRON respectively with diverse genetic background having earliness, good grain type, compact panicle, lodging resistance, disease and insect resistance and high yield potential.

During T. Aus, considering the yield (4.6 t/ha) and good phenotypic performance BR7718-55-1-3 was selected from RYT#1.

During T. Aman, in PYT#1 (Com) IR08L181, 08FAN1, IRRI 132 and IR09L305 were selected for their satisfactory yield performance (4.6-5.1 t/ha) as compared with standard checks (4.1-5.5 t/ha). In PYT#2 (Com) BR7357-11-2-4-1-1-HR3, BRC245-4-19-2-1 and BR7369-16-5-2-3-1 were selected for their satisfactory yield performance (4.7-5.3 t/ha) as compared with standard checks (5.5 t/ha). BRC316-1-1-1 and BRC316-2-2-1 were selected from PYT#3 for high yield potential (4.4-5.2 t/ha) as compared with standard checks (3-4.6 t/ha).

From Boro, BRC297-15-1-1-was selected in PYT#1 for high yield performance (6.5 t/ha) and seven days earliness as compared with standard checks (6.2-6.7 t/ha and 145 days growth duration). From RYT#2 BRC270-2-1-1-2, BRC319-9-1-5 and BRC319-9-1-4 were selected for giving 0.5-1.4 t/ha higher yield than standard checks (5.4- 5.6 t/ha). Considering yield (5.3-5.7 t/ha) and growth duration (143-146 days) BRC298-2-1-2-2 and BRC297-12-3-1-1 were selected as compared with standard checks (5.3- 6.7 t/ha and 146-160 days).

IRRI NILs lines IR64-NIL5{IR64(qTSN4.4-YP9)} and IR101686-1-1{NSIC 158(qTSN4.1-YP4)} gave satisfactory yield (5.3- 5.7 t/ha) as compared with checks (5.7-6.0 t/ha). This experiment is needed to further evaluate for late showing.

During T. Aman season, IR70213-10-CPA4-2-2-2 and B10533F-KN-12-2 were selected in RYT#1 (RLR) for earliness (10 days) and satisfactory yield potential (5.6 t/ha) as compared with standard checks (5.8 6.1 t/ha and 130 days growth duration). Considering yield (5.6 t/ha) and growth duration (121 days) WAS122-IDSA14-WASB-FK1 (NERICA-L-8) was selected from RYT#2 (RLR). In RYT#3 (PQR), BR8226-8-5-2-2, BR8226-11-4-4-3, BR8227-6-2-1 and BR8226-17-1-2 were selected for high yield potential (5-5.7 t/ha) as compared with standard checks (2.8-3.1 t/ha). BR7840-54-3-2-2 and BR8418-1-3 were selected for giving 1 t/ha higher yield and showing 11-14 days earlier than standard check BRRI dhan32 (4.2 t/ha yield and 132 days growth duration) and performed similar yield and growth duration as compared with standard check BRRI dhan39 from RYT#4 (MER). From RYT#5 (GSR), considering yield performance (4.5-4.7 t/ha) IR83340-B-28-B and HHZ5-SAL10-DT1-DT1 were selected as compared with standard checks.

In RYT#3 ((Short duration), NERICA mutant was selected for giving higher yield (6.1 t/ha) than standard checks (5.1 t/ha). In RYT#4 (Favourable Boro) BR7683-30-3-3-4 was selected for its yield potential (6.0 t/ha) and similar growth duration (145 days) as compared with standard checks (5.6-5.7 t/ha) BRRI dhan28 and BRRI dhan60. Considering high yield performance (6.2- 7.1 t/ha) genotypes BR8257-37-1-2-2, BR7833-19-2-3-5, BR8261-19-1-13 and BR7879-17-2-4-HR3-P1 were selected from RYT#5 (Micronutrient) as compared with BRRI dhan28 (5.3 t/ha). In RYT#6 (GSR) HHZ23-DT16-DT1-DT1 and HHZ15-SAL13-Y1 were selected for giving 0.5-1.5 t/ha higher yield than all checks (6-6.4 t/ha). In RYT#1 (Biotech) BR4909-R1-R2 was selected for high yield potential than BRRI dhan28 (4.2 t/ha). From RYT#2 (Biotech) genotype BR6158RWBC2-2-1-1 was selected for higher yield (8.3 t/ha) as compared with standard checks (5.8-7.6 t/ha).

For T. Amman, in AYT#1 (PQR), BR7697-15-4-4-2-1 and BR7697-15-4-4-2-2 were selected for high yield potential (4.8-5.1 t/ha) as compared with standard checks (2.7-4.1 t/ha). In AYT#2 (RLR) considering the yield performance (5.2-5.6 t/ha) genotypes BR7638-7-2-5-2 and AL-29 were selected as compared with standard checks (3.9-5.5 t/ha).

From Boro, in AYT#Com, BR7781-10-3-2-2, BR7358-35-2-1-1 and HHZ23-DT16-DT1-DT1 were selected for high yield potential (5.7-6.5 t/ha) and good phenotypic appearance as compared with standard checks (4.5- 7.0 t/ha).

In AYT#Regional, BR7800-63-1-7-3, BR7781-10-2-3-2, BR7812-19-1-6-1-P4 and BR8245-2-1-4 were selected for high yield potential (6.5-7.1 t/ha), good phenotypic appearance as compared with standard checks (6.0-6.3 t/ha).

In T. Aus, 750 kg BRRI dhan48 breeder seeds were produced. In T. Aman 6150 kg BRRI dhan49, 825 kg BRRI dhan57 and 1800 kg BR10 breeder seeds were produced. In Boro, 9,975 kg BRRI dhan28, 11,250 kg BRRI dhan29, 980 kg BRRI dhan50, 2,775 kg BRRI dhan58 and 6825 kg BRRI dhan69 breeder seeds were produced.

In Boro, both BRRI dhan28 and BRRI dhan62 produced the highest yield on 1 December seeding and BRRI dhan62 yielded higher (8.22 t/ha) than BRRI dhan28 (7.34) having growth duration 140 days and 137 days respectively. In Aman, all the varieties gave higher yield on 1 July seeding and yield decreased with the advent of time.

In Aman season, false smut was the most prevalent among the diseases and found in most of the varieties/lines of BRRI RS, Comilla farm. Incidence (27%) and severity of false smut disease was more in BRRI dhan49 compared to other varieties/ lines. The varieties BR11, BR22, BRRI dhan32 and BRRI dhan46 showed highly susceptible to Tungro disease with 20-55% incidences and 5-9 severity scale. In Boro season, the highest incidence (25%) of neck blast disease was recorded in BRRI dhan64 and the lowest in BRRI dhan58.

In Aman, yield of 27 varieties, ranged from 2.8-5.33 t/ha and showed growth duration ranged from 105-149 days. Considering yield, top five varieties were BRRI hybrid dhan4 (5.33 t/ha), BRRI dhan49 (5.25 t/ha), BRRI dhan44 (5.06 t/06), BRRI dhan46 (4.98 t/ha), and BRRI dhan31 (4.92 t/ha). In Boro, among the 32 varieties, the top most five varieties were BRRI hybrid dhan3 (8.79 t/ha), BRRI hybrid dhan2 (8.48 t/ha), BRRI dhan55 (7.31t/ha), BRRI dhan60 (7.23 t/ha) and BRRI dhan58 (7.15 t/ha) and showed growth duration ranged from 145-147 days.

The advantage in RCM plots over farmers' was 0.38 t/ha. Farmers used 229 kg TSP and 72 kg MOP per hectare on average, which was 179 kg and 30 kg higher TSP and MOP respectively than the RCM recommendation. They used 68 kg less urea on average than the RCM recommendation, which was 252 kg/ha. They did not use any gypsum while the RCM recommendation was 42 kg/ha.

In Aus, average yield of BRRI dhan48 was 4.78 t/ha having duration 108 days. Number of motivated farmer was 500 and amount of produced seed was 6.6 t/ha. Ten demonstrations in Aman and 10 demonstrations in Boro were conducted through EQSS and 25 demonstrations in Aman were conducted in Boro through Harvest Plus. Twenty-eight farmers' training (day long), three SAAO training (day long), 15 field days were conducted on rice production technologies by BRRI RS, Comilla during the reporting year. The regional station also participated in two numbers three-day-long agriculture and tree fairs, one-day-long seed fair and three motivational tours.

VARIETAL DEVELOPMENT

T. Aus

Regional yield trial (RYT). Eleven genotypes were evaluated in RYT#1 and RYT#2 at BRRI RS, Comilla against the standard checks BRRI dhan48 and BR26 to evaluate the advanced breeding lines for development of variety suitable for Comilla region. Twenty-five to thirty-day-old seedlings were transplanted using 2-3 seedlings per hill with the spacing of 20 cm × 15 cm. The unit plot size was 5.4m × 10 rows. The experiment was laid out in RCB design with three replications. Fertilizer doses were 60:15:40:10 kg/ha NPKS with all the amount of P, K and S was applied at the time of final land preparation. N was applied in two splits at 10 and 30 days after transplanting. Crop management such as weeding, disease and insect pests control were done in time. In RYT#1, BR7718-55-1-3 gave (4.6 t/ha) higher yield as compared with BR26 and similar with BRRI dhan48 and showed uniformity at flowering and maturity stage and 127 days growth duration. So, considering the yield and phenotypic performance genotype BR7718-55-1-3 was selected from RYT#1 (Table 1).

Note: This experiment plot has been submerged for 8-10 days after one week transplanting and 18-20 days water logged during maturity due to heavy rainfall.

Rainfed lowland rice (RLR) ecosystem (T. Aman)

Hybridization. Thirty-seven crosses were made using 39 parents for development of improved genotypes with high yield potential along with earliness, photoperiod sensitivity, acceptable grain quality and resistance to diseases and insect pests.

F_1 confirmation. Nine crosses and their respective parents were grown. The crosses were confirmed and registered in BRRI RS, Comilla cross list with station code BRC456 to BRC464.

Growing of F_2 population. F_2 seeds of 15 crosses along with their parents were grown for selection of progenies with emphasis on earliness, plant type, grain type, number of effective tiller and high yield potential than the standard varieties. A total of 578 plant progenies were selected from population of 15 crosses.

Pedigree nursery (F_3, F_4, F_5 and F_7 generations). From the segregating populations 362 F_3, 499 F_4, 111 F_5 and 14 F_7 progenies were grown for selection of desirable progenies with emphasis on plant type, earliness, grain type and grain colour, tolerance to lodging and better phenotypic acceptance over the standard varieties. From F_3, F_4 and F_5 generation 480, 486 and 156 plant were selected respectively and eight breeding lines were bulked from F_7 generation.

Observational trial (OT). One observational trial containing seven genotypes were grown along with standard checks viz BRRI dhan49, BRRI dhan56, BRRI dhan57, BINA dhan7 and BINA dhan13 for selection of genetically fixed lines with uniform plant height, heading, plant type, and grain type along with high yield potential. Each genotype was grown in a 5.4 m × 4 rows plot with a spacing of 20 cm ×15 cm using single seedling per hill for transplanting. Thirty-day-old seedlings were used for transplanting. Fertilizer doses were 100:20:50 kg/ha NPK with all amounts of P and K applied at the time of final land preparation. N was applied in three splits at 15, 30 and 45 days after transplanting. Gypsum and zinc sulphate @ 100 and 10 kg/ha were applied during land preparation. Other cultural operations were done as and when necessary. Three genotypes BRC308-1-1-1-6, BRC315-14-2-3-4, BRC316-26-2-2-1 were selected from OT.

Preliminary yield trial (PYT). In total, 25 genotypes were evaluated in PYT#1 (Com), PYT#2 (Com) and PYT#3 (Com) at BRRI RS, Comilla against standard checks BRRI dhan39, BRRI dhan44, BRRI dhan49, BRRI dhan56, BRRI dhan57, BINA dhan-7 and IR64 for initial yield evaluation and selection of desirable lines. Thirty-

Table 1. Yield and agronomic performance of breeding materials of regional yield trial (RYT), T. Aus 2014-15, BRRI RS, Comilla.

Designation	Seedling ht (cm)	Plant ht (cm)	Growth duration (day)	Yield (t/ha)	Lodging score (%)	Remark
			RYT#1			
BR7718-55-1-3	35	103	127	4.6	50	FSm-2%,uniform at flowering and maturity stage
BR26 (ck)	37	99	126	4.1	40	Low growth
BRRI dhan48 (ck)	34	96	124	4.6	20	Zinc deficiency

DS: 21 Apr 2014, DT: 29 May 2014.

day-old seedlings per hill of each genotype were transplanted @ single seedling per hill with a spacing of 20 cm ×15 cm. The unit plot size was 5 m × 1.6 m. The field layout was RCB design with two replications. Recommended fertilizer doses were applied with a usual split application of urea in three times at 15, 30 and 45 days after transplanting. Other cultural operations were done as and when necessary. In PYT#1 (Com) genotypes IR08L181, 08FAN1, IRRI 132 and IR09L305 were selected for their satisfactory yield performance (4.6-5.1 t/ha) as compared with standard checks (4.1-5.5 t/ha). In PYT#2 (Com) BR7357-11-2-4-1-1-HR3, BRC245-4-19-2-1 and BR7369-16-5-2-3-1 were selected for their satisfactory yield performance (4.7-5.3 t/ha) as compared with standard checks (5.5 t/ha). In PYT#3 genotypes BRC316-1-1-1 and BRC316-2-2-1 for their high yield potentiality (4.4-5.2 t/ha) as compared with standard checks (3-4.6 t/ha).

Regional yield trial (RYT). Five RYTs from Plant Breeding Division of BRRI HQ consisting of 23 genotypes were evaluated in RYT#1 (RLR), RYT#2 (RLR), RYT#3 (PQR), RYT#4 (MER) and RYT#5 (GSR) at BRRI RS, Comilla against the standard checks BR11, BRRI dhan33, BRRI dhan34, BRRI dhan37, BRRI dhan39, BRRI dhan49 and BINA dhan-7 for evaluation of specific and general adaptability of the genotypes in on-station condition. Twenty-five to 30-day-old seedlings were transplanted using 2-3 seedlings per hill with 20 cm × 15 cm spacing. The unit plot size was 5.4m × 12 rows. The experiment was laid out in RCB design with three replications. Fertilizer doses were 92 (200 kg urea): 15 (74 kg TSP): 50 (100 kg MP): 12 (67 kg gypsum): 3.6 (10 kg $ZnSO_4$) kg NPKSZn/ha. All amounts of P, K, S and Zn were applied at the time of final land preparation. Nitrogen was applied in three equal splits at 10-15 DAT, maximum tillering and before PI stage. Crop management such as weeding, disease and insect pests control were done in time. In RYT#1 (RLR) genotypes IR70213-10-CPA4-2-2-2 and B10533F-KN-12-2 were selected for earliness (10 days) and satisfactory yield potential (5.6 t/ha) as compared with standard checks (5.8 6.1 t/ha and 130 days growth duration). Considering yield (5.6 t/ha) and growth duration (121 days) genotype WAS 122-IDSA14-WASB-FK1 (NERICA-L-8) was selected from RYT#2 (RLR). In RYT#3 (PQR) genotypes BR8226-8-5-2-2, BR8226-11-4-4-3, BR8227-6-2-1 and BR8226-17-1-2were selected for high yield potential (5-5.7 t/ha) as compared with standard checks (2.8-3.1 t/ha). From RYT#4 (MER) genotypes BR7840-54-3-2-2 and BR8418-1-3 were selected for giving 1 t/ha higher yield and showing 11-14 days earlier than standard check BRRI dhan32 (4.2 t/ha yield and 132 days growth duration) and performed similar yield and growth duration as compared with standard check BRRI dhan39. In RYT#5 (GSR) considering yield performance (4.5-4.7 t/ha) genotypes IR8340-B-28-B and HHZ5-SAL10-DT1-DT1 were selected as compared with standard checks (Table 2).

Advanced yield trial (AYT). Nine genotypes were evaluated in AYT#1 (PQR) and AYT#2 (RLR) against the standard checks BRRI dhan33, BRRI dhan34, BRRI dhan37, BRRI dhan39, BRRI dhan49 and BINA dhan-7 to evaluate the advanced breeding lines for development of variety suitable for Comilla region. Thirty-day-old seedlings were transplanted in a 5.4 m × 12 rows plot following RCB design with three replications using single seedling per hill at a spacing of 20- × 15-cm. Recommended fertilizer doses were applied with a usual split application of urea in three times at 15, 30 and 45 days after transplanting. Other cultural operations were done as and when necessary. Crop management such as weeding, disease and insect pests control were done in time. In AYT#1 (PQR) genotypes BR7697-15-4-4-2-1 and BR7697-15-4-4-2-2 were selected for high yield potential (4.8-5.1 t/ha) as compared with Standard checks (2.7-4.1 t/ha). In AYT#2 (RLR) considering the yield performance (5.2-5.6 t/ha) genotypes BR7638-7-2-5-2 and AL-29 were selected as compared with standard checks (3.9-5.5 t/ha) (Table 3).

Table 2. Yield and agronomic performance of breeding materials of regional yield trial (RYT), T. Aman 2014-15, BRRI RS, Comilla.

Designation	Seedling ht (cm)	Plant ht (cm)	Growth duration (day)	Yield (t/ha)	Lodging score (%)	Remark
			RYT#1 (RLR)[a]			
IR70213-10-CPA4-2-2-2	49	109	121	5.6		FSm- score 3, ShB- score 3, grain spoted
B10533F-KN-12-2	41	107	119	5.6		ShB- Score 3-5
BRRI dhan32 (ck)	41	124	130	5.8	55	
BRRI dhan49 (ck)	41	104	131	6.1		FSm- score 7, ShB- score 3-5
			RYT#2 (RLR)[b]			
WAS 122-IDSA14-WASB-FK1 (NERICA-L-8)	42	101	121	5.6		FSm- score 1-3, uniform flowering
BRRI dhan56 (ck)	51	115	115	4.5		Leaf droopy
BRRI dhan49 (ck)	44	103	131	6.7		FSm- score 3
			RYT#3 (PQR)[c]			
BR8226-8-5-2-2	36	109	135	5.0		
BR8226-11-4-4-3	37	99	135	5.0		Plant HYV type
BR8226-17-1-2	41	11	133	5.7		Panicle reside under the flag leaf
BR8227-6-2-1	43	123	133	5.4		Uneven tillering, panicle reside under the flag leaf
BRRI dhan34 (ck)	41	135	131	2.8	100	
BRRI dhan37 (ck)	50	129	136	3.1	83	
			RYT#4 (MER)[d]			
BR7840-54-3-2-2	40	117	121	5.5		FSm- score <1, small bold grain
BR8418-1-3	31	101	118	5.3		FSm- score 1-3, uniform flowering
BRRI dhan32 (ck)	36	113	132	4.2	12	
BRRI dhan39 (ck)	34	107	123	5.4		FSm- score 1-3
			RYT#5 (GSR)[e]			
IR8340-B-28-B	38	104	115	4.5		ShB- score 3-5, BB- score 3-5
HHZ5-SAL10-DT1-DT1	36	111	117	4.7		ShB- score 3-5
BRRI dhan39 (ck)	34	114	118	4.6		ShB- score 3-5
BRRI dhan56 (ck)	40	113	112	4.1		ShB- score 5, BB-score 5, RTV score 1-3

FSm=False smut, ShB=Sheath blight, BB=Bacterial leaf blight, RTV=Rice tungro virus, RD=Rat damage.
[a]DS: 14 Jul 2014, DT: 16 Aug 2014. [b]DS: 14 Jul 2014, DT: 17 Aug 2014. [c]DS: 14 Jul 2014, DT: 18 Aug 2014. [d]DS: 16 Jul 2014, DT: 21 Aug 2014. [e]DS: 16 Jul 2014, DT: 16 Aug 2014.

Table 3. Yield and agronomic performance of breeding materials of advanced yield trial (AYT), T. Aman 2014-15, BRRI RS, Comilla.

Designation	Seedling ht (cm)	Plant ht (cm)	Growth duration (day)	Yield (t/ha)	Remark
			AYT#1[a]		
BR7697-15-4-4-2-1	-	117	129	4.8	FSm-1, BB-5
BR7697-15-4-4-2-2	-	112	127	5.1	BB-5
BRRI dhan39 (ck)	-	104	124	2.7	RD-50%
BRRI dhan37 (ck)	-	131	134	4.1	
BRRI dhan34 (ck)	-	137	130	3.7	Ldg-95%
LSD 5%		4.56	1.15	1.20	
			AYT#2[b]		
BR7638-7-2-5-2	-	110	131	5.6	
AL-29	-	105	128	5.2	FSm-1
BRRI dhan33 (ck)	-	108	127	3.9	RD-15%
BRRI dhan39 (ck)	-	109	122	3.8	RD-10%, FSm-1
BRRI dhan49 (ck)	-	99	131	5.5	FSm-7
BINA dhan-7 (ck)	-	98	121	2.7	BB-5-7, RD-30%
LSD 5%		7.2	1.08	1.65	

[a]DS:17 Jul 2014, DT: 22 Aug 2014. [b]DS:17 Jul 2014, DT: 22 Aug 2014.

BRRI RS, Habiganj

SUMMARY

In B. Aman season four tested entries yielded higher than local check Hbj.A.IV (2.75 tha^{-1}) in OT. In RYT, among the tested entries, BR224-2B-2-5(2.94 tha^{-1}), BR5915-B-7 (2.78 tha^{-1}), and Lal-khama (2.80 tha^{-1}) yielded higher than Hbj.A.IV (2.75 tha^{-1}). In RYT, T. Aman 2014, BR8143-15-2-1 (5.7 tha^{-1}) yielded higher than BRRI dhan32 (5.5 tha^{-1}) and BRRI dhan39 (5.2 tha^{-1}) with similar growth duration. In PVT, BR7357-11-2-4-1-1 (5.33 tha^{-1}) yielded higher than BRRI dhan37 (4.06 tha^{-1}) with shorter growth duration. In Boro season, fifteen F_8 plants were selected from F_7 population with desirable characters for the development of varieties suitable for haor Areas. In PYT#1, BR8625-14-7-4-1 (7.5 tha^{-1}) yielded similar to BRRI dhan29 (7.7 tha^{-1}) with shorter growth duration. In PYT#2, none of the tested entries, yielded higher than BRRI dhan29 (7.8 tha^{-1}). In SYT, NERICA L-22 (6.1 tha^{-1}) yielded similar to BRRI dhan28 (6.1 tha^{-1}) with longer growth duration. In RYT, no entry yielded higher than BRRI dhan28 (6.2 tha^{-1}). In RYT#1, BR8096-55-1-9-1 (5.9 tha^{-1}) and BR8076-1-2-2-3 (5.9 tha^{-1}) yielded higher than BRRI dhan50 (5.3 tha^{-1}). In RYT#2, BR7372-18-2-1-HR1-HR6 (Com) (6.1 tha^{-1}) and BR7372-18-3-3-HR3 (Com) (6.0 tha^{-1}) yielded higher than BRRI dhan28 (5.6 tha^{-1}) and BRRI dhan60 (5.4 tha^{-1}) with longer growth duration than BRRI dhan28. In RYT#3, NERICA mutant (4.8 tha^{-1}) yielded lower than BRRI dhan28 (5.2 tha^{-1}) and BRRI dhan45 (4.9 tha^{-1}), In RYT#4 BR7988-10-4-1 (6.2 tha^{-1}) yielded higher than BRRI dhan28 (5.4 tha^{-1}) with similar growth duration. BR7783-AC12-3 (6.6 tha^{-1}) yielded higher than BRRI dhan29 (6.3 tha^{-1}) and BR7671-37-2-2-3-7 (6.6 tha^{-1}) yielded higher than BRRI dhan60 (6.5 tha^{-1}). In RYT# 5**,** BR7840-54-3-2-1 (6.2 tha^{-1}) yielded higher than BRRI dhan28 (5.6 tha^{-1}) with longer growth duration and BR8261-19-1-1-3 (6.3 tha^{-1}) yielded similar to BRRI dhan29 (6.3 tha^{-1}). In RYT# 6, HHZ23-DT16-DT1-DT1 (6.8 tha^{-1}) and HHZ6-SAL3-Y1-SUB2 (6.7 tha^{-1}) yielded higher than BRRI dhan29 (6.4 tha^{-1}) and BRRI dhan60 (6.6 tha^{-1}). In MLT, BR7358-5-3-2-1-HR2 (Com) (5.7 tha^{-1}) yielded similar to BRRI dhan28 (5.8 tha^{-1}) with shorter growth duration. In RYT#1 and 2 (Biotech), BR8072-AC5-4-2-1-2-1 (7.1 tha^{-1}) yielded higher than BRRI dhan28 (6.7 tha^{-1}) and BR6158-RWBC2-2-1-1 (7.9 tha^{-1}) yielded higher than BRRI dhan58 (7.6 tha^{-1}) and BRRI dhan29 (7.8 tha^{-1}).

In the missing element balanced trial, fertilization with complete treatment can gave more than 8 tha^{-1} grain yield at Habiganj farm. Omission of P and S has no effect on decreasing grain yield over the complete treatment but omission of N drastically decreased grain yield. Now-a-days K also has became a great concern for decreasing grain yield in this single cropped area.

The recommended patterns (BRRI dhan46-BRRI dhan29-Fallow) gave 15% higher grain yield and gross margin over existing farmers' patterns. The recommended cropping pattern gave the yield of 11.72 t/ha and gross margin of Tk 222,680/ha. It was because of higher yield advantage between recommended and farmers' practice in both T. Aman and Boro season of newly released variety BRRI dhan46, which allow accommodating BRRI dhan29 in the pattern instead of BRRI dhan28. In Boro season, normal transplanting gave significantly higher grain yield than the double transplanting and delay planting. Significantly the highest grain yield was obtained from normal planting (T_1=8.90 t/ha and T_2=8.80 t/ha) and the lowest grain yield was observed from delayed transplanting of 75-day-old seedlings (7.59 t/ha). DT gave significantly higher grain yield (8.32 t/ha) than the delay planting. Crop duration of delay planting was comparatively longer than the normal and DT.

Total TLS seed production of different popular rice varieties was 35,021 kg during 2013-14. A total of 11,250 kg Breeder seeds of three popular rice varieties were produced and sent to BRRI Breeder Seed Unit. Seven training programmes and 46 field demonstrations (Boro and Aus) were also conducted in the reporting year.

VARIETAL DEVELOPMENT

Deep water rice (B. Aman)

Seventeen homozygous genotypes were grown in the BRRI regional station, Habiganj during DWR 2014. The materials were direct seeded in May after first shower in dry field in a 5 m-row plot with 25 cm spacing between rows. Fertilizers at the rate of 60:40:40:10 kg ha^{-1} NPKS were applied. All the fertilizers were applied at final land preparation except N. N in the form of urea was top dressed twice (after seedling establishment and before flood water enter the field). All other cultural management was done as and when necessary.

Out of 17, BR7730-2B (2.87 tha^{-1}), BR7731-2B (2.97 tha^{-1}), BR7735-2B(2.78 tha^{-1}) yielded higher than local check HbjAIV (2.75 tha^{-1}) (Table 1).

Regional yield trial (RYT). Five advanced genotypes with check HbjA(IV) and Birpala were grown in the BRRI RS, Habiganj during B. Aman 2014. The materials were direct seeded in May after first shower in dry field in a 5 m-10-row plot with 25 cm spacing between rows. One meter spacing was maintained between each entry. Fertilizers at the rate of 60:40:40:10 kg ha^{-1} NPKS were applied. All fertilizers were applied at final land preparation except N. N in the form of urea were top dressed twice (after seedling establishment and before flood water enter the field). All other cultural management was done as and when necessary.

Among the tested entries, BR224-2B-2-5(2.94 tha^{-1}), BR5915-B-7 (2.78 tha^{-1}), Lal-khama (2.80 tha^{-1}) yielded higher than HbjAIV (2.75 t ha^{-1}) (Table 2).

Transpalnt Aman (T. Aman)

Regional yield trial (RYT). In T. Aman season seven advanced breeding lines along with BR26 and BRRI dhan48 as check were planted in a 5.4m-10-row plot with 20 cm spacing between rows. Fertilizers at the rate of 60:40:40:10 kg ha^{-1} NPKS were applied. All fertilizers were applied at final land preparation except N. N in the form of urea was top dressed twice 10 and 30 days after transplanting. All other cultural management practices were done as and when necessary.

Table 1. List of the bulked homozygous materials from OT, DWR 2014.

Designation	Yield (tha^{-1})	Designation	Yield (tha^{-1})
BR7730-2B	2.87	BR7739-2B	2.24
BR7731-2B	2.97	BR7740-2B	2.10
BR7732-2B	2.13	BR7741-2B	2.43
BR7733-2B	2.65	BR7742-2B	2.11
BR7734-2B	2.34	BR7743-2B	2.17
BR7735-2B	2.78	BR7744-2B	2.13
BR7736-2B	2.58	BR7745-2B	2.01
BR7737-2B	2.71	BR7746-2B	2.10
BR7738-2B	2.48	HbjAIV (local ck)	2.75

DS: 4 Jun 2014.

Table 2. List of the DWR lines with yield (tha^{-1}) from RYT (Repeated), DWR 2014.

Designation	Yield (tha^{-1})
BR224-2B-2-5	2.94
BR5915-B-7	2.78
Bazail-65	2.65
Gabura	2.59
Lal-khama	2.80
HbjAIV (local ck)	2.75
Birpala (local ck)	2.40

DS: 4 Jun 2014.

BR8143-15-2-1 (5.7 tha^{-1}) yielded higher than BRRI dhan32 (5.5 tha^{-1}) and BRRI dhan39 (5.2 tha^{-1}) with similar growth duration. BR7840-54-3-2-2 (5.1 tha^{-1}) and BR8418-1-3 (4.9 tha^{-1}) yielded higher than BRRI dhan56 (4.8 tha^{-1}) with longer growth duration (Table 3).

Proposed variety trial (PVT). Two advanced breeding lines along with BRRI dhan39 as check were planted in a 5 m × 6 m plot with 20 cm spacing between rows. Fertilizers at the rate of 100:60:60:10:10 kgha^{-1}NPKSZn were applied. All fertilizers were applied at final land preparation except N. N in the form of urea was top dressed thrice 15 days after transplanting (DAT), 30 DAT and 60 DAT. All other cultural management practices were done as and when necessary.

BR7528-2R-19-HR10 (6.28 tha^{-1}) yielded higher than BRRI dhan39 (6.03 tha^{-1}) with longer growth duration (Table 4).

Two advanced breeding lines along with BRRI dhan39 and BRRI dhan49 as checks were planted in a 5 m × 6 m plot with 20 cm spacing between rows. Fertilizers at the rate of 100:60:60:10:10 kg ha^{-1} NPKSZn were applied. All fertilizers were applied at final land preparation except N. N in the form of urea was top dressed thrice 15 days after transplanting (DAT), 30 DAT and 60 DAT. All other cultural management practices were done as and when necessary. None of the entries yielded higher than the check varities (Table 5).

One advanced breeding line along with BRRI dhan37 as check was planted in a 5 m × 6 m plot

Table 3. Yield and ancillary characters of the advanced breeding lines, RYT, T. Aman 2014.

Designation	Plant ht (cm)	PACP*		Maturity (day)	Yield (t ha^{-1})
		Vegetative stage	Maturity stage		
BR7840-54-3-2-2	111	5	5	115	5.1
BR7879-17-2-4-HR3-P1	130	4	4	121	4.3
BR7671-37-2-2-3-7-3**	98	5	5	116	4.8
BR8143-15-2-1	114	5	5	120	5.7
BR8418-1-3	90	5	5	115	4.9
IR85850-75-2-2-3-2 (IR 10M 300)	103	5	5	115	4.8
PSBRC 82(IRRI 123)	102	5	5	120	5.8
BRRI dhan32(ck)	116	6	6	122	5.5
BRRI dhan39(ck)	103	5	5	120	5.2
BRRI dhan56(ck)	110	5	5	112	4.8
LSD (5%)	2.69			1.55	0.26
CV(%)	1.4			0.8	2.9

DS: 21 Jul 2014, DT: 17 Aug 2014.
*PACP=Phenotypic acceptability. **Tungro infected while others were completely resistant.

Table 4. Yield data of proposed variety trial, Zn enriched rice, T. Aman 2014-15.

Designation	Growth duration (day)	Yield (tha^{-1})
BR7528-2R-19-HR10	138	6.28
BRRI dhan39 (ck)	133	6.03

DS: 15 Jul 2015, DT: 16 Aug 2015.

Table 5. Yield data of proposed variety trial, RLR, T. Aman 2014-15.

Designation	Growth duration (day)	Yield (tha^{-1})
BR7472-16-2-1-2-3	128	4.57
BR7622-5-1-1-1	132	5.42
BRRI dhan39 (ck)	130	4.10
BRRI dhan49 (ck)	133	6.36

DS: 16 Jul 2015, DT: 14 Aug 2015.

with 20 cm spacing between rows. Fertilizers at the rate of 100:60:60:10:10 kg ha^{-1} NPKSZn were applied. All fertilizers were applied at final land preparation except N. N in the form of urea was top dressed thrice 15 days after transplanting (DAT), 30 DAT and 60 DAT. All other cultural management practices were done as and when necessary. BR7357-11-2-4-1-1 (5.33 tha^{-1}) yielded higher than BRRI dhan37 (4.06 tha^{-1}) with shorter growth duration (Table 6).

Table 6. Yield data of proposed variety trial, PQR, T. Aman 2014-15.

Designation	Growth duration (day)	Yield (tha^{-1})
BR7357-11-2-4-1-1	134	5.33
BRRI dhan37 (ck)	139	4.06

DS: 15 Jul 2015, DT: 15 Aug 2015.

IRRIGATED RICE (BORO)

Development of Boro varieties for *haor* areas. Five F_7 s were grown in the regional station, Habiganj during Boro 2014-15 season. The F_7 seedlings were planted in a 2.7 m-row plot with 25 cm spacing between rows. Fertilizers at the rate of 80:60:60:10 kg ha^{-1} NPKS were applied. All fertilizers were applied at final land preparation except N. Nitrogen in the form of urea was top dressed thrice 15, 30 and 45 days after transplanting. All other cultural management practices were done as and when necessary.

Fifteen F_8 plants were selected from F_7 population with desirable characters for the development of varieties suitable for haor areas (Table 7).

Preliminary yield trial (PYT#1). Four advanced breeding lines along with BRRI dhan29 as check was planted in a 5.4 m-10-row plot with 25 cm spacing between rows. Fertilizers at the rate of 100:60:60:10:10 kg ha^{-1} NPKS and Zn were applied. All fertilizers were applied at final land preparation except N. N in the form of urea was

Table 7. List of the F_8 materials, Boro 2015.

Parentage	Selected plants (no.)
AS996/BR19	4
AS996/BRRI dhan45	4
IR7390-53-2-2/BRRI dhan29	3
IR7390-53-2-2/BRRI dhan45	2
BR19/AS996	2
Total selected plant	15

top dressed thrice 15, 30 and 45 days after transplanting. All other cultural management practices were done as and when necessary.

One tested entry BR8625-14-7-4-1 (7.5 tha^{-1}) yielded similar to BRRI dhan29 (7.7 tha^{-1}) with shorter growth duration (Table 8).

Preliminary yield trial (PYT#2). Four advanced breeding lines along with BRRI dhan29 as check were planted in a 5.4m-10-row plot with 25 cm spacing between rows. Fertilizers at the rate of 100:60:60:10:10 kg ha^{-1} NPKS and Zn were applied. All fertilizers were applied at final land preparation except N. Nitrogen in the form of urea was top dressed thrice 15, 30 and 45 days after transplanting. All other cultural management practices were done as and when necessary.

None of the entries, yielded higher than BRRI dhan29 (7.8 tha^{-1}) (Table 9).

Secondary yield trial (SYT). Three advanced breeding lines along with BRRI dhan28 as check were planted in a 5.4m-10-row plot with 25 cm spacing between rows. Fertilizers at the rate of 100:60:60:10:10 kg ha^{-1} NPKS and Zn were applied. All fertilizers were applied at final land preparation except N. Nitrogen in the form of urea was top dressed thrice 15, 30 and 45 days after transplanting. All other cultural management practices were done as and when necessary.

One tested entry, NERICA L-22 (6.2 tha^{-1}) yielded similar to BRRI dhan28 (6.1 tha^{-1}) with longer growth duration (Table 10).

Regional yield trial (RYT). Six advanced breeding lines along with BRRI dhan28 as check was planted in a 5.4 m-10-row plot with 25 cm spacing between rows. Fertilizers at the rate of 100:60:60:10:10 kg ha^{-1} NPKS and Zn were applied. All fertilizers were applied at final land preparation except N. N in the form of urea was top dressed thrice 15, 30 and 45 days after transplanting. All other cultural management practices were done as and when necessary.

The tested entry PR33993-B-15-2-1 (6.0 tha^{-1}) yielded lower than BRRI dhan28 (6.2 tha^{-1}) with similar growth duration (Table 11).

Regional yield trial (RYT), high yield. One advanced breeding line along with BRRI dhan28 as check was planted in a 5.4 m-10-row plot with 25 cm spacing between rows. Fertilizers at the rate of 100:60:60:10:10 kg ha^{-1} NPKS and Zn were applied. All fertilizers were applied at final land preparation except N. Nitrogen in the form of urea was top dressed thrice 15, 30 and 45 days after transplanting. All other cultural management practices were done as and when necessary.

The tested entry BRH11-9-11-4-5B (6.0 tha^{-1}) yielded higher than BRRI dhan 28 and BRRI dhan29 in all the five locations (Table 12).

Table 8. List of the homozygous lines with yield (tha^{-1}) from PYT#1, Boro 2015.

Designation	Plant ht (cm)	PACP		Growth duration (day)	Yield (t ha^{-1})
		Vegetative stage	Maturity stage		
BR8621-13-5-7-3	98	5	5	146	5.8
BR8623-12-6-3-2	106	4	5	148	6.3
BR8624-9-5-3-1	107	5	5	149	5.5
BR8625-14-7-4-1	106	3	3	147	7.5
BRRI dhan29 (ck)	90	3	3	161	7.7

DS: 20 Nov 2014, DT: 30 Dec 2014.

Table 9. List of the homozygous lines with yield (tha^{-1}) from PYT#2, Boro 2015.

Designation	Plant ht (cm)	PACP		Growth duration (day)	Yield (t ha^{-1})
		Vegetative stage	Maturity stage		
BRH1-14-3-4-2	123	5	4	152	6.5
BRH2-12-3-6-2	127	5	5	151	6.2
BRH3-15-2-4-1	133	5	5	150	6.3
BRH4-9-2-4-3-1	118	5	5	149	6.3
BRRI dhan29 (ck)	98	3	3	161	7.8

DS: 20 Nov 2014, DT: 31 Dec 2014.

Table 10. Yield and ancillary characters of the advanced breeding lines, SYT, Boro 2015.

Designation	Plant ht (cm)	PACP		Maturity (day)	Yield (t ha^{-1})
		Vegetative stage	Maturity stage		
NERICA L-1	73	5	5	150	5.8
NERICA L-22	94	4	3	151	6.2
NERICA L-32	84	5	4	152	5.9
BRRI dhan28 (ck)	99	3	3	147	6.1
LSD (5%)	5.39			1.28	0.71
CV(%)	3.1			0.4	5.7

DS: 20 Nov 2014, DT: 30 Dec 2014.

Table 11. Yield and ancillary characters of the advanced breeding lines, RYT# Habiganj, Boro 2015.

Designation	Plant ht (cm)	PACP		Maturity (day)	Yield (t ha^{-1})
		Vegetative stage	Maturity stage		
PR33993-B-15-2-1	89	5	4	148	6.0
BRRI dhan28 (ck)	96	3	3	146	6.2

DS: 20 Nov 2014, DT: 31 Dec 2014.

Table 12. Yield and ancillary characters of the advanced breeding lines, RYT# high yield, Boro 2015.

Designation	Pnicle/plant	Panicle length	Duration	Yield (t/ha)					
			(day)	Gazipur	Rangpur	Nilfamari	Habiganj	Sherpur	Valuka
BRH11-9-11-4-5B	14	25.5	147	7.1	7.9	7.3	8.3	7.6	8.5
BRRI dhan28	13	25.0	145	7.0	6.1	6.0	7.2	6.5	6.7
BRRI dhan29	16	28.5	161	7.3	7.3	7.1	7.5	6.9	7.2

RYT#1(HQ), premium quality rice. Five advanced breeding lines along with BRRI dhan50 and BRRI dhan63 as checks were planted in a 5.4 m-10-row plot with 25 cm spacing between rows. Fertilizers at the rate of 100:60:60:10:10 kg ha^{-1} NPKSZn were applied. All fertilizers were applied at final land preparation except N. N in the form of urea was top dressed thrice, 15 DAT, 30 DAT and five days before PI stage. All other cultural management practices were done as and when necessary.

BR8096-55-1-9-1 (5.9 tha^{-1}) and BR8076-1-2-2-3 (5.9 tha^{-1}) yielded higher than BRRI dhan50 (5.3 tha^{-1}) but yielded similar to BRRI dhan63 (5.9 tha^{-1}) with longer growth duration (Table 13).

Table 13. Yield and ancillary characters of the advanced breeding lines, RYT#1, Boro 2015.

Designation	Plant ht (cm)	PACP		Maturity (day)	Yield (t ha^{-1})
		Vegetative stage	Maturity stage		
IR77734-93-2-3-2	93	5	3	153	5.4
BR8079-52-2-2-2	84	5	3	155	5.5
BR8096-55-1-9-1	84	6	5	153	5.9
BR8076-1-2-2-3	94	6	4	155	5.9
BR8096-48-2-2-4	92	3	4	151	5.5
BRRI dhan50 (ck)	85	3	4	154	5.3
BRRI dhan63 (ck)	81	3	3	148	5.9
LSD (5%)	3.85			1.19	0.56
CV(%)	2.5			0.4	5.6

DS: 6 Dec 2014, DT: 17 Jan 2015.

BRRI RS, Rajshahi

SUMMARY

Four out of eight B. Aus-RYT entries produced higher yield (3.27-4.0 t/ha) than BRRI dhan43 (3.07 t/ha) of them BR7383-2B-23 produced the highest.

Three out of nine T. Aus-RYT entries produced higher yield (4.26-4.67 t/ha) than BR26 and BRRI dhan48 (3.07-4.18 t/ha). Among them BR7718-55-1-3 produced the highest.

Two out of eight somacloned entries BRRI dhan29-SC3-28-16-10-6-HR3 and BRRI dhan29-SC3-28-16-10-4-HR6 produced better yield (3.50-3.68 t/ha) in T. Aus-RYT.

Only one of five anther cultured T. Aman-RYT entries; BR7082-AC9-1-1-2-1-1 produced slightly higher yield (3.20 t/ha) than BRRI dhan48 (3.15 t/ha).

Only one of five T. Aman-RYT(RLR) genotypes; IR70213-10-CPA 4--2-2-2 gave higher yield (4.84 t/ha) than BRRI dhan49 and BRRI dhan32 (3.90-4.68 t/ha).

Nine of 10 T. Aman-RYT(PQR) entries gave higher yield (3.0-4.28 t/ha) than BRRI dhan37 and BRRI dhan34 (1.82-2.95 t/ha). Among them BR8226-17-1-2 produced the highest.

Only two of nine T. Aman-RYT(MER) genotypes; BR7840-54-3-2-2 and PSBRC82 (IRRI123) gave higher yield (5.13-4.92 t/ha) than BRRI dhan32 and BRRI dhan39 (4.71-4.82 t/ha).

Thirty-five of 55 OYT-GSR genotypes produced higher yield (3.04-4.92 t/ha) than BRRI dhan39 and BRRI dhan56 (2.31-2.97 t/ha).

Only HHZ5-DT20-DT3-Y2 from 19 SYT-1 genotypes produced more yield in Godagari (5.04 t/ha) and on-station (5.67 t/ha) than BR11, BRRI dhan32, BRRI dhan39 and HUA565 (5.00-5.39 t/ha).

Only HHZ17-Y16-Y3-Y2, HHZ23-DT16-DT1-DT1 and PSBRC68 from 16 T. Aman-SYT2(GSR) genotypes produced higher yield (4.90-4.94 t/ha) than BRRI dhan39 and BRRI dhan56 (4.28-4.74 t/ha) in on-station, whereas HUANG HUA ZHAN and PSBRC68 produced higher yield (5.05-5.28 t/ha) in Godagari and nine genotypes (4.49-5.50 t/ha) in Tanore.

Only HHZ5-SAL10-DT1-DT1 from six T. Aman-RYT genotypes produced more yield (4.29 t/ha) than BRRI dhan39 and BRRI dhan56 (3.30-3.86 t/ha) in Tanore.

Only BR8076-1-2-2-3 from seven Boro-RYT(PQR) genotypes gave higher yield (5.82 t/ha) than BRRI dhan50 and BRRI dhan63 (4.67-5.17 t/ha).

Only BR7372-18-2-1-HR1-HR6 (Com) from nine RYT-PQR (Com) genotypes produced higher yield (6.75 t/ha) than BRRI dhan28, BRRI dhan50, BRRI dhan60 and BRRI dhan63 (4.85-5.92 t/ha) in Boro.

Seven of 13 Boro-RYT(FB) genotypes produced higher yield (6.11-6.97 t/ha) than BRRI dhan28, BRRI dhan29 and BRRI dhan60 (5.07-6.01 t/ha).

Three from 11 Boro-RYT(MER) genotypes produced higher yield (6.00-6.80 t/ha) than BRRI dhan28 (5.98 t/ha) but none out yielded BRRI dhan29 (7.18 t/ha).

All the five Boro-RYT(GSR) genotypes produced higher yield (6.37-7.15 t/ha) than BRRI dhan60 (6.08 t/ha) but none out yielded BRRI dhan29 (7.56 t/ha).

Three out of 27 Boro-OYT(GSR) materials GSR IR1-9-D15-Y1, GSR IR1-12-Y8-D2 and GSR IR1-9-D13-S2 produced comparable yield (6.11-6.44 t/ha) than BRRI dhan59 and BRRI dhan47 (5.93-6.13 t/ha) in on-farm.

Three out of 22 Boro-PYT(GSR) genotypes HHZ5-DT20-DT3-Y2, HHZ5-Y7-Y2-SUB1, HHZ5-DT20-DT2-DT1 from produced higher yield (5.90-6.25 t/ha) than BRRI dhan59 (5.89 t/ha). Two genotypes; HHZ5-Y7-Y2-SUB1 and HHZ5-DT20-DT2-DT1 produced (5.92-6.25 t/ha) higher than BRRI dhan28 (5.91) in on-farm.

Only IR84678-25-5-B from eight Boro-SYT(GSR) genotypes produced higher yield (7.02 t/ha) than BRRI dhan28 and BRRI dhan59 (6.21-6.35 t/ha) in on-farm.

Four out of seven Boro-RYT1 materials; HHZ15-SAL13-Y1, HHZ15-DT4-DT1-Y1, HHZ23-DT16-DT1-DT1 and HHZ11-DT7-SAL1-SAL1 produced higher yield (6.65-7.64 t/ha) than BRRI dhan29 and BRRI dhan60 (6.12-6.62 t/ha) in on-farm.

Only BR4909-R1-R2 out of six anther cultured RYT-1 materials produced higher yield (6.36 t/ha) than BRRI dhan28 (5.94 t/ha).

The tested genotype BR6158RWBC2-2-1-1 from Biotechnology Division produced higher yield (9.23 t/ha) than BRRI dhan29 and BRRI dhan58 (7.34-8.67 t/ha).

Five out of 16 T. Aman hybrids produced >6 t/ha yield. Among them H993 produced the highest (53.76 kg/day).

Seven out of 19 hybrids of A set produced >8 t/ha yield. Out of them H1046 produced the highest (59.27 kg/day). Ten out of 19 hybrids of B set produced >8 t/ha yield. Among them H1007 produced the highest (59.48 kg/day). Nine out of 18 hybrids of C set produced >9 t/ha yield. Among them H1036 produced the highest (61.03 kg/day) in Boro.

The proposed genotype; BR7357-11-2-4-1-1 produced significantly higher yield (3.49 t/ha) than BRRI dhan37 (1.68 t/ha) in PQR.

Both the proposed genotypes IR83377-B-B-93-3 and IR82589-B-B-84-3 produced higher yield (4.49-5.84 t/ha) than BRRI dhan56 (3.48-4.47 t/ha) in different drought prone areas.

Both the proposed genotypes IR83140-B-36-B-B and IR83140-B-71-B-B produced significantly higher yield (6.10-6.12 t/ha) than BRRI dhan28 (5.39 t/ha) with less water supply.

Twelve out of 88 OYT-STRASA materials gave >3 t/ha yield those out yielded BRRI dhan56, IRRI 123, MTU 1010 (0.90-2.95 t/ha) in controlled condition. Of them IR95836 produced the highest yield (4.46 t/ha) even narrowly higher than the best check IR64 (4.33 t/ha).

Eight out of 55 AYT-STRASA genotypes gave >4.50 t/ha yield in controlled condition that was higher than the yield of Sambha Mahsuri, MTU 1010, Swarna, BINA dhan7 and BRRI dhan56 (2.55-3.62 t/ha). Out of them IR87656-21-1-14 produced the highest (4.88 t/ha). Whereas five produced >4.00 t//ha yield in stressed condition that was also higher than the yield of checks (2.80-3.88 t/ha). Among them IR88903-8-1-1-3 produced the highest (4.34 t/ha).

All of the 14 PVS-STRASA genotypes gave >4 .00 t/ha yield irrespective of site and conditions except stressed at Paba where only IR88864-2-1-1-3, IR88966-45-2-1-4, IR10L282, IR10L276 and IR87761-53-1-1-1 gave >4.00 t/ha yield. Out of them IR87761-53-1-1-1 produced the highest yield (4.24-4.59 t/ha) in stressed and 5.60 t/ha in controlled condition.

The abundance of different insects were found in the light trap. Among them GLH was the highest followed by BPH and YSB. Peak of GLH and WLH observed in November whereas YSB and BPH in October.

Among the natural enemies staphylinid beetle population was found the highest followed by earwig and green mirid bug. Peak of STB and EW was observed in March and June respectively.

The highest number of grasshopper, GLH and rice leaf roller were found in fully controlled plots (9.5, 17.0 and 2.25/20 complete sweep) but the incidence was below the economic threshold level.

The highest number of natural enemies; spider, damsel fly, lady bird beetle and long horned grasshopper were found in 1 m away from the flowering plants of rice bund.

Four times insecticide (Carbofuran 5G @ 10 kg/ha) used plots gave the highest yield but similar to that of 1 m and 4 m away nectar-rich flowering plants grown in bunds surrounded rice crops.

The highest natural enemies and parasitism by *Trichogramma zahiri* were observed in rice field nearby nectar-rich flowering plants. However, the least natural enemies and parasitism were found in four times insecticides applied plots. Moreover, no yield reduction was noticed between rice fields surrounded by flowering plants and insecticide treated plots.

On average 0.80-1.20 YSB were caught per pheromone trap during September and 1.19 to 1.80 during October. The RLR caught was less than that of YSB, which was 0.73-0.93 and 0.54-0.59 during September and October respectively.

About 14 tons truthfully levelled seeds of two T. Aus, 11 T. Aman and five Boro varieties from 2013-2014 fiscal year produce were distributed and sold to the Researchers and local farmers according to their demand.

More than 15 tons TLS were produced from three T. Aus, 12 T. Aman and seven Boro varieties during the reporting year. About 20 tons breeders seeds (BS) were produced from four T. Aman and three Boro varieties and sent to the Genetic Resources and Seed Division.

Regional yield trial (RYT), B. Aus 2014

Eight genotypes including the check BRRI dhan43 were used to evaluate them for yield potential and adaptability. Dry seeding of the genotypes was done in moist soil in a unit plot size 5.4 m × 12 rows with 25 cm row spacing. Genotypes in the field lay out was distributed following RCB design with three replications. Fertilizers PKS and Zn were applied @ 10:30:18:3.6 kg/ha respectively from TSP, MOP, gypsum and zinc sulphate during final land preparation and N @ 60 kg/ha from urea in three splits at 15, 30 and 45 days after seed emergence. Hand weeding was done three times but no herbicide was applied. Plant protection measures were taken as and when necessary. Data were taken on date of flowering and maturity, number of panicles and yield/m^2.

Four tested entries produced higher yield (3.27-4.0 t/ha) than the check (3.07 t/ha) (Table 1). BR7383-2B-23 produced the highest yield (4.0 t/ha) followed by BR7587-2B-3 (3.78 t/ha) and were selected for further advancement.

Regional yield trial (RYT), T. Aus 2014

Nine entries including two checks BR26 and BRRI dhan48 were used to evaluate them for yield potential and adaptability. Seedlings of 26 days were transplanted with 2-3 seedlings/hill. The hill spacing was 25 cm × 15 cm and unit plot size was 5.4 m × 2.0 m. Fertilizers PKS and Zn were applied @ 60:40:40:10 kg/ha respectively from TSP, MOP, gypsum and zinc sulphate during final land preparation and N in two equal splits at 10 and 30 days interval starting after transplanting. Crop management practices such as cultural operations and pest management activities were done in time. Data were recorded on flowering and maturity, plant height, lodging tolerance, phenotypic acceptability and yield.

Three tested entries produced higher yield (4.26-4.67 t/ha) than the checks (3.07-4.18 t/ha) (Table 2). BR7718-55-1-3 produced the highest yield (4.67 t/ha) followed by BR7718-55-1-3 (4.53 t/ha) and selected for further advancement.

Regional yield trial (RYT-Somaclone), T. Aus 2014

Eight entries including three checks WK1, Parija and BRRI dhan48 were evaluated for their yield potential and adaptability. Seedlings of 24 days were transplanted with 2-3 seedlings/hill. The hill spacing was 25 cm × 15 cm and unit plot size was 5.4 m × 2.0 m. Fertilizers PKS and Zn were applied @ 60:40:40:10 kg/ha respectively from TSP, MOP, gypsum and zinc sulphate during final land preparation and N in two equal splits at 10- and 30-day after transplanting. Crop management practices such as cultural operations and pest management activities were done in time. Data were recorded on flowering and maturity, plant height, lodging tolerance, phenotypic acceptability and yield.

Two tested entries BRRI dhan29-SC3-28-16-10-6-HR3 and BRRI dhan29-SC3-28-16-10-4-HR6 performed better (3.50-3.68 t/ha) than the checks (1.52-3.45 t/ha) (Table 3) and were selected for

Table 1. Yield contributing parameters and yield of RYT genotypes, B. Aus 2014.

Designation	Plant ht (cm)	Growth duration (days)	Yield (t/ha)
BR7698-2B-1-9-1	98.0	107	2.91
BR7698-2B-1-9-2	98.3	106	3.47
BR7699-2B-3-13-3	114.3	110	3.07
BR7692-2B-5-2	114.7	104	2.16
BR7692-2B-5-4	105.7	109	2.59
BR7383-2B-23	107.0	103	4.0
BR7587-2B-3	126.7	105	3.78
BRRI dhan43 (ck)	121.3	104	3.07
LSD at 5%	6.73	0.36	0.78

DS: 25 Apr 2014.

Table 2. Yield contributing parameters and yield of RYT genotypes, T. Aus 2014.

Designation	Plant ht (cm)	Growth duration (days)	Yield (t/ha)
BR8113-21-3-1	102.7	118	3.61
BR7922-45-2-2-1	115.7	114	3.53
IR7866-BR-3-1	104.0	110	3.89
BR7708-62-1-1	110.3	113	4.26
BR7718-56-3-1	106.7	110	4.04
BR7718-55-1-3	108.7	110	4.67
BR7718-55-1-3	108.7	82	4.53
BR26 (ck)	110.7	85	4.19
BRRI dhan48 (ck)	99.3	88	4.12
LSD at 5% level	4.26	0.86	0.76

DS: 20 Apr 2014, DT: 15 May 2014.

Regional yield trial (RYT), B. Aus 2014

Eight genotypes including the check BRRI dhan43 were used to evaluate them for yield potential and adaptability. Dry seeding of the genotypes was done in moist soil in a unit plot size 5.4 m × 12 rows with 25 cm row spacing. Genotypes in the field lay out was distributed following RCB design with three replications. Fertilizers PKS and Zn were applied @ 10:30:18:3.6 kg/ha respectively from TSP, MOP, gypsum and zinc sulphate during final land preparation and N @ 60 kg/ha from urea in three splits at 15, 30 and 45 days after seed emergence. Hand weeding was done three times but no herbicide was applied. Plant protection measures were taken as and when necessary. Data were taken on date of flowering and maturity, number of panicles and yield/m^2.

Four tested entries produced higher yield (3.27-4.0 t/ha) than the check (3.07 t/ha) (Table 1). BR7383-2B-23 produced the highest yield (4.0 t/ha) followed by BR7587-2B-3 (3.78 t/ha) and were selected for further advancement.

Regional yield trial (RYT), T. Aus 2014

Nine entries including two checks BR26 and BRRI dhan48 were used to evaluate them for yield potential and adaptability. Seedlings of 26 days were transplanted with 2-3 seedlings/hill. The hill spacing was 25 cm × 15 cm and unit plot size was 5.4 m × 2.0 m. Fertilizers PKS and Zn were applied @ 60:40:40:10 kg/ha respectively from TSP, MOP, gypsum and zinc sulphate during final land preparation and N in two equal splits at 10 and 30 days interval starting after transplanting. Crop management practices such as cultural operations and pest management activities were done in time. Data were recorded on flowering and maturity, plant height, lodging tolerance, phenotypic acceptability and yield.

Three tested entries produced higher yield (4.26-4.67 t/ha) than the checks (3.07-4.18 t/ha) (Table 2). BR7718-55-1-3 produced the highest yield (4.67 t/ha) followed by BR7718-55-1-3 (4.53 t/ha) and selected for further advancement.

Regional yield trial (RYT-Somaclone), T. Aus 2014

Eight entries including three checks WK1, Parija and BRRI dhan48 were evaluated for their yield potential and adaptability. Seedlings of 24 days were transplanted with 2-3 seedlings/hill. The hill spacing was 25 cm × 15 cm and unit plot size was 5.4 m × 2.0 m. Fertilizers PKS and Zn were applied @ 60:40:40:10 kg/ha respectively from TSP, MOP, gypsum and zinc sulphate during final land preparation and N in two equal splits at 10- and 30-day after transplanting. Crop management practices such as cultural operations and pest management activities were done in time. Data were recorded on flowering and maturity, plant height, lodging tolerance, phenotypic acceptability and yield.

Two tested entries BRRI dhan29-SC3-28-16-10-6-HR3 and BRRI dhan29-SC3-28-16-10-4-HR6 performed better (3.50-3.68 t/ha) than the checks (1.52-3.45 t/ha) (Table 3) and were selected for

Table 1. Yield contributing parameters and yield of RYT genotypes, B. Aus 2014.

Designation	Plant ht (cm)	Growth duration (days)	Yield (t/ha)
BR7698-2B-1-9-1	98.0	107	2.91
BR7698-2B-1-9-2	98.3	106	3.47
BR7699-2B-3-13-3	114.3	110	3.07
BR7692-2B-5-2	114.7	104	2.16
BR7692-2B-5-4	105.7	109	2.59
BR7383-2B-23	107.0	103	4.0
BR7587-2B-3	126.7	105	3.78
BRRI dhan43 (ck)	121.3	104	3.07
LSD at 5%	6.73	0.36	0.78

DS: 25 Apr 2014.

Table 2. Yield contributing parameters and yield of RYT genotypes, T. Aus 2014.

Designation	Plant ht (cm)	Growth duration (days)	Yield (t/ha)
BR8113-21-3-1	102.7	118	3.61
BR7922-45-2-2-1	115.7	114	3.53
IR7866-BR-3-1	104.0	110	3.89
BR7708-62-1-1	110.3	113	4.26
BR7718-56-3-1	106.7	110	4.04
BR7718-55-1-3	108.7	110	4.67
BR7718-55-1-3	108.7	82	4.53
BR26 (ck)	110.7	85	4.19
BRRI dhan48 (ck)	99.3	88	4.12
LSD at 5% level	4.26	0.86	0.76

DS: 20 Apr 2014, DT: 15 May 2014.

Table 3. Yield contributing parameters and yield of RYT (Somaclone) genotypes, T. Aus 2014.

Designation	Plant ht (cm)	Growth duration (days)	Yield (t/ha)
BRRI dhan29-SC3-28-16-10-8-HRI	95.7	79	2.99
BRRI dhan29-SC3-28-16-10-6-HR3	107.3	80	3.68
BRRI dhan29-SC3-28-16-10-4-HR5	109.3	80	3.31
BRRI dhan29-SC3-28-16-10-4-HR6	104.7	80	3.50
WK1 (ck)	81.0	80	3.45
Parija (ck)	96.7	80	1.52
Nerica10	89.3	103	0.57
BRRI dhan48 (ck)	95.3	85	2.25
LSD at 5% level	3.88	-	0.59

DS: 1 May 2014, DT: 25 May 2014.

further advancement. Rat badly damaged Parija, Nerica10 and the check BRRI dhan48.

Regional yield trial (RYT-Biotechnology), T. Aus 2014

Five entries including the check BRRI dhan48 were evaluated for their yield potential and adaptability. Seedlings of 20 days was transplanted with 2-3 seedlings/hill. The hill spacing was 25 cm × 15 cm and unit plot size was 5.4 m × 2.0 m. Fertilizers PKS and Zn were applied @ 60:40:40:10 kg/ha respectively from TSP, MOP, gypsum and zinc sulphate during final land preparation and N in two equal splits at 10 and 30 days after transplanting. Crop management practices such as cultural operations and pest management activities were done in time. Data were recorded on flowering and maturity, plant height, lodging tolerance, phenotypic acceptability and yield.

Only one tested entry BR7082-AC9-1-1-2-1-1 produced slightly higher yield (3.20 t/ha) than the check BRRI dhan48 (3.15 t/ha) and was selected for further advancement.

Regional yield trial (RYT), T. Aman 2014

Three regional yield trials for rain-fed lowland rice (RLR), premium quality rice (PQR) and micronutrient (MN) were conducted to evaluate specific and general adaptability of the genotypes. Seedlings of 21-23 days were transplanted in 5.4 m × 12 rows plot with 20 × 15 cm spacing using 2-3 seedlings/hill. The experimental design was RCB with three replications. Fertilizers PKS and Zn were applied @ 17.4:58.5:14:4.3 kg/ha from triple super phosphate, muriate of potash, gypsum and zinc sulphate during final land preparation and N @ 108 kg/ha in three equal splits at 15 days interval starting from 10 days after transplanting (DAT). Crop management practices were done as and when necessary. Supplemental irrigation was given when necessary. Data were recorded on date of flowering and maturity, plant height, lodging tolerance, phenotypic acceptability at vegetative and maturity stage and yield/plot.

Hybrid rice trial for T. Aman 2014

The trials were conducted with 16 genotypes to evaluate specific and general adaptability of the genotypes in on-station condition. Seedlings of 23 days were transplanted in 5 × 6 m plot with 20 × 15 cm spacing using single seedling/hill. The experimental design was RCB with three replications. Fertilizers NPKS and Zn were applied @ 120:26:60:13:3.6 kg/ha from urea. Full doses of TSP, gypsum, zinc sulphate, 1/8th urea 2/3rd MOP were applied during final land preparation. The rest of MOP at 50 days after transplanting (DAT) and rest of urea in two equal splits at 15 and 50 DAT were top dressed. Crop management practices were done as and when necessary. Data were recorded on date of flowering and maturity, plant height, lodging tolerance, phenotypic acceptability and yield/plot.

Five genotypes produced >6 t/ha yield. The genotype H993 produced the highest yield (53.76 kg/day) followed by H994 (51.26 kg/ha) (Table 4).

Hybrid rice trial for A, B and C set, Boro 2014-15

The trials were conducted with 19 genotypes each of A and B set and 18 genotypes of C set to evaluate specific and general adaptability of the genotypes in on-station condition. Seedlings of 35 days were transplanted in 5 × 6 m plot with 20 × 15 cm spacing using single seedlings/hill. The experimental design was RCB with three replications. Fertilizers NPKS and Zn were applied @ 124:26:60:13:3.6 kg/ha from urea. Full doses of TSP, gypsum, zinc sulphate, 1/8th urea 2/3rd MOP were applied during final land preparation. The rest of MOP at 50 days after transplanting (DAT) and rest of urea in two equal splits at 15 and 50 DAT

Table 4. Yield and ancillary characters of the Hybrids for T. Aman 2014.

Designation	Plant ht (cm)	Growth duration (days)	Sterility (%)	Yield (t/ha)
H982	115.7	101	31.44	5.69
H983	103.9	103	28.88	5.14
H984	117.1	117	25.60	5.50
H985	123.0	117	23.80	5.72
H986	103.1	106	29.20	6.07
H987	111.5	107	29.40	5.82
H988	111.9	103	31.12	5.08
H989	116.5	111	24.72	5.33
H990	121.9	109	32.76	6.07
H991	114.7	102	27.40	4.31
H992	117.6	112	27.20	6.09
H993	129.0	117	23.52	6.29
H994	133.9	119	27.60	6.10
H995	114.7	116	23.88	5.21
H996	115.6	99	32.36	4.69
H997	116.9	103	26.80	5.18
LSD at 5% level	1.23	-	-	0.87

DS: 3 Jul 2014, T.T: 22 Jul 2014.

were top dressed. Crop management practices were done as and when necessary. Data were recorded on date of flowering and maturity, plant height, lodging tolerance, phenotypic acceptability and yield/plot.

In the A set seven genotypes produced >8 t/ha yield. The genotype H1046 produced the highest yield (59.27 kg/day) followed by H998 (56.89 kg/ha) (Table 5). In the B set 10 genotypes produced >8 t/ha yield. The genotype H1007 produced the highest yield (59.48 kg/day) followed by H1015 (55.81 kg/ha) (Table 6). In the C set nine genotypes produced >9 t/ha yield. The genotype H1036 produced the highest yield (61.03 kg/day) followed by H1021 (57.70 kg/ha) (Table 7).

PEST MANAGEMENT

Monitoring of pest and natural enemy incidence by using light trap

Rice insect pests and their natural enemies were monitored throughout the year by Pennsylvanian light traps from July 2014 to June 2015 to study the pests and their natural enemies' incidence pattern in light trap and to create a database. The traps were operated with 100 WATT white fluorescent tube light from dusk to dawn and the tube was operated from the nearest electricity sources of the light traps. Insect pests and natural enemies those were attracted to the light of the light trap slipped into the hole of the trap and caught behind in a pot, which was attached with the hole of the trap. Then the insect pest and

Table 5. Yield and ancillary characters of the Hybrids for A set, Boro 2014-15.

Designation	Plant ht (cm)	Growth duration (days)	Sterility (%)	Yield (t/ha)
H1038	110.9	162	12.09	7.79
H1039	88.7	146	18.99	6.14
H1040	115.9	158	19.79	7.87
H1041	81.3	148	9.50	7.80
H1042	89.6	148	10.34	6.65
H1043	92.7	147	8.79	8.14
H1044	94.1	145	11.58	8.21
H1045	91.2	150	11.59	7.68
H1046	100.0	150	8.84	8.89
H1047	92.7	145	5.49	7.91
H1048	101.0	162	17.07	6.56
H1049	87.2	142	5.98	5.33
H1050	88.8	150	14.81	7.45
H1051	104.1	158	14.84	7.82
H1052	104.7	150	13.10	7.43
H1053	90.4	145	8.19	8.18
H998	92.3	148	5.66	8.42
H999	94.7	148	7.14	8.10
H1000	95.1	149	8.88	8.07
LSD at 5% level	2.05	-	-	0.52

DS: 6 Dec 2014, DT: 10 Jan 2015.

Table 6. Yield and ancillary characters of the Hybrids for B set, Boro 2014-15.

Designation	Plant ht (cm)	Growth duration (days)	Sterility (%)	Yield (t/ha)
H1001	91.4	145	5.49	8.67
H1002	83.9	148	11.80	8.23
H1003	108.7	149	10.34	8.21
H1004	83.5	147	8.78	7.01
H1005	89.1	151	12.94	7.61
H1006	95.1	149	15.79	6.73
H1007	93.1	155	4.60	9.22
H1008	90.9	147	8.39	7.72
H1009	90.6	149	11.64	8.37
H1011	100.4	162	13.68	6.67
H1012	100.5	156	9.94	7.81
H1013	98.3	158	13.02	7.96
H1014	95.0	147	8.38	8.38
H1015	106.6	160	21.43	8.93
H1016	101.2	153	11.11	8.15
H1017	103.2	162	15.48	7.50
H1018	81.5	142	8.19	8.06
H1019	95.5	155	6.75	8.42
LSD at 5% level	1.43	-	-	0.59

DS: 6 Dec 2014, DT: 10 Jan 2015.

Table 7. Yield and ancillary characters of the Hybrids for C set, Boro 2014-15.

	(cm)	(days)	(%)	(t/ha)
H1020	109.8	161	13.14	9.26
H1021	93.9	161	9.94	9.29
H1022	95.9	158	8.19	9.24
H1023	93.0	146	14.06	5.64
H1024	90.5	146	12.21	5.88
H1025	90.5	161	12.12	8.33
H1026	99.5	156	6.40	9.07
H1027	101.0	156	13.45	8.30
H1028	98.9	158	9.95	9.27
H1029	96.3	149	9.94	8.56
H1030	91.9	142	9.22	7.07
H1031	98.3	156	10.53	9.12
H1032	94.6	156	11.96	9.09
H1033	78.7	141	11.97	6.99
H1034	95.0	152	9.20	8.90
H1035	98.2	156	13.45	8.31
H1036	103.3	156	7.78	9.52
H1037	97.9	156	9.41	9.08
LSD at 5% level	1.78	-	-	1.78

DS: 6 Dec 2014, DT: 10 jan 2015.

natural enemies were collected, sorted, counted and recorded in the data sheet every day.

The abundance of green leafhopper (GLH), white leafhopper (WLH), brown plant hopper (BPH), white-backed plant hopper (WBPH), yellow stem borer (YSB), pink borer (PB), leaf roller (LR), caseworm (CW), grasshopper (GH), mole cricket (MC), field cricket (FC), rice bug (RB) and stink bug (SB) were found in the light trap during the reporting period. Among the insect pests, GLH populations were found the highest followed by BPH and YSB. Peak of GLH and WLH observed in November whereas YSB and BPH in October rather than a small peak of BPH found in May (Fig. 1).

Among the natural enemies; staphylinid beetle (STB) populations was found the highest followed by earwig (EW) and green mirid bug (GMB). Peak of STB and EW was observed in March and June respectively whereas, BPH showed two peak in November and May (Fig. 2).

Conservation of natural enemies through ecological engineering approaches, T. Aman 2014

The experiment was conducted with BRRI dhan52 in a large field divided into three blocks and each

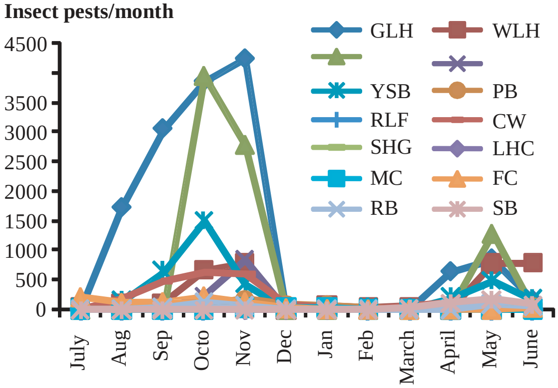


Fig 1. Incidence patterns of major insect pests in light trap, July 2014-June 2015.

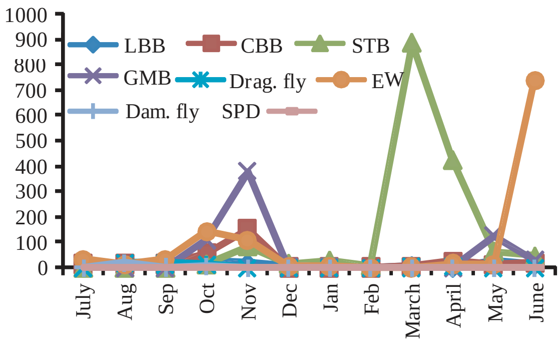


Fig. 2. Incidence pattern of natural enemies of rice insect pests in light trap, July 2014-June 2015.

block into four plots to conserve natural enemies through different ecological engineering approaches. Nectar-rich flowering plants (Cosmos) were planted on bunds of each four plots of the first block to provide food and shelter for different parasitoids. Normal cultivation was done in the second block with no insecticide. Prophylactic use of insecticide was done (Carbofuran 5G @ 10 kg/ha) at 15 days interval (5 times) in the 3rd block after 1st top dressing of urea. Twenty complete sweeps were taken from all the blocks at every 15 days interval up to flowering. Number of insect pest and natural enemies for all the sweeps from different blocks were counted and recorded separately. Parasitism was determined through retrieval method.

The results showed that the highest number of grasshopper (GH), green leafhopper (GLH) and rice leaf roller (RLR) were found in T_4 (9.5, 17.0 and 2.25/20 complete sweep, respectively). But the incidence was below the economic threshold level (Fig. 3). Incase of natural enemies the highest number of spider, damsel fly (Dam. fly), lady bird beetle (LBB) and long horned grasshopper (LHG) (5.75, 11.5, 2.25 and 2.75/20 complete sweep, respectively) were found in T_1 (Fig. 4). In T_3 four time used insecticide (Carbofuran 5G @ 10 kg/ha) but yield was similar to that of T_1 and T_2 where nectar-rich flowering plants grown in bunds surrounded rice crops. Lower yield was observed in T_4 where no insecticide was applied and no flowering plants were grown in rice bunds. Moreover the lowest parasitism occurred by *Trichogramma zahiri* where continuously insectiside was used (Fig. 5).

The highest natural enemies and parasitism by *Trichogramma zahiri* were observed in rice field nearby nectar-rich flowering plants. However, the least natural enemies and parasitism were found in rice field where four times (continuous/ prophylactic) insecticides were applied. Moreover, there was no yield reduction in rice field surrounded by flowering plants compared with insecticide application. So, farmers can avoid the toxic and hazardous insecticides to control the insect pests by growing nectar-rich flowering plants on the bunds of surrounded rice crops.

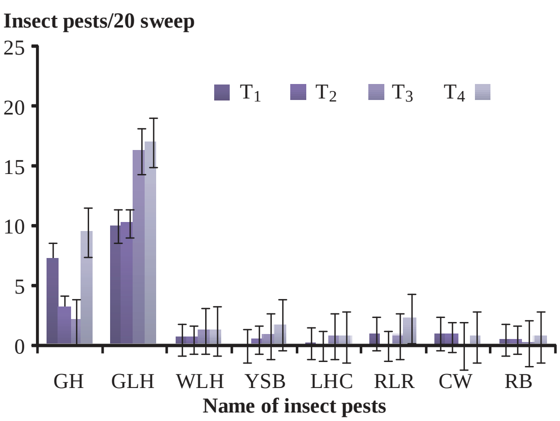


Fig. 3. No. insect pest/20 complete sweep in different treatments (T_1 and T_2 : 1 and 4 m away from the flowering plants of rice bund; respectively, T_3 : Prophylactic insecticide use) and T_4: Control (No insecticide and no flowering plants).

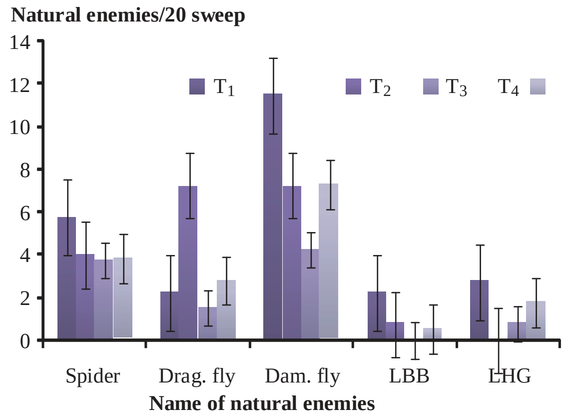


Fig. 4. No. natural enemies/20 complete sweep in different treatments (T_1 and T_2 : 1 and 4 m away from the flowering plants of rice bund; respectively, T_3 : Prophylactic insecticide use) and T_4 : Control (No insecticide and no flowering plants).

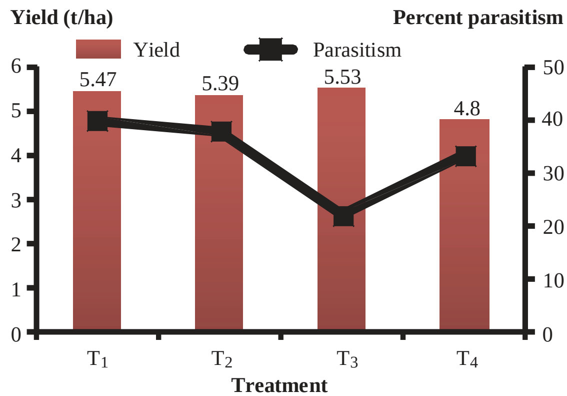


Fig. 5. Parasitism (%) by T. zahiri and yield in different treatments (T_1 and T_2 : 1 and 4 m away from the flowering plants of rice bund; respectively, T_3 : Prophylactic insecticide use) and T_4 : Control (No insecticide and no flowering plants).

BRRI RS, Rangpur

SUMMARY

In T. Aman 2014, PQR genotypes BR8226-8-5-2-2 and BR8226-17-1-2 gave 1.6 t/ha higher grain yield compared to the check variety BRRI dhan34 (RYT).

Two genotypes (HHZ6-SAL3-Y1-SUB2 and HHZ11-DT7-SAL1-SAL1) gave 1.75 and 1.0 t/ha higher yield respectively over the check variety BRRI dhan29 with similar growth duration.

T. Aus (BRRI dhan48)-T. Aman (BRRI dhan62)-Potato (Cardinal)-Mungbean (BARI 6) and Maize (NK40)-T. Aman (BR11)-Potato (Cardinal) gave higher rice equivalent yield and higher return compared to farmers' general practice.

BRRI dhan58 or BRRI hybrid dhan3 may be an alternative of BRRI dhan28 at late planting situation (Braus) after potato harvest in Rangpur region.

BRRI hybrid dhan3 produced higher yield (7.0 t/ha) at 1 March planting with 25-35 days old seedling but gave higher yield (6.40 t/ha) at 15 March planting with 40-day-old seedling.

Prilled urea application by applicator and pre-emergence herbicide + 1HW at 40 DAT may be used to obtain the highest yield of transplant Boro rice BRRI hybrid dhan3.

Better seedling growth with higher yield was obtained from late sowing (December 10 and 20) compared to early sowing (20 November and 1 December).

Polythene covering at day and night is more effective in dry seedbed compared to wet seedbed to reduce seedling mortality, cold injury and disease.

Farmers are growing tobacco at Rangpur and Lalmonirhat mainly because of higher profit.

A total of 10,262 kg TLS and 8,608 kg breeder seed of Aus (BRRI dhan48), T. Aman (BR11, BR22, BRRI dhan34, BRRI dhan46, BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and BRRI dhan62) and Boro (BRRI dhan28, BRRI dhan29, BRRI dhan50, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan60, BRRI dhan62) was produced.

VARIETAL DEVELOPMENT

Observational trial (OT)

Growing and screening of pedigree population. Eight F_2, 54 F_3, 30 BC_1F_3, 47 F_4, 63 F_5, 55 F_6, 27 F_7, 12 F_8 plant progenies (total 288) were grown to select of submergence and medium stagnant water tolerant progenies with improved plant type. A total 333 progenies and 14 bulk populations were selected and preserved from pedigree nursery (F_2-F_8 and BC_1F_3 generations (Table 1).

Secondary yield trial (SYT#2) under stagnant flood and rainfed conditions. Five genotypes along with one check variety were evaluated at rainfed and controlled stagnant conditions. Under rainfed condition, the tested entries performed well but in stagnation condition the lines did not give satisfactory yield and other parameters (Table 2). None of the genotypes were found superior than BRRI dhan44. Two genotypes were selected for SFT testing by Plant Physiology Division, BRRI.

Participatory variety selection (early) under flooded condition, T. Aman 2014. Six submergence and medium stagnant water tolerant high yielding genotypes along with two standard check varieties were evaluated in this trial under natural and

Table 1. List of progenies selected from F_2 population and Pedigree nursery, T. Aman 2014, BRRI RS, Rangpur.

BR no.	Parentage/ Pedigree	Progenies selected
	F_2 generation	
BR10209	IR09F226 × Chiherang-Sub1	7
BR10210	IR09F236 × Chiherang-Sub1	8
BR10211	BRRI dhan23 × Chiherang-Sub1	7
BR10212	BRRI dhan39 × Chiherang-Sub1	5
BR10214	BRRI dhan46 × BRRI dhan51	6
BR10216	BRRI dhan51 × DG1-349	5
BR10217	BRRI dhan51 × Chiherang-Sub1	8
BR10218	BRRI dhan52 × DG1-349	8
Sub-total		54
Generation	No. of crosses	
BC_1F_3	4 (30)	14
F3	11 (62)	73
F4	6 (47)	42
F5	7 (63)	48
F6	9 (55)	63
F7	4 (27)	27
F8	2 (12)	12
Total		333 progenies + 14 fixed lines

Table 2. Performance of the entries from SYT-2 (SFT) under rainfed and flooded conditions, T. Aman 2014.

Genotype	Plant ht (cm)		Duration (day)		Grain yield (t/ha)	
	Rainfed	Flooded	Rainfed	Flooded	Rainfed	Flooded
IR 09F188	102	112	132	130	5.00	3.17
IR 09F181	106	121	138	139	4.12	2.87
IR 09F186	94	103	133	131	4.64	2.58
IR 09F130	106	131	135	129	4.30	2.98
IR 09F222	108	120	137	132	5.16	3.15
BRRI dhan44 (ck)	113	132	143	138	5.16	3.40
LSD at 0.05	6.43	5.17	NS	1.05	0.70	0.70

controlled submergence conditions of Lalmonirhat and BRRI RS, Rangpur. PVS function was arranged at the station field with the gathering of 30 farmers. Each farmer was casted two positive and two negative votes for the best and worst entries, respectively, according to their own judgement. The reasons of liking and disliking for a particular entry were also recorded. The genotype, IR10F365 produce higher yield under controlled submergence condition at BRRI RS, Rangpur (Table 3). Three genotypes were selected based on yield and growth duration. The genotype IR09F365 received the highest vote followed by IR10F130 (Table 5) in on-station PVS function.

Participatory variety selection (late) under controlled submergence condition, T. Aman 2014. Seven submergence and medium stagnant water tolerant high yielding genotypes along with three standard check varieties were evaluated in this trial under controlled submergence condition. PVS function was arranged at on-station field with the gathering of 30 farmers. Among the genotypes, BR9158-19-9-6-9-9 produced higher yield (4.1 t/ha) with good survival (Table 4). In PVS function, BR9158-19-9-6-9-9 obtained the highest vote (Table 5).

Participatory variety selection (late) in natural flood condition, T. Aman 2014. Seven submergence and medium stagnant water tolerant high yielding genotypes along with three standard check varieties were evaluated in this trial under natural flood condition at Lalmonirhat.

PVS function was arranged at Kurul, Lalmonirhat with the gathering of 30 farmers. One genotype, BR9159-8-5-42-5-3 yielded 4.51 t/ha. The highest grain yield was found in BRRI dhan52 (4.65 t/ha) (Table 4). The genotype, BR9159-8-5-40-14-75 received the highest vote (Table 5).

Head to head trial of the *Sub1*-varieties in T. Aman season. Two submergence tolerant high yielding varieties viz BRRI dhan51 and BRRI dhan52 along with respective original mega varieties viz Lal Swarna and BR11 were evaluated for their adaptability in the favourable environments in the on-station and farmers' field under the management practices of researchers. Tested submergence tolerant varieties gave almost similar grain yield in four locations, where no significant difference was found (Table 6).

Table 3. Performance of entries from PVS early trial at BRRI RS, Rangpur and Kurul, Lalmonirhat under control submergence, T. Aman 2014.

Designation	Duration (day)		Plant ht (cm)		Yield (t/ha)	
	BRRI RS, Rangpur	Lalmonirhat	BRRI RS, Rangpur	Lalmonirhat	BRRI RS, Rangpur	Lalmonirhat
IR10F365	145	158	88.4	85	4.0	3.03
IR09F130	141	157	102.6	103	3.8	3.46
BR9157-12-37-13-77-32	135	151	100.9	82	2.6	3.46
BR9157-12-37-13-17-27	134	151	103.9	83	2.5	**3.56**
BR9157-12-37-13-15-30	133	151	102.9	81	2.5	3.25
BR9157-12-37-13-15-25	134	151	98.6	84	2.5	3.25
BINA dhan11(ck)	132	147	84.4	70	3.5	3.29
BRRI dhan33(ck)	-	143	-	89	-	3.09
LSD (0.05)	2.39	1.0	4.92	5.3	0.45	0.21

Table 4. Performance of entries in participatory variety selection (late) under controlled submergence condition, T. Aman 2014, BRRI RS, Rangpur and Kurul, Lalmonirhat.

Designation	Duration (day)		Plant ht (cm)		Yield (t/ha)	
	BRRI RS, Rangpur	Lalmonirhat	BRRI RS, Rangpur	Lalmonirhat	BRRI RS, Rangpur	Lalmonirhat
BR7937-28-1	161	142	104.1	107	3.2	3.52
BR9158-19-9-6-9-9	167	147	104.2	107	**4.1**	3.75
BR9158-19-9-7-8-3	168	148	104.2	105	3.3	4.44
BR9158-19-9-7-8-38	167	148	106.5	108	3.1	4.48
BR9159-8-5-49-1-2	155	134	86.6	88	3.8	4.20
BR9159-8-5-40-14-75	157	135	85.9	89	3.5	4.18
BR9159-8-5-42-5-3	155	134	85.6	87	3.5	4.51
BRRI dhan52 (ck)	161	143	103.1	105	4.5	4.65
BRRI dhan44 (ck)	160	142	93.5	95	2.3	4.04
BRRI dhan49 (ck)	156	140	80.2	82	2.7	4.76
LSD at 0.05	0.87	NS	6.68	7.60	0.62	0.39

Table 5. Preference Analysis of participatory variety selection (Early and late), T. Aman 2014, BRRI RS, Rangpur and Kurul, Lalmonirhat.

Location	Farmer's preference ranking and score			
	1st positive	2nd positive	1st negative	2nd negative
BRRI RS, Rangpur (Early, Controlled)	IR10F365 (0.208)	IR09F130 (0.175)	BR9157-12-37-13-77-32 (-0.133)	BR9157-12-37-13-15-30(-0.100)
BRRI RS, Rangpur (Late, Controlled)	BR9158-19-9-6-9-9 (0.133)	BR9158-19-9-7-8-3 (0.075)	BRRI dhan49 (-0.175)	BRRI dhan44 (-0.133)
Kurul, Lalmonirhat (Late)	BR9159-8-5-40-14-75 (0.262)	BRRI dhan49 (-0.202)	BR7937-28-1 (-0.286)	BR9159-8-5-42-5-3 (-0.036)

In parenthesis data indicated preference score.

Regional yield trial (RYT)

A total of 11 RYTs were conducted under Aus, T. Aman and Boro seasons to develop rice varieties promising for partially irrigated, rainfed lowland (RLR), low inputs (GSR), disease resistance (DR), premium quality (PQR), micronutrient enriched (MN), high yielding rice (Short and long duration) against standard check varieties. Tables 7 and 8 present the results of grain yield and other parameters of different RYTs.

Proposed variety trial (PVT)

A total of six PVTs were conducted under T. Aman and Boro seasons to develop rice varieties promising for partially irrigated (drought), rainfed lowland (RLR), premium quality (PQR), micronutrient enriched (MN), aerobic rice against standard check varieties. Table 9 presents the results of grain yield and other parameters of different PVTs.

CROP-SOIL-WATER MANAGEMENT

Performance of hybrid and inbred rice at late planting situation under T. Aman-Potato-Braus cropping pattern in Rangpur. The experiment was conducted in BRRI RS, Rangpur

Table 6. Grain yield and growth duration of different varieties in head to head trial, T. Aman 14.

Genotype	Yield (t ha^{-1}) and growth duration (day)				Average yield (t ha^{-1})
	L1	L2	L3	L4	
BRRI dhan51	4.7 (141)	4.2 (148)	4.3 (149)	5.1 (142)	4.58
BRRI dhan52	4.0 (140)	5.3 (145)	5.0 (144)	3.8 (139)	4.53
Lal Swarna (Ck)	4.4 (143)	4.2 (147)	4.3 (146)	4.0 (143)	4.23
BR11 (Ck)	4.3 (145)	4.6 (146)	4.8 (145)	5.3 (145)	4.75
LSD (0.05)	0.33	0.07	0.27	0.41	0.27

L1=Pirgachha, L2=Rangpur, L3=Mithapukur, L4=BRRI RS, Rangpur.

Table 7. Grain yield and other parameters of Upland Aus (RYT), 2014, BRRI RS, Rangpur.

Entry	Day to maturity (80%)	Plant ht (cm)	Panicle/m^2	Grain/panicle	1000-grain wt (g)	Yield (t/ha)
BR7698-2B-1-9-1	96	91.5	51	74	19.6	1.27*
BR7698-2B-1-9-2	96	80.7	51	71	28.6	1.20**
BR7691-2B-3-13-3	106	93.3	48	71	26.5	1.10*
BR7992-2B-52	94	91.7	41	67	28.4	0.85*
BR7992-2B-54	100	92.1	48	75	20.6	0.93**
BR7683-2B-2	94	90.9	47	76	28.5	1.10*
BR7587-2B-3	96	108.3	38	74	28.7	0.91**
BRRI dhan43 (ck)	91	94.2	42	75	28.4	0.76*

*Average yield of two replications, **Yield of one replication (Due to rat damage).

Table 8. Grain yield and other characters of different entries under RYT, T. Aman and Boro 2014-15, BRRI RS, Rangpur.

Entry	Seedling ht (cm)	Plant ht (cm)	Duration (day)	Yield (t/ha)
T. Aman				
RYT#1 (RLR)				
IR70213-10-CPA4-2-2-2	32.4	104.3	118	3.76
B 10533 F-KN-12-2	31.5	114.8	108	3.59
BR8033-2-2-1-2	26.9	104.7	127	4.77
BRRI dhan32 (ck)	28.0	125.5	122	4.84
BRRI dhan49 (ck)	27.2	105.5	126	4.87
RY#2 (RLR)				
WAS122-IDSA 14-WAS B-FKR 1 (NERICA-L-8)	28.5	107.8	112	4.88
WAS122-IDSA 1-WAS-2-B-1-TGR132(NERICA-L-16)	29.2	119.1	116	3.62
WAS 161-B-6-B-1 (NERICA-L-36)	28.7	106.9	112	4.65
WAS 161-B-4-B-1-TGR 51 (NERICA –L-32)	26.1	104.8	112	4.18
WAS 191-4-10(NERICA-L-54)	26.4	99.1	113	3.59
NERICA MUTANT	27.6	107.3	99	3.35
BRRI dhan56 (ck)	27.8	111.3	102	4.86
BRRI dhan49 (ck)	25.0	106.0	127	5.42
RYT#3 (PQR)				
BR8226-8-5-2-2	27.4	114.7	143	4.68
BR8226-11-4-4-3	26.8	110.2	144	4.23
BR8226-11-4-6-2	22.7	113.9	143	4.35
BR8294-1-3-2-2	29.0	111.2	112	4.07
BR8226-13-1-2	25.9	115.8	141	4.39
BR8226-17-1-2	27.5	122.1	142	4.63
BR8227-6-2-1	28.6	117.6	130	4.29
BR8515-23-6-3	27.8	107.7	140	1.51
BRRI dhan34 (ck)	28.8	130.4	142	2.98
BRRI dhan37 (ck)	33.3	128.6	155	3.13
RYT#4 (MER)				
BR7840-54-3-2-2	30.8	120.8	115	4.85
BR7879-17-2-4-HR3-P1	43.3	135.1	132	3.51
BR7671-37-2-2-3-7-3	31.0	102.3	113	4.54
BR8143-15-2-1	31.3	115.2	126	4.64
BR8418-1-3	33.5	103.0	113	4.75
IR5856-75-2-2-3-2 (IR10 M 300)	34.2	117.1	115	4.04
PSBRC82 (IRRI 123)	34.1	111.9	115	4.71
BRRI dhan32 (ck)	32.2	137.5	125	5.96
BRRI dhan39 (ck)	29.2	106.4	116	4.56
RYT#5 (GSR)				
IR83140-B-28-B	37.4	116.9	111	4.60
IR83142-B-19-B	38.6	115.9	112	4.42
IR83142-B-60-B	38.2	115.9	112	4.27
HHZ5-SAL10-DT1-DT1	32.6	104.9	111	3.87

Table 8. Continued.

Entry	Seedling ht (cm)	Plant ht (cm)	Duration (day)	Yield (t/ha)
BRRI dhan39 (ck)	30.0	106.5	116	4.43
BRRI dhan56 (ck)	37.4	116.9	106	4.71
Boro				
RYT# 1(PQR)				
IR77734-93-2-3-2	11	83	155	6.00
BR8079-52-2-2-2	13	90	160	6.65
BR8096-55-1-9-1	13	76	155	5.65
BR8076-1-2-2-3	14	92	164	6.90
BR8096-48-2-2-4	14	84	155	5.54
BRRI dhan50 (ck)	11	77	160	5.60
BRRI dhan63 (ck)	11	84	155	5.77
RYT# 2 (PQR-Com) (Result not found due to germination failure)				
RYT# 3 (Short duration)				
NERICA Mutant	14	93	151	6.15
BRRI dhan28 (ck)	12	90	145	7.11
RRI dhan45 (ck)	12	94	145	6.00
RYT # 4 (Favourable Boro)				
BR7683-30-3-3-4	11	91	150	5.42
BR7671-37-2-2-3-7	11	96	150	5.34
BR7988-4-5-3-4	11	72	150	5.33
BR7783-AC12-3	12	96	150	5.02
BR7783-AC13-5	11	94	162	5.24
BR7783-AC14-5	12	97	162	5.46
BR7783-AC6-3-2-2-1	11	94	162	5.40
BRRI dhan29-SC3-28-16-10-8- HR1	10	88	150	6.24
BR7988-10-4-1	10	81	150	5.98
BR7800-63-1-7-3	11	90	150	6.37
BRRI dhan28 (ck)	14	93	150	5.83
BRRI dhan29 (ck)	10	94	165	7.21
BRRI dhan60 (ck)	14	85	150	6.23
RYT#5 (Micronutrient)				
BR7840-54-3-2-1	11	87	154	5.03
BR7840-54-3-4-1	13	95	150	4.21
BR7840-54-3-2-4	13	93	150	5.02
4BR8257-37-1-2-2	15	91	150	4.45
BR7833-19-2-3-5	13	94	150	5.62
BR8261-19-1-1-3	12	94	157	4.93
BR7820-18-1-6-3-P4	12	94	157	4.35
BR7881-62-2-3-7-P3	12	93	164	5.60
BR7879-17-2-4-HR3-P1	16	118	158	5.54
BRRI dhan28 (ck)	13	91	150	6.12
BRRI dhan29 (ck)	10	91	165	6.80
RYT#6 (GSR)				
HHZ15-SAL13-Y1	12	88	162	6.25
HHZ23-DT4-DT1-Y1	11	81	155	7.89
HHZ15-DT4-DT1-DT1	13	80	152	8.04
HHZ11-DT7-SAL1-SAL1	12	82	156	8.61
HHZ6-SAL3-Y1-SUB2	14	90	162	9.35
BRRI dhan29 (ck)	12	93	165	7.61
BRRI dhan60 (ck)	16	80	154	7.14
RYT#7 (High yielding rice, short and long duration, Biotechnology Division)				
Short duration				
BR8072-AC5-4-2-1-2-1	14	76	149	4.30
BR8072-AC7-4-2-1-2-1	17	77	149	5.01
BR8072-AC8-1-1-3-1-1	15	79	149	5.12

Table 8. Continued.

Entry	Seedling ht (cm)	Plant ht (cm)	Duration (day)	Yield (t/ha)
BR8072-AC11-2-3-2-1-1	18	84	149	5.54
BR4909-R1-R2	19	106	159	5.54
BRRI dhan28 (ck)	21	96	143	5.30
Long duration				
BR6158RWBC2-2-1-1	18	80	161	5.75
BRRI dhan58 (ck)	17	102	159	5.62
BRRI dhan29 (ck)	15	95	167	6.75

Table 9. Yield and other parameters of proposed variety trial (PVT) in T. Aman and Boro 2014-15.

Tested entry	Day to flowering	Day to maturity	P. Accep. (at mat.)	Lodging	Grain yield (t ha^{-1})
T. Aman					
PVT (Drought, Rangpur and Lalmonirhat, Av. of two locations)					
IR83377-B-B-93-3	87	110	Fair	No	4.8
IR82589-B-B-84-3	87	110	Fair	No	5.0
BRRI dhan56 (ck.)	80	105	Good	Partial	5.0
PVT (RLR, Rangpur sadar)					
BR7472-16-2-1-2-3	100	125	Good	No	4.5
BR7622-5-1-1-1	100	125	Good	No	4.5
BRRI dhan39 (ck.)	85	110	Fair	No	3.5
BRRI dhan49 (ck.)	100	128	Good	No	4.7
PVT (PQR, Dorshona, Rangpur sadar)					
BR7357-11-2-4-1-1	100	125	Good	No	5.07
BRRI dhan37 (ck)	-	-	-	No	-
PVT (Zn, Rangpur Sadar)					
BR7428-2R-19-HR10	100	125	Fair	No	4.4
BRRI dhan39 (ck)	85	110	Fair	No	3.5
Boro					
PVT (Zn, Nozirerhat, Rangpur sadar)					
BR7833-11-1-1-2-1-2B5	111	136	Good	No	6.20
BR7671-37-2-2-3-7	115	142	Good	No	6.98
BRRI dhan28 (ck.)	114	140	Good	No	7.10
BRRI dhan64 (ck.)	120	148	Good	No	5.89
PVT (Aerobic Rice, Rangpur region, Av. of five locations)					
IR83140-B-36-B-B	111	147	Good	No	6.63
IR83140-B-71-B-B	115	144	Good	No	7.01
BRRI dhan28 (ck)	114	141	Good	No	6.63
BRRI dhan29 (ck)	120	158	Good	No	7.45

farm to evaluate hybrid and inbred rice varieties as Braus after potato harvest using split plot design with three replications. For T. Aman, transplanting was started from 30 July to 30 August with 15 days interval and for Braus, transplanting was started from 1 March to 30 March with 15 days interval. BRRI dhan56, BRRI dhan57, BRRI dhan62 and BRRI hybrid dhan4 were grown during T. Aman. During Braus (2015), BRRI hybrid dhan3, Hira2, SL8-H, BRRI dhan28, BRRI dhan48, BRRI dhan58 and BINA dhan-14 were grown. BRRI dhan56 (4.17 t/ha), BRRI dhan62 (3.74 t/ha) and BRRI hybrid dhan4 (4.24 t/ha) gave higher yield at 30 July planting but BRRI dhan62 (3.95 t/ha) gave higher yield at 15 August planting. Among the varieties, BRRI dhan57 gave the lowest yield at all planting dates. Irrespective of planting dates, BRRI dhan62 gave higher (3.71 t/ha) grain yield as it produced higher number of panicles at all planting dates followed by BRRI dhan56 (3.51t/ha). At 30 August planting, BRRI dhan62 gave higher (3.43 t/ha) yield followed by

BRRI Hybrid dhan4 (3.24 t/ha) and BRRI dhan56 (3.14 t/ha) (Table 10). As Braus, hybrid varieties gave higher grain yield than inbred from 1-15 March planting but inbred variety gave higher yield at 30 March planting. BRRI dhan48 and BRRI dhan58 gave higher yield at 15 March planting. BINA dhan14 gave higher yield at 30 March planting. Irrespective of planting date, BRRI dhan28, BRRI dhan48 and BRRI dhan58 gave statistically similar yield. Similarly, BRRI hybrid dhan3 and Hira2 gave statistically similar yield (>5.41 t/ha, Table 10). So, BRRI dhan58 or BRRI hybrid dhan3 may be an alternative of BRRI dhan28 at late planting situation (Braus) after potato harvest in Rangpur region.

Evaluation of cold tolerance ability of exotic and selected advanced lines under various planting dates in cold prone areas of Bangladesh. The experiment was conducted in BRRI RS, Rangpur farm to find out suitable rice genotypes having cold tolerance. Transplanting was started from 30 December 2014 to 28 January 2015 with seven days interval. Tested rice genotypes were: Exotic (Chines): CH30 and CH39, BRRI selected: IR77496-31-2-1-3-1, IR2266-42-6-2, BR7812-19-1-6-1-P4 & BR7813-1-1-3-13 and Bhutani and BRRI dhan28 (as check). Figure 1 indicates the trend of temperature from mid December to mid February at BRRI RS farm, Rangpur. During that period, temperature went below 10°C for 1 or 2 days, but there was no cold spell. So, real screening against cold was not possible. However, CH39 showed better crop growth and earliness compared to other materials. Although, Bhutani material gave lower yield at all planting dates but showed better seedling growth

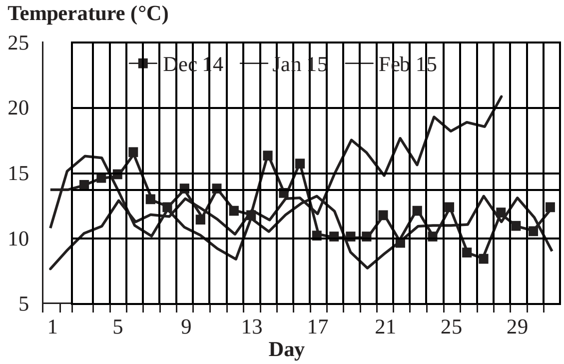


Fig. 1 Minimum temperature (less than 10°C) during crop growing period.

and greenness even in cold. BR7812-19-1-6-1-P4 (6.64 t/ha), IR2266-42-6-2 (6.23 t/ha) and BRRI dhan28 (6.19 t/ha) gave higher yield at 15 January planting but BR7813-1-1-3-1(6.02 t/ha) gave higher yield at 7 January planting. At 15 January planting, IR2266-42-6-2 gave higher yield (6.23 t/ha) but IR77496-31-2-1-3-1 gave higher yield from 21 to 28 January planting (Table 11).

Adjustment of seedling age of hybrid rice under variable planting after potato harvest in Rangpur. The experiment was conducted in BRRI RS, Rangpur farm to find out optimum seedling age of suitable hybrid rice varieties after potato harvest for maximizing grain yield. BRRI hybrid dhan3 gave about 7 t/ha yield at 1 March planting with 25-35-day-old seedling but gave higher yield (6.40 t/ha) at 15 March planting with 40-day-old seedling. Hira2 gave higher yield (6.84-7.05 t/ha) at 1 March planting with 25-30-day-old seedling but gave higher yield (6.13 t/ha) at 15 March planting with 35-day-old seedling. SL8-H gave higher yield (6.53 t/ha) at 1 March planting with

Table 10. Yield performance of inbred and hybrid rice as Braus, Rangpur, 2015.

Braus variety	Mean grain yield (t/ha)			Mean of variety
	1 Mar	15 Mar	30 Mar	
BRRI dhan28	4.93	4.83	5.23	5.00
BRRI dhan48	4.73	5.40	5.00	5.04
BRRI dhan58	4.63	5.67	5.13	5.14
BINA dhan14	4.73	3.83	5.00	4.52
BRRI hybrid dhan3	6.10	5.53	4.60	5.41
SL8-H	6.62	5.67	3.73	5.34
Hira2	6.20	4.77	5.33e	5.43
SE		0.1543		
$LSD_{(0.05)}$		0.3118		

Table 11. Yield performance of cold tolerant genotypes at variable date of planting, BRRI RS, Rangpur, Boro 2014-15.

Genotype	Mean grain yield (t ha^{-1})					Mean of variety
	30 Dec	7 Jan	15 Jan	21 Jan	28 Jan	
BR7812-19-1-6-1-P4	6.08	5.74	6.64	6.01	5.49	5.99
BR7813-1-1-3-1	4.63	6.02	4.05	4.13l	4.21	4.39
IR77496-31-2-1-3-1	5.19	5.14	4.79	5.56	5.55	5.27
IR2266-42-6-2	4.96	5.16	6.23	5.43	5.41	5.48
CH30	4.20	5.01	5.53	5.21	4.94	5.27
Of varietyCH39	5.27	4.29	4.47	4.43	4.58	4.54
BRRI dhan28	5.13	5.30	6.19	4.91	6.12	5.48
Bhutani	4.97	3.93	4.02	3.32 o	3.79	4.01
SE			0.5402			
$LSD_{(0.05)}$			1.0755			

35-40-day-old seedling but gave higher yield (5.74 t/ha) at 15 March planting with 35-day-old seedling (Table 12).

Effect of prilled urea application and weed management options on N use efficiency by using applicator in BRRI hybrid dhan3. The experiment was conducted at BRRI RS, Rangpur farm by following split plot design with three replications to find out suitable weed management option for higher N use efficiency of prilled urea by applicator using BRRI hybrid dhan3. Treatments were 1. Methods of urea application (Main plot): N_1=Prilled urea by broadcasting (1/3 at 20 + 1/3 at 35 and 1/3 at 50 DAT) @ 250 kg/ha, N_2=Prilled urea by applicator @ 200 kg/ha at 2 DAT, N_0= No urea and 2. Weed management options (Sub plot): W_1=Pre-emergence herbicide (Super clean) + 1 HW at 50 DAT, W_2=Post emergence herbicide (Super power) + 1 HW at 50 DAT, W_3=Weeder at 25 DAT + 1 HW at 50 DAT, W_4=HW at 25, 40 and 50 DAT, W_5=No weeding. Interaction of weeding treatments and application of urea exhibited significant influence on number of total tillers m^{-2}. The highest number of total tillers m^{-2} was found from the interaction of N_1W_2 and lowest was noticed at N_0W_5, which was identical with N_1W_5 and N_2W_5. Number of panicle m^{-2} varied significantly due to interaction of weeding method and N application and the highest (372) was obtained from the interaction of N_1W_2, which was significantly similar to that of interaction of N_2W_2. The lowest number of panicle m^{-2} was observed from N_0W_5, which was statistically similar to N_1W_5 and N_2W_5. Interaction effect of weeding and N application exhibited significant influence on number of grains $panicle^{-1}$. The highest number of grains $panicle^{-1}$ (148) was recorded from the treatment combination of N_1W_2 and the lowest (69) was from N_0W_5 (no weeding and no N application). Interaction effect of weeding treatments and N application had significant influence on grain yield. Result showed that (N_1W_2) pre-emergence treatment with N application through prilled urea broadcasting produced the highest grain yield (9.96 t ha^{-1}) and the lowest (2.89 t ha^{-1}) was obtained from the interaction of N_0W_5. Higher grain yield was observed in urea broadcasting (250 kg ha^{-1})

Table 12. Yield performance of hybrid rice as Braus at variable planting with different seedling age, BRRI RS, Rangpur, Boro 2014-15.

Seedling age (day)	Mean grain yield (t/ha)								
	BRRI hybrid dhan3			Hira2			SL8-H		
	1 March	15 March	30 March	1 March	15 March	30 March	1 March	15 March	30 March
20	5.85	4.19	3.04	5.85	4.19	3.04	6.18	3.80	2.06
25	7.14	4.90	3.13	7.05	5.30	2.55	6.30	4.80	2.40
30	5.17	3.04	3.14	6.84	5.25	2.13	6.33	5.13	2.44
35	7.24	5.50	2.95	6.30	6.13	2.57	6.53	5.74	2.81
40	6.37	6.40	2.17	6.40	6.74	2.11	6.54	5.34	1.53
SE					0.1690				
$LSD_{(0.05)}$					0.3358				

compared to prilled urea applicator in all weed management options (Table 13).

Introducing improved cropping pattern for increasing cropping intensity and productivity in Rice-Rice system. The experiment started in T. Aman 2014 in BRRI RS farm to increase the cropping intensity, productivity and income. The initial soil was analyzed. The treatments were T_1=Potato (Cardinal)-Mungbean (BARI Mug 6)-T. Aus (BRRI dhan48)-T.Aman (BRRI dhan62), T_2=Mustard (BARI 14)-Mungbean (BARI 6)-T. Aus (BRRI dhan48)-T. Aman (BRRI dhan62), T_3=Potato (Cardinal)-Maize (Hybrid NK40)-T. Aman (BR11)-Farmers' improve practice, T_4=Boro (BRRI dhan28)-T.Aman (BR11)-Farmers' general practice. After completion of one year study, soil from each plot was collected and tested to evaluate the soil fertility. In T. Aman season, short duration variety BRRI dhan62 was used in T_1 and T_2 (four crop system) and yield was 3.87 and 3.85 t/ha respectively. In T_3 and T_4 (3 crop and 2 crop system respectively) common variety BR11 was used and grain yield was 4.12 and 3.86 t/ha respectively (Table 14). After T. Aman (BRRI dhan62) harvest, Potato was sown in T_1 while the yield was 24.66 t/ha. After BR11 harvest in T_3 the potato yield was 24.17 t/ha. After BRRI dhan62 harvest in T_2, Mustard was sown in T_1 while the yield was 1.16 t/ha. After potato harvest, mungbean was sown in T_1 while the yield was 0.98 t/ha. After mustard harvest in T_2, the mungbean yield was 0.83 t/ha. After Potato harvest in T_3, maize was sown and the yield was 8.38 t/ha. After T. Aman (BR11) harvest, Boro 2015 was grown in T_4 (BRRI dhan28) and the yield was 5.42 t/ha. The yield of BRRI dhan48 in T_1 and T_2 in T. Aus season was 4.5 t ha^{-1}.

Comparing the rice equivalent yield (REY), T_1 obtained the highest yield (yearly total= 30.05 t ha^{-1}) with highest economic return followed by T_3 (yearly total= 23.42 t ha^{-1}, Table 15). Poor yield of mustard and mungbean resulted the lower REY even with four crops (T_2). Total cost of production and net income under different cropping pattern were estimated (Table 16). The results showed that the highest net profit was observed in T_1 (4 crops with early potato and BRRI dhan62) followed by T_3 (Farmers' improved practice). In case of soil fertility evaluation, no change in soil pH, little changes in organic matter and total N and K, much increasing tendency in P, S and Zn were observed.

Long-term effect of three cropped cropping patterns on the agro-economic productivity and soil health. The experiment was conducted during

Table 13. Interaction effect of weeding method and nitrogen application on yield and yield contributing characters of BRRI hybrid dhan3.

Interaction	Plant ht (cm)	Tiller m^{-2}	Panicle m^{-2}	Grain $panicle^{-1}$	Grain yield (t ha^{-1})	Sterility (%)	Harvest index (%)
N_0W_1	91	212 e	186 d	98 d	4.17 d	9.8	41 bcd
N_0W_2	91	221 e	192 d	99 d	4.27 d	9.4	42 bcd
N_0W_3	92	210 e	186 d	95 d	4.33 d	8.7	43 bc
N_0W_4	90	211 e	188 d	93 d	4.02 d	8.3	43 bc
N_0W_5	76	180 f	159 e	69 e	2.89 e	12.6	38 d
N_1W_1	106	376 bc	365 ab	144 ab	9.69 ab	21.9	50 a
N_1W_2	108	392 a	372 a	148 a	9.96 a	14.3	50 a
N_1W_3	107	365 cd	350 c	145 ab	9.65 ab	23.6	50 a
N_1W_4	105	379 b	355 bc	144 ab	9.31 abc	24.3	50 a
N_1W_5	87	188 f	166 e	94 d	3.72 d	19.4	38 d
N_2W_1	104	365 cd	359 abc	132 c	8.80 c	14.4	50 a
N_2W_2	107	381 ab	370 a	138 bc	9.69 ab	15.9	50 a
N_2W_3	105	363 d	354 c	131 c	9.04 bc	14.7	44 b
N_2W_4	106	370 bcd	353 bc	132 c	8.58 c	8.7	49 a
N_2W_5	84	186 f	169 e	92 d	3.80 d	22.1	39 cd
Level of Significance	NS	**	**	**	**	NS	*
CV (%)	3.47	2.69	2.86	3.79	6.25	39.37	5.68

N_1=Prilled urea by broadcasting (1/3 at 20 + 1/3 at 35 and 1/3 at 50 DAT) @ 250 kg/ha; N_2=Prilled urea by applicator @ 200 kg/ha at 2 DAT; N_0= No urea. W_1=Pre-emergence herbicide (Super clean) + 1 HW at 50 DAT; W_2=Post emergence herbicide (Super power) + 1 HW at 50 DAT; W_3=Weeder at 25 DAT + 1 HW at 50 DAT; W_4=HW at 25, 40 and 50 DAT; W_5=No weeding.

Table 14. Grain yield and yield components of BRRI dhan62 and BR11, BRRI RS, Farm, Rangpur, T. Aman 2014.

Interaction	Plant ht (cm)	Tiller/hill	Panicle m^{-2}	Grain $panicle^{-1}$	1000-grain wt (g)	Grain yield ($t\ ha^{-1}$)	Sterility (%)	Harvest index
T_1	101	11	250	71	24.05	3.87	17.2	0.46
T_2	99	12	250	61	23.55	3.85	22.8	0.46
T_3	95	8	175	89	23.21	4.12	19.3	0.48
T_4	95	7	175	92	23.11	3.86	27.9	0.46
$LSD_{0.05}$	2.92	1.2	25.73	15.36	NS	NS	8.49	NS
CV%	1.50	6.33	9.8	9.83	3.09	7.05	13.36	3.0

* T_1 and T_2: BRRI dhan62, T_3 and T_4: BR11.

Table 15. Rice equivalent yield under different cropping patterns, 2014-15, BRRI RS, Rangpur.

Treatment	1st crop yield (t/ha)	2nd crop yield (t/ha)	3rd crop yield (t/ha)	4th crop yield (t/ha)	REY (t/ha)
T_1	BRRI dhan62 = 3.87	Potato = 24.66*	Mungbean = 0.98	BRRI dhan48 = 4.5	30.05
T_2	BRRI dhan62 = 3.85	Mustard = 1.16**	Mungbean= 0.86	BRRI dhan48 = 4.5	13.94
T_3	BR11 = 4.12	Potato = 24.17	Maize = 8.38	-	23.42
T_4	BR11= 3.86	Boro= 5.42	-	-	9.28

Assuming that, *1 t potato= 0.94 t rice (early), 0.63 t rice (late) **1 t mustard = 2.5 t rice, 1t mungbean=3.13 t rice, 1 t maize=0.5 t rice (Rice=Tk 16/kg, Potato=Tk 15/kg early, Potato=Tk 10/kg late Mustard= Tk 40/kg, Mungbean=Tk 50/kg and Maize=Tk 8/kg at harvest).

Table 16. Total cost of production and net income under different cropping pattern (Tk/Bigha), BRRI RS, Rangpur, 2014-15.

Treatment	1st crop (Tk)		2nd crop (Tk)		3rd crop (Tk)		4th crop (Tk)		Total (Tk)		Net income
	Cost	Income	Cost	Income	Cost	Income	Cost	Income	Cost	Income	
T_1	9,885	12,306	23,470	49,425	4,693	6,550	8,727	10,818	46,775	79,099	32,324
T_2	9,885	12,306	5,544	6,200	4,693	5,750	8,727	10,818	28,849	35,074	6,225
T_3	10,385	11,408	24,070	32,870	8,727	8,960	-	-	43,182	53,238	10,556
T_4	10,385	10,782	13,555	14,238	-	-	-	-	23,940	25,020	1,080

T_1=BRRI dhan62-Potato-Mungbean-BRRI dhan48; T_2=BRRI dhan62-Mustard-Mungbean-BRRI dhan48; T_3= BR11-Potato-Maize; T_4=BR11-Fallow-BRRI dhan28.

2014-15 at BRRI RS, Rangpur. The tested cropping patterns were, Potato-Boro-T. Aman, Maize-Mungbean-T. Aman, Boro- T. Aus-T. Aman and Boro-Fallow-T. Aman (ck). The yield of each crop was converted to REY for comparing the system productivity. Use of resources like labour and inputs was recorded for calculating the variable cost and market price of the output at maturity was collected for determining the economic return. In Rangpur, potato yielded 24 t ha^{-1} and maize yield was 9 t/ha. Mungbean yield was 0.25 t ha^{-1}, which was very poor yield due to late sowing. Grain yield of Boro rice was 8.71, 5.07 and 8.46 t ha^{-1} under Boro-Fallow-T. Aman, Boro-T. Aus-T. Aman and Potato-Boro-T. Aman cropping patterns. Grain yield of T. Aus rice was 3.60 t ha^{-1}. Rice equivalent yield (REY) was the highest in Potato-Boro-T. Aman cropping pattern (Table 17).

Production of quality Boro seedlings in dry seedbed under cold prone areas at Rangpur. The experiment was conducted at BRRI RS farm, Rangpur to produce quality seedlings and reduce mortality. Soil and atmosphere temperature were monitored after imposing the treatments. The treatments were: T_1 = Polythene covering during night up to 30 DAS, T_2 = Polythene covering during day up to 30 DAS and T_3 = Control. After completing the treatments all seedlings were transplanted at 40 DAS to evaluate the yield performance. Higher number of seedling was observed in T_2 in all sowing dates except 1st December (Table 18). Polythene covering during night and day produced good quality seedlings compared to control in dry condition. But 5-10% seedling mortality, cold injury and brown spot disease were observed in both treatments while those were 50-60% in control. Good quality seedlings were produced at 10 December and 20 December sowing compared to 20 November and 1 December. Seedling mortality, cold injury and brown spot disease were lighter in early sowing (20 November and 1 December) compared to late

Table 17. Yield of rice, potato and mungbean and REY under different cropping patterns, BRRI RS, Rangpur, 2014-15.

Cropping pattern	Grain/Tuber yield (t/ha)				REY (t/ha)
	Maize/Potato	Boro	T. Aus/Mungbean	T. Aman	
		Rangpur			
Boro-Fallow-T. Aman	-	8.71	-	4.00	12.81
Boro-T. Aus-T. Aman	-	5.07	3.60	4.68	13.35
Maize-Mungbean-T. Aman	9.00	-	0.25	4.86	9.50
Potato-Boro-T. Aman	24.00	8.46	-	4.13	27.59

Table 18. Stand establishment at 25 DAS as influenced by dry seedbed management (Av. of three replications), Boro 2014-15.

Treatment	Number of seedlings/m^2			
	1st Set (20 Nov 14)	2nd Set (1 Dec 14)	3rd Set (10 Dec 14)	4th Set (20 Dec 14)
T_1	2544	2872	1520	2048
T_2	2524	2732	1752	2820
T_3	2460	2784	1360	2084

T_1=Polythene covering during night up to 30 DAS; T_2=Polythene covering during day up to 30 DAS; T_3=Control.

sowing (10 and 20 December) (Table 19). The seedling mortality was much higher in dry seedbed without polythene covering. Higher grain yield was observed from the seedlings of late sowing (10 and 20 December) and seedlings of polythene covered seedbed.

Production of quality Boro seedlings in wet seedbed under cold prone areas at Rangpur. The experiment was conducted at BRRI RS farm, Rangpur to produce quality seedlings and reduce mortality. Sprouted seeds of BRRI dhan28 were sown on the seedbed. Soil and atmosphere temperature were monitored after imposing the treatments. The treatments were: T_1 = Polythene covering during night up to 30 DAS, T_2 = 25% rice bran with soil in seedbed, T_3 = Seedbed with continuous water and T_4 = Control. After completing the treatments all seedlings were transplanted at 40 DAS to evaluate the yield performance. None of the seedbed management treatment obtained consistently higher number of seedlings at 25 DAS (Table 20). But good quality seedlings were produced in polythene covering during night, 25% rice bran with soil and continuous water in treated seed bed compared to control. In some of the treated plots, 2-5% mortality, cold injury and brown spot disease were observed (Table 21). Among the sowing times, very good quality seedlings were in 1 December sowing compared to that of 20 November, 10 December and 20 December. Higher grain yield was observed from the seedlings of late sowing (10 and 20 December) and that produced from different treated seedbed compared to control. Seedling mortality and brown spot was much higher in dry seedbed compared to wet seedbed.

Table 19. Performance of seedlings under different treatments at 40 DAS as influenced by dry seedbed management (Av. of three replications), Boro 2014-15.

Treatment			Mortality %	Cold injury %	Remark
1st Set (20 Nov 14)	:	T_1	10	10	Brown spot (30%)
		T_2	5	5	Brown spot (20%)
		T_3	50	50	Brown spot (50%)
2nd Set (1 Dec 14)	:	T_1	15	10	Brown spot (20%)
		T_2	10	5	Brown spot (20%)
		T_3	60	50	Brown spot (20%)
3rd Set (10 Dec 14)	:	T_1	<5	<5	Brown spot (5%)
		T_2	<5	<5	Brown spot (5%)
		T_3	>5	>10	-
4th Set (20 Dec 14)	:	T_1	5	5	Brown spot (<5%)
		T_2	<5	<5	Brown spot (<5%)
		T_3	20	15	Brown spot (5%)

T_1=Polythene covering during night up to 30 DAS; T_2=Polythene covering during day up to 30 DAS; T_3=Control.

Table 20. Stand establishment at 25 DAS as influenced by wet seedbed management (Av. of three replications), Boro 2014-15.

Treatment	Number of seedlings/m^2			
	1st Set (20 Nov 14)	2nd Set (1 Dec 14)	3rd Set (10 Dec 14)	4th Set (20 Dec 14)
T_1	1480	3020	1832	2536
T_2	1608	2776	2192	2708
T_3	1492	3024	1856	3004
T_4	1448	2816	2072	2484

Table 21. Performance of seedlings under different treatments at 40 DAS as influenced by wet seedbed management (Av. of three replications), Boro 2014-15.

Treatment			Mortality %	Cold injury %	Remark
1st Set (20 Nov 14)	:	T_1	<5	-	Brown spot (20%)
		T_2	<5	5	Brown spot (20%)
		T_3	<5	5	Brown spot (20%)
		T_4	>5	5	Brown spot (20%)
2nd Set (1 Dec 14)	:	T_1	-	-	Brown spot (20%)
		T_2	-	2	Brown spot (20%)
		T_3	-	-	Brown spot (20%)
		T_4	<5	3	Brown spot (20%)
3rd Set (10 Dec 14)	:	T_1	-	-	-
		T_2	-	-	-
		T_3	-	-	-
		T_4	-	-	-
4th Set (20 Dec 14)	:	T_1	-	-	-
		T_2	-	-	-
		T_3	-	-	-
		T_4	-	-	-

T_1 = Polythene covering during night up to 30 DAS; T_2=25% rice bran with soil in seedbed; T_3=Seedbed with continuous water; T_4=Control.

TECHNOLOGY TRANSFER

Demonstration of modern T. Aus varieties at Rangpur region 2014 (IAPP). Demonstration of BRRI dhan48 was conducted in eight farmers' field at four locations of Rangpur region (Rangpur-2, Nilphamari-2, Lalmonirhat-2. Kurigram-2) in Aus 2014. The unit plot size was one Bigha (33 decimal). Average grain yield of BRRI dhan48 was 4.58 tha^{-1} (Table 22) and preferred by the farmers because of higher grain yield and less pest infestation.

Demonstration of DSR techniques using short duration varieties during T. Aman (IAPP). Three demonstration trials were conducted in Nilphamary sadar during T. Aman 2014 with dry DSR using BRRI dhan33, BRRI dhan56, BRRI dhan57 and BRRI dhan62. Sowing was completed from 12-16 July. Forty kg ha^{-1} seed was used. Herbicide Glyphosate @ 3.0 L ha^{-1} was applied at 5-7 days before sowing. Pendimethylene @ 1.5 L ha^{-1} was applied at 2-3 days after sowing. The highest grain yield was found in BRRI dhan33 (4.68 t/ha) followed by BRRI dhan56 (4.36 t/ha, Table 23). Farmers' reaction of this technology was positive because of no water for land puddling, timely sowing and low rainfall for plant growing as well as low production cost.

Varietal trials of newly released BRRI varieties during Boro, 2014-15 (IAPP). A varietal trial was conducted in farmers' field during Boro 2014-15 in four locations of Rangpur, Nilphamari, Lalmonirhat and Kurigram under IAPP project. Four varieties (BRRI dhan28, BRRI dhan58, BRRI dhan59 and BRRI dhan60) were used in this trial. BRRI dhan58 gave the highest grain yield in all locations followed by BRRI dhan59, BRRI dhan28 and BRRI dhan60 (Table 24).

The farmers' of all locations have chosen BRRI dhan58 because of grain yield, plant type and shorter growth duration.

Table 22. Location wise grain yield and yield components of BRRI dhan48, Aus 2014 (IAPP).

Location	Farmer’s name	Plant ht (cm)	Panicle m^{-2}	Grain $panicle^{-1}$	1000-grain wt (g)	Yield (t ha^{-1})	Duration (day)
Pirganj, Rangpur	Abdul Kader	105	292	92	25.3	6.04	103
	Jamal kha	106	305	89	24.5	5.74	103
Sadar Lalmonirhat	Baneshor	103	272	72	24.1	3.55	98
	Romen	102	296	92	24.7	4.67	100
Rajarhat, Kurigram	Anath Chandro	104	264	85	24.5	4.36	102
	Jharu Barmon	101	288	90	24.6	4.57	102
Sadar Nilphamari	Aminur	100	245	90	24.6	4.29	101
	Motaleb	101	235	89	24.1	3.40	99
Mean		103	272	88	24.7	4.58	101

Table 23. Yield and yield components of short duration varieties as DSR, T. Aman 2014.

Village	Farmers name	Variety	Plant ht (cm)	Panicle m^{-2}	Grain $panicle^{-1}$	1000-grain wt (g)	Yield (t ha^{-1})	Sterility (%)
Laxmichap, Sadar, Nilphamari	Adhar	BRRI dhan33	98	301	78	25.3	4.00	34
		BRRI dhan56	110	273	79	23.2	3.01	28
		BRRI dhan57	104	292	59	23.0	2.70	34
		BRRI dhan62	94	288	78	24.9	3.98	26
	Dev Roy	BRRI dhan33	100	273	76	24.0	3.43	39
		BRRI dhan56	112	247	73	24.5	3.23	27
		BRRI dhan57	105	238	66	23.7	2.78	34
		BRRI dhan62	103	283	77	24.2	3.75	15
Berubandh, Jaldhaka Nilphamari	Jagobandhu	BRRI dhan33	106	295	81	24.5	4.68	26
		BRRI dhan56	115	291	80	22.8	4.36	25
		BRRI dhan57	110	284	72	22.4	4.25	29
		BRRI dhan62	106	317	86	24.5	4.51	17

Table 24. Grain yield and yield components of four varieties, Boro 2014-15 (Ave. of three replications), Rangpur.

Variety	Plant ht (cm)	Panicle m^{-2}	Grain $panicle^{-1}$	1000-grain wt (g)	Sterility (%)	Grain yield (t ha^{-1})
BRRI dhan28	97	309	105	22.50	23	6.0
BRRI dhan58	92	292	115	22.96	23	7.0
BRRI dhan59	74	296	108	24.56	26	6.3
BRRI dhan60	87	370	99	26.19	21	5.9

HarvestPlus project activities

BRRI RS, Rangpur conducted 25 demonstrations with BRRI dhan62 in 35 locations under Rangpur, Lalmonirhat, Kurigram, Nilphamari and Gaibandha districts in T. Aman 2014. Maximum crops were harvested at 95-100 days after sowing. The highest grain yield was found in Kathalbari sadar Kurigram (4.0-4.7 t ha^{-1}) and the lowest yield was found in Shahabajpur sadar, Rangpur (3-3.4 t ha^{-1}). In Minikit plots, the highest yield was found 4.5 t/ha in Bagerbazar, Pirganj, Rangpur and the lowest yield 3.0 t ha^{-1} in Rajarhat, Kurigram and Shahabajpur sadar, Rangpur (3.2 t ha^{-1}). The farmer's reaction about BRRI dhan62 was positive because of shorter growth duration (chance of early Rabi crops establishment, fine grain and zinc enriched. Negative reaction was reported from some farmer for low yield (some area) and poor cooking quality.

Twenty-three demonstrations of BRRI dhan64 were conducted in different locations under Rangpur region during Boro 2014-15. The locations were sadar, Taraganj and Mithapukur of Rangpur district and one location of Gaibandha sadar. The highest grain yield was found in Sadar Gaibandha (5.6 to 5.8 t ha^{-1}) followed by sadar (5.4 to 5.8 t ha^{-1}) Rangpur, Taraganj (4.9 to 5.7 t ha^{-1}) and Mithapukur (4.4 to 5.7 t ha^{-1}). The lowest grain yield was recorded in Mithapukur because of poor field management, high weed and neck blast infestation. The farmer's reaction about BRRI dhan64 was not satisfactory mostly due to bold grain.

Enhanced Quality Seed Supply Project (EQSSP) BRRI regional station, Rangpur conducted 24 varietal demonstration trials with BRRI dhan48, BRRI dhan52 and BRRI dhan58 in Aus, Aman and Boro respectively at different upazilas of four districts at Rangpur, Nilphamari, Lalmonirhat and Gaibandha during 2014-15. The variety demonstration trials were within 33 decimal area of each farmer's plot. In addition, daylong 15 farmers' training and five field days were conducted. The average grain yield of BRRI dhan48 was 4.5 t ha^{-1}, BRRI dhan52 was 5.5 t ha^{-1} and BRRI dhan58 was 7.5 t ha^{-1}. About 450 farmers (Male 400 and Female 50) participated and gathered knowledge on modern rice cultivation techniques from those training programmes. At the time of field day in all locations, farmers' showed positive response and expressed their interest to grow this variety in upcoming Boro season. BRRI dhan58 yielded from 6.7 to 8.0 t ha^{-1} which was higher than mega variety BRRI dhan28 (6.0-7.0 t ha^{-1}) but similar to BRRI dhan29 having seven days earlier.

SOCIO-ECONOMIC STUDY

Impact and profitability of tobacco production in Rangpur region. There were three selected upazilas viz Taraganj and Rangpur sadar of Rangpur and Aditmari of Lalmonirhat district for this survey type study. About 60 respondents were selected using simple random sampling technique for collecting primary data and information. The survey data were collected through direct interviewing the farmer’s using structured questionnaire. For enhancing reliability and minimizing errors, data were recorded in local units that were converted into standard units. The yield received by the tobacco farmers was 2,443 kg/ha of tobacco leaf as a main product as well as 964 kg/ha tobacco plant as a byproduct. Tobacco leaf and plant price were Tk 75/kg and Tk 35/kg respectively. The tobacco growers received gross return of Tk 2,16,965/ha and net return was Tk 83,534/ha. The benifit cost ratio (BCR) found from tobacco production was 1.63 (Table 25). The respondents were asked to give the reasons for expanding their cultivated area for tobacco production. All farmers stated that it is profitable crop than the other crops. About 70% farmers stated, it was traditional cultivation in Rangpur region. Moreover, 50% farmers reported that they cultivated tobacco as they received loan and other materials from Tobacco Company during cultivation. About 15% farmers stated that their environment is more favourable for tobacco production that’s why they cultivated tobacco. Actually farmers are growing tobacco mainly due to higher profit and net return.

Table 25. Per hectare profitability of tobacco production in selected locations in Rangpur.

Item	Amount and price (Tk)
Yield from main product (kg/ha)	2443
Yield from byproduct (kg/ha)	964
Tobacco leaf price (Tk/kg)	75
Tobacco plant price (Tk/kg)	35
Return from main product (Tk/ha)	1,83,225
Return from byproduct (Tk/ha)	33,740
Gross return	2,16,965
Variable cost	70,681
Total cost	1,33,431
Gross margin	1,46,284
Net return	83,534
BCR	1.63

BRRRI RS, Satkhira

SUMMARY

From the result of regional yield trial (RYT) in Aus season, we could suggest BR7718-55-1-3 and BR7708-62-1-1 as two promising genotypes for Aus rice. Among RYT of T. Aman season, BR8227-6-2-1 was found to be a high yielding genotype with other positive traits for premium quality rice (PQR) and BR8033-2-2-1-2 was found better for rainfed lowland rice (RLR). BR7697-16-2-2-1-1 was found as better genotypes in advanced line adaptive research trial (ALART) for PQR. In another ALART for salinity, three entries (IR77092-B-2R-B-10, IR78761-B-SATBI-68-6 and IR83484-3-B-7-1-1-1) were found as promising genotype. In proposed variety trials (PVT), both IR78761-B-SATB1-28 and IR78761-B-SATB1-23-3-26 genotypes yielded higher than standard check BRRI dhan53 with few days advantages of growth duration. In case of PVT for drought tolerant genotypes, IR82589-B-B-84-B yielded the highest followed by IR83377-B-B-93-3 and the check produced lowest yield, but growth duration was longer in the evaluated lines. In another PVT, Zn enriched line BBR7528-2R-119-HR10 produced much higher yield (6.46 t ha^{-1}) compared to check BRRI dhan39 (5.12 t ha^{-1}), but growth duration was one week longer. From observational trial eleven genotypes were selected as advanced line. From different secondary yield trials, IR78761-B-SATB2-4-25-3, IR78 IR87868-2-AJY1-B, IR85926-11-3-1-AJY1-B, IR77674-B-20-1-2-1-3-6-4-AJY and IR84095-AJY-301-SDO4-B were found as better genotypes compared to BRRI dhan53 and BRRI dhan54. In participatory variety selection, BR78761-B-SATB1-41-2 was found to be better and chosen by the participants. Among 28 BRRI developed modern T. Aman inbreed varieties and one hybrid variety, BR11 and BRRI dhan49 was found better than the others. In RYT for PQR during Boro season, IR77734-93-2-3-2 was found to be a promising genotype whereas BR6158RWBC2-2-1-1 and BR7683-30-3-3-4 were found as better than the checks in favourable Boro. From the ALART for PQR, BR7781-10-2-3-2 was suggested to release as a variety. In PVT, though both the proposed lines (BR7671-37-2-2-3-7 and BR7833-11-1-1-2-1-2B5) yielded higher than standard checks, but BR7671-37-2-2-3-7 was proposed as new variety considering all attributes. In saline gher, NPKS should apply as fertilizer for optimum yield whereas the nutrient condition of non-saline gher was sufficient for optimum yield and no fertilizer except nitrogen is needed in this case (trial for several years is needed). In saline gher areas, BRRI hybrid dhan2, BRRI hybrid dhan3 and BRRI dhan67 might be suitable varieties (validation is needed for several years) whereas BRRI dhan55 and BRRI dhan28 showed good performance in non-saline gher. A total of 25.54 tons breeder seeds were produced and sent to GRS Division, BRRI, Gazipur.

RESEARCH ACTIVITIES

Regional yield trial (RYT)

Seven selected entries were evaluated at BRRI farm Satkhira based on their yield performance and growth duration comparing with BR26 and BRRI dhan48 in Aus 2014. Twenty-six-day-old seedlings were transplanted in 5.0 m × 2.4 m plot following RCB designs with three replications using 2-3 seedlings hill^{-1} maintaining 15 cm × 20 cm spacing. The recommended cultural practices were followed. Among the tested entries, BR7718-55-1-3 yielded (4.64 t ha^{-1}) significantly higher than the other entries except BR7708-62-1-1 (4.29 t ha^{-1}) (Table 1). Both of these varieties showed growth duration of 110 days which was less than BRRI

Table 1. Yield, plant height, PACP and growth duration of RYT entries during Aus 2014.

Designation	Plant ht (cm)	PACP	Yield (t ha^{-1})	Growth duration (day)
BR8113-21-3-1	93	4	3.84	126
BR7922-45-2-2-1	96	6	3.26	110
IR71866-3R-3-1	95	6	3.37	108
BR7708-62-1-1	94	4	4.29	110
BR7718-56-3-1	94	6	3.81	105
BR7716-49-1-3	85	7	2.75	108
BR7718-55-1-3	104	4	4.64	110
BR26	86	6	3.74	105
BRRI dhan48	86	5	3.65	113
CV (%)	1.1	9.4	8.8	0.0
LSD (0.05)	1.75	0.86	0.56	0.26

DS: 30 Apr 2014, DT : 2 Jun 2014.

dhan48 (113 days) but little longer than BR26 (105 days). Plant height of BR7718-55-1-3 was longer (104 cm) than BR7708-62-1-1 (94cm) and checks (86cm). Considering all attributes, BR7718-55-1-3 and BR7708-62-1-1 could be two promising genotypes for Aus season.

Preliminary yield trial (PYT)

Five entries selected by Plant Breeding Division of BRRI were evaluated at BRRI RS farm, Satkhira comparing with BRRI dhan44 and BRRI dhan52. Twenty-six-day-old seedlings were transplanted in 5.0 m × 2.4 m plot following RCB designs with three replications using 2-3 seedlings hill^{-1} maintaining 15 cm × 20 cm spacing. The recommended cultural practices were followed. BRRI dhan44 yielded the highest (4.29 t ha^{-1}) among the tested entries, which was statistically similar yielder compared to BRRI dhan52 (4.09 t ha^{-1}) and BR8748-19-1 (3.92 t ha^{-1}) entries but statistically different with other entries (Table 2). BR7934-16-1-1-1-2-2 yielded the lowest (3.28 t ha^{-1}). Growth duration was lower for BRRI dhan44 and BRRI dhan52 (128 and 129 days respectively) compared to other entries (in between 134 and 140 days).

Regional yield trial (RYT)

Several RYT were conducted at BRRI RS farm, Satkhira in T. Aman 2014. Two-three seedlings hill^{-1} were transplanted in a 5.0 m × 2.4 m plot following RCB designs with three replications maintaining 25 cm × 15 cm spacing. The recommended cultural practices were followed.

Table 2. Yield and growth duration of different entries of PYT during T. Aman 2014.

Designation	Yield (t ha^{-1})	Growth duration (day)
BR7937-10-1-1-1-1-2	3.52	134
BR7934-16-1-1-1-2-2	3.28	134
BR8159-28-8-5-8-2	3.46	138
BR8748-19-1	3.92	134
BR7930-20-2-2-2-2-1	3.47	140
BRRI dhan44	4.29	128
BRRI dhan52	4.09	129
CV (%)	10.2	0.4
LSD (0.05)	0.68	0.94

DS: 10 Jul 14, DT: 13 Aug 14.

RYT for rainfed lowland rice (RLR)

Plant Breeding Division selected three genotypes to evaluate their performances comparing with BRRI dhan32 and BRRI dhan49. Among the entries, BR8033-2-2-1-2 produced the highest yield (6.09 t ha^{-1}) which was statistically similar with IR70213-10-CPA 4-2-2-2 (5.55 t ha^{-1}) and BRRI dhan49 (5.53 t ha^{-1}) but statistically higher than B 10533 F-KN-12-2 (4.44 t ha^{-1}) and BRRI dhan32 (4.79 t ha^{-1}) (Table 3). IR70213-10-CPA 4-2-2-2 and BR8033-2-2-1-2 entries showed taller plant type (117 and 116 cm respectively) compared to other entries (106-108 cm). Phenotypic acceptability was better for BR8033-2-2-1-2 in both vegetative and reproductive stages. Growth duration of the highest yielder entry BR8033-2-2-1-2 was three days earlier than the check varieties, but three and five days later than IR70213-10-CPA 4-2-2-2 and B 10533 F-KN-12-2 entries respectively.

In another RYT for RLR, six entries were evaluated comparing with BRRI dhan56 and BRRI dhan49. BRRI dhan49 yielded the highest (5.78 t ha^{-1}) among the tested entries (Table 4), which was statistically similar yielder compared with WAS 122-IDSA 1-WAS-2-B-1-TGR 132 (NERICA-L-16) (5.65 t ha^{-1}) but statistically different than the other entries. Growth duration of NERICA MUTANT was the lowest (106 days) followed by BRRI dhan56 (111 days) and the highest in BRRI dhan49 (129 days). Other entries showed more or less similar growth duration (in between 117-124 days). Phenotypic acceptability was better for BRRI dhan49 in both vegetative and reproductive stages.

RYT for premium quality rice (PQR)

Eight entries were compared with BRRI dhan34 and BRRI dhan37. Among the tested entries BR8227-6-2-1 showed statistically higher yield (7.25 t ha^{-1}) than the other entries (Table 5). BR8226-8-5-2-2, BR8226-17-1-2 and BR8226-13-1-2 showed better yield (6.54, 6.50 and 5.95 t ha^{-1} respectively) among the other entries. Growth duration was the lowest in BR8294-1-3-2-2 (120 days) and the highest in BRRI dhan37 (156 days). BR8227-6-2-1, BR8226-8-5-2-2 and BR8226-17-1-2 entries showed less growth

Table 3. Yield and some other characters of RYT (RLR) entries during T. Aman 2014.

Designation	Plant ht (cm)	PACP Veg.	PACP Repr.	Yield (t ha^{-1})	Growth duration (day)
IR70213-10-CPA 4-2-2-2	117	2	2	5.55	125
B 10533 F-KN-12-2	108	3	3	4.44	123
BR8033-2-2-1-2	116	1	2	6.09	128
BRRI dhan32	108	2	3	4.79	131
BRRI dhan49	106	1	2	5.53	131
CV%	4.2	31.3	28.5	10.3	0.3
LSD (0.05)	1.14	1.14	1.22	1.02	0.64

DS: 10 Jul 14, DT: 6 Aug 14.

Table 4. Yield and yield contributing characters of RYT (RLR) entries during T. Aman 2014.

Designation	Plant ht	PACP Veg.	PACP Repr.	Yield (t ha^{-1})	Growth duration (day)
WAS 122-IDSA 14-WAS B-FKR 1 (NERICA-L-8)	107	3	3	4.55	117
WAS 122-IDSA 1-WAS-2-B-1-TGR 132 (NERICA-L-16)	121	2	2	5.65	124
WAS 161-B-6-B-1 (NERICA-L-36)	106	3	3	4.48	121
WAS 161-B-4-B-1-TGR 51 (NERICA-L-32)	106	4	3	4.59	118
WAS 191-4-10 (NERICA-L-54)	105	3	3	3.94	121
NERICA MUTANT	104	3	4	2.63	106
BRRI dhan56	104	3	4	4.05	111
BRRI dhan49	107	2	1	5.78	129
CV (%)	1.6	22.3	20.7	14.2	0.4
LSD (0.05)	3.06	1.12	1.07	1.11	0.88

DS: 10 Jul 14, DT: 6 Aug 14.

Table 5. Plant height, yield, PACP and growth duration of different entries of RYT (PQR) during T. Aman 2014.

Designation	Plant ht (cm)	PACP Veg.	PACP Repr.	Yield (t ha^{-1})	Growth duration (day)
BR8226-8-5-2-2	121	1	1	6.54	138
BR8226-11-4-4-3	109	2	2	5.78	138
BR8226-11-4-6-2	106	2	2	5.36	138
BR8294-1-3-2-2	120	3	3	4.33	120
BR8226-13-1-2	112	3	2	5.95	133
BR8226-17-1-2	117	1	1	6.50	135
BR8227-6-2-1	128	1	1	7.25	141
BR8515-23-6-3	128	4	4	3.48	155
BRRI dhan34	152	3	4	3.79	146
BRRI dhan37	146	3	4	3.50	156
CV (%)	2.5	13.7	17.0	6.7	0.3
LSD (0.05)	5.31	0.56	0.71	0.60	0.63

DS: 10 Jul 14, DT: 8 Aug 14.

duration and less plant height compared to the checks. Phenotypic acceptability was better for these entries as well.

RYT for micronutrient enriched rice (MER)

Seven promising entries were evaluated compared with BRRI dhan32 and BRRI dhan39 during T. Aman 2014. BRRI dhan32 yielded the highest (5.16 t ha^{-1}) followed by PSBRC 82 (4.86 t ha^{-1}) and BR8418-1-3 (4.85 t ha^{-1}) among the tested entries (Table 6). The lowest yield was observed in BR7671-37-2-2-3-7-3 (3.72 t ha^{-1}). Growth duration was the lower for BR8418-1-3 and BR7840-54-3-2-2 (113 days) and other entries showed more or less similar growth duration (in between 117 and 127 days).

RYT for green super rice (GSR)

Four entries were evaluated comparing with BRRI dhan39 and BRRI dhan56. BRRI dhan39 yielded the highest (6.50 t ha^{-1}) followed by BRRI dhan56 (6.40 t ha^{-1}) and HHZ5-SAL10-DT1-DT1 (5.91 t ha^{-1}) among the tested entries (Table 7). Growth duration of these three varieties were similar (123,

Table 6. Yield and yield contributing characters of RYT (MER) entries during T. Aman 2014.

Designation	Plant ht (cm)	PACP Veg.	PACP Repr.	Yield (t ha^{-1})	Growth duration (day)
BR7840-54-3-2-2	110	2	2	4.69	113
BR7879-17-2-4-HR3-P1	138	3	2	4.71	126
BR7671-37-2-2-3-7-3	102	3	3	3.72	123
BR8143-15-2-1	115	3	3	4.73	127
BR8418-1-3	96	3	3	3.85	113
IR85850-75-2-2-3-2	110	3	3	4.19	117
PSBRC 82	108	2	2	4.86	119
BRRI dhan32	123	2	1	5.16	123
BRRI dhan39	109	2	3	4.14	127
CV (%)	13.0	11.3	32.1	10.7	0.7
LSD (0.05)	24.84	0.50	1.38	0.83	1.42

DS : 10 Jul 14, DT: 6 Aug 14.

Table 7. Yield and yield contributing characters of RYT (GSR) entries during T. Aman 2014.

Designation	Plant ht (cm)	PACP Veg.	PACP Repr.	Yield (t ha^{-1})	Growth duration (day)
ir8340-b-258-b	107	6	6	4.73	116
IR83142-B-19-B	108	7	7	3.94	114
IR83142-B-60-B	111	6	6	4.09	114
HHZ5-SAL10-DT1-DT1	116	5	5	5.91	125
BRRI dhan39	116	5	5	6.50	123
BRRI dhan56	115	5	4	6.40	124
CV (%)	1.2	14.2	14.4	7.8	0.5
LSD (0.05)	2.52	1.44	1.47	0.75	1.03

DS: 10 Jul 14, DT: 10 Aug 14.

124 and 125 days respectively) but higher than the other entries (114-116 days).

Advanced line adaptive research trial (ALART)

Several experiments were done at BRRI RS, farm Satkhira during T. Aman 2014 to evaluate advanced lines following RCB design with three replications. The recommended cultural practices were followed in these experiments. Plant height at maturity, growth duration, yield and phenotypic acceptability (PACP) at both vegetative and reproductive stages were recorded.

ALART for PQR

Four advanced lines were evaluated comparing with BRRI dhan37.The highest yield was obtained from BR7697-16-2-2-1-1 (5.00 t ha^{-1}) which was statistically similar with BR7697-15-4-4-2-1 (4.83 t ha^{-1}) and BR7697-15-4-4-2-2 (4.60 t ha^{-1}) but significantly higher than BR7369-52-3-2-1-1 (4.50 t ha^{-1}) and BRRI dhan37 (3.00 t ha^{-1}) (Table 8). The lowest plant height, panicle m^{-2}, filled grains/panicle and 1000 grain weight was found in BR7697-16-2-2-1-1. Growth duration of all entries were more or less similar.

ALART for RLR

Three advanced lines were selected and their performance were evaluated comparing with checks of BRRI dhan32 and BRRI dhan49. The tested entries didn't show significant yield differences. High grain yield was obtained from BRRI dhan32 and the lowest from BR7638-7-2-5-2 entry (Table 9). All other attributes were more or less similar in the tested entries.

ALART for salinity

Six advanced lines were evaluated comparing with BRRI dhan41 and BRRI dhan54. IR77092-B-2R-B-10 yielded the highest (4.70 t ha^{-1}) followed by IR78761-B-SATBI-68-6 (4.60 t ha^{-1}) and IR83484-3-B-7-1-1-1 (4.45 t ha^{-1}) entries (Table 10). Among the tested entries, these three entries gave significantly higher yield than BRRI dhan41 (3.40 t ha^{-1}). They produced higher yield than BRRI dhan54 (4.25 t ha^{-1}) also. Growth duration of IR77092-B-2R-B-10 was similar compared with

Table 8. Growth duration, yield and yield related data of ALART (PQR), T. Aman 2014.

Designation	Plant ht (cm)	Panicle m^{-2}	Filled grains/ panicle	Yield (t ha^{-1})	Growth duration (day)	1000-grain wt (g)
BR7697-15-4-4-2-1	113	214	127	4.83	127	19
BR7697-15-4-4-2-2	113	206	119	4.60	128	19
BR7697-16-2-2-1-1	111	198	113	5.00	132	18.7
BR7369-52-3-2-1-1	113	203	116	4.50	132	20
BRRI dhan37 (ck)	123	255	116	3.00	133	18.7
CV (%)	1.8	9.0	5.8	4.8	0.0	3.0
LSD (0.05)	3.94	36.33	12.89	0.40	0.0	1.09

DS: 10 Jul 14, DT: 7 Aug 14.

Table 9. Growth duration, yield and yield related data of ALART (RLR), T. Aman 2014.

Designation	Plant ht (cm)	Panicle m^{-2}	Filled grains/ panicle	Yield (t ha^{-1})	Growth duration (day)	1000-grain wt (g)
V_1=BR7468-12-1-1-1-1	106	259	104	3.95	127	19.33
V_2 =BR7472-16-2-1-2-1	107	259	105	3.66	128	19.00
V_3=BR7638-7-2-5-2	97.1	268	74	3.60	132	18.70
V_4=BRRI dhan32 (ck)	112	243	110	4.24	132	20.00
V_5=BRRI dhan49 (ck)	90	278	103	3.96	133	18.70
CV (%)	2.0	6.7	10.9	6.2	0.2	3.0
LSD (0.05)	3.78	32.88	20.31	0.46	0.48	1.08

DS: 10 Jul 14, DT: 7 Aug 14.

Table 10. Growth duration, yield and yield related data of ALART (Salinity) T. Aman 2014.

Designation	Plant ht (cm)	Panicle m^{-2}	Filled grains/ panicle	Yield (t ha^{-1})	Growth duration (day)	1000-grain wt (g)
IR73055-8-1-1-3-1	107	281	128	4.23	123	22
IR83484-3-B-7-1-1-1	112	217	93	4.45	114	26
IR78761-B-SATBI-68-6	122	259	113	4.60	123	21
IR83440-4-B-11-2-1-1-AJYI-B	95	292	126	3.90	110	23
IR77092-B-2R-B-10	108	259	93	4.70	130	20
BR9377-9-21-3B	101	250	117	3.80	147	20
BRRI dhan41 (ck)	117	263	90	3.40	143	21
BRRI dhan54 (ck)	115	220	108	4.25	129	19
CV (%)	1.5	1.8	11.2	8.0	0.0	8.2
LSD (0.05)	2.80	7.98	21.42	0.58	0.0	3.09

DS: 10 Jul 14, DT: 13 Aug 14.

BRRI dhan54, but IR78761-B-SATBI-68-6 was one week earlier whereas IR83484-3-B-7-1-1-1 was two weeks earlier than BRRI dhan54. Plant height of IR77092-B-2R-B-10 (108 cm) and IR83484-3-B-7-1-1-1 (112 cm) entries were little shorter than BRRI dhan54 (115 cm) and BRRI dhan41 (117 cm) but IR78761-B-SATBI-68-6 showed little taller plant type (122 cm).

Proposed variety trial (PVT)

Two most promising genotypes were selected to evaluate them in T. Aman 2014 in farmer's field with the direct supervision of plant breeder and scientists of BRRI RS, Satkhira. Thirty-day-old seedlings were transplanted using 2-3 seedlings $hill^{-1}$ with a spacing of 25 × 15 cm. Standard management practices were followed as and when necessary.

PVT for salinity resistance

Field evaluation of two genotypes has been completed during T. Aman 2014 in PVT trials at different upazilas of Khulna and Satkhira districts. Both IR78761-B-SATB1-28 and IR78761-B-SATB1-23-3-26 genotypes yielded higher than standard check BRRI dhan53 (Table 11). Four, among eight locations, IR78761-B-SATB1-28 produced the highest yield and in

Table 11. Proposed variety trial (Salinity) in T. Aman 2014 under BRRI, Satkhira.

Varities/Line	Flowering (day)	Maturity (day)	Duration (day)	Yield t ha^{-1}	Salinity dS/m
		Kulia, Dabhata, Satkhira Sadar[a]			
IR78761-B-SATB1-28	17 Oct 2014	11 Nov 2014	124	4.78	2.8-6.70
IR78761-B-SATB1-23-3-26	14 Oct 2014	07 Nov 2014	120	4.92	
BRRI dhan53 (ck)	19 Oct 2014	15 Nov 2014	128	4.32	
		Dhankhali, Munshiganj, Shamnagar[b]			
IR78761-B-SATB1-28	10 Oct 2014	04 Nov 2014	117	4.12	3.17-5.25
IR78761-B-SATB1-23-3-26	07 Oct 2014	02 Nov 2014	115	4.18	
BRRI dhan53 (ck)	14 Oct 2014	08 Nov 2014	121	3.61	
		Baruikathi, Dumuria, Khulna (Suffered by Rodents)[c]			
IR78761-B-SATB1-28	08 Oct 2014	10 Nov 2014	123	2.65	7.10-9.50
IR78761-B-SATB1-23-3-26	04 Oct 2014	08 Oct 2014	121	3.10	
BRRI dhan53 (ck)	11 Oct 2014	15 Nov 2014	128	2.35	
		Nawpara, Asasuni, Satkhira[d]			
IR78761-B-SATB1-28	18 Oct 2014	10 Nov 2014	123	2.1	6.50-10.50
IR78761-B-SATB1-23-3-26	17 Oct 2014	09 Nov 2014	122	2.0	
BRRI dhan53 (ck)	20 Oct 2014	13 Nov 2014	126	1.80	
		Fultola, Batiaghata, Khulna[e]			
IR78761-B-SATB1-28	14 Oct 2014	05 Nov 2014	118	5.13	3.10-5.37
IR78761-B-SATB1-23-3-26	09 Oct 2014	01 Nov 2014	114	5.45	
BRRI dhan53 (ck)	10 Oct 2014	06 Nov 2014	119	4.52	
		Sharankhola, Bagerhat[f]			
IR78761-B-SATB1-28	02 Oct 2014	26 Oct 2014	109	4.15	2.51-4.67
IR78761-B-SATB1-23-3-26	01 Oct 2014	24 Oct 2014	107	4.13	
BRRI dhan53 (ck)	04 Oct 2014	28 Oct 2014	111	3.73	
		Tikarampur, Tala, Satkhira[g]			
IR78761-B-SATB1-28	12 Oct 2014	07 Nov 2014	120	5.30	2.17-3.39
IR78761-B-SATB1-23-3-26	09 Oct 2014	04 Nov 2014	117	5.28	
BRRI dhan53 (ck)	14 Oct 2014	09 Nov 2014	122	4.71	
		Dhulihor, Satkhira Sadar[h]			
IR78761-B-SATB1-28	07 Oct 2014	04 Nov 2014	117	5.26	2.55-3.25
IR78761-B-SATB1-23-3-26	04 Oct 2014	30 Nov 2014	113	4.78	
BRRI dhan53 (ck)	10 Oct 2014	07 Nov 2014	120	4.55	

[a]DS: 10 Jul 14, DT: 9 Aug 14. [b]DS: 10 Jul 14, DT: 9 Aug 14. [c]DS: 10 Jul 14, DT: 8 Aug 14. [d]DS: 10 Jul 14, DT: 12 Aug 14. [e]DS: 10 Jul 14, DT: 3 Aug 14. [f]DS: 10 Jul 14, DT: 27 ul 14. [g]DS: 10 Jul 14, DT: 2 Aug 14. [h]DS: 10 Jul 14, DT: 6 Aug 14.

another four locations IR78761-B-SATB1-23-3-26 produced the highest yield. In all the locations, performance of standard check BRRI dhan53 were less than the evaluated lines. In addition, the evaluated lines have advantage of less growth duration. Growth duration was shortest for IR78761-B-SATB1-23-3-26 followed by IR78761-B-SATB1-28.

PVT for drought resistance

In case of drought tolerant genotypes, IR82589-B-B-84-B yielded the highest followed by IR83377-B-B-93-3 and check produced the lowest yield (Table 12). But growth duration was longer in the evaluated lines.

PVT for RLR

Among RLR entries, the tested entries produced less grain yield compared to check BRRI dhan39 but better than check BRRI dhan49 (Table 12).

PVT for Zn enriched rice

Zn enriched line BBR7528-2R-119-HR10 produced much higher yield (6.46 t ha^{-1}) compared

Table 12. Proposed variety trial (PVT) in T. Aman 2014 under BRRI, Satkhira.

Varities/Line	Flowering (day)	Maturity (day)	Duration (day)	Yield t ha^{-1}
		PVT (Drought)[a]		
IR83377-B-B-93-3	09 Oct 2014	02 Nov 2014	115	4.50
IR82589-B-B-84-B	07 Oct 2014	01 Nov 2014	114	4.73
BRRI dhan56(ck.)	03 Oct 2014	28 Nov 2014	110	3.92
		PVT (RLR)[b]		
BR7472-16-2-1-2-3	17 Oct 2014	11 Nov 2014	124	5.29
BR7622-5-1-1-1	15 Oct 2014	10 Nov 2014	123	4.93
BRRI dhan39 (ck)	14 Oct 2014	08 Nov 2014	121	5.45
BRRI dhan49 (ck)	22 Oct 2014	14 Nov 2014	127	4.48
		PVT (Zinc)[c]		
BBR7528-2R-119-HR10	12 Oct 2014	06 Nov 2014	119	6.46
BRRI dhan39(ck)	05 Oct 2014	30 Nov 2014	112	5.12
		PVT (PQR)[c]		
BR7357-11-2-4-1-1	09 Oct 2014	07 Nov 2014	120	4.44
BRRI dhan37(ck)	29 Oct 2014	27 Nov 2014	140	3.30

[a]Location- Shreecona, Sharsha, Jessore; DS: 10 Jul 14, DT: 5 Aug 14. [b]Location- Basghata, Satkhira Sadar; DS: 10 Jul 14, DT: 10 Aug 14. [c]Location- Betla, Satkhira Sadar; DS:10 Jul 14, DT: 31 Jul 14.

to check BRRI dhan39 (5.12 t ha^{-1}), but growth duration was one week longer (Table 12).

PVT for PQR

For premium quality rice, the line BR7357-11-2-4-1-1 produced much higher yield (4.44 t ha^{-1}) than the check BRRI dhan37 (3.30 t ha^{-1}) with advantage of 20 days growth duration.

ACTIVITIES UNDER STRASA PROJECT

Observational trial (OT)

Forty-three genotypes in OT were evaluated at Asasuni, Satkhira compared with checks of BRRI dhan53 and BRRI dhan54. Standard cultural practices were followed**.** Among 43 genotypes, eleven genotypes were selected as advanced line (Table 13). The highest yield (4.59 t/ha) was found in BRRI dhan54 (ck), which was followed by BRRI dhan53 and the lowest yield (1.67 t/ha) was observed in BR8715-10-7-11. The water salinity of the field varied between 4.10 to 6.0 ds/m (Table 22).

Preliminary yield trial (PYT)

Eleven Aman entry were evaluated comparing with BRRI dhan53 and BRRI dhan54. The highest yield (3.96 t/ha) was found in BR8715-10-7-13 followed by IR10T116 and the lowest yield (1.67 t/ha) was observed in BR8715-10-7-1 (Table 14). The water salinity of the field varied between 4.10 to 6.0 ds/m (Table 22).

Secondary yield trial (SYT)

Three SYT were conducted at saline conditions in Asasuni, Satkhira compared with checks of BRRI dhan53 and BRRI dhan54. In the first SYT, ten entries were evaluated where the highest yield (3.33 t/ha) was found in IR78761-B-SATB2-4-25-3 followed by BRRI dhan54 and the lowest yield (0.53 t/ha) was observed in IR78767-B-SDO1-3-AJY2 (Table 15). In another SYT, the highest yield (2.97 t/ha) was found in IR78 IR87868-2-AJY1-B followed by IR85926-11-3-1-AJY1-B and BRRI dhan54. The lowest yield (1.78 t/ha) was observed in IR83440-4-B-11-2-1-1-AJY1-B (Table 16). In the third SYT, IR77674-B-20-1-2-1-3-6-4-AJY produced the highest yield (3.68 t/ha) followed by IR84095-AJY-301-SDO4-B and the lowest yield (1.68 t/ha) was observed in IRRI126 (Table 17). The water salinity of the field varied between 4.10 to 6.0 ds/m (Table 22).

Participatory variety selection (PVS)

The trials for PVS were set up at BRRI Benerpota farm, Shamnogor, Kaliganj and Debhata of Satkhira. Nine most promising genotypes suitable

Table 13. Yield performance of OT at Asasuni, Satkhira during T. Aman 2014.

Genotype	Maturity (day)	Plant ht (cm)	Tiller no./hill	Panicle length (cm)	Yield (t/ha)	PACP
BR8715-10-7-11	124	98	10	20	1.67	5
BR9090-2	125	87	13	23	3.72	5
BR9090-4	125	88	10	21	3.71	4
BR8715-1	127	104	9	23	2.08	4
BR8715-4	126	101	12	24	3.33	5
BR8718-1	112	90	18	26	2.06	6
BR8727-1	129	114	10	25	2.89	5
BR8737-1	113	106	7	24	2.51	7
BR8742-7	119	104	10	24	2.48	3
BR8743-2	118	109	5	26	2.09	3
BR8747-5	126	97	10	24	3.71	4
BRRI dhan53 (ck)	124	96	9	22	4.18	3
BRRI dhan54 (ck)	135	100	11	24	4.59	4

DS: 5 Jul 2014, D/T: 10 Aug 2014.

Table 14. Yield performance of PYT at Shamnogor, Satkhira during T. Aman 2014.

Genotype	Maturity (day)	Plant ht (cm)	Tiller no./hill	Panicle length (cm)	Yield (t/ha)	PACP
IRRI147	114.5	103.5	8.5	24.5	2.86	7.5
IR85925-11-2-2-AJY1-B	115.0	118.5	9.5	25.0	2.77	5.0
IR84940-9-2-2-1-AJY1-B	110.5	123.5	11.0	25.5	2.22	5.0
IR83412-6-B-5-1-1-1-AJY1-B	113.5	109.0	11.0	25.5	3.06	4.0
IR86385-170-1-1-B	112.5	92.5	10.0	24.0	1.69	7.5
IR10T116	117.0	129.5	8.5	24.0	3.17	4.0
BR8715-10-7-1	118.0	130.0	10.5	24.5	1.67	4.0
BR8715-10-7-13	119.0	127.0	10.5	23.5	3.96	3.5
BR8715-10-7-23	118.5	126.5	10.5	27.0	2.49	3.5
BR8727-9-11-7	118.5	138.0	9.5	26.0	2.77	3.5
BR8727-9-11-8	117.5	135.5	11.5	24.5	1.88	3.5
BRRI dhan53 (ck)	117.5	117.5	12.5	23.5	2.76	4.0
BRRI dhan54 (ck)	132.0	131.0	9.5	25.0	2.70	4.0

DS: 8 Jul 2014, DT: 7 Aug 2014.

Table 15. Yield performance of SYT1 at Shamnogor, Satkhira during T. Aman 2014.

Genotype	Maturity (day)	Plant ht (cm)	Tiller no./hill	Panicle length (cm)	Yield (t/ha)	PACP
IR77660-B-9-1-3-2-1-17-4-1	111.5	99.5	10.5	24.0	2.00	4.5
IR10T118	111.5	112.0	9.5	27.0	1.94	7.0
IR77674-3B-8-2-2-14-2-AJY2	102.5	100.5	9.5	25.0	1.05	9.0
IR77674-3B-8-2-2-14-4-AJY1	98.0	49.5	8.0	*	*	9.0
IR77674-3B-8-2-2-8-2-AJY6	99.0	46.0	9.0	*	*	9.0
IR78767-B-SDO1-3-AJY2	105.0	101.5	7.0	21.0	0.53	9.0
IR83484-3-B-7-1-1-1	112.0	105.0	7.0	21.5	2.26	7.0
IR86385-117-3-1-B	111.0	96.5	9.5	20.0	1.64	7.5
IR86385-184-1-1-B	110.5	97.0	10.0	21.0	2.19	7.5
IR78761-B-SATB2-4-25-3	115.0	111.5	9.0	23.5	3.33	4.5
BRRI dhan53 (ck)	116.0	116.5	11.0	21.5	2.82	4.0
BRRI dhan54 (ck)	131.0	123.5	9.5	24.0	2.97	4.0

DS: 8 Jul 2014, DT: 7 Aug 2014. *selection.

for saline prone area were selected for this trial. The trial was conducted at farmer's field in the salt affected areas of Satkhira district following standard cultural practices.

At BRRI RS, Satkhira farm, the crop was harvested and selected by active participation of the farmers. Around 110 farmers participated in PVS activities. The average best yield (4.52 t ha^{-1}) was found in BR78761-B-SATB1-41-2 followed by BR11-Saltol (4.17 t ha^{-1}) and the lowest yield (3.19 t ha^{-1}) was found in IR83439-4-B-4-1-1-1-AJY1-B entry at BRRI Binerpota farm (Table 18).

Table 16. Yield performance of SYT-2 at Shamnogor, Satkhira during T. Aman 2014.

Genotype	Maturity (day)	Plant ht (cm)	Tiller no./hill	Panicle length (cm)	Yield (t/ha)	PACP
IR86385-48-2-1-B	113.5	103.5	10.0	21.0	1.81	5.0
IR86385-117-1-1-B	102.0	100.5	12.0	24.0	2.13	4.0
IR87868-2-AJY1-B	113.5	102.5	12.0	24.5	2.97	5.0
IR10T114	113.0	109.5	9.0	24.5	2.07	5.5
IRRI147	114.0	102.5	12.0	23.5	2.79	7.0
IR83441-6-B-5-2-1-1-AJY1-B	112.5	99.5	11.5	22.5	2.55	6.0
IR85926-11-3-1-AJY1-B	114.5	115.0	11.0	28.5	2.82	4.5
IR83440-4-B-11-2-1-1-AJY1-B	111.5	103.5	8.5	25.5	1.78	5.0
IR83439-4-B-4-1-1-1-AJY1-B	115.5	111.0	13.0	24.5	2.61	5.0
IR84649-308-7-1-B-AJY1-B	107.5	96.5	10.5	22.5	1.82	6.0
BRRI dhan53 (ck)	117.5	116.5	11.5	23.5	2.79	3.5
BRRI dhan54 (ck)	133.0	135.0	11.0	24.5	2.80	3.5

DS: 8 Jul 2014, D/T: 7 Aug 2014.

Table 17. Yield performance of SYT-3 at Shamnogor, Satkhira during T. Aman 2014.

Genotype	Maturity (day)	Plant ht (cm)	Tiller no./hill	Panicle length (cm)	Yield (t/ha)	PACP
IR72049-B-R-22-3-1-1	125.0	125.0	**	**	8.0	8.0
IR77674-B-20-1-2-1-3-6-4-AJY	100.0	108.0	9.0	27.0	*3.68	7.0
IR77674-3B-8-2-2-8-3-AJY4	101.5	104.0	9.0	25.0	*1.57	8.0
IR77674-3B-8-2-2-12-5-AJY2	100.0	100.0	**	**	4.5	4.5
IR77674-3B-8-2-2-14-4-AJY2	96.0	110.0	8.0	26.0	*2.82	8.0
IR83416-7-B-12-3-1-3- AJY1-B	115.0	110.5	9.5	24.0	2.45	7.5
FL416	113.0	100.0	11.0	21.5	2.19	5.5
IR84089-7-3-AJY1-B	120.0	111.0	9.5	22.5	3.40	5.5
IRRI126	119.0	129.5	9.5	22.5	1.68	4.5
IR84095- AJY-301-SDO4-B	121.0	121.0	10.5	24.5	3.44	4.5
IR83408-B AJY1-1-SFO2-1	113.0	115.5	8.5	22.0	1.78	5.0
IR87868-9-AJY1-B	116.0	100.5	9.5	24.5	2.25	6.0
BRRI dhan53 (Std. ck)	118.0	116.5	9.5	24.0	3.02	0.0
BRRI dhan54 (Std. ck)	134.0	130.5	10.0	26.0	3.16	3.5

**damaged by rat. *replication 1 damaged by rat. DS: 08 Jul 2014, DT: 7 Aug 2014.

Table 18.Yield performance of PVS genotypes at BRRI farm, Satkhira at T. Aman 2014.

Genotype	Maturity (day)	Plant ht (cm)	Tiller no./hill	Panicle length (cm)	Yield (t/ha)	PACP
BR8371-18-20-52-124	136.0	120.5	10.0	22.0	4.02	3
BR8371-18-20-52-145	136.5	114.0	10.0	22.0	3.55	3
BR11-Saltol	135.0	120.5	9.5	23.0	4.17	4
IR83439-4-B-4-1-1-1-AJY1-B	121.5	107.5	8.5	22.5	3.19	5
IR83441-6-B-5-2-1-1-AJY1-B	113.5	106.0	10.5	25.0	3.36	5
BR78761-B-SATB1-41-2	117.5	122.5	9.5	22.0	4.52	4
IR78761-B-SATB1-52-1	115.5	118.0	10.5	21.0	4.13	4
IR78761-B-SATB2-17-1	116.5	119.0	10.5	22.0	3.79	3
BR8371-18-20-52-55	135.5	119.5	10.5	22.0	3.73	3
BR11 (ck)	134.0	116.5	10.5	22.5	3.91	3
BRRI dhan53 (ck)	121.5	119.5	12.5	23.5	4.07	4
BRRI dhan54 (ck)	134.0	129.5	12.5	24.5	4.11	4

DS: 5 Jul 2014, DT: 5 Aug 2014.

The field was non-saline area. On the other hand, the average highest yield (4.40 t ha^{-1}) was found in BR11 followed by BRRI dhan54 (ck) and the lowest yield (3.13 t ha^{-1}) in IR83441-6-B-5-2-1-1-AJY1-B at Shamnogor (Table 19). The salinity varied between 04.10 and 6.00 dS/m (Table 22).

At Kaliganj, BR78761-B-SATB1-41-2 line yielded the highest (4.92 t ha^{-1}) followed by IR78761-B-SATB1-52-1, BR8371-18-20-52-145 and BR11-Saltol lines whereas the lowest yield (3.57 t ha^{-1}) was found in BR8371-18-20-52-55 (Table 20). The salinity varied between 3.5 ot 5.1

Table 19. Yield performance of PVS genotypes at Shamnogor, Satkhira, T. Aman 2014.

Genotype	Maturity (day)	Plant ht (cm)	Tiller no./hill	Panicle length (cm)	Yield (t/ha)	PACP
BR8371-18-20-52-124	135.0	116.0	9.5	22.5	4.07	4.0
BR8371-18-20-52-145	136.0	120.0	13.0	22.5	3.73	4.0
BR11-Saltol	136.0	120.5	12.5	24.5	4.09	4.0
IR83439-4-B-4-1-1-1-AJY1-B	117.0	116.0	9.0	24.5	3.23	5.5
IR83441-6-B-5-2-1-1-AJY1-B	116.5	110.5	10.5	24.5	3.13	7.0
BR78761-B-SATB1-41-2	115.5	116.5	12.0	22.5	4.14	4.5
IR78761-B-SATB1-52-1	115.5	115.5	14.5	21.5	4.15	4.0
IR78761-B-SATB2-17-1	115.5	111.0	11.5	22.5	3.53	4.5
BR8371-18-20-52-55	135.0	117.5	14.0	23.0	3.89	5.0
BR11 (ck)	135.0	110.5	13.0	24.0	4.40	4.5
BRRI dhan53 (ck)	123.0	117.5	13.0	24.5	3.86	4.0
BRRI dhan54 (ck)	136.0	125.0	14.0	26.0	4.31	4.0

DS: 5 Jul 2014, DT: 7 Aug 2014.

Table 20. Yield performance of PVS genotypes at Kaliganj, Satkhira during T. Aman 2014.

Genotype	Maturity (day)	Plant ht (cm)	Tiller no./hill	Panicle length(cm)	Yield (t/ha)	PACP
BR8371-18-20-52-124	137	104.0	9.0	20.5	3.99	6.5
BR8371-18-20-52-145	139	112.0	10.5	21.5	4.34	6.5
BR11-Saltol	136	113.5	10.0	22.5	4.34	5
IR83439-4-B-4-1-1-1-AJY1-B	124	102.0	9.0	23.0	4.09	6.0
IR83441-6-B-5-2-1-1-AJY1-B	116	98.5	10.0	22.0	3.93	7.0
BR78761-B-SATB1-41-2	115	112.0	9.5	22.5	4.92	4.5
IR78761-B-SATB1-52-1	117	118.0	11.5	21.5	4.35	4.5
IR78761-B-SATB2-17-1	119	111.0	10.0	23.5	3.68	4.5
BR8371-18-20-52-55	123	112.5	11.5	22.5	3.57	7.0
BR11 (ck)	141	107.5	11.5	22.5	3.64	4.5
BRRI dhan53 (ck)	126	113.0	12.0	23.5	4.03	4.5
BRRI dhan54 (ck)	134	125.0	13.0	25.5	4.09	4.5

DS: 5 Jul 2014, DT: 5 Aug 2014.

dS/m (Table 22). At Debhata, IR78761-B-SATB1-52-1 was the best yielder (4.84 t ha^{-1}) followed by BR78761-B-SATB1-41-2 and the lowest yield (2.41 t ha^{-1}) was found in IR78761-B-SATB2-17-1 (Table 21). The farmer's preference and the yield performance of the genotypes have been correlated with some exceptions. Water salinity of the experimental plots were stable over the growing period and was found from 3.22 ds/m to 4.00 dS/m (Table 22).

RYT for Boro varieties

Several sets of RYT entries were selected and their yield performance was evaluated and growth duration was compared with different check varieties during Boro 2014-15. The recommended cultural practices were followed.

RYT for PQR

IR77734-93-2-3-2 yielded the highest (6.5 t/ha) among the tested genotypes which was statistically similar yielder with BR8079-52-2-2-2, BR8076-1-2-2-3, BRRI dhan63 (ck), BR8096-48-2-2-4 and BR8096-55-1-9-1 (Table 23). BRRI dhan50 (ck) was the lowest yielder (5.5 t ha^{-1}). On the other hand IR77734-93-2-3-2, BR8079-52-2-2-2 and BR8076-1-2-2-3 superseded the yield of both the check varieties BRRI dhan50 (ck) and BRRI dhan63 (ck). Growth duration of BRRI dhan63 (ck) was the shortest (136 days) among the tested genotypes followed by BR8096-55-1-9-1, IR77734-93-2-3-2, BR8096-48-2-2-4. Growth duration of BRRI dhan50 (ck) was the longest (144 days) among the tested genotypes.

RYT for favourable Boro (FB)

Ten Boro entries were selected to evaluate their performances compared with BRRI dhan28, BRRI dhan29 and BRRI dhan60. BR7683-30-3-3-4 yielded the highest (7.4 t ha^{-1}) among the tested genotypes, which were statistically similar with BR7671-37-2-2-3-7, BR7800-63-1-7-3, BR7988-4-

Table 21. Yield performance of PVS genotypes at Debhata, Satkhira during T. Aman 2014.

Genotype	Maturity (day)	Plant ht (cm)	Tiller no./hill	Panicle length (cm)	Yield (t/ha)	PACP
BR8371-18-20-52-124	137	100.5	11.0	22.5	3.84	5
BR8371-18-20-52-145	139	108.0	10.5	23.0	4.10	5
BR11-Saltol	136	109.5	9.0	23.5	4.18	5
IR83439-4-B-4-1-1-1-AJY1-B	127	102.5	12.0	23.5	4.04	4.0
IR83441-6-B-5-2-1-1-AJY1-B	121	99.5	11.0	22.5	4.25	5.0
BR78761-B-SATB1-41-2	119	110.5	12.0	22.5	4.75	3.0
IR78761-B-SATB1-52-1	120	116.5	11.0	23.5	4.84	5.0
IR78761-B-SATB2-17-1	119	113.5	9.0	22.5	2.41	5.0
BR8371-18-20-52-55	123	110.5	9.5	22.5	2.57	7.5
BR11 (ck)	141	109.5	11.0	21.0	2.87	7.5
BRRI dhan53 (ck)	126	116.0	11.0	23.5	3.97	4.0
BRRI dhan54 (ck)	133	127.5	11.0	26.5	4.22	4.0

DS: 05 Jul 2014, DT: 9 Aug 2014.

Table 22. Salinity data of PVS fields.

Date	EC (ds/m)		
	Debhata	Kaliganj	Shamnogor
5 Aug 14	3.9	4.1	6.0
13 Aug 14	3.7	5.1	5.5
23 Aug 14	3.8	4.1	4.6
28 Aug 14	3.4	3.5	4.1
3 Sep 14	3.5	3.4	4.9
10 Sep 14	3.6	3.9	5.0
17 Sep 14	3.5	3.4	5.3
30 Sep 14	4.0	4.5	4.9
7 Oct 14	3.2	4.3	5.3
14 Oct 14	3.6	4.7	4.6
21 Oct 14	3.8	4.1	4.5

Table 23. Yield and yield contributing characters of different entries of RYT for PQR during Boro 2015.

Designation	Growth duration (day)	PACP (Veg.)	PACP. (Repro.)	Seedling length (cm)	Plant ht (cm)	Yield (t/ha)
IR77734-93-2-3-2	139	2.0	2.0	15.0	97.0	6.5
BR8079-52-2-2-2	142	2.0	2.3	17.0	90.3	6.3
BR8096-55-1-9-1	137	2.0	2.7	16.0	86.7	5.8
BR8076-1-2-2-3	140	3.0	4.0	20.0	103.0	6.1
BR8096-48-2-2-4	139	3.0	2.7	17.0	95.0	5.9
BRRI dhan50 (ck)	144	4.0	5.0	10.2	78.7	5.5
BRRI dhan63 (ck)	136	5.0	6.0	21.0	77.7	5.9
CV (%)	0	7.2	15.2	10.7	4.0	9.1
LSD (0.05)	0.99	0.38	0.90	3.10	6.32	0.96

DS: 9 Dec 2014, DT: 10 Jan 2015.

5-3-4, BRRI dhan28 (ck), BR7783-AC13-5 and BRRI dhan60 (ck) (Table 24). BRRI dhan29 (ck) yielded the lowest (5.6 t ha^{-1}). On the other hand BR7671-37-2-2-3-7, BR7800-63-1-7-3 and BR7988-4-5-3-4 superseded the yield of all the three check varieties. Growth durations of BRRI dhan28 (ck) was the shortest (135 days) among the tested genotypes followed by BR7683-30-3-3-4, BRRI dhan29-SC3-28-16-10-8-HR1 (COM), BR7800-63-1-7-3. Growth duration of BRRI dhan29 (ck) was the longest (152 days).

RYT for MN

Nine Boro entries were evaluated compared with BRRI dhan28 and BRRI dhan29. The yield of BRRI dhan29 (ck) was the highest (7.6 t ha^{-1}), which was statistically similar with BR8261-19-1-1-3 (7.4 t ha^{-1}), BR7881-62-2-3-7-P3 (7.2 t ha^{-1}), BR8257-37-1-2-2 (7.1 t/ha), BR7833-19-2-3-5 (6.8 t ha^{-1}) and BR7879-17-2-4-HR3-P1 (6.8 t ha^{-1}) (Table 25). BR7840-54-3-4-1 gave the lowest yield (5.8 t ha^{-1}) among the tested genotypes. Growth durations of BR8257-37-1-2-2 was the shortest

Table 24. Yield and yield contributing characters of different entries of RYT (FB) during Boro 2015.

Designation	Growth duration (day)	PACP (Veg.)	PACP. (Repro.)	Seedling length (cm)	Plant ht (cm)	Yield (t/ha)
BR7683-30-3-3-4	136.0	2.0	2.0	19.1	87.7	7.4
BR7671-37-2-2-3-7	137.0	2.0	2.0	19.4	87.3	7.1
BR7988-4-5-3-4	139.0	2.0	2.0	17.4	78.0	6.7
BR7783-AC12-3	144.0	4.0	5.0	16.0	100.3	5.9
BR7783-AC13-5	146.0	4.0	5.0	16.2	102.0	6.2
BR7783-AC14-5	148.0	5.0	6.0	16.2	100.3	5.9
BR7783-AC6-3-2-2-1	148.0	5.0	6.0	15.9	102.0	5.9
BRRI dhan29-SC3-28-16-10-8-HR1(COM)	136.0	6.0	6.3	13.0	79.3	5.9
BR7988-10-4-1	137.0	5.7	5.0	13.4	84.7	5.7
BR7800-63-1-7-3	136.0	5.0	4.0	20.3	97.3	6.9
BRRI dhan28 (ck)	135.0	6.0	5.0	20.5	96.3	6.5
BRRI dhan29 (ck)	152.0	6.0	6.0	16.3	99.0	5.6
BRRI dhan60 (ck)	137.0	4.0	3.0	17.7	89.3	6.1
CV (%)	0.0	3.7	3.6	9.8	4.6	14.3
LSD (0.05)	0.10	.26	.26	2.8	7.12	1.5

DS: 9 Dec 2014, DT: 12 Jan 2015.

Table 25. Yield and yield contributing characters with growth duration of different entries of RYT (MN) during Boro 2015.

Designation	Growth duration (day)	PACP (Veg.)	PACP. (Repro.)	Seedling length (cm)	Plant ht (cm)	Yield (t/ha)
BR7840-54-3-2-1	138	2	2	16.1	98.0	6.5
BR7840-54-3-4-1	134	3	4	18.6	96.0	5.8
BR7840-54-3-4-4	134	3	4	19.5	94.0	5.9
BR8257-37-1-2-2	133	2	2	16.3	95.0	7.1
BR7833-19-2-3-5	141	2	3	17.3	114.3	6.8
BR8261-19-1-1-3	136	3	3	19.2	107.3	7.4
BR7820-18-1-6-3-P4	141	4	5	18.9	102.3	6.6
BR7881-62-2-3-7-P3	146	5	6	16.4	110.0	7.2
BR7879-17-2-4-HR3-P1	144	5	6	19.2	133.0	6.8
BRRI dhan28 (Ck)	134	3	2	19.3	97.0	6.7
BRRI dhan29 (ck)	152	4	6	18.6	102.0	7.6
CV (%)	0	0	0	10.6	2.8	7.0
LSD (0.05)	00	00	0.53	3.25	5.08	0.82

** Second and third replication were not transplanted due to shortage of seedling. DS: 10 Dec 2014, DT: 13 Jan 2015.

(133 days) followed by BR7840-54-3-4-1 (134 days), BR7840-54-3-4-4 (134 days) , BR8261-19-1-1-3 (136 days). On the other hand BR8261-19-1-1-3 gave only 0.2 t/ha lower yield than BRRI dhan29 (ck) but 16 days earlier than BRRI dhan29 (ck). BR8257-37-1-2-2 gave 0.5 t ha^{-1} lower yield than BRRI dhan29 (ck) but 19 days earlier than BRRI dhan29 (ck).

RYT for short duration

In first trial one Boro entry was evaluated compared with BRRI dhan28 and BRRI dhan45. BRRI dhan28 (ck) yielded the highest (5.8 t ha^{-1}) among the tested genotypes and there was no significant variation among the genotypes (Table 26). Growth duration of BRRI dhan45 (ck) (130 days) was the shortest. Growth duration of BRRI dhan28 (ck) (136 days) was the longest. In second RYT, five short duration Boro entries were evaluated compared with BRRI dhan28. Among the tested genotypes BR4909-R1-R2 yielded maximum (5.9 t ha^{-1}), which was statistically identical with BRRI dhan28 (ck) (5.8 t ha^{-1}), BR8072-AC5-4-2-1-2-1 (5.7 t ha^{-1}) BR8072-AC8-1-1-3-1-1(5.5 t ha^{-1}) (Table 27). BR8072-AC7-4-1-2-2-1 and BR8072-AC11-2-3-2-1-1 gave minimum yield (3.3 t ha^{-1}). On the other hand BR4909-R1-R2 superseded the yield of BRRI dhan28 (ck). Growth duration of BR8072-AC5-4-2-1-2-1, BR8072-AC7-4-1-2-2-1, BR8072-AC8-1-1-3-1-1 and BR8072-AC11-2-3-2-1-1 were similar and shorter (138 days). And growth duration of BR4909-R1-R2 was the longest (142 days).

Table 26. Yield and yield contributing characters with growth duration of different entries of RYT (SD1) during Boro 2015.

Designation	Growth duration (day)	PACP (Veg.)	PACP (Repro.)	Seedling length (cm)	Plant ht (cm)	Yield (t/ha)
NERIKA Mutant	134.0	3.7	3.0	18.8	90.7	5.5
BRRI dhan28 (ck)	136.0	2.7	2.0	18.4	89.7	5.8
BRRI dhan45 (ck)	130.0	3.0	2.7	16.7	90.3	5.7
CV (%)	0	15.2	13	11.1	2.2	8.2
LSD (0.05)	0.15	0.94	0.66	3.99	3.99	0.94

DS: 9 Dec 2014, DT: 10 Jan 2015.

Table 27. Yield and yield contributing characters with growth duration of different entries of RYT (SD2) during Boro 2015.

Designation	Growth duration (day)	PACP (Veg.)	PACP (Repr.)	Seedling length (cm)	Plant ht (cm)	Tiller/ hill	Spikelet/ panicle	% sterility	Yield (t/ha)
BR8072-AC5-4-2-1-2-1	138.0	3.0	2.7	12.7	84.3	10.3	95.7	10.5	5.7
BR8072-AC7-4-1-2-2-1	138.0	4.0	4.0	18.1	80.0	11.3	98.3	5.5	5.3
BR8072-AC8-1-1-3-1-1	138.0	3.0	2.0	14.1	85.3	13.0	93.8	6.2	5.5
BR8072-AC11-2-3-2-1-1	138.0	4.0	3.0	15.4	85.0	10.3	104.6	7.3	5.3
BR4909-R1-R2	142.0	3.0	2.0	16.0	104.7	12.3	127.2	12.5	5.9
BRRI dhan28 (ck)	139.0	3.0	2.7	18.4	84.0	13.3	86.8	5.6	5.8
CV (%)	0	0	12.2	11.9	2.8	11.3	8.8	36.7	5.4
LSD (0.05)	0	0.17	0.59	0.53	4.36	2.4	15.8	5.2	0.54

DS: 6 Dec 2014, DT: 7 Jan 2015.

RYT for FB

One Boro entry was selected by Biotechnology Division of BRRI and submitted to BRRI regional station Satkhira to evaluate their yield performance and growth duration compared with BRRI dhan28 and BRRI dhan29. BR6158RWBC2-2-1-1 yielded the highest (6.4 t/ha). On the other hand BR6158RWBC2-2-1-1 superseded the yield of both check varieties BRRI dhan58 (5.8 t/ha) and BRRI dhan29 (6 t/ha) (Table 28). Growth duration of both BRRI dhan58 and BR6158RWBC2-2-1-1 were same and short (142 days). Growth duration of BRRI dhan29 was the longest (154 days).

Table 28. Yield and yield contributing characters with growth duration of different entries of RYT (FB) during Boro 2015.

Designation	Growth duration (day)	PACP (Veg.)	PACP (Repr.)	Seedling length (cm)	Plant ht (cm)	Tiller/ hill	Spikelet/ panicle	% sterility	Yield (t/ha)
BR6158RWBC2-2-1-1	142.0	2.0	2.0	16.9	104.6	11.3	108.1	14.7	6.4
BRRI dhan58	142.0	2.7	2.7	16.5	88.3	11.7	92.3	18.2	5.8
BRRI dhan29	154.7	2.3	2.3	11.8	92.0	13.3	87.3	16.7	6.0
CV (%)	0.2	20.2	20.2	10.4	2.0	4.8	7.7	11.5	3.1
LSD (0.05)	0.67	0.94	0.94	3.12	3.77	1.15	14.66	3.8	0.37

DS: 6 Dec 2014, DT: 7 Jan 2015.

BRRI RS, Sonagazi

SUMMARY

During the reporting period, 81 breeding lines were evaluated in replicated trials of which 21 entries appeared promising for further evaluation. In proposed variety trial BR7528-2R-19-HR10 and BR78761-B-SATB1-28-3-24 yielded higher against their respective checks and have been released as T. Aman varieties named BRRI dhan72 and BRRI dhan73. For Boro rice, N is the most limiting element and STB based fertilizer dose along with 25% higher NPK was the most profitable fertilizer package in saline charland ecosystem. Cultivation of *khesari* as a relay crop in T. Aman season suppressed the soil salinity than fallow land in Sonagazi areas. In Sonagazi regions, BR11 and BRRI dhan29 performed better in T. Aman and Boro seasons respectively. During the reporting period, the station produced 43 ton seeds of recently developed BRRI varieties and also arranged 20 farmers' training and several farmers' field days.

VARIETAL DEVELOPMENT

Regional yield trial (RYT) during Aus 2014-15

Seventeen breeding lines were evaluated in two different RYTs at BRRI RS farm, Sonagazi against standard checks of BR26 and BRRI dhan48. Advanced line IR71866-3R-3-1 performed better for RYT in partially irrigated Aus against check of BR26 and BRRI dhan48 while entries BRRI dhan29-SC3-28-16-10-8-HR1, parija and Wk1 yielded higher for RYT somaclone Aus than their respective check of BRRI dhan48 and were selected for further trial.

Regional yield trial (RYT) during T. Aman 2014-15

Eighteen breeding lines were evaluated in three different RYTs at BRRI RS farm, Sonagazi against standard checks of BRRI dhan32, BRRI dhan39, BRRI dhan49 and BRRI dhan56. Among these, three breeding lines, RYT-GSR gave higher yield, two entries gave higher yield for RYT-RLR and four entries showed higher yield for RYT-drought than their respective checks and were selected for further evaluation.

Regional yield trial (RYT) during Boro 2014-15

For Plant Breeding Division, 41 breeding lines were evaluated in five different RYTs at BRRI RS farm, Sonagazi along with standard checks BRRI dhan28, BRRI dhan29, BRRI dhan45, BRRI dhan50, BRRI dhan60 and BRRI dhan63. Among them, one entry gave higher yield for RYT-PQR, three entries gave higher yield for RYT-GSR and also four entries yielded higher for RYT-FB than their respective checks and were selected for further evaluation. In case of Biotechnology Division, five breeding lines were evaluated in two different RYTs at BRRI RS farm, Sonagazi along with standard checks of BRRI dhan28, BRRI dhan29 and BRRI dhan58. Of them, none of the breeding lines performed better over the checks.

PVT (Salt tolerance)

For proposed variety trial (PVT), two salt tolerant genotypes as new variety were evaluated in two farmer's field of Cox's Bazar sadar against standard check of BRRI dhan53. Both the salt tolerant lines of BR78761-B-SATB1-28-3-24 and BR78761-B-SATB1-28-3-26 gave higher yield than the standard check with similar growth duration and were selected for release as salt tolerant T. Aman varieties.

PVT (High zinc)

One high zinc genotype for new variety was evaluated in farmer's field of Sonagazi, Feni along with the check of BRRI dhan39. High zinc line of BR7528-2R-19-HR10 gave the higher yield than the standard check with six days higher growth duration and was selected for release as a high zinc T. Aman variety.

Two proposed genotypes for new variety were evaluated in farmer's field of Sonagazi, Feni along with check of BRRI dhan28 and BRRI dhan64. Proposed line of BR7833-11-1-1-2-1-2B5 gave the higher yield than the standard check with three days shorter growth duration and was selected for release as Boro varieties in favourable environment.

Long-term missing elements trial

The experiment was initiated on a permanent layout at the BRRI RS farm, Sonagazi during Boro 2014-15 season viewing missing element approach using seven treatments in RCB design with three replications. NPKSZn @ 140-20-30-15-4 was used in this experiment. Complete fertilizer treatment (NPKSZn) gave significantly higher grain yield than the all missing along with N missing plot (Table 1). However, P, K, S and Zn missing plot gave the statistically similar grain yield with NPKSZn treatment. It is concluded that, in Boro rice N is the most limiting nutrient element for saline charland ecosystem.

Evaluation of soil management packages for rice production in char land ecosystem

The experiment was initiated at the BRRI RS farm, Sonagazi during Boro 2014-15 season viewing to identify the proper soil management packages through organic and inorganic amendments in char land ecosystem. A total of six different fertilizer combinations were imposed in this experiment. Soil test based fertilizer (NPKSZn @ 140-20-30-15-4) was used in this experiment. The STB based fertilizer dose along with 25% higher NPK (T_3) gave statistically higher grain yield than that of control treatment along with local farmers' practice (Table 2). However, T_2, T_4 and T_5 treatments obtained the statistically similar yield with T_3 treatment.

Soil salinity scenario of BRRI RS, Sonagazi farm soil

During the dry period, outside the coast embankment of the Bangladesh Water Development Board (BWDB), most of the char land remains fallow due to soil salinity stress and drought. But some farmers grow *kheshari* in their fallow land after harvesting Aman rice. From a study at Sonagazi farm soil, it was found that the salinity level (1:5 soil water ratios) of *khesari* covered land was lower than fallow land. Soil salinity of fallow land remains high up to March after first shower in April it declined sharply. It may be due to increase of soil moisture content.

Table 1. Effect of long-term missing element on the grain yield of Boro rice (BRRI dhan61) at the BRRI RS farm, Sonagazi in 2014-15.

Treatment	Grain yield (t/ha)
All missing	1.40
NPKSZn	5.97
- N	1.80
- P	5.40
- K	5.47
- S	5.53
- Zn	5.36
$LSD_{0.05}$	0.62
CV (%)	7.30

Table 2. Effect of different fertilizer combinations on the grain yield of Boro rice (BRRI dhan61) at the BRRI RS farm, Sonagazi in 2014-15.

Treatment	Grain yield (t/ha)
T_1=Control	1.76
T_2=Soil test based fertilizer (NPKSZn @ 140-20-30-15-4 kg/ha)	4.70
T_3=T_1 + 25% over NPK	4.74
T_4=T_1 + 25% over NPKSZn	4.71
T_5=T_1 + Rice straw @ 3.0 t/ha (oven dry basis)	4.56
T_6=Local farmers practice (NPK @ 120-10-30 kg/ha)	3.49
$LSD_{0.05}$	0.49
CV (%)	6.90

Evaluation of different T. Aman varieties at direct wet seeded condition

BRRI RS, Sonagazi cultivated about 50 acres of land under direct wet seeded condition during T. Aman 2014 season to observe the yield performance of rice under wet seeded conditions. BRRI dhan32, BRRI dhan40, BRRI dhan41, BRRI dhan44, BRRI dhan46, BRRI dhan49 and BR23 were used as test varieties. Sprouted seeds of the respective varities were broadcast uniformly on well-prepared puddled field on 1^{st} week of July to last week of August. Seed rate was 50 kg/ha. In wet seeded condition, BRRI dhan46 produced the highest yield of 3.70 t/ha followed by BRRI dhan49 (3.3 t/ha), while BRRI dhan32 gave the lowest yield of 2.20 t/ha (Fig. 1). The yield difference among the varieties was 0.24 t/ha.

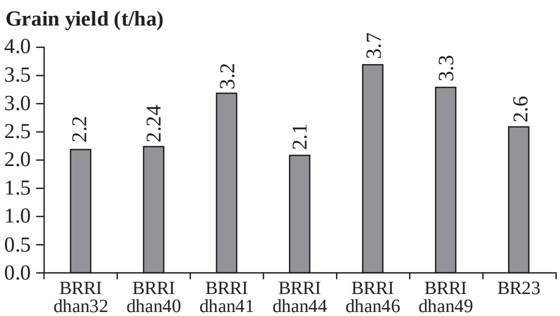


Fig. 1. Grain yield (t/ha) of different varieties at direct wet seeded condition during T. Aman season.

BRRI RS, Kushtia

Regional yield trial (RYT), upland rice (Aus) 2014. Seven breeding lines namely, BR7698-2B-1-9-1, BR7698-2B-1-9-2, BR7699-2B-3-13-3, BR7992-2B-5-2, BR7992-2B-5-4, BR7383-2B-23 and BR7587-2B-3 were tested at Boria, Kushtia as upland rice (Aus) in 2014. BRRI dhan43 was used as the standard checks. The unit plot size was 5 m × 10 m with spacing of 25 cm between the rows. Dry direct seeding was done in rows. The trial was designed in RCB with three replications. Standard agronomic practices were followed to grow the lines/varieties. Data were taken on the yield and some agronomic characteristics.

The yield of the tested lines ranged from 1.6 t to 2.5 t/ha. The lines BR7698-2B-1-9-1, BR7698-2B-1-9-2 and BR7383-2B-23 gave the highest yield (2.5t/ha) followed by BR7992-2B-5-4, BR7587-2B-3. One line BR7699-2B-3-13-3 gave the lowest yield (1.6 t/ha) among the tested lines. Growth duration of the lines was more or less similar to the standard check BRRI dhan43 (Table 1). Plant height of the tested lines was 1.20-34.0 cm shorter than the check (114.8 cm).

RYT, T. Aus 2014. Seven materials were tested at Boria, Kushtia in T. Aus season 2014. The materials were BR8113-21-3-1, BR7922-45-2-2-1, IR71866-3R-3-1, BR7708-62-1-1, BR7718-56-3-1, BR7716-49-1-3 and BR7718-55-1-3. BR26 and BRRI dhan48 were used as standard checks. Thirty-day-old seedlings were planted in 5.4 m x 1.6 m unit plots with 20 cm × 15 cm spacing. The trial was designed in RCB with three replications. Standard agronomic practices were followed to grow the lines/varieties. Data were taken on the yield and some agronomic characteristics.

The yield of the tested lines ranged from 4.2 to 5.4 t/ha. The highest yield 5.4 t/ha was observed in the lines BR7708-62-1-1 and BR7716-49-1-3 which was 1.10 t/ha higher than the check and lowest yield 4.2 t/ha was found from the line BR8113-21-3-1. The range of the growth duration was 105-118 days where the growth duration of the check varieties was 112 days (BR26) and 108 days (BRRI dhan48) (Table 2).

RYT, T. Aus 2014. Seven materials were tested at Boria, Kushtia in T. Aus season 2014. The materials were BRRI dhan29-SC3-28-16-10-8-HR1, BRRI dhan29-SC3-28-16-10-6-HR3, BRRI dhan29-SC3-28-16-10-4-HR5, BRRI dhan29-SC3-28-16-10-6-HR6, Parija, WK1 and Nerica10. BRRI dhan48 was used as standard check. Thirty-one-day-old seedlings were planted in 5.4 m × 1.6 m unit plots with 20 cm × 15 cm spacing. The trial was designed in RCB with three replications. Standard agronomic practices were followed to grow the lines/varieties. Data were taken on the yield and some agronomic characteristics.

The yield of the tested lines ranged from 4 .10 to 5.30 t/ha. The highest (5.30 t/ha) and the lowest (4.10 t/ha) yield was observed in the line Parija and WK1 respectively. The range of the growth duration was 98-109 days where the growth duration of the check varieties was 110 days (BRRI dhan48) (Table 3).

Proposed variety trial (PVT), drought, T. Aman 2014. The proposed variety trial was performed with IR83377-B-B-93-3, IR82589-B-B-84-3 and BRRI dhan56 (Std. ck) at Boria, Kushtia in T. Aman season 2014. Thirty-day-old seedlings were planted in 6 m × 5.0 m unit plots with 20 cm × 15 cm spacing. The trial was designed in RCB with three replications. Standard agronomic

Table 1. Performance of some RYT lines, upland rice (Aus) 2014.

Designation	Plant ht (cm)	Growth duration (day)*	TGW (gm)	Yield (t/ha)
BR7698-2B-1-9-1	84.8	110	25.3	2.5
BR7698-2B-1-9-2	81.8	108	24.1	2.5
BR7699-2B-3-13-3	104.3	112	20.5	1.6
BR7992-2B-5-2	113.6	108	29.9	2.1
BR7992-2B-5-4	99.6	114	25.3	2.3
BR7383-2B-23	91.2	108	23.7	2.5
BR7587-2B-3	112.3	110	21.9	2.3
BRRI dhan43 (ck)	114.8	108	21.2	2.1
LSD (0.5)				

DS: 20 Apr 2014.

Table 2. Performance of some BRRI developed RYT lines, T. Aus 2014.

Designation	Growth duration (day)	Plant ht (cm)	TGW (gm)	Yield (t/ha)
BR8113-21-3-1	118	92.6	22.0	4.2
BR7922-45-2-2-1	110	103.1	23.3	4.5
IR71866-3R-3-1	101	93.0	23.5	4.3
BR7708-62-1-1	112	95.5	22.1	5.4
BR7718-56-3-1	109	90.2	24.1	4.8
BR7716-49-1-3	105	93.0	20.8	5.4
BR BR7716-49-1-37718-55-1-3	110	93.1	21.4	5.2
BR26 (ck)	112	96.6	24.2	4.5
BRRI dhan48 (ck)	108	88.9	22.3	4.3
LSD (0.5)				

DS: 28 Apr 2014, DT: 28 May 2014.

Table 3. Performance of some BRRI developed RYT lines, T. Aus 2014.

Designation	Growth duration (day)	Plant ht (cm)	TGW (gm)	Yield (t/ha)
BRRI dhan29-SC3-28-16-10-8-HR1	107	88.2	20.0	4.47
BRRI dhan29-SC3-28-16-10-6-HR3	104	106.4	19.8	4.90
BRRI dhan29-SC3-28-16-10-4-HR5	103	106.4	19.5	5.10
BRRI dhan29-SC3-28-16-10-6-HR6	104	105.0	19.2	4.60
Parija	109	96.0	23.4	5.30
WK1	98	81.9	19.7	4.10
Nerica10				V. Late
BRRI dhan48 (ck)	110	98.3	23.7	4.80
LSD (0.5)				

DS: 28 Apr 2014, DT: 29 May 2014.

practices were followed to grow the lines/variety. Data were taken on the yield and some agronomic characteristics.

Yield of the line IR83377-B-B-93-3 (6.29 t/ha) and IR82589-B-B-84-3 (5.97 t/ha) were higher than the check variety BRRI dhan56 (4.69 t/ha). Growth duration of both the lines was similar to the check variety BRRI dhan56 (Table 4). Therefore, the material (IR83377-B-B-93-3 and IR82589-B-B-84-3) can be proposed as a variety in drought prone situation.

PVT, RLR, T. Aman 2014. The proposed variety trial was performed with BR7472-16-2-1-2-3, BR7622-5-1-1-1and BRRI dhan39, BRRI dhan49 (Std. ck) at Boria, Kushtia in T. Aman 2014. Thirty-one-day-old seedlings were planted in 6 m × 5.0 m unit plots with 20 cm × 15 cm spacing. The trial was designed in RCB with three replications. Standard agronomic practices were followed to grow the lines/variety. Data were taken on the yield and some agronomic characteristics.

Yield (6.03 t/ha) of the proposed line BR7472-16-2-1-2-3 was higher than both the check varieties BRRI dhan39 and BRRI dhan49 (5.23 &5.69 t/ha). Growth duration of the proposed line BR7472-16-2-1-2-3 was similar to that of the check variety BRRI dhan49 but eight days longer than the check variety BRRI dhan39. On the other hand, grain yield (5.42 t/ha) of another proposed line BR7622-5-1-1-1 was higher than the check variety BRRI dhan49 (5.23 t/ha) but lower than the check BRRI dhan39 (5.69 t/ha). Growth duration of the proposed line BR7622-5-1-1-1 was three days shorter than the check variety BRRI dhan49 but five days longer than check variety BRRI dhan39

Table 4. Performance of proposed variety trial (PVT) lines, drought, T. Aman 2014.

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	TGW (gm)	Yield (t/ha)
IR83377-B-B-93-3	120	104.6	256		6.29
IR82589-B-B-84-3	120	120.6	232		5.97
BRRI dhan56 (ck)	119	110.3	222		4.69

DS: 9 Jul 2014, DT: 8 Aug 2014.

(Table 5). Therefore, the material (BR7472-16-2-1-2-3) could be proposed as a variety.

PVT, premium quality rice (PQR), T. Aman 2014. The line BR7357-11-2-4-1-1 with BRRI dhan37 as check was tested to observe the yield and some agronomic performance at Boria, Kushtia in T. Aman season 2014. Thirty-one-day-old seedlings were planted in 6 m × 5.0 m unit plots with 20 cm × 15 cm spacing. The trial was designed in RCB with three replications. Standard agronomic practices were followed to grow the lines/variety. Data were taken on the yield and some agronomic characteristics.

The proposed material BR7357-11-2-4-1-1 gave 1.63 t/ha higher grain yield with 18 days shorter growth duration than the check variety BRRI dhan37 (Table 6). Number of panicles/m^2 (254) of the proposed material was higher than the check variety BRRI dhan37 (234) and this character might be contributed to the yield. Considering the above yield and yield contributing characters the material (BR7357-11-2-4-1-1) can be proposed as a variety.

PVT, micro nutrient (MN), T. Aman 2014. The line BR7528-2R-19-HR10 with BRRI dhan39 as check was tested to observe the yield and some agronomic performance at Boria, Kushtia in T. Aman 2014. Thirty-one-day-old seedlings were planted in 5m × 5.0m unit plots with 20 cm × 20 cm spacing. The trial was designed in RCB with three replications. Standard agronomic practices were followed to grow the lines/variety. Data were taken on the yield and some agronomic characteristics.

Yield (5.13 t/ha) and growth duration (130 days) of the proposed material BR7528-2R-19-HR10 was poorer to the check variety BRRI dhan39 (Table 7). Number of panicles/m^2 (222) of the proposed material was lower than the check variety BRRI dhan39 (230) and this character might be contributed to the yield. Considering the above yield and yield contributing characters the proposed line might be considered for further evaluation.

Regional yield trial (RYT), RLR-1, T. Aman 2014. Three entries were tested at Boria, Kushtia in T. Aman 2014. The materials were IR70213-10-CPA 4-2-2-2, B 10533 F-KN-12-2 and BR8033-2-2-1-2. BRRI dhan32 and BRRI dhan49 were used as standard checks. Thirty-four-day-old seedlings were planted in 5.4 m x 12 rows unit plots with 20 cm x 15 cm spacing. The trial was designed in RCB with three replications. Standard agronomic practices were followed to grow the lines/varieties. Data were taken on the yield and some agronomic characteristics.

The yield of the tested lines ranged from 5.26 to 5.78 t/ha. IR70213-10-CPA 4-2-2-2, B 10533 F-KN-12-2 and BR8033-2-2-1-2 gave similar yield with the check varieties BRRI dhan49 (5.56 t/ha) but lower than the check BRRI dhan32 (6.28 t/ha). Among the tested line IR70213-10-CPA 4-2-2-2 gave the higher grain yield with shorter growth duration. Growth duration (125 days) of the line IR70213-10-CPA 4-2-2-2 was 5-10 days earlier than the standard check BRRI dhan32 and BRRI dhan49 (130 and 135 days respectively) and 1000 grain wt (29.5 gm) was so high to both the check

Table 5. Performance of proposed variety trial (PVT) lines, RLR, T. Aman 2014.

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	TGW (gm)	Yield (t/ha)
BR7472-16-2-1-2-3	129	117.7	213		6.03
BR7622-5-1-1-1	127	116.9	212		5.42
BRRI dhan39 (ck)	122	104.3	231		5.69
BRRI dhan49 (ck)	130	90.7	262		5.23

DS: 9 Jul 2014, DT: 9 Aug 2014.

Table 6. Performance of proposed variety trial (PVT) lines, PQR, T. Aman 2014.

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	TGW (gm)	Yield (t/ha)
BR7357-11-2-4-1-1	129	121.1	254		4.99
BRRI dhan37 (ck)	147	126.0	234		3.26

DS: 9 Jul 2014, DT: 9 Aug 2014.

Table 7. Performance of PVT lines, MN, T. Aman 2014 .

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	TGW (gm)	Yield (t/ha)
BR7528-2R-19-HR10	130	105.7	222		5.13
BRRI dhan39 (ck)	125	95.4	230		5.27

DS: 9 Jul 2014, DT: 9 Aug 2014.

varieties BRRI dhan49 and BRRI dhan49 (20.47 and 19.37 gm) (Table 8).

RYT, RLR-2, T. Aman 2014. Six entries were tested at Boria, Kushtia in T. Aman 2014. The materials were WAS122-IDSA 14-WAS B-FKR 1(NERICA-L-8), WAS122-IDSA 1-WAS -2-B-1-TGR 132 (NERICA-L-16), WAS 161-B-6-B-1(NERICA-L-36), WSA 161-B-4-B-1-TGR 51 (NERICA-L-32), WAS 191-4-10 (NERICA-L-54) and NERICA mutant. BRRI dhan56 and BRRI dhan49 was used as standard checks. Twenty-five-day-old seedlings were planted in 5.4 m × 12 rows unit plots with 20 cm × 15 cm spacing. The trial was designed in RCB with two replications. Standard agronomic practices were followed to grow the lines/varieties. Data were taken on the yield and some agronomic characteristics.

The yield of the tested lines ranged from 4.44 to 6.59 t/ha. WAS122-IDSA 14-WAS B-FKR 1. (NERICA-L-8), WAS122-IDSA 1-WAS -2-B-1-TGR 132 (NERICA-L-16) and WSA 161-B-4-B-1-TGR 51 (NERICA-L-32) gave similar yield to both check varieties BRRI dhan56 (5.43 t/ha) and BRRI dhan49 (5.49 t/ha) but more than 1.0 t/ha higher yield found from line WAS 161-B-6-B-1(NERICA-L-36). Growth duration of the lines WAS 161-B-6-B-1(NERICA-L-36) was seven days earlier than the standard check BRRI dhan49 (132 days) but 9 days longer than the check BRRI dhan56 (115 days). Plant height of these two lines was intermittent than both the standard checks and lodging tendency was not occurred. Thousand-grain weight (TGW) was similar to both the check varieties BRRI dhan56 and BRRI dhan49 (23.27 and 25.60 gm) (Table 9).

RYT, PQR, T. Aman 2014. Eight materials were tested at Baradi, Kushtia in T. Aman season 2014. The materials were BR8226-8-5-2-2, BR8226-11-4-4-3, BR8226-11-4-6-2, BR8294-1-3-2-2, BR8226-13-1-2, BR8226-17-1-2, BR8227-11-6-2-1 and BR8515-23-6-3. BRRI dhan34 and BRRI dhan37 were used as standard checks. Twenty-six-day-old seedlings were planted in 5.4 m × 12 rows unit plots with 20 cm × 15 cm spacing. The trial was designed in RCB with two replications. Standard agronomic practices were followed to grow the lines/varieties. Data were taken on the yield and some agronomic characteristics.

The yield of the tested lines ranged from 2.76 to 5.62 t/ha. Most of the lines gave higher grain yield than both the check varieties (BRRI dhan34 and BRRI dhan37) except the line BR8515-23-6-3. The highest yield was observed in the line BR8227-11-6-2-1 (5.62 t/ha) and it was about 1.85-2.01 t/ha higher yield than the standard check BRRI dhan34 (3.77 t/ha) and BRRI dhan37 (3.61 t/ha) fallowed by line BR8226-8-5-2-2 (5.17 t/ha) and BR8226-13-1-2 (4.84 t/ha). Growth duration of the lines BR8227-11-6-2-1 and BR8226-8-5-2-2 were similar with the check variety BRRI dhan37 but longer than the check BRRI dhan34 and line BR8226-13-1-2 similar with the check BRRI dhan34 but shorter than the check BRRI dhan37. All of the entries showed shorter plant height than the check varieties BRRI dhan34 and BRRI dhan37 (Table 10).

RYT of micronutrient enriched rice (MER), T. Aman 2014. Seven materials were tested at

Table 8. Performance of some rainfed low land rice (RLR) lines, T. Aman 2014.

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	TGW (gm)	Yield (t/ha)
IR70213-10-CPA 4-2-2-2	125	107.2	265	29.5	5.78
B 10533 F-KN-12-2	126	114.6	285	23.03	5.26
BR8033-2-2-1-2	133	97.2	319	18.47	5.43
BRRI dhan32 (ck)	130	116.9	271	20.47	6.28
BRRI dhan49 (ck)	135	99.5	323	19.37	5.56

DS: 14 Jul 2014, DT: 17 Aug 2014.

Table 9. Performance of some rainfed low land rice (RLR) lines, T. Aman 2014

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	TGW (gm)	Yield (t/ha)
WAS122-IDSA 14-WAS B-FKR 1. (NERICA-L-8)	122	102.7	341	26.37	5.68
WAS122-IDSA 1-WAS -2-B-1-TGR 132 (NERICA-L-16)	125	107.8	279	27.20	5.62
WAS 161-B-6-B-1(NERICA-L-36)	124	102.1	352	25.43	6.59
WSA 161-B-4-B-1-TGR 51 (NERICA-L-32)	123	101.1	323	26.40	5.33
WAS 191-4-10 (NERICA-L-54)	123	95.2	291	24.40	4.71
NERICA mutant	114	104.7	244	24.70	4.44
BRRI dhan56 (ck)	115	115.3	265	23.27	5.43
BRRI dhan49 (ck)	132	94.3	262	25.60	5.49

DS: 14 Jul 2014, DT: 9 Aug 2014.

Baradi, Kushtia in T. Aman 2014. The materials were BR7840-54-3-2-2, BR7879-17-2-4-HR3-P1, BR7671-37-2-2-3-7-3, BR8143-15-2-1, BR8418-1-3, IR85850-75-2-2-3-2(IR10M 300) and PSBRC 82(IRRI 123). BRRI dhan32 and BRRI dhan39 were used as standard checks. Thirty-day-old seedlings were planted in 5.4 m × 12 rows unit plots with 20 cm × 15 cm spacing. The trial was designed in RCB with two replications. Standard agronomic practices were followed to grow the lines/varieties. Data were taken on the yield and some agronomic characteristics.

The yield of the tested lines ranged from 4.93 to 5.62 t/ha. Most of the lines gave more or less similar grain yield to the check variety BRRI dhan32 except lines BR8418-1-3 and BR7879-17-2-4-HR3-P1. The highest yield was observed in the line BR8143-15-2-1 (5.62 t/h) and it was about 0.06 t/ha and 0.76 t/ha higher yield than the standard check BRRI dhan32 (5.56 t/ha) and BRRI dhan39 (4.86 t/ha) respectively fallowed by line IR85850-75-2-2-3-2(IR10M 300) and PSBRC 82(IRRI 123 (5.49 t/ha). Growth duration of the line BR8143-15-2-1 was 18 days and 13 days shorter than the checks BRRI dhan32 (129 days) and BRRI dhan39 (125 days), respectively (Table 11). Therefore, the line BR8143-15-2-1 might be considered for further evaluation.

Table 10. Performance of premium quality rice in T. Aman 2014.

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	TGW (gm)	Yield (t/ha)
BR8226-8-5-2-2	138	101.4	353	36.63	5.17
BR8226-11-4-4-3	143	88.7	329	18.63	4.63
BR8226-11-4-6-2	139	94.2	305	16.37	4.31
BR8294-1-3-2-2	119	111.1	220	18.33	4.33
BR8226-13-1-2	132	109.1	306	16.37	4.84
BR8226-17-1-2	135	105.1	289	19.50	4.74
BR8227-11-6-2-1	136	110.8	236	22.23	5.62
BR8515-23-6-3	131	110.1	264	16.33	2.76
BRRI dhan34 (ck)	132	133.8	251	10.30	3.77
BRRI dhan37 (ck)	137	134.4	263	14.13	3.61

DS: 17 Jul 2014, DT: 13 Aug 2014.

Table 11. Performance of some RYT (MER) T. Aman 2014.

Designation	Growth duration (day)	Plant ht (cm)	Panicle (no./m^2)	TGW (gm)	Yield (t/ha)
BR7840-54-3-2-2	122	116.9	169	24.88	5.21
BR7879-17-2-4-HR3-P1	132	127.3	192	24.42	5.02
BR7671-37-2-2-3-7-3	126	100.9	247	25.95	5.15
BR8143-15-2-1	112	112.9	191	25.77	5.62
BR8418-1-3	121	94.5	274	21.26	4.93
IR85850-75-2-2-3-2 (IR10M 300)	128	100.3	291	24.50	5.49
PSBRC 82 (IRRI 123)	128	100.3	291	24.50	5.49
BRRI dhan32 (ck)	129	118.3	230	22.17	5.56
BRRI dhan39 (ck)	125	100.1	219	23.30	4.86

DS: 14 July 2014, DT: 15 Aug 2014.