Annual Report
2019 -20




KRISHI GOBESHON A FOUNDATION
A non-profit foundation for sustainable support to agricultural research & development

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Executive Chairman, BARC, and
Chairman, Board of Directors, KGF

Message

Agriculture provides food security on the one hand, and, on the other, livelihood opportunities and incomes for a sizeable portion of the people of Bangladesh. It has also been almost the exclusive catalyst of poverty alleviation and, to date, remains a very important driver of sustainable economic development in the country. Banking on a strong agrarian economy, Bangladesh fared well over the past decade in developing non-farm economic activities and exports. Today, agriculture employs around 43% of the work force and accounts for some 15% of the GDP of Bangladesh. Agriculture has played an important role in meeting the eligibility criteria for Bangladesh to break free from the UN Least Developed Countries list and will contribute substantially in achieving the Sustainable Development Goals (SDGs), especially SDG2 which mandates ending hunger.

The contemporary story of agriculture in Bangladesh is a story of fast growth and spectacular accomplishments in all sub-sectors like crops, fisheries and livestock. The country now produces enough grains, vegetables, fruits, fish and livestock for domestic consumption and even accumulates some surpluses for exports. At the world level, Bangladesh at present ranks third in the production of rice, the staple food crop and the traditional source of protein, inland fish, and is one of the top ten producers of potato, vegetables and fruits like mango, jackfruit and guava. The success stories of agriculture in Bangladesh owe greatly to the collective initiatives and efforts of agricultural researchers, extension experts and farmers as well as to congenial Government strategies and policies for agricultural research and development. The Krishi Gobeshona Foundation (KGF), since its inception in 2007, has been playing an important role agricultural research and development in the country, financially and technically facilitating and sponsoring research, training and extension initiatives and work by the Bangladesh NARS institutions, universities, DAE, NGOs and private enterprises, emphasizing need-based quality work. KGF, it is hoped, will continue and strengthen its initiatives and programs in promoting agricultural research and development in the future contributing to production boosts and improvement of farmers' livelihoods and incomes.

I am happy to know that, commensurate with one of KGF's main objectives s, i.e., knowledge and technology dissemination and uptake, the results and impacts of KGF sponsored agricultural research and development projects and programs are regularly monitored, recorded and documented in assorted quarterly and annual publications, such as, newsletters, technical bulletins, annual reports, etc. Efforts of KGF colleagues for the publication of the 11th Annual Report 2019-20, some setbacks owing to the Covid-19 pandemic notwithstanding, deserve praise and appreciation. I hope that agricultural researchers and extension specialists, social workers and community leaders, government planners and strategists will find this publication useful as a resource and reference document related to agricultural research, technology generation and dissemination.

Shaikh Mohammad Bokhtiar, *PhD*

Executive Director, KGF

Preface

The present global economic outlook is challenging, yet Bangladesh continues to be the fastest growing economy in the Asia-Pacific region, and is seen by international development agencies as a model for growth even in these trying times. The agriculture sector of the country, with great successes in the production of crops, fish and livestock, keeps contributing significantly to this growth. In the last decade, the Bangladesh agriculture sector has grown substantially, at a rate of about 3.8%, in spite of dwindling arable land area and intensifying natural adversities like climate change. Research and technology generation, dissemination and implementation by agricultural scientists, extension specialists and farmers coupled with Government policies targeted at achieving food and nutritional security, sustainable intensification and development of climate resilient agriculture, as mandated by Vision 2021, have been instrumental in boosting agricultural production. The Krishi Gobeshona Foundation (KGF), through sponsoring and supporting agricultural research and technology dissemination endeavors of NARS institutions, universities, DAE, NGOs and private enterprises, has earned itself a niche as a key partner in the agricultural research and development arena of Bangladesh.

The programs and projects sponsored by KGF over the years generated a number of promising technologies pertaining to crop, livestock and fisheries production in Bangladesh. Of late, KGF has taken initiatives to expand the horizon of perspectives and actions to enhance collaboration, both nationally and internationally, translate data and information into policy and strategy recommendations for the Government and other stake holders. The Foundation is also emphasizing assertive and visible measures for technology dissemination and uptake. As a promoter and sponsor of agricultural research and development in the country, KGF envisages and attempts to play a key role in national agricultural policy formulation, development of the Eighth Five Year Plan, achievement of the UN Strategic Development Goals (SDG), etc. To achieve the desired goal of addressing complex production constraints and post-production environments in the present day agriculture sector of Bangladesh where many actors interacting in diverse issues--legal, agro-business, trade, consumer demand, media, marketing, global negotiations, climate change, international and regional linkages, etc.--are involved, KGF tries to orient its initiatives and actions in a responsive manner and in proper directions.

Modern technologies and scientific information are the main drivers of agricultural production in any country, but in order to actually generate value, they need to be successfully transferred to farmers' fields and entrepreneurs' markets. Publications play an important role in knowledge and technology dissemination as well as in enhancing the visibility of KGF as a unique centre for the sponsorship and patronization of agricultural research and development in Bangladesh. In view of this, KGF has been regularly publishing annual reports as a useful and effective vehicle of information and knowledge sharing. This Annual Report, 2019-20, 11th in the series, presents a brief account of the initiatives, activities and achievements of KGF during the fiscal year July 2019 to June 2020. Results of research and development work on crops, fisheries, livestock, agricultural engineering, farming systems, socioeconomics, agro-forestry and enterprise development during this period are documented in the annual report. Statements of financial progress and audit during the same period are also documented in this annual report. I gratefully acknowledge the continued guidance and advice of the honorable members of the General Body and Board of Directors in running the affairs of KGF, and would like to thank scientists and professionals of all collaborating institutions and organizations including KGF for their valuable contributions in the project operations and achievements. The efforts of KGF colleagues who diligently compiled and edited this annual report are sincerely acknowledged. Scientists, extension specialists, policy makers, teachers, students and other stakeholders in the agriculture sector of Bangladesh, I hope, will find this document informative and useful. KGF always appreciates critique, comments and suggestions from readers.

Jiban Krishna Biswas, *PhD*

Abbreviations and Acronyms

Abbreviations and Acronyms

ACIAR	:	Australian Center for International Agricultural Research
ADP	:	Annual Development Program
AEZ	:	Agro-ecologi cal zone
AIS	:	Agriculture Information Service
AWD	:	Alternate Wetting and Drying
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BCR	:	Benefit cost ratio
BINA	:	Bangladesh Institute of Nuclear Agriculture
BKGET	:	Bangladesh Krishi Gobeshona Endowment Trust
BLRI	:	Bangladesh Livestock Research Institute
Boro	:	Wetland transplanted rice grown in the winter season in Bangladesh
BR	:	Basic Research
BRRI	:	Bangladesh Rice Research Institute
BSFIC	:	Bangladesh Sugar and Food Industries Corporation
BSMRAU	:	Bangabandhu Sheikh Mujibur Rahman Agricultural University
BSRI	:	Bangladesh Sugarcrop Research Institute
CA	:	Conservation Agriculture
CDB	:	Cotton Development Board
CEB	:	Community Engagement Biosecurity
CEP	:	Capacity Enhancement Program
CGP	:	Competitive Grants Program
CGR	:	Crop Growth Rate
CHT	:	Chittagong Hill Tracts
CRP	:	Commissioned Research Program
CSO	:	Chief Scientific Officer
CVASU	:	Chittagong Veterinary and Animal Science University
DAE	:	Department of Agricultural Extension
DLS	:	Department of Livestock Services
DoF	:	Department of Fisheries
ED	:	Executive Director
FAO	:	Food and Agriculture Organization of the United Nations
FGD	:	Focal group discussion
FMD	:	Foot and mouth disease
GIS	:	Geographical information system
GnB	:	General Body
GO	:	Government Organization
GoB	:	Government of Bangladesh
HARS	:	Hill Agricultural Research Station

Abbreviations and Acronyms

HRC	:	Horticulture Research Center
HYG	:	High yield goal
HYV	:	High Yielding Variety
ICP	:	International Collaborative Program
KGF	:	Krishi Gobeshona Foundation
KII	:	Key Informant Interview
KSSL	:	Krishibid Somobay Somity Limited
LAI	:	Leaf area index
M & E	:	Monitoring and evaluation
MAA	:	Memorandum and Articles of Association
MoA	:	Ministry of Agriculture
NAR	:	Net assimilation rate
NARS	:	National Agricultural Research System
NATP	:	National Agricultural Technology Project
NGO	:	Non-government organization
OFRD	:	On Farm Research Division
PCR	:	Project Completion Report
PGR	:	Plant growth regulator
PRTC	:	Poultry Research and Training Center
PSO	:	Principal Scientific Officer
R&D	:	Research and development
RB	:	Repeat breeder
RCT	:	Resource conservation technology
RFV	:	Relative feed value
RGR	:	Relative growth rate
RS	:	Remote sensing
SAU	:	Sher-e-Bangla Agricultural University
SyAU	:	Sylhet Agricultural University
SO	:	Scientific Officer
SSO	:	Senior Scientific Officer
T. Aman	:	Wetland transplanted rice grown in the monsoon season in Bangladesh
T. Aus	:	Wetland transplanted rice grown in the pre-monsoon summer season in Bangladesh
TAC	:	Technical Advisory Committee
TDN	:	Total digestible nutrient
TPP	:	Technology Piloting Program
UAO	:	Upazila Agriculture Officer
UNDP	:	United Nations Development Program

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Krishi Gobeshona Foundation
Dedicated to Agricultural Research and Development

Krishi Gobeshona Foundation (KGF), established in 2007, is an institutional innovation for agricultural research and development in Bangladesh.

Vision

The vision of KGF is to foster an enabling environment for promoting quality agricultural research and capacity enhancement for sustaining agricultural productivity, farm incomes and food and nutritional security.

Objectives

The major objective of KGF is to improve the quality of agricultural research to address demand driven priority research issues for achieving food and nutritional security and improve rural livelihoods.

Programs and Activities

KGF sponsors agricultural research and development projects under four-programs viz., a) Competitive Grants Program, b) Commissioned Research Program, c)Capacity Enhancement Program and d) International Collaborative Program. The Foundation implements pilot projects under the Technology Piloting Program to the disseminate technologies generated by sponsored research projects. In addition, very recently, KGF took some novel initiatives opening up new horizons in the agricultural R&D arena of Bangladesh: (i) Technology commercialization (ii) Data and information services, (iii) Technical support to policy makers, (iii) Awareness building and technology dissemination through media coverage and (iv) International partnership for information, knowledge and technology exchange.

1. Executive Summary

Established in 2007 under the Companies Act 1999 as a Bangladesh government sponsored non-profit autonomous research grant making organization, the Krishi Gobeshona Foundation (KGF) has been engaged in facilitating and fostering a pluralistic agricultural research environment for public organizations (NARS institutes, universities, other government and autonomous organizations and institutions, NGOs and private enterprises of Bangladesh. KGF sponsors and finances research and development work to address existing and emerging issues related to agricultural development and lives and livelihoods of the farming community in the country. KGF sponsorship of agricultural research and development work is organized in four programs: (a) Competitive Grants Program (CGP), (b) Commissioned Research Program (CRP), (c) Capacity Enhancement Program (CEP), and (d) International Collaborative Program (ICP). KGF also implements a Technology Piloting Program (TPP) to accelerate the dissemination and uptake of potentially useful technologies generated by the research projects.

The Bangladesh Krishi Gobeshona Endowment Trust (BKGET) began funding KGF after the end of NATP Phase-I in 2013. Since then, four public announcements for the award of research grants under CGP with BKGET funding have been made in 2013, 2015 and 2017-18, 2018-19. A total of 60 (14 under CGP 1st call, 19 under CGP 2nd call and 27 under CGP 3rd call) project grants were awarded following a rigorous selection process by the Technical Advisory Committee (TAC) of KGF. In addition, 8 basic research projects (BR) were awarded in 2017-18 to BRRI and BARI. Besides, in between the 3rd and 4th public calls, KGF received 19 proposals from different organizations which were screened through the review process as per the KGF Operational Manual. Considering their merit, TAC recommended 3 projects which were awarded in 2018-19 following approval by the KGF Board of Directors. A few more are in the pipeline awaiting a KGF decision.

All of the 14 projects under the 1st call and 7 projects under the 2nd call were successfully completed and their achievements were highlighted in the previous progress reports. Later, 8 projects under the 2nd call have also been successfully completed in 2018-2019. Besides, all projects awarded under the 3rd call along with the remaining projects of the 2nd call and the unsolicited projects are now at different stages of implementation, the progresses of which have been highlighted in this annual report for 2019-20. Also, 7 BR projects (one BR project was discontinued upon the reviewer's recommendation) are continuing well as per schedule. The progresses of the 7 ongoing BR projects have been summarized in this report.

In early March, 2019 KGF made the 4th public call for submission of full research project proposals under CGP. In response, 319 project proposals (crops-101, livestock-63, agricultural engineering-07, aquaculture and fisheries-40, natural resource management-43, socioeconomics-21 and cross-cutting issues-44) were received. KGF shortlisted 252 projects for reviews, overviews and selection by KGF program specialists, TAC members and invited experts in the relevant disciplines. In the process, 72 proposals received interim acceptance for probable awards and the proponents were invited to present the proposals for discussion and deliberations by an expert panel. Fifty-five of the proposals (crops-15, NRM-11, agricultural engineering-2, livestock-10, fisheries-11, cross-cutting-3 and socio economics-3), categorized as (a) acceptable as first track (b) considered for second track acceptability and (c) rejected due to one or more reasons like poor write up, inconsistency, duplication of or similarity with ongoing research activities by others. Were screened out for review by special sub-committees. Finally, 29 proposals were selected as first track proposals by TAC for executive decision to be taken by the KGF Board regarding funding and sponsorship.

Projects under the Commissioned Research Program (CRP) are designed and developed to address agricultural production issues in hitherto marginal and underutilized areas of the country which could otherwise be rendered productive with appropriate technologies and interventions. At present, five long-term CRP projects namely, (i) Harnessing the Potential of Hill Agriculture: Enhancing Crop Production

through Sustainable Management of Natural Resources, (ii) Modeling Climate Change Impact on Agriculture and Developing Mitigation and Adoption Strategies for Sustaining Agricultural Production, (iii) Strengthening Sugarcane Research and development in Chittagong Hill Tracts, (iv) Hill Livestock: Increasing Livestock Production in the Hills through Better Husbandry, Health Services and Improving Market Access Through Value and Supply Chain Management, and (v) Development of Upazila Land Suitability Assessment and Crop Zoning System of Bangladesh are being implemented in CHT and a few other areas of the country. CRP-I has been completed. The first phase of CRP II project has been completed, and there have been suggestions to begin the 2nd phase which would include livestock and fisheries in addition to crops.

Four projects are presently in progress under the Capacity Enhancement Program (CEP), such as, (a) Capacity Enhancement of NARS through Agricultural Research Management Information System (ARMIS) the 1st phase of which ended successfully in 2016, and a KGF grant award for the 2nd phase has been made this year, (b) Adaptive Trials on Seaweed Cultivation in Coastal Areas, (c) Mitigating Greenhouse Gas Emission from Rice-Based Cropping Systems through Efficient Fertilizer and Water Management, and (d) Skill Development Training for Scientists, Field Veterinarians, Livestock Workers and Poultry/Dairy Farmers. CEP-IV has been completed.

KGF also explores avenues of undertaking collaborative research programs with universities and/or organizations of developed countries under the International Collaborative Program (ICP). Three ICP projects viz., (a) Cropping System Intensification in the Salt Affected Coastal Zones of Bangladesh and West Bengal, India, (b) Nutrient Management for Diversified Cropping in Bangladesh, and (c) Incorporating Salt Tolerant Wheat and Pulses into Small Holder Farming Systems in Southern Bangladesh presently being implemented in collaboration with Murdoch University, Australia and University of Western Australia funded jointly by KGF-BKGET and ACIAR. ICP-I has been completed. In order to expedite dissemination and uptake, KGF pilots promising technologies generated earlier by CGP projects.

Out of the five pilot projects awarded, one already ended successfully and the remaining four are in progress. Research institutes, universities, some government organizations, NGOs, private entrepreneurs, such as, BARI, BRRI, BJRI, BAU, BSMRAU, HSTU, Rajshahi University, CVASU, Sylhet Agricultural University, National Institute of Biotechnology (NIB), DoF, PUBSS, SUSHILON, etc. are involved in the implementation of these projects as recipients of KGF grants.

In addition to regular activities like management of on-going projects, monitoring, reviewing and evaluation, KGF organized meetings of the Board of Directors and holds research review workshops. KGF arranged seen (67th to 73rd) Board meetings, six (28th to 33rd) Technical Advisory Committee (TAC) meetings, one Annual General Meeting (AGM), and 15 project coordination/review workshops and 15 seminars/meetings attended by local and foreign dignitaries like the Minister for Agriculture, GOB, Agriculture Secretary and scientists from abroad. Besides, KGF responded to queries from different bodies like the Parliamentary Standing Committees, MoA, ADB, IMED, ERD, Planning Commission and also from KGF Board, through reports or presentations.

In the previous year (2018-19), KGF took some novel initiatives opening up new horizons in the agricultural research and development arena of Bangladesh, such as, (i) Commercialization of technology for upscaling production of two broiler chicken strains developed at BAU and popularization, dissemination and branding of live and dressed chickens through a pilot project under the legal framework of a tripartite agreement among BAU, the Inventors and KGF, (ii) Building international partnership with organizations like APAARI (Thailand), ICIMOD (Nepal), ISCAR (India) and ICCCAD (Bangladesh) for information, knowledge and technology exchange, (iii) Policy initiatives to work on policy issues and analysis to provide policy support and guidance to stake holders in agricultural RESEARCH AND DEVELOPEMNT, entrepreneurship, planning and policy making and production. KGF's efforts in this respect so far have resulted in the establishment of a free access data center with a digital data base on 40 years of work on various sectors of agriculture (crops, fisheries, livestock, etc.), initiation of analysis and policy briefs, assessment of the food grain procurement system in Bangladesh with implications for policy, assessment of Aus rice production constraints and

opportunities and policy recommendations for ERE (education-research-extension) coordination, (iv) Technical support to policy makers --KGF assigned agriculture experts to provide policy support to the Ministry of Agriculture on technical aspects of the following issues of national importance: National agriculture extension policy 2018, Foreign agricultural investment policy (on-going), Agricultural mechanization policy (on-going), (iv) Awareness building and technology dissemination--KGF initiated an awareness and technology dissemination drive through TV broadcasts, and to expedite this, signed an MoU with the TV channel "ATN Bangla"; video clips of relevant project activities in farmers' fields and interviews of farmers/scientists/extension workers are recorded and telecast as 25-minute episodes titled "KGF Sonali Din". Work related to some of these initiatives continued through 2019-20.

Achievements and highlights of the completed projects and implementation progress of the ongoing projects are presented briefly in this annual report for 2019-20. Lists of completed and on-going CGP projects (Call I, Call II, Call III and Basic Research) are shown in Annex 1, 2, 3 and 4.

2. Introduction

2.1 Background

KGF is a grants awarding organization established in 2007 under the Company Act of 1994. It is an institutional innovation to foster and sustain a competitive environment for public and private institutions, enterprises and NGOs engaged in agricultural research and development in Bangladesh. KGF creates a common platform, with a pluralistic approach, for interactions, cooperation and collaboration among the stakeholders in the fields of agricultural technology generation, validation and dissemination. The Foundation also facilitates capacity enhancement through human resources and infrastructure development. To proceed with its mandate of facilitating quality research, technology generation and dissemination in the agriculture sector, KGF cultivates and maintains close partnership and collaboration with national and international scientific communities. Financial support for KGF is provided and sustained by the profits of an endowment fund maintained by the Bangladesh Krishi Gobeshona Endowment Trust (BKGET) created by the Government of Bangladesh (GoB) in 2008.

The Foundation functions with autonomy and transparency under the supervision of a Board of Directors (Board) and a General Body (GnB). The General Body of KGF consists of fifteen members and the Board of Directors consists of seven members elected from among the members of GnB. The GnB members are distinguished personalities from different disciplines of agriculture representing both public and private sectors of Bangladesh. KGF is closely associated with mainstream agricultural research institutions and organizations in Bangladesh through BARC. The Executive Director, appointed by the Board, is the Chief Executive of KGF. The Foundation operates various programs covering crops, livestock, fisheries, natural resources management, climate change adaptation, unfavorable ecosystems, commercialization, marketing, value chains and other cross cutting issues.

2.2 Programs of KGF

KGF awards agricultural research and development projects to the most eligible professionals and institutions under four programs viz., a) Competitive Grants Program, b) Commissioned Research Program, c) Capacity Enhancement Program, and d) International Collaborative Program. In addition, the Foundation implements pilot projects under the Technology Piloting Program to disseminate technologies generated by sponsored research projects.

2.2.1 Competitive Grants Program (CGP)

KGF provides funds and technical support to address location specific, demand driven, multi-disciplinary short- to medium-term research projects involving public and private sectors through open circulars inviting proposals related to thematic areas focusing frontier research, safe and nutritious food, on-farm applied and adaptive research including marketing, agricultural commercialization, socioeconomics and value addition. During the process of implementation of CGP projects, it was realized that, in some cases, the problems to be addressed required prior understanding through basic research. To address this concern, the two major NARS institutions of the country, BARI and BRRI, were asked to submit proposals on basic research for funding from KGF. These projects, related to rice, potato and sesame, are being implemented under a special program, termed Basic Research (BR).

2.2.2 Commissioned Research Program (CRP)

Agricultural production in unfavorable ecosystems of Bangladesh is hindered by region specific problems and constraints. Given the need for harnessing the production potentials of these unfavorable ecosystems and enhancing their contributions to the national agricultural output, KGF organized a series of consultation meetings with heads of different research organizations and other relevant stakeholders and identified a few vulnerable areas of national importance like the Chattogram Hill Tracts (CHT), coastal ecosystem, drought-prone northern and northwestern regions and impact of climate change on agriculture. Concept notes on these agricultural research and development issues were prepared and placed before the KGF Technical Advisory Committee (TAC) and, subsequently, before the KGF Board for consideration. TAC recommended and the KGF Board approved the concept notes and suggested to include the haor areas in CRP. The concept notes, upon further consultation with renowned

agricultural experts, were developed into full research proposals prioritizing the research topics and agenda. Finally, the following five projects were finally approved by TAC and the KGF Board, which are being implemented in the respective areas and regions by multi-disciplinary, multi-institutional scientific teams:

(a) Harnessing the potential of hill agriculture: Enhancing crop production through sustainable management of natural resources

(b) Modeling climate change impact on agriculture and developing mitigation and adaptation strategies for sustaining agricultural production in Bangladesh

(c) Strengthening sugarcane research and development in the Chattogram Hill Tracts

(d) Hill livestock: Increasing livestock production in the hills through better husbandry, health service and improving market access through value and supply chain management

(e) Development of upazila land suitability assessment and crop zoning system of Bangladesh

The first phase of the CRP project, "Modeling climate change impact on agriculture and developing mitigation and adaptation strategies for sustaining agricultural production in Bangladesh", ended in June 2019 and the project outputs were reported in the KGF annual report for 2018-19. The second phase of the project awaits initiation.

2.2.3 Capacity Enhancement Program (CEP)

KGF arranges short- to medium-term training programs in relevant areas for capacity enhancement of scientists from NARS institutions, agricultural universities and NGOs, so that they can design and develop research projects to address agricultural problems and implement them independently and successfully. KGF also provides financial support for capacity building in terms of research infrastructure and facilities development.

2.2.4 International Collaborative Program (ICP)

KGF explores avenues for undertaking short to medium term collaborative programs through co-financing with national and international universities and organizations of the developed countries like ACIAR/CSIRO (Australia), NRI (UK),NUFIC (Netherlands), Cornell University (USA), etc. Collaboration with international agencies plays an important role in improving the quality of agricultural research and scientific capacity building enhancement in Bangladesh. Research/ technology dissemination projects under ICP are designed and implemented jointly by scientists of KGF, Bangladesh NARS/universities and collaborating overseas counterparts.

2.2.5 Technology Piloting Program (TPP)

Projects under TPP are meant for technology dissemination to the end users. Important and promising technologies generated by CGP and other projects having potentials of substantially enhancing productivity and production in the various sub-sectors of agriculture in Bangladesh are first scrutinized and their extrapolation domains thoroughly evaluated by a team of experts including desk officers of KGF through FGDs, KIIs, personal consultations and field visits. Selected technologies are then incorporated into TPP projects for financing and implementation by KGF in partnership with DAE/NGOs to promote and foster large scale farmer adoption of the technologies. /

2.3 Grant making process for CGP projects

KGF follows standard procedures for grant making. The greatest share of project funds is allocated to CGP. The flow chart of the competitive grant making process is shown in Fig. 1.

Steps	Grant Making Process
1	Identification of priority researchable areas/issues in thematic areas of each sub-sector of agriculture by TAC followed by Board approval
2	Public call by KGF for submission of research proposals on specific researchable issues under thematic areas following a prescribed format within one month
3.	Screening of the proposals by TAC/KGF professionals following some specific criteria
4.	Peer reviews of the responsive proposals (technical, physical, financial and conceptual aspects) by expert reviewers following some specific criteria and score sheet (80% score)
5.	Overview and short listing of the reviewed proposals by TAC based on qualifying score
6.	Appraisal (oral presentation) of the short listed proposals by probable PIs before TAC (20% score)
7.	Ranking and recommendation of the proposals by TAC for Board approval
8.	Issue of award letter to successful PIs for rationalization (technical and financial) of the approved project proposals if needed in consultation with KGF expert professionals
9.	Signing of MoU (terms and conditions) between KGF and head/authorized person of the implementing organization(s) for implementation of the project

Fig. 1. Flow diagram showing grant making process for CGP projects

2.4 Technical Advisory Committee (TAC)

The Technical Advisory Committee (TAC) plays a key role in the processing and recommending of research proposals under different programs of KGF. It is an independent body formed by the Board of Directors drawing members from high reputation and representation from diversified categories. The tasks the TAC performs are: i) provide strategic guideline ensuring the quality of research and its relevance to the countries goals and objectives s, ii) reviewing priority researchable areas and select issues appropriate for calling proposals under KGF funding, iii) recommend resource allocation for CGP projects/programs, iv) identify where new initiatives may be required and v) overview the proposals reviewed by the peer reviewers and make recommendation to the board.

2.5 Accomplishments during 2019-2020

This 11th Annual Report of KGF which covers activities carried out during the period July 2019 to June 2020. During this period, a total of 57 projects were in operation under different programs related to crops, livestock and fisheries. A number of institutions were involved in implementing the projects. Sector-wise distribution of the projects under the different programs is shown in Table 1.

Table 1. Sector-wise distribution of projects under different programs in 2019-20

Programs		Total projects (No.)	Sector-wise project (No.)		
			Crops	Livestock	Fisheries
CGP	2nd Call	5	05	00	00
	3rd Call	30	19	07	04
	Basic Research	07	07	00	00
CGP total		**42**	**31**	**07**	**04**
CRP		04	03	01	00
CEP		04	03	01	00
ICP		03	03	00	00
TPP		04	01	01	02
Grand total		**57**	**41**	**10**	**06**

2.6 Financial progress

In the reporting period of 2019-20, KGF received Tk. 34,50,27,810 from BKGET and the expenditure made was Tk. 33,06,14,341, i.e., 95.8 % of the funds. Thus, the progress in program implementation, finance-wise, was satisfactory.

2.7 Other activities

For the management of on-going projects under different programs, KGF performs regular desk and field monitoring and evaluation of the projects, arrange review workshops, consultation meetings, etc. KGF also organized arranged Board meetings, GnB meetings and other consultative group meetings during the period under report.

Research Highlights

Competitive Grants Program (CGP)

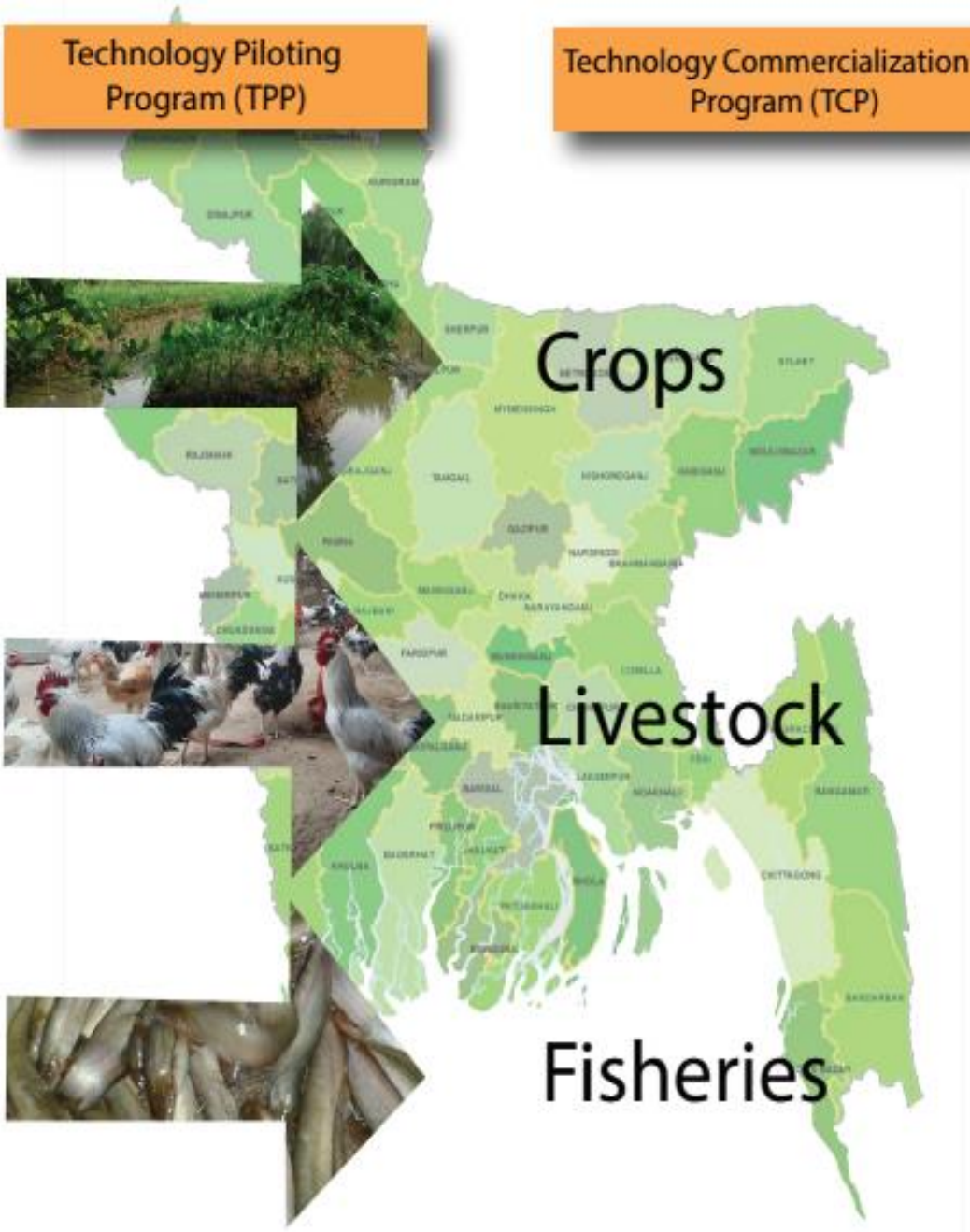
Commissioned Research Program (CRP)

Capacity Enhancement Program (CEP)

International Colaborative Program (ICP)

Technology Piloting Program (TPP)

Technology Commercialization Program (TCP)



3. Research Highlights

3.1 Crops

3.1.1 Competitive Grants Program (CGP)

- An improved mechanical seeder developed by BARI was found suitable for planting different types of crops such as wheat, maize, lentil, mungbean and cowpea under strip tillage and zero tillage conditions.
- Honey, pollen and propolis yields were increased with improved bee boxes and bee stocks in comparison with traditional methods at three sites of Sirajganj, Gazipur and Shatkhira (Sundarban area) districts. The first artificially inseminated queen in the country was developed.
- High-moisture paddy and maize can be dried quickly, in only 5-6 hrs, using two-stage drying techniques in contrast to conventional drying practices that require 10-20 hrs or longer. One commercial scale two-stage dryer unit with a daily throughput capacity of 14 t in two batches has been developed.
- Twenty-three technologies for crop, livestock and fish production were developed for integrated crops-agroforestry-livestock-fish farming in *haor* areas. Farm productivity increased substantially and incomes of *haor* households practicing integrated farming were enhanced from the baseline mark of Tk. 50,854 per farm to Tk. 2,69,577 per farm after interventions.
- The modified BARI potato planter-harvester was found suitable for planting different varieties of potato. A great advantage of the mechanical over manual operations was that the machine reduced the labor requirement by 90% and the planting cost by 75%. The mechanical harvesting of potato was also advantageous in terms of labor requirement and costs, saving 60% of the labor requirement and 57% of the cost.
- A survey of the occurrence of wheat blast, 37 out of 135 fields were identified with the incidence of wheat blast which was about 27% of the total surveyed fields. Nine suspected alternative hosts were identified for *Magnaporthe oryzae* pathotype *Triticum* (MoT). Thirteen elite wheat genotypes were found resistant which can be used for the development of blast resistant lines or varieties. A cocktail of the fungicides Tebuconazole, Trifloxystrobin and Tricyclazole was proved to be effective both as a preventive and curative measure against wheat blast. Sprays or soil incorporation of silicon and boron were also found to be effective in suppressing wheat blast infestation. Gamma irradiation of seeds produced 13 promising blast resistant wheat mutants. In collaboration with UK and Canadian researchers, some S-genes were edited by using CRISPR/Cas9. These transformants are being tested against the MoT fungus.
- A set of agro-environmental resources geo-database from image analysis was developed including digital elevation model, slope map, aspect map, and soil map for a selected upazila.
- BARI developed eggplant varieties, BARI Begun-8 and BARI Begun-10, were found to be superior to the local variety, Volanath in terms of yield and economic returns. Likewise, the BARI hyacinth bean varieties, BARI Sheem-1, BARI Sheem-4 and BARI Sheem-6 performed better than the local local variety, Kartika. BARI Sheem-1 was found to be suitable for growing as a relay crop with BARI Begun-8/BARI Begun-10. Relaying BARI Sheem-1 with BARI Begun-8/BARI Begun-10 increased yields and enhanced economic returns by reducing production costs from those needed for sole crops.
- Seven off-season/year round jackfruit germplasm from were identified. Orchards of BARI developed jackfruit varieties have been established in farmers'fields in three districts (Gazipur, Khagrachari and Narsinghdi).
- The BARI developed cropping patterns (CP), Aman-fallow-watermelon, T. Aman-fallow-bitter gourd, T. Aman-potato-sesame, T. Aman-potato-mungbean and T. Aman-fallow-bottlegourd,

were found to be agro-economically superior to the traditional T. Aman-fallow-fallow CP in terms of rice equivalent yield, net income and production efficiency in coastal saline areas.

- A solar cabinet dryer was designed and fabricated by the Farm Machinery and Postharvest Process Engineering Division, BARI, Gazipur with locally available materials. The dryer was designed to generate desirable temperature (<45°C) from solar radiation suitable for vegetable seed drying. Performance of the solar powered vegetable seed dryer was evaluated with red amaranth and sweet guard seeds.
- A total of 252 rice germplasm/varieties/lines were screened against the rice gall midge (GM). Ten different groups of germplasm and BRRI varieties were screened. The resistant genotype(s) were used in breeding programs for hybridization between two parents, and in Rapid Generation Advance (RGA) studies to develop high-yielding GM resistant line(s)/varieties. Validation experiments of GM resistant sources/donors were conducted in GM endemic areas.
- French bean, soybean and pea can be introduced in between short-duration T-Aman rice and late Boro rice. Introduction of these bean species not only increased the system productivity and annual economic returns but also enhanced soil fertility.
- A survey revealed that approximately 43.94% of jackfruits, i.e., about 4.5 t go to waste, which is almost half of the total production. Three value-added jackfruit products such as, fresh cut jackfruit bulb (ripened), fresh cut tender jackfruit and jackfruit jam with good amounts of nutritional compounds such as, ascorbic acid, carotenoids, total phenols, antioxidants, etc. have been developed to reduce post harvest losses of jack fruit.
- IPM package consisting of hand picking and destruction of infested flower/pods and shoot along with yellow sticky and sex pheromone traps and weekly insecticide sprays was found to be a good IPM package for country beans. On the other hand, an integrated disease management package comprising Tricho-compost in pit, seed treatment with Bordeux mixture and foliar spray of Tricho-leachate worked well.
- Fusarium wilt and gummy stem blight (GSB) are the major diseases of watermelon caused by the fungal pathogens *Fusarium oxysporum* f. sp. *niveum* (FON) and *Didymella bryoniae*, respectively. Isolates of the pathogens showed varying infection abilities.

3.1.2 CGP Basic Research

- Chloroplast (cp) and cpDNA isolation protocols have been refined for cpDNA isolation for chloroplast genome sequencing of potato. Marked variations among the progenies were found in terms of late blight disease resistance. For developing QTL maps, DNA was extracted from the populations, work on genotyping is in progress.
- Eight rice genotypes have been phenotypically detected as blast resistance. One HYV type rice germplasm has been selected as a blast resistant pure line that can give a 6.0 t/ha yield within 140 days. One advanced line was selected for evaluation in the BRRI Advance Line Adaptive Research Trial (ALART) program for promoting as a blast resistant variety.
- Sesame was found to possess adaptive mechanisms at both physiological and biochemical levels for tolerance of waterlogging implying that there is scope for investigation at the gene level to discover waterlogging tolerant genes of sesame and develop tolerant varieties.
- Following field and molecular screening of 60 wheat lines for different heat tolerant traits, 6 genotypes were identified as potential parents. A distinct breeding design as well as crossing plan was established using adaptable local cultivars and 37 crosses were done at RRS, BWMRI, Gazipur. F1s were collected, processed and stored at 400 C, and F2s were raised from the F1s of limited crosses.

3.1.3 Commissioned Research Program (CRP)

- Three earthen dams, one culvert-cum-water retention structure, two rainwater harvesting reservoirs, and three deep tube wells have been built at different locations under the Commissioned Research Project (CRP)-Hill Agriculture to provide irrigation facilities and potable water for agricultural and domestic uses in the Chattogram Hill Tracts (CHT) districts. Irrigation scheduling and water requirements of cabbage and tomato were determined. Delineation of 18 watersheds have been completed and relevant maps and reports prepared. Land management techniques for continuous crop production without fallowing in the jhum system comprising fertilizer application (N60 P20 K30 S12 or NPK briquette) were developed. The technique of cultivation of leguminous crops (cowpea, yard long bean, country bean, etc.) as relay crops was developed. Improved management practices for mango and litchi for higher and quality production in the existing orchards were developed. BARI Kola (Banana)-3, BARI Malta-1, BARI Dragon Fruit-1 and Red Lady Papaya showed good prospects for cultivation in CHT, which need to be piloted. The Modified Khagrachari Model was developed for profitable homestead production of vegetables such as, BARI Shim-6, BARI Panikachu-2 and BARI Panikachu-6, BARI Lau-4, BARI Jharsheem-3, etc. Integrated pest management (IPM) practices to control major insect pests of jhum crops were developed. One row cotton + two row rice configuration was identified as a viable planting configuration for intercropping. Improved jhum systems for rice (cockroo), maize (BHM-9), cotton (CB-12), sesame (sada geisha), local pumpkin and marpha were developed. Fourty four (44) local landraces of 27 different crops like fruits, vegetables and cereals were collected from the three CHT districts. Eleven fruit/vegetable growers' organizations were formed in Bandarban (9) and Rangamati (2) districts. Analysis of existing supply chain/value chains and upgrading of existing chains of selected fruits and vegetables in Bandarban and Rangamati were accomplished. Value chain analysis for mango, litchi and jackfruit in Khagrachari was completed covering 130 fruit growers.
- Physical facilities including a sugarcane crossing shed and a fuzz processing building were established at the new campus of the Bandarban Station (CHT) of BSRI. Field trials revealed the superiority of BSRI Akh 42, BSRI Akh 41, Co 208 and China as chewing clones and of VMC 86-550, Ranangoan, Q 69 and BSRI Akh 41 as gur cane varieties. Application of fertilizers @ 125% of recommended doses was found to be agro-economically viable for sugarcane production in CHT. Three sugarcane varieties viz., BSRI Akh 41, BSRI Akh 42 and VMC 86-550 were identified for good ratooning ability. Sugarcane intercropping with high-value crops like soybean and okra as second intercrops (after harvesting of the first intercrop) was found to be a profitable practice in the Khagrachari district.
- An online GIS-based crop zoning interactive information system (CZIIS) software and related database have been developed for crop zoning and crop suitability delineation. A mobile app "Khamari" has been developed for use by farmers and other stake holders, which can be downloaded from the Google Play Store. An agri-advisory web portal has been developed to provide services and advice. Work on uploading soil fertility maps, agro-climatic maps, upazila-wise cropping sequences data, etc. is in progress.

3.1.4 Capacity Enhancement Program (CEP)

- Under the agricultural research database project (ARMIS), 1,670 new entries of research information were added to the databank. Linkages and active communications with the 20 targeted organizations are being closely maintained to expedite data entries, editing and final recording into the databank. The KGF web-site was redesigned adding a digital banner depicting the birth centenary of Bangabandhu Sheikh Mujibur Rahman. Updating the ARMIS software to make them more user friendly is in progress.
- Seaweed yield may be increased by 10 to 15% if seeded 3 days before the full moon and harvested 3 days after the next full moon (24 days' field duration). The green seaweed Ulva lactuca (sea lettuce) can be grown in open sea during January to March of the year. February is

the best time to produce this seaweed. There is a possibility of large scale seaweed production of the seaweeds G. tenuistipitata var. liui and U. lactuca in different areas along the coast of Cox's Bazar. It is also possible to produce seaweeds in ghers (prawn producing ponds) with special management. Preliminary trials are in progress for optimizing agar extraction from Gracilaria tenuistipitata. Different seaweed recipes, e.g., seaweed pakora, soup, salad, jelly, etc. have been developed.

- The alternate wetting drying (AWD) method of irrigation for rice and urea deep placement (UDP) reduce the emission of geenhouse gases (GHG) in rice-based cropping patterns. UDP greatly reduced ammonia volatilization and nitrous oxide and methane emissions and increased rice grain yield significantly compared with the prilled urea broadcasting. The AWD practice for Boro rice reduced methane emission by 10% compared with continuous standing water in the field without any yield penalty. Incorporation of mustard between T. Aman and Boro rice reduced methane emission compared with that in a yearly three-rice cropping pattern.
- A total of 205 scientists, veterinarians and farmers have been trained in the use of molecular techniques in microbiology, veterinary surgery and radiographic imaging techniques, advanced dairy farming, poultry farming and community livestock heath services. Experts from the Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), Chennai, India were the resources persons for the training on surgery and radiographic imaging.

3.1.5 International Collaborative Program (ICP)

- Under an International Cooperative Program (ICP) involving KGF, ACIAR, Bangladesh NARS organizations and Murdoch University, Australia, socioeconomic surveys and analyses indicated significant fertilizer nutrient use gaps between current farmers' practices and scientific recommendations in Bangladesh. In the northern region, recommended balanced NPKSZn and B fertilizer doses for various crops in diverse cropping patterns have been found to significantly increase system productivity and profits over local farmers' practices. Nitrogen and potassium commonly, and in some areas phosphorus and sulfur have been found to be the limiting nutritional factors for crops in the northern region. Conservation agriculture practices appeared to be promising in comparison with the traditional intensive tillage practices in terms of land productivity, soil fertility maintenance and production cost savings. Sunflower appeared promising as an additional crop in the largely sole T. and sowing methods and fertilizer doses were developed for sunflower on coastal saline land. For growing Rabi crops like maize in coastal areas with low pH soils, a combination of lime and phosphorus fertilizer was found to be a very good management option.
- A project on cropping system intensification in the salt affected coastal zones of Bangladesh and West Bengal, India was completed. This project generated useful technologies to introduce new crops to increase cropping intensity and enhance productivity of the salt-affected marginal lands of the coastal zone. Initiation of a second phase for dissemination and large scale adoption of these technologies in the coastal zone is under consideration by KGF with co-funding from ACIAR.
- Demonstration of a production technology package of mungbean comprising line sowing with the cultivar BARI Mung 6 in late January with fertilizer and insecticide applied was done in the Barishal Division with some also in Khulna. For cowpea production, demonstrations were conducted in three districts of Barisal in the 2019/20 season. The package included a new cultivar, seed drilling and fertilizer with insecticides applied. Lentil and green pea production packages could be used in upland pockets of Barishal. At CSIRO, Australia both a benchmark set of 24 diverse BARI wheat lines and a large diverse collection of 150 wheat lines representing genetic diversity in the BWMRI breeding program have been screened for salt tolerance resulting in the identification of useful broad genotypic variation for this trait.

3.2 Livestock

3.2.1 Competitive Grants Program

- Dairy farms with a history of diarrheal symptoms were found to be strongly associated with Campylobacter infection in cattle and humans. The circulating bacteria in animal sources have been genotyped as Mycobacterium africanum (M. orygis) that help ascertain the causative agent of animal TB in Bangladesh. The prevalence of bTB and associated risk factors in farming cattle have been assessed.
- Zoonotic diseases in animal and bird samples were found to be of viral, parasite, bacterial, fungal origins. Canine parvovirus (CPV), feline pan leukopenia virus (FPLV) and feline calicivirus (FCV) were found in samples. E. coli, Salmonella, Staphylococcus spp. Shigella, Campylobacter, Proteus spp. Vibrio spp. on selective media were found in samples from cats and dogs.
- Value addition to rice straw as cattle feed through urea and molasses was found to be useful in maintaining good cattle health and milk productivity.

3.2.2 Commissioned Research Program

- Production performance and survival of sheep in the hilly environment of CHT have been improved through introduction of improved husbandry, feeding and management practices. The incorporation of suitable unconventional tree leaves and herbs in the rations of livestock and poultry may reduce feed costs and enhance productivity of animals. The crossbred chickens were found to be better in terms of egg production and egg characteristics.

3.2.3 Capacity Enhancement Program

- So far a total of 205 scientists, veterinarians and farmers have been trained in the relevant fields' like the use of molecular techniques in microbiology, veterinary surgery and radiographic imaging techniques, advanced dairy farming, poultry farming and community livestock heath services.

3.2.4 Technology Piloting Program

- Mobile veterinary services at farmers' doorsteps were found to be very helpful for livestock farmers. A group of 500 farmers was thoroughly trained on livestock rearing, hygienic management of farms, deworming and vaccination, signs and symptoms of sickness and first aids. Artificial insemination was performed at farmer's doorsteps and 362 calves (including 15 Brahma calves) were born during this study period. A toal of 192 farmers cultivated different types of fodder grass in their homesteads or on fallow lands. Livestock mortality was significantly reduced. Milk yield per cow per day increased from 2.43 L/cow/day to 4.31 L/cow/day. Total livestock growth increased by 20.1%.

3.3 Fisheries

3.3.1 Competitive Grants Program

- Net weight gain, % weight gain, specific growth rate (SGR) and survival rate (%) of tilapia were better in probiotic treated ponds than in control ponds. Probiotics increased immunity by increasing the hemoglobin, RBC and WBC levels of fish blood. Maintaining proper biosecurity measures, using probiotics and refraining from the use of chemical drugs and antibiotics comprise a model health management protocol for aquafarms.
- For better fish handling and processing to reduce post-harvest losses, a hand operated ice crusher and self-powered water agitator were developed. Good quality value added items, e.g.,

Pangas powder and Pangas pickle from Pangas fish were developed which can be produced commercially to create business as well as employment.

- Aquamimicry system could be an attractive and sustainable option for the productive shrimp culture in Bangladesh. The amounts of phytoplankton and zooplankton were found to be higher, disease infestation and mortality of shrimp lower, growth of shrimp better and profits higher in aquamimicry ponds than those in traditional culture ponds.
- Rohu (Labeo rohita), Gulsha (Mystus cavasius) and Pabda (Ompok pabda) fish feeding with formulated feed enriched in PUFA and barley showed that PUFAs improved the eggs and sperm quality of fish. Beta-glucan improved the immunological profile of fish. Hatching and survival percent fry were higher in fry fed with PUFAs and beta glucan enriched food.

Technical Progress Crops

Crop agriculture has grown fast, through impressive accomplishments, from the huge and recurrent shortfalls of the 1970s and 1980s to today's self-sufficiency or near self –sufficiency contributing greatly to the national endeavor to achieve food security for the Bangladeshi populace. Today, Bangladesh is the 3rd largest producer of vegetables, 4th largest producer of rice, the staple food crop and 8th largest producer of potato in the world. Development of HYV crop varieties and suitable production technologies played an important role in bringing about dramatic crop production boosts in the country.

KGF, since its inception in 2017,has been a proud partner in agricultural R&D in Bangladesh with through sponsoring and supporting agricultural research and technology dissemination project: in the year 2018-19 with KGF sponsorship and involvement,58 projects on-going, 69% (40) of which were related to crop in these projects, some up-coming technologies for the production of cercal, legumes, ,vegetables and fruits not only in the favorable ecological systems but also in the marginal eco: stems like the coastal saline lands, chattogram Hill Tracts, haors, char areas and low-lying perpetually water-logged basin areas have been tested. In addition, the projects yielded useful scientific information with potential to be developed into viable technologies in the near future. A burning issue of the day, i.e, the effect of climate on crop agriculture and development of climate smart production technologies has also been addressed. This section provides an interesting and exciting throughput from KGF sponsored projects.

4. Technical Progress in 2019-20

4.1 CROPS

4.1.1 CGP 2nd Call Projects

4.1.1A Completed Projects

1. Project Code and Title: TF 23-AM/15. Improvement and validation of the BARI seeder for grain crops under different cropping patterns and soil conditions

Implementing Organization: Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Dr. Md. Ayub Hossain, FMPE Division, BARI

Locations: Gazipur, Rajshahi and Patuakhali

Budget: Tk. 64.97 lakh

Duration: March 2017 to Feb 2020

Intoduction: In Barind areas, where the average annual rainfall is only about 1500 mm compared with the national average of 2300 mm, there is a scarcity of groundwater. Boro rice is the major crop in the Barind area, which is totally irrigated by ground water. The water table in the areas is receding and it is estimated that in some areas the depth to water table will be doubled by the year 2030. Good Rabi crops can be established if seeding can be done just after T. Aman harvest using the residual soil moisture. Timely tillage, seed sowing and covering can be done in a single pass using the BARI developed power tiller operated seeder in the dry Barind area as well as in the coastal region. If this seeder works well in two different ecologically adverse situations such as the Barind and coastal areas, then it can be used anywhere in the country.

Objective: To standardize a seeder machine for seeding of different grain crops and to evaluate the field performance on different soil types.

Materials and Methods: In this final year (2019-20) of the project, the improved BARI seeder (Fig. 2) was extensively field tested as a machine for reduced tillage (PTOS), strip tillage (ST) and zero tillage (ZT) in comparison with conventional tillage by power tiller (PT) in project areas of the districts of Rajshahi in the Barind region and Patuakhali in the costal region.

Results and Discussion: The effective field capacities of PTOS, ST, ZT, and PT were found to be 0.102, 0.118, 0.098 and 0.086 ha/hr, respectively (Table 2). The field efficiencies of PTOS ST, ZT, and PT were estimated as 78.38, 77.49, 75.75 and 78.41, respectively. The tilling depths from soil surface with PTOS, ST, ZT and PT were 5.86, 5.92, 3.78 and 7.48 cm, respectively. About 66% fuel was saved by PTOS compared with that by PT. The improved seeder was found suitable for planting different types of crops such as wheat, maize, lentil, mungbean and cowpea. During Rabi 2019-20, with the improved seeder, 7.20 ha (wheat 6.15 ha, maize 0.36 ha and lentil) of crops were planted at the Rajshahi project locations and 3.98 ha (1.28 ha maize, 2.31 ha mungbean, and 0.36 ha cowpea) were planted at the Patukhali project locations. The highest crop yields were obtained from reduced tillage (PTOS) except in case of wheat

Fig. 2. The BARI developed multi-purpose seeder machine

outdoing the ST, ZT or conventional method. In Rajshahi, the highest yield of wheat was achieved with ST followed by PTOS. The technical skill of 10 workshop mechanics was developed through practical training for fabricating quality seeder machines. At four project locations (upazila), 120 machine operators and farmers were trained through four practical training sessions on the operation, repair and maintenance of the improved seeder machine. Awareness raising among farmers was done through four field days at the project locations in which 160 farmers participated.

Table 2. Field performances of different seed planting machines, Kalapara, Patuakhali, Rabi 2019-20

Treat	Reqd. tilling passes	Forward speed (km/h)	Tilling width (cm)	Tilling depth (cm)	Fuel use (L/ha)	Effective field capacity (ha/hr)	Field efficiency (%)
Seeder (PTOS)	Single	1.38	120	6.15	11.77	0.109	78.43
Strip tillage	Single	1.33	120	6.12	11.57	0.108	77.54
Zero tillage	Single	1.36	120	3.98	12.14	0.103	76.81
Power tiller	Two	1.86	60	7.52	28.74	0.087	78.73

Conclusions: The field performance of the seeder machine was found satisfactory and gained farmer acceptance in both Rajshahi and Patuakhali. The farmers of Rajshahi liked ST for wheat but in Patuakhali they liked full tillage for planting of crops. The project ended with a completion workshop held on 28 May, 2020 at BARI, Gazipur attended by scientists and farm machinery manufacturers. The project gave scientific outputs which can be translated into useful technologies for mechanized crop establishment.

2. Project Code and Title: TF 26-ARI/15. Validation and upscaling of bee-keeping practices for improving yield and quality of bee products

Implementing Organizations: Sher-e-Bangla Agricultural University (SAU) and Shushilon

Principal Investigator: Dr. Mohammed Sakhawat Hossain, Professor, Department of Entomology, SAU, Dhaka

Locations: Sher-e-Bangla Agricultural University (SAU), Dhaka and farmers' fields in Gazipur, Sirajganj and Shatkhira districts

Budget: Tk. 188.057 lakh

Duration: May 2015 to Oct 2018

Introduction: Bee-keeping is an important sub-sector of agriculture. Although there are many types of bee products present in the bee hives, i.e., honey, beeswax, pollen, propolis, royal jelly, bee venom, etc., beekeepers only harvest honey and very little amount of wax from the bee hives in Bangladesh. Pollen can be used as a protein supplement for human beings as well as for bees when there is a huge shortage of bee food in the nature. Bee-keepers are not able to collect pollen due to lack of knowledge and technology of pollen trapping. Similarly, propolis or bee glue has high medicinal value and is good for human health, but propolis production is nearly zero in Bangladesh. Bee-keeping is done in the country only for honey production and almost all the honey is harvested from brood boxes. This practice is not scientific and is unhygienic, which not only deteriorates honey quality but also damages the hive structure killing the bee broods resulting in very low bee population in the hive. This project investigated scientific ways of bee-keeping not only for honey and other bee products.

Objective: To improve the quality and yield of bee products and enhance the capacity of bee-keepers

Materials and Methods: The SAU apiary was developed with different types of bee boxes and bee stocks. Honey, pollen and propolis were collected from improved bee boxes and bee stocks at three sites of Sirajganj, Gazipur and Shatkhira (Sundarban area) districts and yields were compared with those achieved with traditional methods. Appropriate carbohydrate based food sugar syrup ratio was fixed for maintaining bee hive in the dearth period. Natural pollen feeding effect was also observed in the dearth period. Observations were made on pests and diseases of bees. Bee stocks were maintained at the SAU apiary for queen breeding and drone breeding purposes. Fifty-six random queens were brought to the laboratory from the three project sites to understand the causes of queen reproductive inferiority. The queens were weighed and dissected. Additionally, three groups of queens were reared in an ad hoc apiary: naturally mated queen, grafted naturally mated queen and grafted artificially inseminated queen. Queens were grafted in artificial queen cups, a group of queens was inseminated artificially and other two groups were allowed to mate naturally. Different morphological and anatomical measures and brood occupation areas of the queens were measured and analyzed statistically.

Results and Discussion: Sher-e-Bangla Agricultural University (SAU) has an improved apiary with different types of bee boxes and bee stocks. Research and development program has completed in SAU-KGF apiary, farmers field (beekeepers' apiary) and SAU-KGF honeybee laboratory. Honey, pollen and propolis yield were increased in comparison with traditional methods at three sites of Sirajganj, Gazipur and Shatkhira (Sundarban area) districts. Detailed results were reported in KGF Annual Report 2018-19. Bee stocks were maintained at SAU apiary for queen breeding and drone breeding. The first artificially inseminated queen in the country was developed at the honeybee research laboratory of SAU.

Conclusions: Honey production can be increased by 30% (4000 mt to 5200 mt) in the country if technologies generated by this project are adopted and utilized properly. In addition, 25 metric tons of pollen and 10 metric ton of propolis can be harvested, which were not harvested in the past. If one breeding station is developed, a minimum of 5000 fertile queen bees can be obtained in a year. Hygienic bee-keeping can be initiated which can boost the export value of honey produced in the country.

The project ended successfully. Reviewers and experts have recommended dissemination of this CGP-generated apiary technology through a technology piloting project (TPP).

3. Project Code and Title: TF 29-AM/15. Design and development of a two-stage drying technique for drying of high moisture grains

Implementing Organization: Haji Danesh University of Science and Technology (HDUST), Dinajpur

Principal Investigator: Prof. Md. Sazzat Hossain Sarker, Dept. of Food Engineering and Technology (HDUST)

Location: HDUST

Budget: Tk. 125.51 lakh

Duration: Mar 2017 to Feb 2020

Introduction: At the commercial level, only the LSU (Louisiana State University) type dryer is used for drying of parboiled rice in Bangladesh. However, un-parboiled rice is also dried using this dryer. In case of maize drying, the sun drying method is very common although this entails the possibility of grain quality deterioration, microbial infestation and wastage. During continuous and heavy rains, huge amounts of maize are wasted at the farm level due to lack of proper drying techniques. To date, the use of two-stage drying using high temperature fluidized bed dryer followed by any low temperature dryer has not been observed in commercial grain drying in Bangladesh although two-stage paddy drying is being practiced at the industrial level in many humid tropical countries like Thailand, Philippines, Indonesia, Taiwan and Malaysia. This project aims to develop suitable two-stage drying techniques that can minimize post-harvest losses of grain and yield high quality dried product at a reasonable cost.

Objective: To develop an efficient two-stage drying technique for drying of high moisture paddy and maize grains and to evaluate the performance efficiency of the two-stage drying technique

Materials and Methods: Laboratory scale fluidized bed, mixed flow (LSU type) and fixed bed dryers have been designed and fabricated successfully for grain drying experiments and other research, which are available in the Laboratory of the Department of Food Engineering and Technology, HDSTU, Dinajpur. Prototype-cum-commercial two-stage dryers have been successfully fabricated and installed at the mill site. Lab scale, prototype and commercial fluidized bed, mixed flow (LSU type) and fixed bed dryers have been developed successfully which are completely ready for use in grain drying experiments and other research. Drying operation was initiated.

Results and Discussion: High moisture paddy and maize can be dried quickly, in only 5-6 hrs, using the two-stage drying techniques in contrast to conventional drying practices that require 10-20 hrs or longer. One commercial scale two-stage dryer unit with a daily throughput capacity of 14 t in two batches has been installed at the mill site. Commercial paddy and maize drying operations have been demonstrated successfully in the last Aman (December 2019 to January 2020) and Boro seasons. The drying cost in the two-stage dryer facility ranged from only Tk. 0.50 to Tk. 0.70 per kg which was lesser than that for the conventional farmers' sun-drying practices. Few rice millers and maize processors were motivated to install the two-stage dryer facility at their mill sites. Two conference papers and two journal papers have been published.

Conclusions: The two- stage drying techniques employing fluidized bed drying, tempering followed by either mixed flow drying (LSU dryer type) or fixed bed drying or sun drying have been developed for drying of high moisture paddy and maize for the first time in Bangladesh. Moist grain with 23-27% moisture content can be dried to13-14 % quickly by only 4-6 hrs using the developed drying techniques in contrast to existing drying practices where drying time is usually 10 to 20 hrs. The quality attributes of the grains dried with the two-stage dryer were found to be better mostly than those of the grains dried by the existing drying methods.

4. Project Code and Title: TF 31-VC/15. Market and value chain studies of selected fruits and vegetables with special reference to post-harvest losses and food safety in Bangladesh

Implementing Organizations: Bangladesh Agriculture Research Institute (BARI), Gazipur and Center for Development and Competitive Strategies Ltd. (CDCS), New DOHS Mohakhali, Dhaka 1206

Principal Investigator: Dr. M. Abdul Matin, CSO, Agricultural Economics Division, BARI, Joydebpur, Gazipur

Locations: Entomology Division, BARI, Gazipur and Jashore, Jhenidah, Rajshahi and Bogura

Budget: Tk. 245.00 lakh

Duration: Mar 2017 to Feb 2020

Intoduction: Huge amounts of fruits and vegetables are damaged and contaminated every year due to their perishability, seasonality, bulkiness, and also due to poor infrastructure and inadequate postharvest handling and processing. The use of hazardous chemicals and preservatives in fruits and vegetables seriously affects their quality and safety. This situation needs to be improved through better post-harvest technologies, value chain management, awareness building and innovative business incubation schemes that promote market-responsive agro-MSMEs. This project was designed to develop awareness among fruit producers and traders and introduce some efficient value chain management practices with improved postharvest technologies for fruits and vegetables, develop an inclusive business model and a piloting scheme in order to provide incubation support to some selected agro-MSMEs.

Objective: Introduction of some efficient value chains for fruits and vegetables marketing to reduce postharvest losses and make foods safe for the consumers.

Materials and Methods: In this study, bio-rational pest management approaches (sex pheromone trap) were tried for the control of insect pests of mango and bitter gourd. A limited number of selected pesticides were also applied following Good Agricultural Practices (GAP), where the pre-harvest intervals (PHI) of the selected pesticides for mango and bitter gourd were followed. Samples of mango and bitter gourd were collected from the project farmers' fields of Jhenaidah and Jashore districts during the months of December and January and quantification of pesticide residues was done in the Pesticide Analytical Laboratory of the Entomology Division of BARI, Gazipur. The collected samples were extracted and cleaned using the QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) method and quantification of residues of the pesticide Cypermethrin used for mango and the pesticide Diazinon used for bitter gourd was done using gas chromatography coupled with ECD and FTD detectors. A business model for safe food was developed.

Results and Discussion: The project had two major components, safe food and agribusiness.

Safe food

In this study, bio-rational pest management approaches, sex pheromone trap, fruit bagging (Fig. 3) were tried for the control of insect pests of fruits and vegetables. A limited number of selected pesticides were also applied following good agricultural practices (GAP). Among the 30 samples of mango and bitter gourd tested, none was found contaminated with any pesticide residue. On the other hand, in several studies conducted in the Pesticide Analytical Laboratory, Entomology Division of BARI, Gazipur about 30% samples of fruits and vegetables samples collected from the market, were found to be contaminated with pesticide residues.

Fig. 3. Bagging for safe fruit

Business model

In respect of development of an inclusive (safe food) business model and a piloting scheme to provide incubation support to some selected agro-MSMEs, the main approach is to intervene taking three major areas in consideration: (1) Knowledge and technology transfer, (2) Access to safe inputs and machinery, and (3) Market knowledge and market access. Intervention was aimed at building capacity of the farmers as well as value chain actors on safe food production, harvesting and post-harvest management, and connecting those to safe input and technology suppliers and along the chain create and incubate entrepreneurs at different levels. Such trained actors at different levels are expected to shorten the chain as much as possible between farmer-agro entrepreneur and consumer and thereby ensure greater value for all actors both in terms of quality and benefit.

Conclusions: This project was completed successfully with a project completion report out.
The project achievements included 1) creation of the first ever farmers' safe brand, 2) first ever private investment in safe postharvest management by farmers, 3) establishment of innovative market channels, 4) successful operation of a self-sustaining agribusiness model that proved to have Covid-19 resilience. The benefits and outcomes of the project were: 1) post-harvest losses came down from 12% to 7%, 2) change in farming and postharvest management practices--pesticide use was reduced to 2-3 times from 6-8 times per season, 3) greater financial benefits to farmers and agro entrepreneurs, 5) increase in profitability (5-23%) based on agro produce, 6) enhanced integration of different levels of stakeholders, 7) establishment of quality control and monitoring framework, 8) consumer access to safe fruits and vegetables.

5. Project Code and Title: TF 33-ARI/15. Farm productivity improvement in *haor* areas through an integrated farming systems approach

Implementing Organization: Sylhet Agricultural University, Sylhet

Principal Investigator: Dr. Md. Abul Kashem, Professor, Dept. of Soil Science, Faculty of Agriculture, Sylhet Agricultural University

Locations: *Haor* areas of the Sunamganj district

Budget: Tk. 185.24 lakh

Duration: August 2015-December 2019

Introduction: The *haor* areas in northeastern Bangladesh are still under-developed due to their physiographic and hydrological settings inspite of potential high productivity. The *haor*s are flooded to variable depths from late May to October every year, and only one crop in a year can be grown in the Rabi season. Usually Boro rice, potato, groundnut, sweet potato, mustard, pulses, etc. are grown, but the crops are often affected by natural calamities like flash floods, hailstorms and insect pests. With a fishing area of 114793 ha, *haor*s are also important suppliers of fresh water fish, but the poor have very limited access to land and fishing ground. Homestead land erosion, siltation and flash floods frequently occur and severely limit yields or even destroy most of the crops. The *haor* areas, thus, are highly food insecure for the poor and extreme poor people. This project addressed the issue of increasing farm productivity through the interventions with technologies pertaining to crops, live-stock, fisheries in an integrated farming systems (IFS) approach.

Objective: To develop farming systems technologies for diversifying and intensifying farming and enhancing farm productivity incomes in *haor* areas.

Materials and Methods: At the initiation of the site RRA, PRA, baseline survey, etc. were conducted to characterize site, identify researchable problems and prioritize research agenda. Twenty-five farms were selected for integrated farm development and whole farm analysis was done. In all, 117 experiments were conducted as component studies. Technology disemination and adoption activities were carried out among *haor* farm households to improve the productivity of rice, homestead vegetables and fruits, fish, poultry, duck, cattle, sheep, and homestead agroforestry species. Some new crops, including 10 creeper and winter homestead vegetables for growing in and around homesteads were introduced.

Results and Discussion: The project was successfully completed in 2019-20. Twenty-three technologies for crop, livestock and fish production were developed following farmer participator intervention tests (Table 3) during the four years of the project. Adoption of the new farming systems technologies by *haor* farm households improved the productivity of rice, homestead vegetables and fruits, fish, poultry, duck, cattle, sheep, and agroforestry systems. Diversification and intensification of farming and non-farming activities generated employment and income. Efficient mobilization and management of natural resources were achieved through capacity building of the participants by training, motivation, consultation and making inputs available for sustainable production systems. The salient features of component results as well as integrated farms are given below.

Table 3. Interventions tested for agricultural production boosts in *haor* areas of Sunamganj

Enterprise	Traditional practices	Interventions
Rice	BRRI dhan28, BRRI dhan29, Birun	BRRI dhan28, BRRI dhan29, BRRI dhan50, BRRI dhan58, BRRI dhan63, Tapi boro, Rata boro, Begum bichi, Atobshail
Field crops	-	BARI sorisha-14, BARI sorisha-15
Vegetables	Local bottle gourd, radish, Indian spinach, water spinach, sponge gourd, local country bean, jute, red amaranth, stem amaranth.	Lady's finger, ash gourd, ridge gourd, snake gourd, bitter gourd, cucumber, chilli, cabbage, cauliflower, bottle gourd (hybrid), pumpkin, red amaranth, stem amaranth, tomato, eggplant, spinach, squash, coriander, cucumber, yard long bean
Agroforestry	*Hijal* and *Koroch*	Mango, guava, litchi, coconut, *ber*, papaya, mahogany, rain tree
Livestock	Local poultry, duck, pigeon, sheep, cow	New poultry breed (Fayoumi, Sonali), Duck breed (Jhindin, Khaki Campbell), pigeon, highly prolific breed of sheep (Garole), vaccine for *ranikhet* disease, fowl pox, duck plague disease of poultry and duck, deworming, FMD for cattle
Fish	Fish catching	Fish culture (seasonal and perennial ponds), cage culture, sanctuary

Crops and agroforestry

Haor areas remain under inundation from 6-8 months of the year. No other tree could survive here except *Hijal* and *Koroch*. Participating farmers were given some fruit and timber saplings for planting in the during dry season so that they could survive the following monsoonal flooding. This increased the total number of trees in the project area from 7 to 40.

Fig. 4. Integrated farming system in the *haor* environment

Boro rice had been the only field crop in the *haor* areas in the past. New rice varieties viz. BRRI dhan50, BRRI dhan58, BRRI dhan63, BRRI dhan50, Tepi Boro and Atabsail were adopted. During implementation of this project, monocropped *kanda* lands were converted into double cropped lands through the introduction of mustard, potato, coriander, okra, cauliflower, cabbage, etc. to increase cropping intensity, land productivity and raise farmer's incomes. Vegetable production was rare among *haor* people. Earlier, on an average they used to earn only Tk. 214 per farm with traditional production practices. Introduction of early winter vegetables (cabbage, cauliflower and tomato) enabled the poor farmers to produce for domestic consumption as well as increase family incomes through sale of vegetables. Every farm family of the project area was encouraged with seeds and training to grow assorted seasonal

vegetables like cabbage, cauliflower, tomato, eggplant, chili, bottle gourd, country bean, pumpkin, squash, red amaranth, spinach, bitter gourd, ash gourd, ridge gourd, sponge gourd, snake gourd, Indian spinach, etc. for year round cultivation in the homestead. The farmers were very responsive to vegetable cultivation and earned Tk. 45591 per farm with a minimal investment of Tk.2644 per farm.

Fish

The main occupation of *haor* people is fish catching during monsoon. Pond fish culture experiments were conducted in both homestead ponds and perennial ponds for three years. In homestead ponds the experiments were conducted by stocking *Catla catla, C. mrigala, P. gonionotus and C. carpio* (mirror carp) in different species combinations under fertilized and feeding conditions. The farmers were given monosex tilapia, *sharputi* and carp fry to start fish culture in seasonal ponds. They harvested their fish from ponds during off season of the *haor* fish and used for family consumption. An experiment was conducted with monosex and GIFT tilapia in cage conditions. A higher income (gross return Tk. 6947 and gross margin Tk. 1847) was generated from GIFT than monosex tilapia (gross return Tk. 6499 and gross margin Tk. 1300). Among the participants one farmer started to culture monosex tilapia in cage. As the study area remained under flood water for more than 8 months last year, fishermen continued fish catching almost throughout the year.

Livestock

Project interventions increased the number of poultry per farm from 4 to 14, that of duck from 3 to 80 and that of cow from 2 to 3. Regular vaccination and deworming reduced the mortality and improved livestock health, greatly reduced mortality mortality of poultry, and the the intervention proved to be a great success. Before project interventions, the average income per farm was about Tk. 10368.88 from eggs, chicken and duck. Incomes increased substantially with gross margin of Tk. 109374 per farm, owing to support in the forms of regular vaccination, feeding, regular monitoring, etc.

Economic benefits

Farm and non-farm income diversification patterns showed that diversified households are in better position than non-diversified households. The food and nutritional security of small-scale fishermen of *haor* were miserable, and food and nutritional security is poor. This study suggested some policy guidelines to the concerned fishing community to take necessary actions for the improvement of the fishermen living in the *haor*. Technological interventions positively impacted incomes for *haor* farmers. The benefit-cost ratio of duck farming was 1.97 indicating high profitability. The average annual total income of a project farmer was Tk 51530 compared with that of a non-project farmer which was Tk. 39936. The interventions also improved livelihood farmers of the *haor* area within two years.

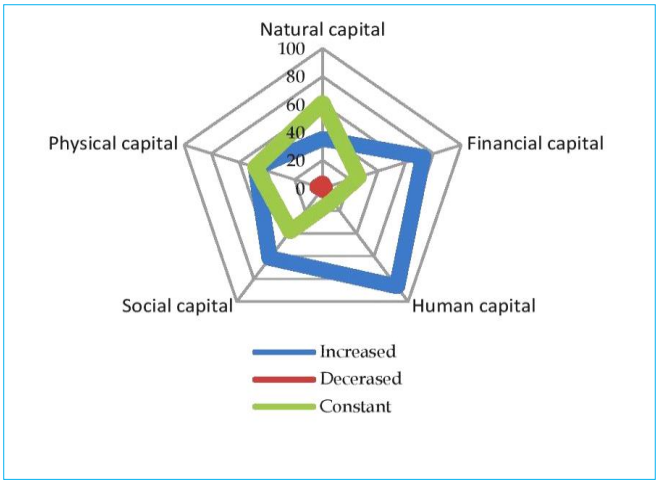


Fig. 5. Livelihood status of farmers in a village at one the integrated farming systems project the site in the

Conclusions: In the *haor* areas of northeastern Bangladesh, there is an opportunity of substantially enhancing farm productivity and farmers' incomes and livelihoods through interventions with technologies pertaining to crops, livestock and fisheries in an integrated farming systems (IFS) approach. In *haor* villages addressed by this farming systems project, technological interventions increased farm household incomes by 58.87%. The incomes of households practicing integrated farming increased from the baseline mark of Tk. 50,854 per farm to Tk. 2,69,577 per farm after

interventions. Initially, the gross return was about Tk. 1,45,048 and gross margin Tk. 50,854 against an investment of Tk. 72,317 per farm. After intervention with integrated farming systems technologies, farmers had made a gross margin Tk. 2,65,026 where the gross return was Tk. 3,26,446 per farm. Overall, the interventions increased crop diversification, homestead production, labour productivity, employment generation, women empowerment and efficiency of resources management. The project scientists recommended dissemination of the technologies generated by this project through DAE, DLS, DoF and NGOs to increase farm productivity in the *haor* areas of Bangladesh, and emphasized the need for agricultural mechanization in the *haor* areas for rice cultivation.

4.1.2 CGP 3rd Call Projects

4.1.2A *Completed Projects*

6. Project Code and Title: TF 42-AE/17. Development and adoption of a low-cost small potato planter and harvester for profitable potato production

Implementing Organization: Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Dr.Md. Arshadul Haque, Farm Machinery and Postharvest Division, BARI, Gazipur

Locations: Gazipur, Munshigonj, Debiganj

Budget: Tk. 44.72 lakh

Duration: Nov 2017 to Oct 2020

Introduction: Potato plays an important role in the economy and food security of Bangladesh but the planting and harvesting operations, being carried out manually, are slow, time consuming, costly, and labor intensive which cuts down the farmers' profit margins. Moreover, severe labor shortages during the peak planting and harvesting seasons further complicate the situation for the potato farmers. Power tiller driven, cost effective small potato planter and harvester machines can be an effective tools to mitigate labor shortages and reduce production costs. BARI has developed small, farmer-friendly potato planter and harvester machines but their adoption is slow due to lack of commercial availability of the machines and farmer awareness. This project aimed to facilitate large scale farmer adoption of potato machinery through field demonstrations, capacity building of farmers and others involved in potato farming and increasing the number of machinery service providers.

Objective: To develop and popularize efficient small potato planter and harvester machines for minimizing the cost of potato production in potato growing areas.

Materials and Methods: The BARI potato planter (Fig. 5) and harvester machines were redesigned to eliminate operational problems observed in earlier field trials. During 2019-20, the modified potato planter and harvester were evaluated in 16 farmers' fields of Bogura (Gabtali and Shibganj upazilas) and Jashore (Sadar and Jhikargacha upazilas) to popularize mechanized potato planting and harvesting among farmers. The tools were also also evaluated at the BARI Regional Agricultural Research Station (RARS), Jashore, Tubercrop Research Sub-Station, Bogura, Breeders' Seed Production Centre (SPC), Debiganj, Panchagarh

Fig. 5. The BARI potato planter machine

and in farmers' fields of Rajshahi. Machine planted fields were compared with manual planting.

Results and Discussion: Effective field capacity of the potato planter and harvester were 0.11 and 0.10 ha/hr, respectively. Efficiencies of the potato planter and harvester were 76 and 74%, respectively. The yield of potato planted with the planter was higher but statistically similar as that in manually planted fields irrespective of location or variety. However, the planter reduced the labour requirement by 90% and the planting cost by 75% compared with manual planting. Likewise, the harvester machine saved 57% cost and 60% labour compared with manual harvesting. During Rabi 2019-20, 0.77, 0.88 and 4.65 ha of potato were planted at the project locations of Bogura, Jashore and Panchagarh, respectively, with the planter machine. Experiments on mechanical planting and harvesting were conducted in 0.13 ha of fields at Rajshahi. Beside the experimental areas, self-motivated farmers at Jhikargacha, Jashore used the potato planter in 2.43 ha of land and the harvester in 4.84 ha. The BARI potato planter and harvester were found effective at all project locations. In Bogura and Jashore, 60 machine operators and farmers were trained on the operation, repair and maintenance of the BARI potato planter and harvester machines through two practical training sessions. Farmers' field days, TV telecasts and newspaper reporting were done to create country-wide awareness about farm mechanization.

Conclusions: The power tiller operated potato planter-harvester machine, with the ability of tilling the land, placing potato seeds at regular intervals and earthing up on a single run, developed by BARI proved to be handy for potato farmers in field trials and demonstrations in various areas of northern and western Bangladesh. The potato planter can substantially reduce the labor requirement and planting costs compared with manual planting. Likewise, the harvester machine can save labor and costs by more than 50%. Use of the machine instead of manual planting and harvesting of potato has the potential to markedly increase potato farmers' profits.

CGP Basic Research Projects

7. Project Code and Title: BR 1-C/17: Study of the physiological mechanisms related to water and heat stress tolerance in wheat genotypes

Implementing Organization: Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Dr. Imrul Mosaddek Ahmed, SSO, Plant Physiology Division, BARI, Joydebpur, Gazipur

Locations: Plant Physiology Division, BARI, Gazipur and Breeders' Seed Production Center (BSPC), Debiganj

Budget: Tk. 97.921 lakh

Duration: Mar 2017 to Feb 2020

Introduction: Impacts of abiotic stresses on crop plants have been mostly studied by applying a single stress factor such as drought or high temperature in controlled experiments. However, field crops often encounter multiple stresses such as drought and elevated temperature simultaneously during a certain stage of development. In fact, the combination of drought and high temperature is a major stress factor that restricts wheat growth and production in many regions of the world including Bangladesh. Earlier studies showed that drought and high air temperature significantly decreased crop growth and yield. In this study, the plant water status and yield responses of BARI wheat varieties/lines to heat, drought and both at anthesis were investigated.

Objective: To study the physiological, biochemical and molecular changes in wheat under combined water and heat stresses in drought and heat tolerant wheat genotypes.

Materials and Methods: During the reporting period (2019-20), two screening experiments for tolerance to drought and heat stresses were conducted with wheat genotypes selected from last year's experiments for each stress type.

Results and Discussion: Wheat plants put under drought stress showed a significant decrease in plant height, shoot dry weights; the genotype BWSN 31 was less affected whereas BWSN 33, BARI Gom 26 and BARI Gom 33 were more affected under drought.

A substantial degradation of chlorophyll content was inferred from the SPAD readings for the 4 genotypes under drought. Among the 4 genotypes, BWSN 31 was the least affected by drought stress followed by BARI Gom 26, BARI Gom 33 and BWSN 33. In this work, SPAD value was decreased might be inhibition of photosynthesis which was caused by stomatal factors, and possibly also by the inhibition of chlorophyll synthesis.

The activities of enzymes involved in reactive oxygen species (ROS) scavenging changed significantly due to stress. Plants under drought showed significant increases in peroxidase (POD) and catalase (CAT) activities relative to control. Among genotypes, the highest increase in POD activity was recorded in BWSN 33, and the highest increase in CAT activity was observed in BARI Gom 25. Similar increased expression patterns of ascorbate peroxidase (APX) activity were observed in all genotypes except BWSN 33 under drought. However, the expression patterns of APX activity were different between BWSN 31 and the other genotypes. The responses of the two varieties BARI Gom 26 and BARI Gom 33 started with significant increase in APX activity under drought stress. Based on present findings, it could be concluded that water stress alters the equilibrium between free radical production and enzymatic defence reactions in wheat and the response depends on the severity of water deficit.

Hyper-accumulation of ROS in plant cells is one of the main effects of drought stress. The present study demonstrated that drought stress induced oxidative stress expressed as an increase in lipid peroxidase activity experessed as the content of melanodialdehyde (MDA) and cell membrane stability index (CMSI) in wheat leaves over control (Fig. 6). Drought induced a dramatic increase in MDA production in the leaves of wheat. When compared with control, MDA content increased in all genotypes under drought. Importantly, the MDA content in drought treated plants of BWSN 31increased less over the control, which reflected a higher level of tolerance of this genotype to drought. CMSI changed slightly, when plants were exposed to drought. CMSI is also considered an indicator of stress tolerance in plants, including resistance to drought. CMSI is often affected by lipid peroxidation caused by ROS under stress conditions.

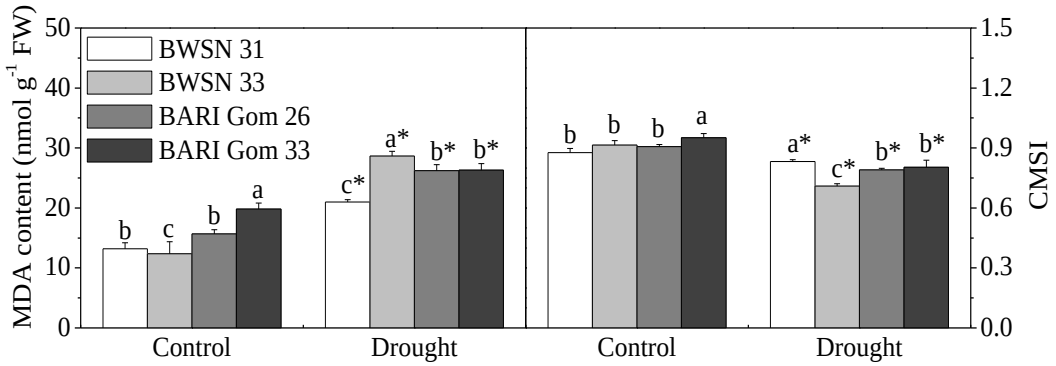


Fig. 6. Effect of drought stress on MDA content and CMSI of four wheat genotypes

A greater increase in the soluble sugar content was observed in BWSN 31 compared with BWSN 33 under drought. In general, drought stress results in lower carbon assimilation, the concentration of soluble sugars in leaves increase (under moderate stress) or are constant (under intense stress), because growth and export are also inhibited. Soluble protein contents also increased in leaves of BWSN 31 under drought, while in BARI Gom 26 and BARI Gom 33, a slight increase in soluble protein content was observed. Relative to the other genotypes, the protein level in BWSN 31 increased the fastest under drought. However, it decreased in BWSN 33.

The phenotypic changes in spikes of BWSN 31, BWSN 33, BARI Gom 26 and BARI Gom 33 during drought are shown in Table 5. Spike growth significantly differed among the genotypes under drought. Compared with BWSN 31, spike length significantly ($P<0.05$) decreased in BWSN 33, BARI Gom 26 and BARI Gom 33 under drought stress conditions. The grains per spike were significantly reduced in BWSN 33, BARI Gom 26 and BARI Gom 26; this component was affected in BWSN 31 under drought treatment compared to control. The drought stress treatments significantly reduced percentage of grain-setting in BWSN 33, BARI Gom 26 and BARI Gom 26, while BWSN 31 remained almost unaffected (Table 5).

Wheat plants that were subjected to drought exhibited significant decreases in grain yield and 1000-grain weight, BWSN 31 showing the smallest affected. BARI Gom 26 gave the highest grain yield and 1000-grain weight under control conditions, but it showed the most substantial changes under stress. The 1000-grain yield and the filled grains per spike measurements were correlated, which may explain the yield loss in cultivated wheat compared to BWSN 31 under drought. The decline in yield was possibly associated with the reduction in spikelet fertility and grain filling (Table 4).

Table 4. Effects of of drought stress on yield and yield components of four wheat genotypes

Treatment	Spike length (cm)	Filled grains/ spike	Unfilled grains/ spike	Filled grains/ spike (%)	1000 grain weight (g)	Grain yield/plant (g)
	BWSN 31					
Control	9.43 a	50.00 a	5.00 a	90.91a	42.95 a	32.08 a
Drought	8.16 b	42.66 b	10.50 b	80.25b	36.97 c	22.76 b
	BWSN 33					
Control	8.5 a	41.67 a	7.00 a	85.62a	38.84 a	24.94 a
Drought	5.27 b	22.67 b	14.00 b	61.82b	25.28 c	10.81 b
	ARI Gom 26					
Control	9.5 a	42.33 a	5.00 a	89.44a	50.59 a	28.02 a
Drought	5.57 b	28.00 b	12.00 b	70.00b	32.26 b	15.15 b
	ARI Gom33					
Control	8.5a	50.33 a	8.00a	86.28a	45.3a	30.22a
Drought	6.6b	32.00 b	14.00b	69.57b	30.2b	16.12b
$LSD_{0.05}$	1.2	3.9	2.2	4.6	3.4	3.1
CV (%)	5.6	11.0	8.5	12.0	9.6	4.9

Conclusions: The project experiements on the tolerance of wheat to abiotic stresses like drought and high temperature yielded interesting scientific information on physiological, biochemical and molecular changes in wheat under combined water and heat stresses ultimately reflected in wheat yield response to combined abiotic stresses. Repeated screening trials indicated variable responses of wheat genotypes, and BWSN 31 was identified as a genotype tolerant to a broad spectrum of abiotic stresses including drought, the tolerance being associated with an increase in the activities of CAT, POD and APX. Further experiments using molecular and genetic approaches are required to more precisely define the molecular and cellular mechanisms underlying the acclimatization of BWSN 31 to drought stress.

8. Project Code and Title: BR 2- C/17: Linkage and QTL mapping of tungro resistance in rice

Implementing Organization: Bangladesh Rice Research Institute **(**BRRI), Gazipur

Principal Investigator: Dr. MA Latif, CSO and Head, Plant Pathology Division, BRRI, Gazipur-1701

Location: Plant Pathology Division, BRRI, Gazipur

Budget: Tk. 69.00 lakh

Duration: Mar 2017 to Feb 2020

Introduction: Identification of QTL in the local rice cultivar Kumragoir, responsible for tungro resistance, will be a milestone in developing Tungro resistant rice through marker assisted selection (MAS). For this purpose, a parental survey was conducted by using molecular markers to detect polymorphism between the parents, BRRI dhan48 and Kumragoir.

Objective: To identify QTLs with linked markers for Tungro resistance in the rice landrace, Kumragoir

Materials and Methods: To find the polymorphism of primers between Kumragoir and BRRI dhan48, polymorphic survey of primer was conducted across 12 chromosomes of rice using SSR marker in the previous years of the project. Out of 400 primers, 98 showed polymorphism between the two parents. A cross between two parents was made to find out F_1 generation. Then advanced populations were developed and backcrossing was done between heterozygous progeny and BRRI dhan48 to produce BC_2F_1 seeds. BC_2F_1 were grown in the field and confirmed through molecular marker. Selfing was done for the production of BC_2F_2 seeds and BC_2F_2 seeds were harvested. In addition, Tungro sources were collected from different parts of Cumilla, Jhenaidah, Gazipur, Rangpur, Rajshahi, Habiganj and the virus source is being maintainedthrough the insect acquisition method. In the year under report, QTL studies were done.

Results and Discussion: Twelve QTLs (LOD value >3) i.*e. qRTVR3, qRTVR3.1, qRTVR4.2, qRTVR9, qRTVR9.3, qRTVR10, qRTVR10, qRTVR10.4, qRTVR10, qRTVR11, qRTVR11.5, qRTVR11* were identified by the Qgene software. Among these, five significant ($p < 0.05$; 0.01) QTLs, i.e., *qRTVR3.1, qRTVR4.2, qRTVR9.3, qRTVR10.4* and *qRTVR11.5*, were found in chromosomes 3, 4, 9, 10 and 11, respectively. Out of these, four major QTLs (*qRTVR3.1, qRTVR4.2, qRTVR10.4* and *qRTVR11.5)* explained 12.2, 10.8, 12.2 and 10.8 % phenotypic variations and one minor QTL *qRTVR9.3* explained 3.8% phenotypic variation.

Conclusions: The markers RM5548, RM6487, RM242, RM5806, RM536 were found linked with the QTLs *qRTVR3.1, qRTVR4.2, qRTVR9.3, qRTVR10.4* and *qRTVR11.5*, respectively. These linked markers may be used in marker assisted selection for the development of Tungro resistant rice varieties.

9. Project Code and Title: BR 3-C/17. Exploring new sources of blast resistance and pyramiding blast resistant genes into Boro rice

Implementing Organization: Bangladesh Rice Research Institute **(**BRRI), Gazipur

Principal Investigator: Dr. Tahmid Hossain Ansari, Principal Scientific Oficer, Plant Pathology Division, BRRI, Gazipur 1701

Locations: BRRI, Gazipur, Cumilla, Rangpur, Khulna

Budget: Tk. 99.1 lakh

Duration: Mar 2017 to Feb 2020

Introduction: Among the biotic stresses, the blast disease has emerged as a major threat to rice in Bangladesh. Rice yield losses amounting to 11-46% occur at low to medium pressures of the blast disease. An outbreak of this disease in BRRI dhan28 and BRRI dhan29 during Boro 2014-15 caused as high as 90% neck infection in some rice fields of the Rangpur region resulting in almost 100% yield loss. The disease historically prevails as a chronic problem in the southern coastal region and the northern region of Bangladesh in both wet and dry seasons. On-farm management practices of the disease rely solely on chemical control which is costly and at the same time harmful to the environment contaminating the food chain. A crop and environment friendly safe option would be to develop and grow blast resistant rice varieties. This project studies the possibilities of developing blast resistant rice

varieties through identification of new sources of major resistant gene against the blast disease and introgression of known resistant genes into existing cultivars.

Objective: To find new sources of major resistant gene(s) against blast disease in the native rice land races.

Materials and Methods: In the previous years, (2017-18 and 2018-19), screening of rice genotypes, crossing, genotyping of the phenotypic ally resistant *jhum* rice germplasm through marker assisted selection (MAS) were done intitially. Phenotypic reactions of 38 rice genotypes to blast were evaluated at rice blast hot spots in Rangpur, Satkhira and Gazipur during T. Aman, 2018. These were again tested during Boro 2018-19 in Gazipur, Rangpur and Dinajpur. Molecular identification of the *Pi9* gene in these germplasm were surveyed using five primers NMSMPi9-1, 9-Pro, RM8225, Pb8 and Pb14. The project with further work involving (1) introgression of Pi9 and Pita2 gene(s**)** in the background of BRRI dhan28, BRRI dhan29 and BRRI dhan63 and selection of advanced generations, (2) pyramiding blast resistant genes and confirmation of crosses through MAS, (3) regional yield trials (RYT) advanced lines in different blast prone environments in Cumilla, Rangpur, Khulna and Gazipur.

Results and Discussion: Eight rice genotypes were selected as resistant to blast in the Uniform Blast Nursery (UBN). Two HYV type germplasm were selected as blast resistant at hot spots, one of them showing the ability to yield 6.0 t/ha within 140 days. Two blast resistant homozygous fixed lines having the Pi9 gene in the background of BRRI dhan28 have been selected which can give an equal yield with similar growth duration of the recurrent parent. Back cross generations with both Pi9 and Pita2 genes have been developed in the back ground of BRRI dhan28 (BC2F1), BRRI dhan29 (BC1F1) and BRRI dhan63 (BC1F1). One advanced line was selected for evaluation in the BRRI Advance Line Adaptive Research Trial (ALART) program for promoting as a blast resistant variety.

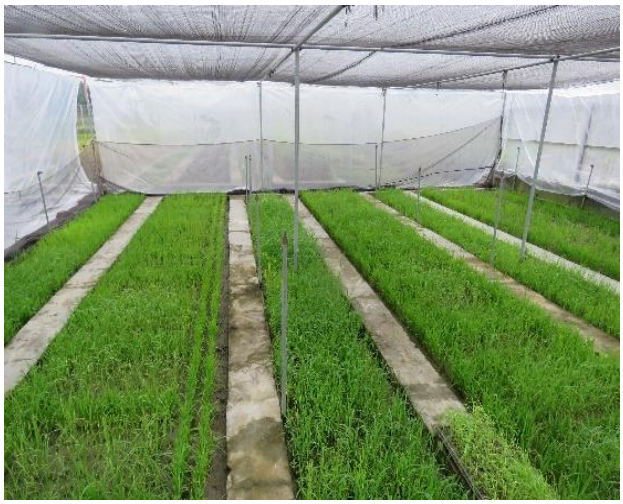


Fig. 7. Net house for screening rice varieties for blast tolerance

Coclusions: The project ended generating useful scientific information and advanced breeding materials that may help rice breeders and patghologists develop blast resistant rice MVs. Meanwhile, one advanced breeding line has already been selected as a promising line for further evaluation by BRRI as a potential blast resistant rice variety.

10. Project Code and Title: BR 4-C/17. Physiological mechanisms of waterlogging tolerance in sesame

Implementing Organization: Bangladesh Agricultural Reserach Institute (BARI), Gazipur

Principal Investigator: Dr. A F M Shamim Ahsan, Senior Scientific Officer, Plant Physiology Division, BARI, Gazipur

Location: Plant Physiology Division, BARI, Gazipur

Total budget: Tk. 66.7619 lakh

Duration: April 2017 to March 2020

Introduction: Waterlogging severely affects sesame cultivation in Bangladesh and is a major factor limiting the sesame area coverage and restricting the yield to a meager 0.5-0.6 t/ha. For example, the area under sesame cultivation was about 91,000 ha in 1989 which drastically declined to 33,000 ha in 2012. This major abiotic stress leads to a series of morphological, physiological, biochemical and

anatomical changes that adversely affect the growth and development as well as yield of sesame. Generally, plant adaptations to waterlogging or oxygen deprivation in the soil include avoidance strategies at the morpho-anatomical and metabolic levels. However, the waterlogging tolerance mechanism in sesame is not fully understood. This project studies reactions of sesame to waterlogging with a view to understanding the mechanisms responsible for waterlogging tolerance in some genotypes.

Objective: To explore the dynamics and mechanism of anaerobic proteins and antioxidant enzymes together with the morpho-anatomic adaptations in waterlogged sesame and to identify waterlogging tolerant sesame genotypes.

Materials and Methods: During the reporting period, two experiments were conducted in the pot house of the Plant Physiology Division, BARI, Gazipur. In the first experiment, five waterlogging tolerant and two sensitive sesame genotypes were used (selected from the 110 sesame genotypes through field and pot experiments earlier) in pot culture and the best waterlogging tolerant sesame genotypes based on physiological parameters (photosynthetic pigments, net photosynthetic rate, stomatal conductance, transpiration rate and intracellular CO_2 concentration, etc.) were selected under different durations of waterlogging (24, 48 and 60 hours) at the flowering stage. In the 2nd experiment, two sesame genotypes tolerant to waterlogging (G7 and G3) and one susceptible genotype (G1) (selected from previous experiment) were grown in pot culture to explore the physiological and biochemical mechanisms of waterlogging tolerance in sesame during the period, February to June, 2020. Thirty-four days-old seedlings were treated by three different duration of waterlogging (48, 72 and 120 hours). Physiological and biochemical characteristics were assessed on the 3rd day after removal of waterlogging (DARW).

Results and Discussion:. The most damaging effects of water stress were observed in all the genotypes when waterlogged for 60 hours. The stress induced leaf chlorosis in all the genotypes, but symptoms of serious damage showed up earlier in the sensitive genotypes (G1 and G6) and they did not survive even 48 hours of waterlogging. All the studied parameters

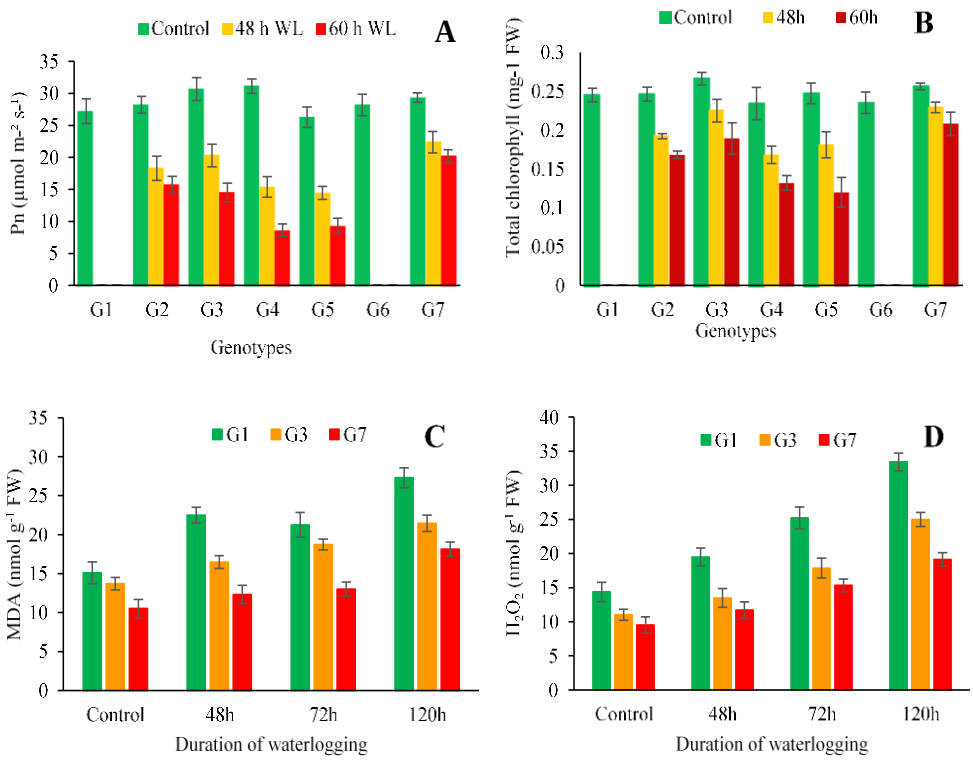


Fig. 8. Effect of waterlogging on the net photosythesis rate (A) and total chlorophyll (B), MDA (C) and H_2O_2 contents in the leaves of sesame

were significantly low in all the tolerant genotypes expect intracellular CO_2 concentration with increasing waterlogging duration. Results also showed that, chlorophyll contents (Chlo A, Chlo B and total Chlo) of leaves decreased (Fig. 8) in both waterlogging conditions, which verifies the damaging effect of stress on the leaf photosynthetic apparatus. Carotenoid content also showed similar pattern of reduction. However, reduction of photosynthetic pigments was lower in G7, which was identical with G3 and G2 genotypes and a higher reduction was found in G4, followed by G5 sesame genotypes. From the study, the genotypes G7, G3 and G2 selected as tolerant against waterlogging stress.

In the second experiment, it was observed that the longer the plant remained waterlogged, the greater was the damage. Waterlogging stress increased the contents of MDA and H_2O_2 in all the sesame genotypes, but the magnitude of increase was significantly lower in both tolerant genotypes than in the susceptible genotype. Activities of the antioxidants viz., APX, GPX, POD, GSH and proline increased with increasing duration of waterlogging in all the genotypes, but the degree of increase was significantly higher in tolerant genotypes than in the sensitive G1. In contrast, the magnitudes of reduction in CAT, AsA and GR activities were higher in sensitive than in tolerant genotypes, at all waterlog duration.

Conclusions: The project experiments provided important insights into physiological and metabolic changes occurring in sesame due to waterlogging for various periods of time. Waterlogging induced leaf chlorosis, decreased chlorophyll contents of leaves decreased and affected the photosynthetic apparatus. These adverse effects were less marked in the more stress tolerant genotypes. On the other hand, waterlogging stress increased the contents of MDA and H_2O_2 in all the sesame genotypes, but the magnitude of increase was significantly lower in both tolerant genotypes than in the susceptible genotype. The experiments demonstrated that sesame possesses adaptive mechanisms at both physiological and biochemical levels to tolerate waterlogging stress implying that there is scope for investigation at the gene level to discover waterlogging tolerant genes of sesame and develop tolerant varieties.

11. Project Code and Title: BR 7-C/17. Rice physiological development through trait discovery for boosting rice yield in changing climatic conditions

Implementing Organization: Bangladesh Rice Research Institute (BRRI), Gazipur

Principal Investigator: Dr. Md. Ansar Ali, Director (Research), BRRI, Gazipur

Budget: Tk. 110.00 lakh

Duration: Mar 2017 to Feb 2020

Introduction: The production growth rate of rice, the staple food crop of Bangladesh, needs to outpace the population growth rate to sustain food security for the populace in the long run. In order to achieve this, rice varieties need to be upgraded in terms of gowth and yield. Combining such desirable phenotypic traits as higher initial vigor, stiffness of culm, optimum tillering without unproductive tillers, optimized leaf size and angle and orientation of top three leaves, higher photosynthesis of top three leaves during grain filling, green leaf duration (stay green trait), high radiation (light/energy) use efficiency, etc. with high-yielding genotypes may be a useful agronomic option to boost yield. This project attempted to identify, optimize and combine available current high-yielding ideotypes in terms yield and yield component traits that include panicle, leaf, light interception and solar radiation use efficiency, lodging resistance and some other important traits as a means of maximizing the yield potential of rice.

Objective: To improve rice plant types to increase photosynthesis and radiation use efficiency contributing to higher biomass yield and harvest index for raising the yield potential.

Materials and Methods: Thirty-eight desirable phenotypic traits including panicle, leaf, light interception and solar radiation use efficiency, lodging resistance and some other important traits were earmarked for the study. In the previous years, 343 genotypes from the BRRI Gene Bank were characterized and 25 were identified harboring important traits. Banshphool Acc. No. 3954) was identified for better top 3 leaf characters (top 3 leaf length and area), spikelet number/m^2 and an advanced line BR (Bio) 9786-BC2-65-1-1 for higher total dry matter and yield. Combining better ideotypes (BRRI dhan47, BRRI dhan71 and BRRI dhan86) in the background of BRRI dhan28 and BRRI dhan29 was in progress. Development of double haploid population through anther culture technique was in optimization stage. Around 49,964 F_1 anthers from all cross combinations were cultured on N_6 media. In 2019-20, 50 accessions from the BRRI Gene Bank germplasm were tested during in the T. Aman and Boro seasons.

Results and Discussion: Based on better performances in terms of different parameters like short stature, effective tiller number, days to maturity, panicle length, number of filled grains per panicle, thousand grain weight, culm diameter and L/B ratio for both paddy and dehulled grain, 5 germplasm (RWBC-2-9, Rahman dhan, RWBC-2-10, BR6107-R1-1 and BR5778-156-1-HR1) were selected for further physiological characterization. In-depth physiological characterization of 13 and 12 selected genotypes were carried out during T. Aman 2019 and Boro 2020 seasons, respectively. BRRI dhan47, BRRI dhan86, BRRI dhan29, Fatema dhan and Banshphool (3954) showed better top 3 leaf character as well as spikelet number per square meter.

In the trait development study, to combine better physiological traits with high yield potential, a few backcrosses were carried out for the cross combinations of BRRI dhan28/BRRI dhan47, BRRI dhan29/BRRI dhan47, BRRI dhan71/BRRI dhan47 and their reciprocal combinations. A total of 82 BC5F1 seeds of the cross combination BRRI dhan29/BRRI dhan47 and BRRI dhan47/BRRI dhan29 combinations were produced. Another cross combination of BRRI dhan71/BRRI dhan47 produced 1850 BC3F1 seeds. Three promising progenies having higher yield potential and better top 3 leaf characters have been selected for further advancement and physiological characterization. For developing double haploid populations, 262 F1 seeds were produced from 9 new crosses (Binadhan10/BRRI dhan47, BRRI dhan47/ Binadhan10, BRRI dhan47/BRRI dhan92, BRRI dhan87/BRRI dhan47, BRRI dhan47/BRRI dhan87, BRRI dhan47/BRRI dhan86, BRRI dhan86/ BRRI dhan47, BRRI dhan47/BRRI dhan28 and BRRI dhan28/BRRI dhan61). Around 27835 anthers were plated for all the cross combinations but only 15 calli and 2 green plants were regenerated from the cross combination BRRI dhan28/BRRI dhan61 (Fig. 9).

Fig. 9. Two green rice plants regenerated from the callus of a BRRI dhan28/BRRI dhan61 combination

Coclusions: The project ended with good results indicating the availability of germplasm with desirable phenotypic characteristics which can be used to upgrade exisiting rice MVs for growth and yield enhancement. Based on the display of such desirable traits as short stature, effective tiller number, days to maturity, panicle length, number of filled grains per panicle, thousand grain weight, culm diameter and L/B ratio for both paddy and dehulled grain, 5 rice genotypes were selected for further physiological characterization. Three promising progenies having higher yield potential and better top 3 leaf characters were selected for further advancement and physiological characterization. For developing double haploid populations, 262 F1 seeds were produced from 9 new crosses.

4.1.2B *Ongoing Projects*

12. Project Code and Title: TF 41-SBR/17. Development and adoption of cotton-based cropping systems for drought-prone highlands of Chattogram Hill Tracts

Implementing Organizations: Cotton Development Board (CDB), 6th floor, Rear Building, Khamarbari, Dhaka-1215 and Agrarian Research Foundation (ARF)

Principal Investigator/Coordinator: Dr. Md. Farid Uddin, Eexecutive Director, CDB, 6th floor, Rear Building, Khamarbari, Dhaka-1215

Locations: Bandarban, Khagrachari, Rangamati

Budget: 149.5 lakh

Duration: Feb 2018 to Jan 2021

Introduction: The Chattogram Hill Tracts (CHT) constitutes about one tenth of the total area of Bangladesh. Less than 6% of CHT land area is suitable for agriculture. Two types of agriculture are observed in the area: (i) intensive cropping in the valleys and (ii) seasonal cropping in the sloping uplands, mostly jhum. Jhum is the dominant system which mostly depends on rainfall. Drought is a common phenomenon and is the major constraint to agricultural production. This project was designed to develop agronomic practices for cotton and white maize and popularize a high-productivity cotton-based cropping system to replace the traditional jhum cultivation practice in CHT. The project also studied value chain linking indigenous farmers with markets in three hill districts.

Objective: Development cotton-based improved cropping patterns and associated agronomic practices and adoption of improved technologies by farmers of CHT.

Materials and Methods: Following an on-station experiment at the Cotton Research Center, Balaghata, Bandarban and a base line survey (150 farmer households) on socio-economic conditions of farmers in Bandarban and Khagrachari, 20 on-farm experiments were set up in farmers' fields in Bandarban (12) and Khagrachari (8) by CDB (12) and ARF (8) in the previous year (2018-19). During the 2nd year (2019-20), 40 field trials were conducted on rice-cotton and rice-maize strip cropping systems with traditional *jhum* as the control treatment.

Results and Discussion: On an average, a 102% increase in income from rice-cotton strip cropping/maize-rice strip cropping was obtained over that from the traditional *jhum* sytem. Considering the prospects of rice, cotton and maize for improving the livelihood of the *jhum* farmers, it was decided to continue the research-demonstration work in the the 3rd year by allocating 50% land for rice, 25% for cotton and 25% for maize under the strip cropping system (Fig. 10).

Fig. 10. Cotton, rice and maize intercropping in CHT

Conclusions: Interventions consisting of improved cotton-rice/cotton-maize cropping systems showed promise in terms of enhancing land productivity and farmers' incomes substantially over the traditional *jhum* cropping system in CHT. The research and demo work will be continued in the third year of the project (2020-21)

13. Project Code and Title: TF-43-C/17. Livelihood improvement through farming systems research and development in the floating agriculture system

Implementing Organizations: Bangladesh Agricultural Research Institute (BARI) and Palli-Bangla Unnayan Shahojogita Sangstha (PBUSS)

Principal Investigator-cum-Coordinator: Dr. M. Akkas Ali, PSO, On-Farm Research Division (OFRD), BARI, Gazipur

Locations: The perennially waterlogged and flood prone areas (vulnerable ecosystem) of Pirojpur, Gopalganj and Bagerhat

Duration: Nov 2017 to May 2021

Budget: Tk. 260.00 lakh

Introduction: Farmers in the perennially flooded areas of Gopalganj, Barishal, Bagerhat and Pirojpur districts in the southern region of Bangladesh have adopted an indigenous, hydroponics-like system of crop production namely, "floating agriculture" (locally known as "bhasoman/dhapchash") to cope with flooding. However, although the floating agriculture system has the potential to provide food security and incomes for the millions of small households who have no access to land but live close to large bodies of water, productivity and diversity are low due to lack of modern technologies and farmers' knowledge. Farmers of this region do not cultivate forage, practice homestead gardening, modern livestock raering or fishing techniques. This project was designed to develop integrated farming system based floating agriculture to increase the production of vegetables, spices, forage, livestock and fish in the flood-prone districts of southern Bangladesh.

Objective: To generate floating agriculture based modern and appropriate technologies for increasing the production of vegetables, spices, forage, livestock, fish and homestead gardening in an integrated farming system (IFS).

Materials and Methods: Floating bed experiments on screening of vegetables, spices and forage under floating bed conditions, standardization of bed size, nutrient management, case culture, homestead, pest control and effect of different management practices are being conducted in five upazilas of Gopalgonj, Pirojpur and Bagerhat districts. The different components of floating agriculture based integrated farming (Fig. 11) being tested are year round vegetables and fruits, HYV seeds, cropping patterns and production technologies for floating beds and mainland, de-worming and vaccination of livestock, mono-sex tilapia fish culture, etc. The residues of water hyacinth used to prepare the floating beds are used for crop production in the main land as a good source of compost.

Fig. 11. Growing vegetables on floating beds, fishing and homestead livestock rearing in an integrated farming system for perennially flooded basin areas

Results and Discussion: Promising vegetables such as, okra (Choyonika), bottle gourd (Tafsi), Indian spinach (Jotai), broccoli (Laura), knolkhol (Challenger), spices such as, turmeric (BARI Holud-5), chili

(local) and grasses (Napier) have been indentified as suitable for growing on floating beds. At all locations, okra yield was satisfactory and the benefit cost ratios (BCR) considering variable costs were 1.52 to 1.90. In on-farm participatory trials on vegetables, spices and grass production technologies in the districts of Gopalganj, Pirojpur and Bagerhat districts, BARI Dherosh-2, BARI Puishak-2, BARI Halud-5, Brocolli (Laura), Knolkhol (Challenger) produced highest yields and low disease infestation compared to other varieties. BARI developed vegetables, spices and BLRI developed Para grass performed better at all locations as a new crop.

Conclusions: The project demonstrated that there are good opportunities of enhancing agrcultural production on floating beds, homesteads and water bodies in an integrated farming system in the perennially flooded southern districts of Bangladesh. New varieties of vegetables, spices and grasses have been identified which coud be extended in these areas. The project demos motivated farmers to include new crops, especially broccoli in their cropping patterns. The floating agriculture based farming systems with new crops and cropping patterns, livestock rearing and fish-in-case culture could substantially enhanced farmers' incomes in the rather unfavorable flood ecosysytems of the low-lying basin areas of southern Bangladesh.

14. Project Code and title: TF 50-C/17. Management of wheat blast caused by *Magnaporthe oryzae* pathotype *Triticum* introduction

Implementing Organizations: Bangladesh Wheat and Maize Research Institute (BWMRI), Nashipur, Dinajpur; BAU, Mymensingh and BSMRAU, Gazipur

Coordinator: Dr. Naresh Chandra Deb Barma, Director General, BWMRI

Locations: Jashore, Dinajpur, Mymensingh, Gazipur, Meherpur, Chuadanga

Budget: Tk. 305.87 lakh

Duration: Apr 2018 to Jun 2021

Introduction: Wheat blast is a fearsome fungal disease caused by *Magnaporthe oryzae* (syn. *Pyricularia oryzae*) pathotype *Triticum* (MoT). The disease was first discovered in the Parana State of Brazil in 1985 and has since been a serious biotic constraint to wheat production in the warmer parts of the Southern Cone Region of South America. In February 2016, the first outbreak of wheat blast outside South America was recorded in several southwestern and southern districts of Bangladesh. Genomic analysis of the fungal isolates established that the wheat blast observed in Bangladesh was caused by a South American lineage of MoT. The disease incidence was significantly widespread affecting approximately 15% (about 15,000 ha) of Bangladesh's total wheat area and causing yield losses, in some areas reaching up to 100%. Outbreak of the disease was attributed to high temperature and prolonged high humidity due to high precipitation at the flowering stage. This large scale emergence of wheat blast is very alarming and significant given the levels of crop loss incurred by small farmers relying on wheat as the second most important cereal crop. Most importantly, this emerging disease represents a serious threat not only to wheat production in Bangladesh but also to regional food security in South Asia, where the people consume over 100 million tons of wheat per annum.

Wheat blast may significantly impact wheat production because: 1) MoT has a very high evolution potential, 2) the strain introduced in Bangladesh represents the most aggressive type, 3) the pathogen is both seed and air borne, 4) most commercial wheat cultivars are susceptible, 5) resistance sources are limited worldwide and their durability is questionable, 7) the disease develops very rapidly, giving little time for remedial measures, actions, 7) known fungicides are partially effective under moderate to low disease pressure, and fungicide resistance has been observed, and 8) there are knowledge gaps on this devastating disease. This underlines an urgent need to develop integrated disease management solutions through multiple interventions to mitigate the threat of wheat blast in Bangladesh and stem its spread to South Asia and other wheat growing regions with similar climates. The major focus of this multi-institute (BARI, BAU and BSMRAU) coordinated project includes variability in MoT population, its epidemiology, field diagnostics, agronomic manipulation, testing fungicidal efficacy and development of durable blast resistant wheat variety through classical breeding and genome editing.

Objective: The main objective of the project is to develop various disease management technologies including resistant varieties to contain the emerging threat of wheat blast in Bangladesh.

Materials and Methods: The major project activities include field surveys in the western-southwestern districts to assess the extent of damage to wheat caused by the blast disease, screening of wheat genotypes for resistance to the disease, molecular studies involving the causative agent, *Magnaporthe oryzae* pathotype *Triticum*, and development and filed testing of management methods to contain wheat blast.

BWMRI: An intensive field survey of blast in 135 farmers' fields and trial sites of major wheat-growing areas in 27 districts of Bangladesh and disease rating based on the 0-100 scale

were done in the 2019-20 wheat season. Head blast incidence and severity were estimated on spikes as percentage of spike infection referred to as incidence and percentage of diseased area on infected spikes referred to as severity and finally the disease severity was calculated following the formula, disease severity (%) = (incidence x severity) * 100. Twenty-eight (MoT) isolates were cultured from infected samples of wheat and others hosts (triticale, barley, durum, grasses, etc.) collected during the last growing season and preserved on sterilized filter paper in falcon tubes at -81^{o}C. Morpho-physiological characteristics of the collected isolates were recorded. For molecular characterization, 151 isolates out of 200 were used for DNA extraction followed by molecular analysis using MoT3 (MoT-specific marker) molecular marker through PCR assay. In addition, during this reporting period, 17 isolates were amplified with ITS sequence using ITS4 and ITS5 primer sets, and used for sequencing. After sequencing, neighbor joining phylogenetic analysis was done for the mentioned isolates sequences with other publicly available ITS sequences of *Pyricularia* spp. In field screening experiments during 2019-20, 350 entries including susceptible/resistant checks were screened against wheat blast under inoculated conditions (Fig. 12) in a precision phenotyping platform (PPP) at BARI RARS, Jashore and at BWMRI, Dinajpur. Forty elite wheat genotypes from diverse sources including susceptible/resistant checks were evaluated against wheat blast under MoT inoculated conditions at BARI RARS, Jashore.

Fig. 12. Wheat germplasm screening for blast tolerance

BAU: BAU studied the MoT infection pathway in wheat involving roots, stem, rachis, spikes, awns and seeds. Blast management methods including seed treatment with the fungicides Nativo @ 0.06%, Filia @2.0 ml/L and Sun Fighter @ 2.0ml/L as a preventive measure were also studied.

BSMRAU: Studies included molecular diagnosis, genome epidemiology, and development of durable blast resistant wheat by genome editing. Whole genome sequencing of MoT isolates of Bangladesh was performed to study genome mutation and recombination rate of the isolates linked to disease epidemiology. The DNAs of *M. oryzae* isolates sampled from wheat, barley and torpedo grass were sequenced using Illumina HiSeq 2500 producing 125 base paired-end threads. In collaboration with UK and Canadian researchers, some *S*-genes were edited by using CRISPR/Cas9. To perform genome editing, a Golden Gate vector pBHt2-REP from the pCAMBI derived pBHt2G vector was constructed. The vector was domesticated through removal of BsaI cloning sites. An RFP-marker was inserted, which is expressed in *E. coli*, allowing for red-white selection of transformants. These transformants

were tested against MoT. To find out an alternative to the synthetic chemical fungicides to combat wheat blast, 170 probiotic bacteria were screened against a virulent isolate of MoT, BTJP4-5.

Results and Discussion:

BWMRI: Prevalence and variability of *Magnaporthe oryzae* pathotype *Triticum* causing wheat blast and screening of wheat genotypes for resistance to the disease

A varying level of disease frequency was observed among the surveyed fields. Thirteen districts were identified with blast infection and one (Bogura) of them was a newly affected district. Out of 135 fields surveyed, 37 fields were identified with wheat head blast infection which accounted in approximately 27% of the total fields surveyed. Fields planted at the optimum time (November 15-30) mostly escaped or had very low disease severity. The highest level of spike incidence (80%) with higher severity (60%) was observed in wheat fields of Meherpur district, while the lowest (1%) level of incidence was observed in the fields of Kustia, Jhenaidah and Chuadanga districts. Blast incidence was most frequently observed in susceptible cultivars like BARI Gom 26, Prodip, BARI Gom 25, Bijoy etc. The overall disease severity of the affected districts was comparatively lower (<1%) than the previous years (2019). During the surveillance, blast-affected spikes with no superficial infection was collected from the affected fields and all the samples were brought to the BWMRI pathology laboratory for further studies.

Different isolates of MoT showed different types of morphological behaviors like light to deep gray colonies, whitish mycelia with or without concentric ring and round margins, and good to variable growth. The isolates were identical to wheat blast isolates from Brazil, Paraguay and Bangladesh (previous isolates).

Pathogenicity test for MoT was standardized to evaluate pathogenic variability and cross infectivity of the isolates. Nine suspected alternative hosts of *Magnaporthe* spp. were identified. Cross infection happened among the hosts of wheat, triticale, barley and durum. An important finding was that, the wheat blast isolate could infect and produce distinct symptoms on goose grass (*Eleucine indica*) leaves under laboratory conditions but the goose grass isolates could not infect wheat.

Among the 350 entries evaluated, 32 lines were selected based on the least blast severity, 1000-grain weight, grain yield and other agronomic characters assessed over locations. A significant variation in terms of disease severity was observed among the genotypes. A high percentage of genotypes was found with minimum disease infection. Among 350 lines, 286 demonstrated immune response, and 33 were found to be resistant, 11 moderately resistant and the rest susceptible to the blast disease. The percentage of disease severity of the selected lines ranged from 0 to 26%, while those of the checks ranged from 0 to 76.31%. The resistant and moderately resistant lines will be subjected to artificial inoculation in the next season and their responses examined.

The 40 elite wheat genotypes tested demonstrated varying degrees of reaction to the disease. Out of them 13 scored as resistant showing 0.2 to 6.7% disease severity but none of them was found to be immune. The resistant variety, BARI Gom 33, demonstrated a highly resistant reaction (0.3%) while the susceptible variety, BARI Gom 26, showed 87.6% disease severity. The newly released varieties, WMRI Gom 3 (BAW 1254) and WMRI Gom 2 (BAW 1208) showed highly resistant (0.2%) and tolerant (33.6%) reaction to the disease, respectively. Some other genotypes viz., Indian variety, BAW 1272, BAW 1280, BAW 1286, BAW 1297, BAW 1322, BAW 1323, BAW 1328, BAW 1338, BAW 1358 and BAW 1363 were found promising with less than 10% disease severity.

BAU: Management of wheat blast: A holistic approach with emphasis on early stage detection for forecasting

The transmission pathway of the causative agent, *Magnaporthe oryzae* pathotype *Triticum* (MoT), in wheat extends from seed to root to stem and then to rachis (Fig. 13). The fungal pathogen can be present at the vegetative growth stages of wheat plants raised from infected seeds. Pre-heading growth stage (53-57 after sowing-DAS) is the critical stage for infection by the blast pathogen. Wheat stubbles carry MoT round the year i.e., the pathogen can be transmitted from wheat plants in one season to those in the subsequent season. Thus, destruction of wheat stubbles from infested wheat fields is recommended for the mitigation of whaet blast. A cocktail of the fungicide Tebuconazole, Trifloxystrobin and Tricyclazole was proved to be effective both as a preventive and curative measure against wheat blast. Sprays or soil incorporation of silicon and boron were also found to be effective in suppressing the wheat blast infestation. Gamma irradiation of seeds produced 13 promising blast resistant wheat mutants.

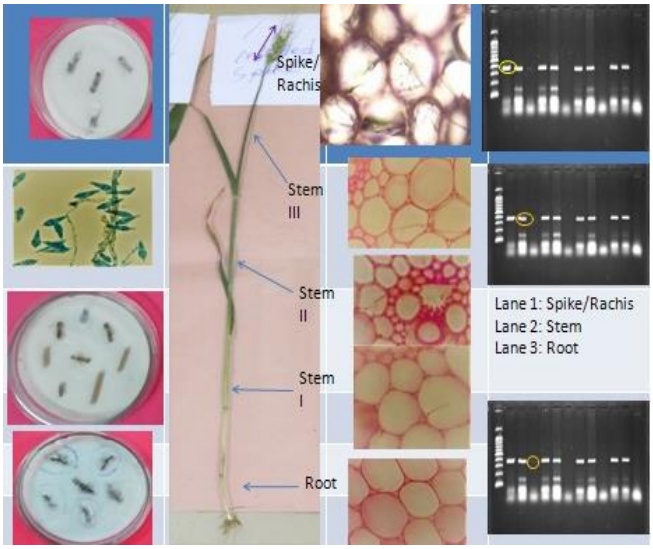


Fig. 13. Movement of the wheat blast pathogen *Magnaporthe oryzae* pathotype *Triticum* from root to rachis in wheat (variety BARI Gom26)

BSMRAU: Molecular diagnosis, genome epidemiology, and development of durable blast resistant wheat by genome editing

Rapid detection of the wheat blast pathogen Magnaporthe oryzae Tricicum pathotype using genome-specific primers

In a sequencing of the genomes of a large number of MoT and MoO isolates, two DNA fragments, MoT-6098 and MoT-6099, were successfully identifield in the genome of MoT that are absent in the genome of the rice-infecting *M. oryzae Oryzae* pathotype (MoO) and other fungi. The specificity of the two markers by PCR analyzing 53 MoT and MoO isolates from South America and Bangladesh (Figure-1) was demonstrated and confirmed. To test the usefulness of these two markers, the loop-mediated isothermal amplification (LAMP) method was first developed to detect the MoT at isothermal conditions without the use of a PCR machine. To develop a more convenient method, the Cas12a protein and guide RNAs (gRNAs) to target the MoT-6098 and MoT-6099 sequences were used. The activated Cas12a showed indiscriminate single-stranded DNase (ssDNAase) activity. The combined target-dependent Cas12a ssDNase activation with recombinase polymerase amplification (RPA) and nucleic acid lateral flow immunoassay (NALFIA) helped develop a new method that accurately, sensitively and cost-effectively detects MoT-specific DNA sequences in the infected wheat plants and seeds. This novel strip-like kit can widely be used for rapid detection of wheat blast in asymptomatic wheat plants, seed lots, and alternate hosts for the surveillance and monitoring of the wheat blast. Furthermore, commercialization of this rapid blast detection kit would enhance its worldwide use in the plant quarantine, farmers' fields and research laboratories.

Discovery of linear liopeptides from Bacillus subtilis that suppress wheat blast disease

Five linear lipopeptides derived for a strain of *Bacillus subtilis* were discovered that effectively suppressed growth and infection of MoT both *in vitro* and *in vivo.* Among the 5 compounds studied, gageotetrin B (5) displayed the highest mycelial growth inhibition of MoT followed by gageopeptide C (3), gageopeptide D (4), gageopeptide A (1) and gageopeptide B (2) with minimum inhibitory concentrations (MICs) of 1.5, 2.5, 2.5, 10.0 and 10.0 µg/disk, respectively. Application of these natural compounds also completely blocked formation of conidia in the MoT fungal mycelia in the agar

medium. Further bioassay revealed that these compounds (1-5) inhibited the germination of MoT conidia and if germinated, induced deformation of germ tube and/or abnormal appressoria. Interestingly, application of these linear lipopeptides (1-5) remarkably suppressed wheat blast disease on detached wheat leaves.

Screening of CRISPR-Cas edited S-gene mutant lines against wheat blast pathogen
Twelve rice orthologus *S*-genes namely, *ERF922, Dja6_1, Dja6_2, Rac4, Rac5, HDT701, WRKY28_1, WRKY28_2, OB-fold, Pi21, Cul3* and *PLdbeta* were identified in wheat genome. These genes were targeted for deletion in the wheat genome using CRISPR-Cas9 genome editing technology. Approximately, 7,000 mutant lines were screened. Detached leaves assay revealed that some of the mutant lines exhibited moderate resistance to the wheat blast pathogen. Forty moderately resistant mutant lines were transferred to growth chambers for plant growth and seed collection for head inoculation assay.

Conclusions: The magnitude of damage to wheat in Bangladesh caused by the dreaded blast disease has been assessed and some pioneering work on molecular characterization and genome sequencing of the causative agent, *Magnaporthe oryzae* pathotype *Triticum* (MoT), development of management methods for the control of the disease and screening of wheat genotypes for resistance to the pathogen has been done so far by the project scientists. A varying level of blast disease frequency was observed in farmers' wheat fields across the western-southwestern districts, fields planted at the optimum time (November 15-30) mostly escaping the infestation or having very low disease severity. Different isolates of MoT showed different types of morphological behaviors and good to variable growth. The isolates were identical to wheat blast isolates from Brazil and Paraguay. A significant variation in terms of blast disease severity was observed among the 350 wheat genotypes tested; from among them, 32 lines were selected for further evaluation. Out of the 40 elite wheat genotypes tested, 13 scored as resistant showing 0.2 to 6.7% disease severity but none of them was found to be immune. The newly released wheat varieties, WMRI Gom 3 (BAW 1254) and WMRI Gom 2 (BAW 1208) showed highly resistant (0.2%) and tolerant (33.6%) reaction to the disease, respectively. A new kit that accurately and cost-effectively detects MoT-specific DNA sequences in the infected wheat plants and seeds was developed which can be widely used for rapid detection of wheat blast in asymptomatic wheat plants, seed lots, and alternate hosts for the surveillance and monitoring of the wheat blast; commercialization of this rapid blast detection kit would enhance its worldwide use in plant quarantine, farmers' fields and research laboratories. Five linear lipopeptides derived for a strain of *Bacillus subtilis* were discovered that effectively suppressed growth and infection of MoT both in vitro and in vivo. A cocktail of three ngicides proved to be effective both as a preventive and curative measure against wheat blast. Sprays or soil incorporation of silicon and boron were also found to be effective in suppressing wheat blast infestation.

15. Project Code and Title: TF 51-SBR/17. Assessment of cropping patterns for sustainable intensification in drought and saline-prone ecosystems using remote sensing and geospatial modeling

Implementing Organization: Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Dr. Md. Golam Mahboob, SSO, ASICT Division, BARI

Locations: Drought prone Barind Tract regions of Rajshahi, Chapai Nawabganj, Naogaon, Bogura, Natore, Sirajganj, Gaibandha, Jaipurhat, Dinajpur and Rangpur

Budget: Tk.122.901 lakh

Duration: Apr 2018 to Mar 2021

Introduction: Remote sensing and geospatial modeling can play a vital role in the assessment of cropping patterns and availability of natural resources for use in systems intensification (SI) planning in agriculture. Recent provisions of access to high performance cloud servers for large volumes (up to planetary scale) remote sensing image analysis offer a time and cost saving mechanism by providing

analytical algorithms and ground referenced data. Bangladesh NARS institutes have developed and released many modern crop varieties and technology options (e.g. management practices, farm machinery) for water and other resources conservation which could fit well in area specific cropping patterns to achieve SI goals in different areas in the drought and salinity stressed ecosystems of Bangladesh. Geospatial modeling can help suggest appropriate cropping patterns with the optimum use of available natural resources in these vulnerable ecosystems. This research project addresses the issue of sustainable cropping intensification in problematic agro-ecologies of Bangladesh like the drought stressed agro-ecosystem prevailing in the Barind Tract of Bangladesh.

Objective: To develop an agro-environmental resources and constraints geo-database and crop type maps for the dry season using remote sensing image analysis.

Materials and Methods: Remote sensing and geospatial modeling tools are being used to address the High Barind Tract covering 11 upazillas of Chapainawabganj, Naogaon and Rajshahi districts. Two reconnaissance surveys were conducted in March/2019 and July/2019 in the study area with a view to identifying potential Unmanned Arial Vehicle (UAV) operational research fields to observe pros/cons analytically as per the rules and regulations provided by the Civil Aviation Authority of Bangladesh (CAAB) regarding UAV flying. The study aimed at providing high-resolution crop type and cropping pattern maps for the study area from satellite imagery. Historical land use/cover change analysis at a time lapse of every ten years since 2001 were conducted for dry season cropping practices mostly by using Landsat data archives. Sentinel 2 satellite data of recent years were used to assess land use at a higher spatio-temporal resolution. Vegetation indices (NDVI, EVI and GMVI) from Landsat archives and Sentinel 2 satellite data until 2018 were downloaded from the Google Earth Engine for the entire High Barind Tract using customized codes written in Java Script. During the reporting period (July 2019-June 2020), a reconnaissance survey (2nd) was done for UAV flight site selection. Necessary ground data were collected as well from study area to train satellite images for crop type mapping. A crop inventory for the entire Barind Tract was prepared according to the methodological framework. Six major crop types, predominant in the area, were chosen for delineation from satellite image classification namely: maize, lentil, mustard, potato, Boro rice, and wheat. A total of 28 cloud-free Sentinel 2A (MSS, level-1C) satellite imagery (10m spatial 10 days and temporal resolution) were downloaded (https://scihub.copernicus.eu/) of the recent year (2019-2020) for the dry season (October-March) which were analyzed using desktop based geospatial software tools and the Google Earth Engine (GEE) platform.

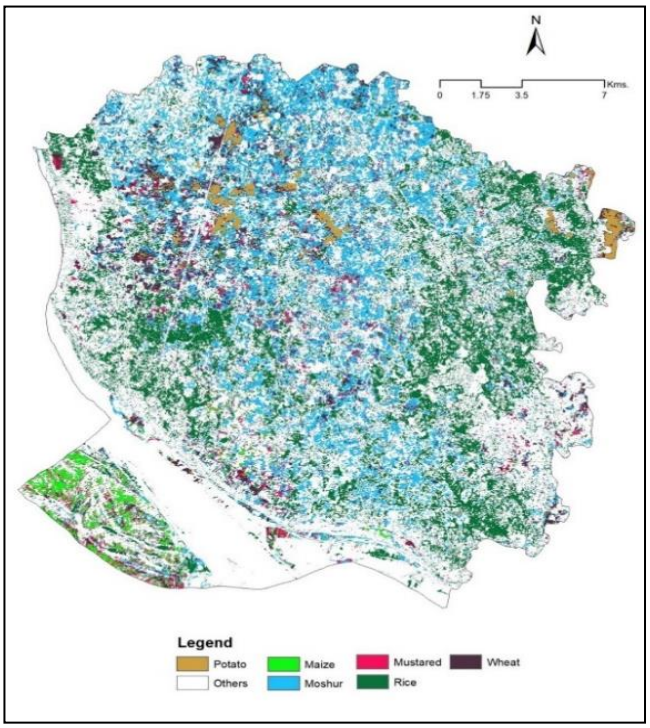


Fig. 14. Dry season crop type map, Godagari upazila, Rajshahi, 2019-20

Results and Discussion: An algorithm was developed to delineate dry season crops using Sentinel-2 imageries in a pilot area (Godagari upazila) (Fig. 14). Results show that *Boro* rice and lentil occupied most of the area with 8,543.12 ha (17.35% of the total upazila) and 8381.55 ha (17.02%), respectively. Wheat, mustard, maize and potato shared area 2,087.89 (4.24%), 1,731.55 (3.52%), 798.76 (1.62%) and 658.58 ha (1.34%), respectively during 2019-2020 *Rabi* season. Other areas (water bodies, others crops, orchards, settlement, etc.) shared the maximum area coverage with 27,052.42 ha (54.92%). The overall accuracy of the classified map was found 75% while comparing with the ground truth data. Besides, a set of agro-environmental resources geo-database from

image analysis was developed including digital elevation model, slope map, aspect map, and soil map for the selected upazila.

Conclusions: Classification of agricultural lands (crop types) of smallholding farms has been challenging in Bangladesh due to small plot sizes and huge variability over time and space. Remote sensing image analysis offer a time and cost saving mechanism by providing analytical algorithms and ground referenced data. Geospatial modeling can help suggest appropriate cropping patterns with the optimum use of available natural resources in these vulnerable ecosystems. This project addresses the issue of sustainable cropping intensification in problematic agro-ecologies of Bangladesh like the drought stressed agro-ecosystem prevailing in the Barind Tract of Bangladesh employing remote sensing techniques and geospatial modeling. A set of agro-environmental resources geo-database from image analysis was developed including digital elevation model, slope map, aspect map, and soil map for the selected upazila.

16. Project Code and Title: TF-52-C/17. Adaptation of BARI released hyacinth bean varieties and up-scaling the farmers' innovation for productivity enhancement in the Narsinghdi region

Implementing Organizations: Bangladesh Agricultural Research Institute (BARI) and Chinishpur Dipshikha Mohila Samity (CDMS), Narsingdi (NGO)

Principal Investigator: Dr. Md. Moshiur Rahman, PSO, Regional Horticulture Research Station (RHRS), BARI, Shibpur, Narsingdi

Locations: RHRS, BARI, Shibpur, Narsinghdi and Sadar and Shibpur upazilas of Narasinghdi district

Budget: Tk. 67.5 lakh

Duration: Feb 2018 to Jan 2021

Introduction: A few farmers' innovations are practiced in the Narasinghdi region and farmers achieve high agro-economic returns from them. One such farmers' innovation is the eggplant+hyacinth bean relay cropping system where late-stage eggplant stands are used as a support for the bean plants which saves high costs of erecting bamboo trellis normally used in commercial bean cultivation. In most cases, farmers grow local cultivars of hyacinth bean. Up-scaling and refinement of this technology with modern varieties and their widespread adoption are needed. This project aims to evaluate and popularize the eggplant+hyacinth bean relay-cropping technology refined with the inclusion of BARI released eggplant and hyacinth bean varieties in four upazilas of Narsinghdi.

Objective: To introduce and disseminate BARI released eggplant and hyacinth bean varieties and up-scale farmers' innovation.

Materials and Methods: In the previous years (2017-18 and 2018-19), suitable BARI released hyacinth bean varieties in winter were tested at RHRS, Shibpur, Narsinghdi and in farmers' fields in the Sadar and Shibpur upazilas of Narsinghdi through relay cropping of the bean with eggplant for up-scaling the farmers' innovation. Adaptive trials the two BARIM eggplant varieties, BARI Begun-8 and BARI Begun-10, were conducted in farmers' fields and at RHRS. In 2019-20, three summer hyacinth bean varieties viz., BARI Sheem-7, Sikribi Sheem-1 and Sikribi Sheem-2 were tested as a relay crop planted between two eggplant rows with a sole crop of summer hyacinth bean under traditional practices old eggplant stands as a support and normal practices with bamboo trellis. Data on growth and yields of hyacinth bean and eggplant as well as profitability were studied and analyzed.

Results and Discussion: The BARI developed eggplant varieties, BARI Begun-8 and BARI Begun-10, were found to be superior to the local variety, Volanath in terms of yield and economic returns. Likewise, the BARI hyacinth bean varieties, BARI Sheem-1, BARI Sheem-4 and BARI Sheem-6 performed better than the local local variety, Kartika. BARI Sheem-1 was found to be suitable for growing as a relay crop with BARI Begun-8/BARI Begun-10. Relaying BARI Sheem-1 with BARI Begun-8/BARI Begun-10 reduced production costs from those needed from sole crops and increased yields and economic returns.

Conclusions: BARI released eggplant and hyacinth varieties and novel agronomic practices such as growing hycinth bean as a relay crop with eggplant using the eggplant stands as support for the bean crop instead of the traditional practice of erecting bamboo trellis were successfully tested in the Narsinghdi district. The improved eggplant and hyacinth bean varieties were found to be more productive and hence acceptable to vegetable growers of the district. In addition, relaying hyacinth bean with eggplant reduced production costs from those needed for sole crops, increased yields and economic returns. The results could be a good example to motivate researchers and farmers for testing and adopting locally suitable varieties, cropping patterns and agronomic management innovations to enhance the productivity and profitability of vegetable crops in other regions of the country.

17. Project Code and Title: TF 53-C/17. Production and dissemination of BARI released year round jackfruit variety and its management packages

Implementing Organizations: Bangladesh Agricultural Research Insitute (BARI), Gazipur and an NGO, Society for Sustainable Development for the Rural and Urban Areas (SSURDA)

Principal Investigator: Dr. Md. Jillur Rahman, SSO, Pomology Division, Horticulture Research Center (HRC), BARI, Gazipur

Locations: Gazipur, Mymensingh, Khagrachari and Narsingdi

Budget: Tk. 63.92 lakh

Duration: Feb 2018 to Jan 2021

Introduction: Jackfruit (*Artocarpus heterophyllus)* is the national fruit of Bangladesh, which traditionally, has a short (June-August) harvest period and the wastage of the fruit is high, 20-30%. BARI has developed three varieties of jackfruit, viz. BARI Kanthal-1, a regular bearing high-yielding variety which is harvested in mid-May to June, BARI Kanthal-2, an off-season regular bearing variety which is harvested during January to March and BARI Kanthal-3, a year round regular bearing variety which is harvested in September to June. A standard variety cannot be maintained through seed propagation due to the heterozygous nature of the trees, this can be done only by vegetative propagation, and grafting is commonly practiced for this purpose. Quality planting materials and improved management practices comprising appropriate fertilizer doses and irrigation to prevent fruit dropping, pollination and pest control are needed for high year round jackfruit production. This project was initiated to disseminate material and technologies for year round jackfruit production.

Objective: Dissemination of improved grafting and management packages for jackfruit varieties released by BARI for seasonal and off-season production.

Materials and Methods: A baseline survey for identifying year round/off-season jackfruit germplasm in Khagrachari, Ramgarh, Narsingdi and Gazipur was conducted and their fruits collected and evaluated. At the same time, scions were collected to produce saplings through grafting. An orchard with BARI developed jackfruit varieties has been established at the Fruit Research Farm, BARI, Gazipur. Experiments on grafting of jackfruit are being conducted at the Fruit Research Farm, BARI, Joydebpur and Hill Agriculture Research Station (HARS), BARI, Ramgarh, Khagrachari with three jackfruit varieties (BARI Kanthal-1, BARI Kanthal -2 and BARI Kanthal -3). Thirty farmers (including 5 nursery men) were selected for trials with grafted jackfruit saplings. In the second year of the project (2019-20), every farmer (25 farmers of Khagrachari and Narsingdi districts) was supplied five saplings of each of the three jackfruit varieties to set up orchards. At the same time, 5 nursery men of the two districts were supplied five saplings of each variety. These orchards of grafted jackfruit plants would act as mother tree orchards. Activities to establish an orchard of BARI developed jackfruit varieties in the Mymensingh district were in progress.

Results and Discussion: Orchards of BARI developed jackfruit varieties had been established in farmer's fields and nursery men of 3 districts (Gazipur, Khagrachari and Narsingdi). Same work will be done in Mymensingh and orchards of BARI developed jackfruit varieties would be established in four more districts. Performance of BARI developed jackfruit varieties was observed at Fruit Research Farm, BARI, Joydebpur, Gazipur. Plant height increased by about 127% in BARI Kanthal-1, 223% in BARI Kanthl-2 and 224% in BARI Kanthal-3, and after one year on January 26, 2020 plant height of BARI Kanthal-1, BARI Kanthl-2 and BARI Kanthal-3 were recorded to be 3.04 m, 2.91 m and 2.92 m, respectively. At the same time, base girth increased from 5.43 cm in January 2019 to 17.6 cm in January, 2020 in case of BARI Kanthal-1; 4.14 cm in January 2019 to 20.6 cm in January, 2020 in case of BARI Kanthal-2 and 4.01cm in January 2019 to 20.3 cm in January, 2020 in case of BARI Kanthal-3, respectively. Growth and development of grafted jackfruit plants were satisfactory for fruit bearing.

Fig. 15. Exeperimental jackfruit orchard in Gazipur

Performance of 12 exotic year round and red jackfruit germplasm was observed at the Fruit Research Farm, Joydebpur, Gazipur. Growth and development of the grafted jackfruit plants were satisfactory.

The greatest grafting success was recorded in January grafting with BARI Kanthal-1 (78.2%) followed by January grafting with BARI Kanthal-2 (76.8%). Plant height, base girth and canopy spreading increased with the increased split application of fertilizer (N and K) of grafted jackfruit plant (BARI Kanthal-3).

Coclusions: New jackfruit varieties and technologies appear promising for the year round production and availability of the delcious, nutritious and popular fruit in Bangladesh. Growing off season and year round varieties will boost production, cut down the current fruit wastage to an acceptable level, increase jackfruit growers' profits and open up opportunities for export of jackfruit contributing to the national economy.

18. Project Code and Title: TF 54-SBR/17. Improvement of cropping systems applying different agronomic management practices in salinity affected coastal zone of south-western part of Bangladesh for attaining food security and sustainability

Implementing Organization: Bangladesh Agricultural Research Insitute (BARI)

Principal Investigator: Dr. Kawsar Uddin Ahammad, PSO, Regional Agricultural Research Station, BARI, Jashore

Locations: Khulna and Satkhira

Budget: Tk. 260.0 lakh

Duration: Jan 2018 to Dec 2020

Introduction: Scarcity of non-saline irrigation water and high soil salinity during the winter season are the major problems of crop production in this region. For improving the food and nutrition security situation in this region it is imperative that the conventional cultivation practices and methods be replaced by environment-friendly and socio-economically beneficial ones. There is ample opportunity

to adopt a T. Aman-Rabi-fallow/Kharif-I cropping system replacing the traditional single crop, low-productivity, low-profit Fallow-T. Aman-fallow system as a technology to increase cropping intensity in the salinity affected southwestern region with the introduction of new crops like pulses, oil seeds, vegetables, spices, etc., using salt tolerant varieties, growing crops on raised beds, mulching, rainwater harvesting in 'kunni' (mini pond) or canal for irrigation. In view of these possibilities, this project was initiated to study and demonstrate the T. Aman-Rabi-fallow/Kahrif-I cropping pattern with the use of appropriate varieties and improved technologies of crop establishment, residual soil moisture use and irrigation in the southwestern coastal saline zone.

Objective: To increase cropping intensity in coastal saline areas through improved, agro-economically viable cropping systems and agronomic management practices.

Materials and Methods: Base line surveys on local crop production practices and agro-economic issues were completed early in the project implementation. The project locations were farmers' fields in Dacope, Batiaghata and Dumuria uazilas of Khulna district and Shyamnagar, Kaliganj and Sadar upazilas of Sathkhira district. Eleven BARI developed salt-tolerant varieties of Rabi crops namely mustard, grasspea, wheat, potato, maize, gardenpea, bitter gourd, sweet gourd, bottle gourd, water melon and sunflower and two Kharif crops namely mungbean and sesame were grown in 123 farmers' fileds (24.51 ha) in the project area using relay and mulching techniques. The BRRI developed short duration T. Aman rice variety, BRRI dhan75, was cultivated in 16.51 ha of land of 80 farmers replacing long-duration local T. Aman varieties.

Fig. 16. Introducing water melon in T. Aman-fallow cropping system in coastal saline areas

Results and Discussion: The average seed yields of mustard, mungbean, gardenpea, grasspea, sesame were 0.9, 0.5, 0.85, 0.48 and 0.73 t/ha, respectively. The average grain yields of rice, wheat and maize were 4.47, 3.6 and 5.9 t/ha, respectively. The economical yield of potato, sweet gourd, bitter gourd, bottle gourd and watermelon were 25.2, 5.9, 8.9, 37.1 and 44.63 t/ha, respectively. The highest total rice equivalent yield (TREY) 27.02 t/ha was found for the T. Aman-fallow-watermelon cropping pattern followed by 19.25, 18.25, 13.08 and 10.98 t/ha for the T. Aman-potato-sesame, T. Aman-potato-mungbean, T. Aman-fallow-bottle gourd and T. Aman-allow-bitter gourd patterns, respectively. These innovative cropping patterns increased the rice equivalent yield (REY) by 80-85% over the farmers' traditional pattern. The highest marginal income (Tk. 4, 60,300/ha, net income (Tk. 4, 11, 645/ha) and marginal benefit cost ratio (6.63) came from the cropping pattern that gave the highest TREY (T. Aman-fallow-watermelon). This pattern also showed the highest production efficiency (162 kg/ha/day), sustainable yield index (80.25%) and systems profitability (Tk. 1128/ha/day). The highest land use efficiency 75.07 % was obtained from the cropping pattern T. Aman-gardenpea-sesame. The tested cropping patterns increased farmers' incomes by about 80 to 95%.

Conclusions: Scarcity of sweet water for irrigation and high soil salinity especially in the dry winter season restrict farmers to growing only one monsoon rice crop a year in the traditionally followed Fallow-T. Aman-fallow cropping pattern in the salt-affected Khulna, Bagerhat and Satkhira districts of the southwestern coastal saline zone of Bangladesh. This project, however, has clearly demonstarated that there is a good scope of cropping intensity in the salinity affected southwestern region with the introduction of new crops like pulses, oil seeds, vegetables, spices, etc., in the cropping patterns, growing salt tolerant varieties and applying improved management practices. These interventions have been shown to substantially increase land use efficiency, production efficiency, systems profitability,

sustainable yield index and farmers' net incomes in the agro-ecologically challenged cosatal saline region of Bangladesh.

19. Project Code and Title: TF 55-AE/17. Development and adoption of a solar cabinet dryer for vegetable seeds

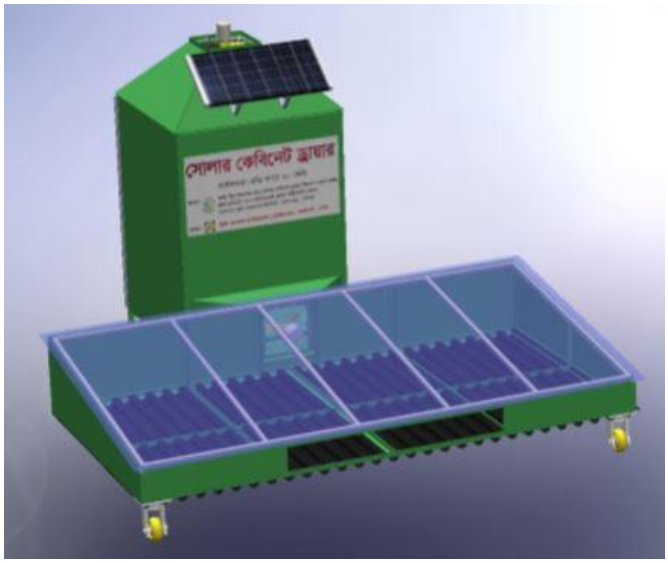
Implementing Organization: Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Dr. Md. Nurul Amin, Farm Machinery and Postharvest Process Engineering (FMPE) Division, BARI, Gazipur

Locations: BARI, Gazipur and RARS, BARI, Jashore

Budget: 20.45 lakh

Duration: March 2018 to February 2021



Introduction: Moisture content plays a major role in determining the shelf life of seeds. Vegetable seeds normally contain 60-80% moisture at the stage of physiological maturity. The seed moisture content needs to be reduced to a safe level of 8-9% by sun or air drying or mechanical drying to preserve seed quality during storage. In the sun drying method, seeds are dried sometimes at low temperature and sometimes at high temperature which deteriorates seed quality. Sometimes, continuous rains for a few days restrict traditional seed drying and whole lots of seeds are spoiled. This project attempted to design and fabricate an eco-friendly cabinet solar dryer for drying of vegetable seeds to reduce seed losses and produce good quality vegetable seeds.

Objective: Designing and fabrication of a solar powered and electricity backup vegetable seed dryer, its performance evaluation and dissemination.

Materials and Methods: A solar cabinet dryer was designed and fabricated by the Farm Machinery and Postharvest Process Engineering Division, BARI, Gazipur with locally available materials such as, MS box, MS flat bar, MS angle bar, MS sheet, GP sheet, SS net, insulation materials, DC fan, PV module, polyethylene sheet, cork sheet, etc. for drying of 10-15 kg of moist vegetable seeds. The dryer was designed to generate desirable temperature (<45°C) from solar radiation suitable for vegetable seed drying. To reduce the temperature differences among the trays of the dryer, additional two dry heaters of 500 W capacity were vertically incorporated adjacent the upper two trays. A battery of 12 V was connected with two fans for running the fans when in absence of electricity or insufficient sunshine during drying operation. The battery is charged by a controller through a solar panel. Performance of the solar powered vegetable seed dryer was evaluated with red amaranth and sweet gourd seeds. Modification of the dryer was done during September to November 2019 and a prototype fabricated (Fig.17). Dried seeds (moisture content of 7.0% on the wet basis) of red amaranth (7.95 kg) were used for evaluating the performance of the dryer during 30-31 January 2020. The dried seeds were wetted with water at 18% moisture content (wb). The dryer was tested for freshly harvested seeds of sweet gourd (616 g) collected from the Joydebpur Chourasta wholesale market, Gazipur during 24-25 June 2020.

Results and Discussion: Optimum drying temperatures for safe storage moisture content of red amaranth seeds and sweet guard seeds were determined. The moisture of red amaranth

Fig. 17. Isometric view of the solar cabinet dryer developed at BARI

was reduced from an initial moisture content of 18% to the final moisture content of 7.0% (wb) by the solar cabinet dryer in 8 hours of drying time. The average temperatures of the heater zone, bottom tray and upper tray were found to be 43.99°C, 42.70°C and 41.57°C and relative humidity (RH) at the said points were 44.00, 46.60 and 49.25%, respectively. The temperature in the heater zone was about 10 °C higher than the ambient temperature and RH was 25% lower than that of the ambient air. The moisture content of sweet guard seeds was reduced from 41.59% to 9.23% (wb) in 6 hours of drying period. The moisture content of seeds in bottom tray was 1.13% lower than that of upper tray. In total 2 kWh electric energy was used for drying of 616g moist (41.59%) sweet guard seeds for 6 hours. Electric energy was used for testing of dryer without load, ambient temperature increased and relative humidity decreased with exposure period. Temperature and inside the heater zone slightly increased up within one hour and later it was steady up to 41.2 °C which is suitable for drying of seeds. Average temperature in the heater zone was 10.4 °C higher and relative humidity was 31.1% lower than those of ambient. Solar energy was used for testing of dryer without load, drying air temperature of bottom tray was higher (1.21°C) than that of top trays but successive upper trays temperature was gradually little decreased. Temperature of all trays varied from 42.77 to 43.98°C which are suitable for drying of vegetable seeds. Two batches of training program of solar cabinet dryer among the farmers and seed growers was conducted at Srirumpur, Jibonnagar, Chuadanga on 17 June 2019 and RARS, Jashore 8 February 2020. Contract growers of The Metal Company, seed growers and farmers of Jashore showed interest in using the dryer. Two training programs for farmers, seed growers and seed companies were onducted. A booklet titled "Introduction and Use of BARI Solar Cabinet Dryer" was printed. Linkage between researcher and manufacturer were developed.

Conclusions: Drying of seeds in Bangladesh is normally carried out by the traditional sun drying method which is tedious and time-consuming and it often results in inferior quality due to dependence on weather conditions and vulnerability to contamination with insects, pests, dust and dirt. Seeds are often damaged due to continuos rains and high humidity. The eco-friendly cabinet solar dryer seed dryer designed and fabricated by agricultural engineers of BARI through this project offers an opprortunity for farmers and commercial growers of vegetable seeds to quickly dry their produce, prevent seed damage and increase incomes and profits.

20. Project Code and Title: TF 56-C/17. Collection and characterization of potential germplasm of rape seed-mustard and participatory salt tolerant short duration variety development for increasing cropping intensity in southern coastal Bangladesh

Implementing Organizations: Bangladesh Agricultural University (BAU), Mymensingh and Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Prof. Dr. Lutful Hasan, Dept. of Plant Breeding and Genetics, BAU

Locations: BAU, Mymensingh, BARI, Gazipur, and Bagherhat, Khulna, Barishal

Budget: Tk. 125 lakh

Duration: Jan 2018 to Mar 2021

Introduction: The Perspective Plan of Bangladesh (PPB) for 2010-21 aimed at increasing the production of domestic oil seeds for providing the population with 40 g/person/day (14.6 kg/yr) of edible oil. As per PPB, the estimated demand for edible oil would be 24.91 lakh tons by the year 2021 whereas the domestic production of edible oil is only 2.19 lakh tons per annum on an average, necessitating the import of around 12.90 lakh tons yearly. Twenty-eight Brassica varieties developed by different institutions are mostly suited to favorable environments in Bangladesh, but marginal lands like the coastal saline lands remaining idle or underutilized may be used to grow mustard to increase oilseed production in the country. However, for mustard cultivation in the coastal saline zone, salt tolerant varieties are required. Some tolerant genotypes are available at BAU and BARI which can be used to develop new varieties suitable for growing in the coastal area. This project attempts to address the issues of development and adoption of salt tolerant rapeseed and mustard varieties in the coastal region of Bangladesh.

Objective: To develop high-yielding, short-duration, salt tolerant rapeseed mustard varieties and disseminate improved cultivation technologies among farmers in the southern coastal region of Bangladesh.

Materials and Methods: The project was implemented in 27 upazilas of five districts in the southern coastal zone of Bangladesh. A total of 1620 beneficiary farmers were selected in these upazilas. Twenty-five potential rapeseed mustard genotypes were screened at BAU for salt tolerance, 5 genotypes were selected. Yield performance of the 5 selected genotypes was studied at BAU field laboratories. Yield and yield contributing characters were recorded and analyzed. Pot culture experiments were conducted with the 5 selected genotypes to investigate the effect of different salinity levels (6, 8, 10 and 12 dS/m) on seed yield and yield contributing characters of. Training camps were organized for the participating farmers of the projects areas to train them on the aim of the project work, ways and means of better livelihood, effect of salinity on crop rpoduction and improved cultivation technologies for salt tolerant, high- yielding and short-duration mustard. The seeds of already developed advanced lines were multiplied at the Genetics and Plant Breeding experimental farm of BAU and at the BARI research farm, Gazipur.

Results and Discussion:

Development of salt tolerant rapeseed mustard varieties

Out of the 25 local and exotic genotypes of rapeseed mustard, 5 advanced promising genotypes namely, BD-6950, BD-7104, BD-10115, Jun-536 and BJDH-12were selected for further evaluation as salt potential salt tolerant varieties. The selected genotypes were evaluated for determining genetic divergence at molecular level based on SSR marker. Genetic divergence was found among the studied genotypes, olecular analysis revealed diversity among these genotypes in different locii related to salinity tolerance. The genotype BD-6950 gave the highest seed yield (2197.92 kg/ha) followed by BD-7104 (2190.42 kg/ha) and BD-10115 (2121.08 kg/ha), outyielding the check variety, BARI sarisha-14, by about 30%. Soil salinity affected yield components and yield of the rapeseed genotypes to various extents. In general, plant height, number of secondary branches, length of primary branches and leaf area, 1000 seed weight, 1000 seed weight and seed yield per plant were negatively affected by soil salinity. The genotypes BD-6950, BD-7104 and Jun-536 performed better than the other to genotypes; especially BD-7104 showed better interaction performance compared to others in terms of days to first flowering, days to maturity, chlorophyll content, 1000 seed weight, seed yield per plant.

Principal component analysis (PCA) revealed that days to first flowering and days to maturity had contrasting association with other variables for salinity stress tolerance in genotype BD-7104 and BD-10115 at higher salinity levels (8 dS/m and 10 dS/m). BD-6950, BD-7104, BD-10115 and Jun-536 were identified as salt tolerant genotypes.

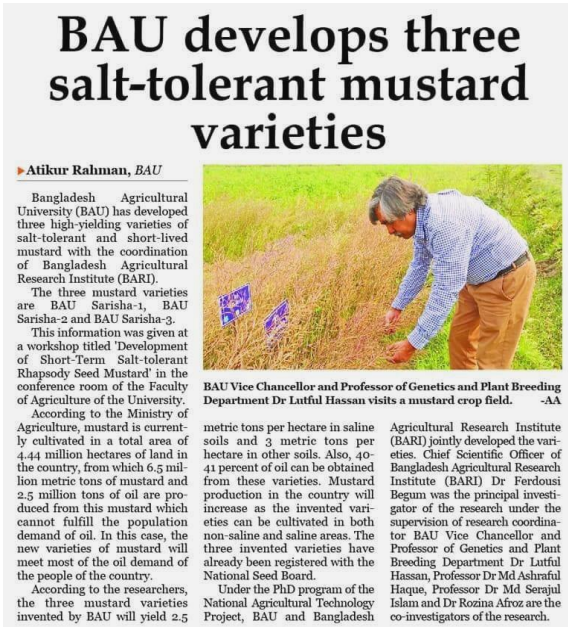
Reactive oxygen species (ROS) and scavenging role of antioxidants against salt stress were assessed at the BAU laboratory. Plants are endowed with H_2O_2 metabolizing enzymes such as catalases (CAT), ascorbic peroxidases (APX), peroxidases reductases (POD). These enzymes have scavenging role on reactive oxygen species (ROS) like H_2O_2. In this study, activity of APX and CAT showed minor genotypic variations in rapeseed mustard advanced breeding lines under various salinity stresses. Interestingly, activity of POD showed striking variation among five advanced breeding lines of rapeseed mustard. Activities of POD markedly increased in BD-6950 and BD-7104 genotypes at both 30 and 60 min after the treatment at 6EC indicating that these two genotypes have innate capacity to manage the activity of reactive oxygen species (ROS). Activities of POD also increased in BD-10115 and BJDH-12 at both 30 and 60 min after the treatment at the 8EC salinity level. In the saline susceptible variety BARI sarisha-14, the activity of POD did not differ between control and salinity stress.

In demonstration trials in 140 selected beneficiary farmers' fields of the project areas, the highest seed yield of 2355 kg/ha was obtained with genotype BD-6950. The 2nd and 3rd highest yields were 2335 and 2332 given by BD-7104 and BD- 10115, respectively. BD-6950 was also the earliest maturing genotype (86 days) followed closely by BD-7104 (88 days) and BD-10115 (91 days). All of these three lines may be considered early maturing. Overall, genotypes BD-6950, BD-7104 and BD-10115 were

found to be salt tolerant (able to complete their life cycle in 6 to 12 dS/m), high-yielding (30% higher yield than check variety BARI sarisha-14), medium staured (plant height 105 cm), having a growth duration (81 to 91 days) similar as that for the popular varieties and stable across the natural saline environment. These three newly developed genotypes can be grown in low-lying salt affected coastal areas and can be planted up to the 1st week of December. With these desirable attributes, these three genotypes were recommended for cultivation in the southern coastal saline region. The rapeseed genotypes, BD-6950, BD-7104 and BD-10115, were finally registered with the Seed Wing of the Ministry of Agricuture for release as new mustard varieties such as, BAU Sarisha-1, BAU Sarisha-2 and BAU Sarisha-3 (Fig. 18 and 19).

Income generation and farmers' response

In the base line survey it was observed that the selected beneficiary farmers grew T. Aman rice and local conventional mustard varieties which fetched a total gross return of Tk. 44538/ha. The adoption of newly developed salt-tolerant high-yielding rapeseed mustard genotypes replacing the traditional varieties increased the gross return to Tk. 52130/ha. Not only that, for lands where growing only a single crop (T. Aman rice) per year used to be the tradition, introduction of mustard as a second crop increased the cropping intensity to 200%. All participating farmers in the project areas as well as other farmers in general were satisfied with the performance of the newly introduced crop, mustard, following T. Aman rice opening up opportunities for increasing cropping intensity, land productivity and incomes. They expressed their willingness to grow the newly developed salt-tolerant high-ielding rapeseed mustard varieties in the Rabi season after T. Aman rice harvest.



BAU develops three salt-tolerant mustard varieties

▸**Atikur Rahman,** *BAU*

Bangladesh Agricultural University (BAU) has developed three high-yielding varieties of salt-tolerant and short-lived mustard with the coordination of Bangladesh Agricultural Research Institute (BARI).

The three mustard varieties are BAU Sarisha-1, BAU Sarisha-2 and BAU Sarisha-3.

This information was given at a workshop titled 'Development of Short-Term Salt-tolerant Rhapsody Seed Mustard' in the conference room of the Faculty of Agriculture of the University.

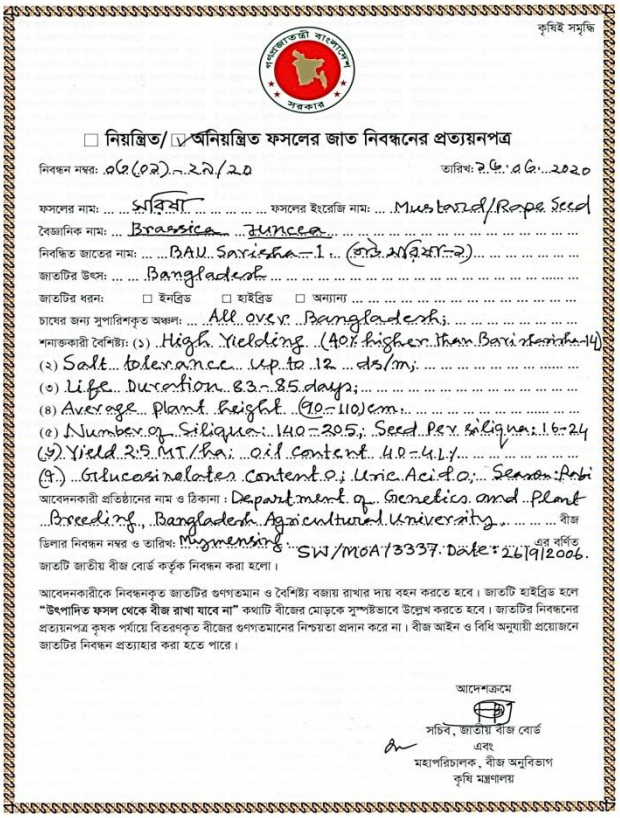
According to the Ministry of Agriculture, mustard is currently cultivated in a total area of 4.44 million hectares of land in the country, from which 6.5 million metric tons of mustard and 2.5 million tons of oil are produced from this mustard which cannot fulfill the population demand of oil. In this case, the new varieties of mustard will meet most of the oil demand of the people of the country.

According to the researchers, the three mustard varieties invented by BAU will yield 2.5 metric tons per hectare in saline soils and 3 metric tons per hectare in other soils. Also, 40-41 percent of oil can be obtained from these varieties. Mustard production in the country will increase as the invented varieties can be cultivated in both non-saline and saline areas. The three invented varieties have already been registered with the National Seed Board.

Under the PhD program of the National Agricultural Technology Project, BAU and Bangladesh Agricultural Research Institute (BARI) jointly developed the varieties. Chief Scientific Officer of Bangladesh Agricultural Research Institute (BARI) Dr Ferdousi Begum was the principal investigator of the research under the supervision of research coordinator BAU Vice Chancellor and Professor of Genetics and Plant Breeding Department Dr Lutful Hassan, Professor Dr Md Ashraful Haque, Professor Dr Md Serajul Islam and Dr Rozina Afroz are the co-investigators of the research.

BAU Vice Chancellor and Professor of Genetics and Plant Breeding Department Dr Lutful Hassan visits a mustard crop field. -AA

Fig. 18. Newspaper report on the release of three salt-tolerant mustard varieties developed by BAU



কৃষিই সমৃদ্ধি

☐ নিয়ন্ত্রিত/ ☑ অনিয়ন্ত্রিত ফসলের জাত নিবন্ধনের প্রত্যয়নপত্র

নিবন্ধন নম্বর: ০৫(০২)-২৯/২০ তারিখ: ২৬/০৫/2020

ফসলের নাম: সরিষা ফসলের ইংরেজি নাম: Mustard/Rape Seed

বৈজ্ঞানিক নাম: Brassica Juncea

নিবন্ধিত জাতের নাম: BAU Sarisha-1 (বাউ সরিষা-১)

জাতটির উৎস: Bangladesh

জাতটির ধরন: ☐ ইনব্রিড ☐ হাইব্রিড ☐ অন্যান্য

চাষের জন্য সুপারিশকৃত অঞ্চল: All over Bangladesh.

শনাক্তকারী বৈশিষ্ট্য: (১) High Yielding (40% higher than Bari sarisha-14)

(২) Salt tolerance up to 12 ds/m;

(৩) Life Duration 83-85 days;

(৪) Average Plant height (90-110) cm;

(৫) Number of Siliqua: 140-205; Seed per Siliqua: 16-24

(৬) Yield 2.5 MT/ha; Oil content 40-41%

(৭) Glucosinolates content 0; Uric Acid 0; Season: Rabi

আবেদনকারী প্রতিষ্ঠানের নাম ও ঠিকানা: Department of Genetics and Plant Breeding, Bangladesh Agricultural University. বীজ ডিলার নিবন্ধন নম্বর ও তারিখ: Mymensingh SW/MOA/3337. Date: 26/9/2006. এর বর্ণিত জাতটি জাতীয় বীজ বোর্ড কর্তৃক নিবন্ধন করা হলো।

আবেদনকারীকে নিবন্ধনকৃত জাতটির গুণগতমান ও বৈশিষ্ট্য বজায় রাখার দায় বহন করতে হবে। জাতটি হাইব্রিড হলে **"উৎপাদিত ফসল থেকে বীজ রাখা যাবে না"** কথাটি বীজের মোড়কে সুস্পষ্টভাবে উল্লেখ করতে হবে। জাতটির নিবন্ধনের প্রত্যয়নপত্র কৃষক পর্যায়ে বিতরণকৃত বীজের গুণগতমানের নিশ্চয়তা প্রদান করে না। বীজ আইন ও বিধি অনুযায়ী প্রয়োজনে জাতটির নিবন্ধন প্রত্যাহার করা হতে পারে।

আদেশক্রমে

সচিব, জাতীয় বীজ বোর্ড
এবং
মহাপরিচালক, বীজ অনুবিভাগ
কৃষি মন্ত্রণালয়

Fig. 19. Certificate of registration of BAU Sarisha-1as a new salt-tolerant mustard variety

Conclusions: This project researched the probability growing mustard as a second crop after monsoon rice in the salt-affected coastal region of Bangladesh. Through extensive laboratory and on-farm evaluation of local and exotic genotypes of rapeseed mustard, the project scientists succeeded in identifying and developing three short-duration, high-yielding genotypes with phenotypic and metabolic attributes enabling them to grow and yield well on moderately to strongly saline lands. These three genotypes have been ultimately released as new varieties of rapeseed mustard suitable for cultivation in the southern coastal zone. Growing these salt-tolerant mustard varieties as a second crop

after T. Aman rice in the cropping sequence would help increase land productivity and enhance farmers' incomes and minimize vulnerability of farmers to salinity stress in the unfavorable coastal ecosystem as well as contribute to a much needed boost in oil seed production in the country.

21. Project Code and Title: TF 57-C/17. Identification of resistant sources against gallmidge and development of tolerant advanced breeding lines

Implementing Organization: Bangladesh Rice Research Institute (BRRI), Gazipur

Principal Investigator: Dr. Moffazzel Hossain, PSO, Entomology Division, BRRI, Gazipur

Locations: Kapasia (Gazipur), Natore (Sadar), Kaharol (Dinajpur), Chunarughat (Habiganj), Sadar upazila (Cox's Bazar)

Budget: Tk.130.80 lakh

Duration: February 2018 to January 2021

Introduction: The rice gall midge, *Orseolia oryzae*, is a major dipteran pest of rice affecting most rice growing regions in Asia, Southeast Asia and Africa. In Bangladesh, gall midge incidence is more severe in the T. Aman rice season than in any other season. Gallmidge infestation is observed scatteredly all over the country at the vegetative stage of rice during the T. Aman season, but its incidence is endemic in the districts of Natore, Rajshahi, Dinajpur, Mymensingh, Netrakona, Gazipur, Tangail, Comilla, Brammanbaria, Sylhet, Chittagong Sherpur, Barisal and Cox's Bazar. To date, very little work has been done in Bangladesh on breeding for gall midge resistance and management of the pest. No resistant variety against gallmidge is available in Bangladesh except BRRI dhan33. Identification of a resistant source is a prerequisite for resistant variety development. This project emphasizes screening of a large number of rice cultivars for the identification of resistant sources that could be used in developing gallmidge resistant varieties.

Fig. 20. Gall midge affected rice plant with onion shoot/silver shoot symptoms

Objective: To identify gall midge biotype(s) available in Bangladesh and screen rice germplasm for resistant source(s) to develop high-yielding gall midge resistant rice varieties.

Materials and Methods: Suitable project sites were selected from five distinguish districts of Bangladesh. The facility of gallmidge (Gm) rearing house has improved. A total of 252 rice germplasm/varieties/lines were screened against Gm during the reporting period. Ten different groups of germplasm (e.g., BR cross materials/lines, IRBPHN (SVIN), IR materials, RYT, RYT1, RYT2, ZER, Local germplasms, BR(path), BR(bio), BR(Hybrid) and BRRI varieties were screened against rice Gm. In addition, the un-infested tillers were selected as breeding materials for further study. The resistant genotype(s) were rescued/removed from the infested tray and were grown in the field under normal condition to complete their life cycles. These genotype(s) were used in breeding program for hybridization between two parents, and Rapid Generation Advance (RGA) studies to develop high yielding Gm resistant line(s)/varieties. Validation experiments of Gm resistant sources/donors were conducted in the T. Aman, 2019 season in the Gm endemic areas especially at the five project sites viz., Kapasia (Gazipur), Natore Sadar), Sadar/Kaharol (Dinajpur), Chunarughat (Habiganj) and Cox's Bazar Sadar. The same experiments of Gm resistant donors were conducted again in T. Aman, 2020 season in Gm endemic areas (Gazipur, Natore, Pabna, Dinajpur, Gaibandha, Habiganj and Cox's Bazar based on survey information.

Results and Discussion: The facility of gallmidge rearing house has been improved. Out of 893 rice germplasm/entries, a total of 14 highly resistant (HR) including BRRI dhan33, 12 resistant (R), 8 moderately resistant (MR) and 8 moderately susceptible (MS) donor parents were identified during two and half years implementation of this project. In the year under report, out of the 82 BR cross materials, two lines, BR11035-4R-72, BR11035-4R-190, were recorded as HR and one line, BR11035-4R-135, as R. Another two entries (BR11033-4R-158 BRRI dhan74) were MR and only one (Habu Balam-RLR) was MS to Gm (Table 5). Out of 49 IRBPHN19 germplasms, IRBPHN19,R-1,S-4 was found HR against Gm. The remaining the test entries, i.e., IR materials, RYT, RYT1, RYT2, ZER, local germplasm, BR(path) and BR(bio) showed susceptible (S) to highly susceptible (HS) reactions against Gm. In the Gm screening program, BRRI dhan49 was used as the susceptible check and BRRI dhan33 as the resistant check, which was the only resistant source.

Fig. 21. Gallmidge rearing and screening house, Entomology Division, BRRI, Gazipur

Table 5. Screening of twelve different groups of germplasm against rice gall midge, July 2019 to June 2020)

Group	Total entries	Rice germplasm/variety	Tiller number	% onion shoot	Reaction
BR crosses	145	BR11035-4R-72	42	0.01	HR
		BR11035-4R-190	30	0.01	HR
		BR11035-4R-135	35	2.08	R
		BR11033-4R-158	31	6.90	MR
IRBPHN	49	IRBPHN19, R-1, S-4	20	0.01	HR
IR materials	3	Diff. entries		>50	HS
RYT	11	”			HS
RYT1	4	”			HS
RYT2	8	”			HS
ZER	7	”			HS
BR (bio)	2	”			HS
BR(Path)	3	”			HS
BR (Hybrid)	7	”			HS
BRRI Variety	10	BRRI Dhan74	15	10.37	MR
Local Variety	3	Habu Balam RLR	36	13.3	MS
Total	252				

BRRI plant breeders made 18 crosses with 8 breeding lines for Gm resistance, and developed 1229 F1 seeds. These crosses were confirmed as true F1s during T. Aman season 2019 and were advanced through the rapid generation advance (RGA) method (Fig. 22). Also the F2 plant populations were screened against Gm populations or biotype(s) and the following crosses were confirmed during the reporting period. These 10 crosses registered into BRRI cross list. Around 26200 F2 progenies will be grown in field RGA to advance the generations quickly.

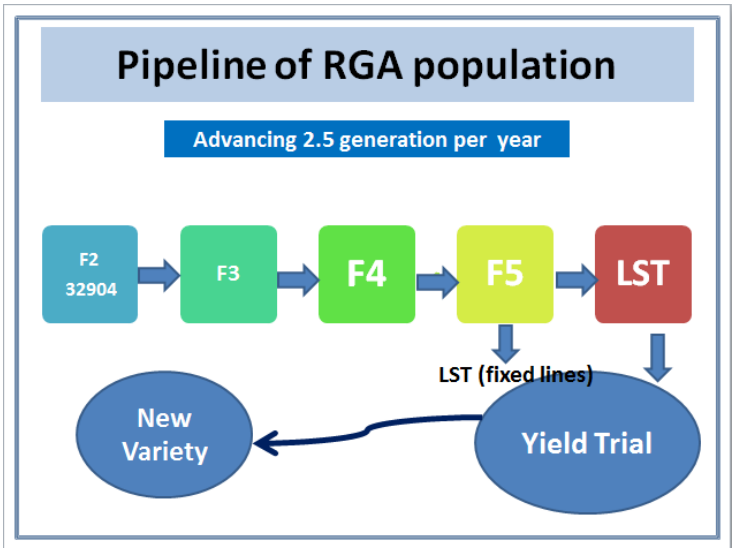


Fig. 22. Method for advancing generation through FRGA/RGA

Conclusions: The gall midge is a major dipteran pest that damages rice plants especially in the monsoon season (T. Aman) in Bangladesh. This project, through extensive surveys, identified the most affected areas of the country. A number of resistant germplasm/breeding lines have been identified through rigorous screening in the gall midge screening house and field trials. Using these genotypes as resistant sources, rice breeders are trying to develop varieties resistant to gall midge.

22. Project Code and Title: TF-58-C/17. Sustainable management of maize insect pests with special emphasis on the corn borer, the emerging species through innovative, participatory and collaborative research

Implementing Organization: Bangladesh Agricultural niversity (BAU), Mymensingh

Principal Investigator: Prof. Dr. Khandakar Shariful Islam, Dept. of Entomology, BAU, Mymensingh 2202

Locations: BAU, Mymensingh; Chuadanga, Gaibandha

Budget: Tk. 97.90 lakh

Duration: February 2018 to Mar 2021

Introduction: Maize is a unique crop because of its high nutritional value, versatile use and relatively low cost of production. This crop is gaining increasing popularity and government attention in Bangladesh for its high yield, high protein content and diverse use as a livestock and poultry feed and in bakery. Presently, the domestic production of maize can meet only 35-40% of the national requirement and the rest is imported at the expense of valuable hard currency. Insect pest infestation, however, is one of the major limiting factors constraining maize production in the country. Although a dozen major insect pests cause severe damage to maize, the corn earworm and the fall armyworm are especially becoming serious threats for the maize crop. This necessitates the development of eco-friendly IPM based pest control measures, which this project addresses.

Objective: Development, validation and scaling-up of IPM measures to manage maize insect pests in an eco-friendly way.

Materials and Methods: Incidences of maize pest complex and prevalence of natural regulatory forces in the ecosystem were studied in the project areas (Mymensingh, Chuadanga and Gaibandha) to assess the relationship between the maize pests and their natural enemies. Studies on the baseline toxicity of insecticides were conducted including two diamide products namely, clorantraniliprole (Coragen) and flubendiamide (Belt 25WG). Experiments on the effectiveness of cultural, mechanical means and efficacy of bio-rational measures and chemical pesticides on the management of major maize insect pests were conducted and some more are in progress to develop new IPM packages. Small scale farm level validation trials of different IPM technologies are planned for the Rabi 2019-20 season in farmers' fields in Mymensingh, Chuadanga and Gaibandha districts in collaboration with Department of Agriculture Extension (DAE). Up-scaling of developed technologies in farmers' fields of Chuadanga and Gaibandha through economic analysis of all the developed technologies will be done.

Fig. 23. Laboratory tests on the effect of various insect pests on maize and field evaluation of IPM packages

Results and Discussion: Intensive cropping, human intervention, and climate change are playing a role in increasing the insect population in maize, and among a dozen of major insect pests identified from different parts of the country, Corn Borer (CB) (*Helicoverpa zea*) and Fall Armyworm (FAW) (*Spodoptera frugiperda*) were found as emerging pests causing significant damage to the maize crop.

The treatment Thiamethoxam 20% + Chlorantraniliprole 20% @ 0.4g/L was found to be the most effective followed by Emamectin benzoate 5 SG @ 1g/L and Spinosad 45 SC 0.4 ml/L against CB and FAW. Bio-control agents such as entomopathogenic bacteria, fungus, viruses and parasitoid caused a significant reduction in CB and FAW infestations (P>0.1). The biopesticide HNPV @ 0.3 g/L and Bt @ 1.5 g/L showed better performance than the others resulting in 67.15% and 54.06% CB mortality, respectively.

A field trial with *Metarhizium anisopliae* @ 8 g/L against FAW showed 52.5% infestation reduction followed by SNPV @ 0.2g/L indicating these can be effective biological control agent of FAW (Table 6).

Table 6. Field evaluation of different microbial pesticides on the management of fall army warm, *Spodoptera frugiperda* at first vegetative stage at different time intervals during Robi season in sundarganj upazilla

Treat	Mean percentage of infested leaf at				Cumulative mean	Reduction (%) of infested leaf from control
	Before application	1 DAT	3 DAT	7 DAT		
T_0	32.24ab	33.44a	36.32a	41.16a	36.86a	
T_1	27.35c	25.17b	21.63cd	19.61cd	22.14c	39.95
T_2	28.81c	27.12b	25.65cd	23.76bc	25.51bc	30.80
T_3	30.41abc	29.62ab	28.67ab	26.42b	28.24b	23.40
T_4	33.59a	30.15a	18.86ab	15.42b	19.59b	52.02
Significance level	NS	*	***	***	**	
$LSD_{(0.05)}$	4.55423	4.99	4.90	5.27	5.98	
CV (%)	8.21	9.30	9.35	10.47	11.46	
SE	2.044	2.241	2.201	2.37	2.68	

In a column, means followed by different letters are significantly different; * 5% level of probability, ** 1% level of probability, *** 0.1% level of probability, NS= non-significant; DAT= days after treatment; T0= control, T1= nuclear polyhedrosis virus (Spodo-NPV) @ 0.2g/L, T2 = Bacillus thuringiensis (Bio-bit) @0.4g/L, T3= Beauveria bassiana (BABA) @ 1ml/L and T4= Metarhizium anisopliae (Green META) @8g/L

The parasitoid *Bracon hebetor* developed well in 4th and 5th instar larvae of the two species and its release against *H. zea* and *S. frugiperda* resulted in 54% and 45.3 % infestation reduction respectively which indicates it as a promising candidate for integrated pest management of these pests.

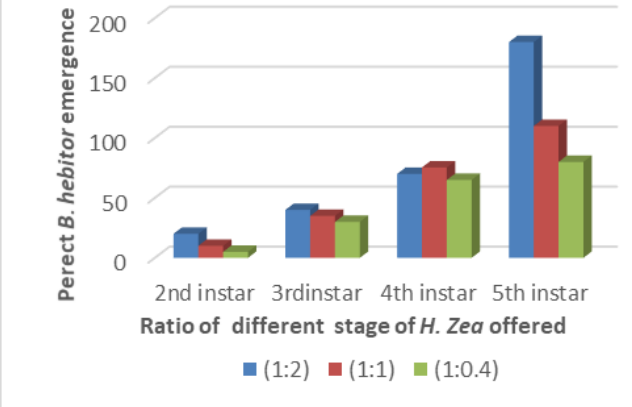


Fig. 24. The ovipositional preference of *Bracon hebetor* on different instars of corn borer, *Helicoverpa zea* in the laboratory at relative humidity 70-75% and temperature 25-30° C, IPM laboratory, Department of Entomology, BAU

Efficacy of new diamide insecticides viz., clorantraniliprole and emmamectin against FAW and their compatibility with *B. hebetor* in the laboratory and farm on the basis of mortality using LC_{50} values showed that the toxicity to the parasitoid was less within the mortality range of 31-37% and 26-30% respectively. The laboratory and field tests also indicated higher efficacy of the pesticide Virtako (thiamethoxam + chlorantraniliprole) and emmamectin benzoate against FAW as well as their less disruptive effect to natural enemies would be a better choice for integrated management of FAW in maize ecosystem of Bangladesh.

Validation tests of different IPM modules among the farm communities proved their acceptability due to their effectiveness in insect control as indicated by yield gains and relatively low cost involvement. As can be seen in Table 7, 25-47% increases in the yield of of healthy cobs were achieved by the use of different IPM packages with 13-58% less cost involvement.

Table 7. Economic analysis of bio-pesticide based IPM packages for maize

IPM package	% yield increase over Non-IPM	% reduction of pest mgt. cost from non-IPM
Clean cultivation (V2)+pheromone trap+ *Brancon hebitor* (V4_V6)	24.0-29.5	13.5-16.50
Variety+weeding (V2)+pPheromone trap + *Metrahizium* (V4_V6)	33.0-45.0	29.5-50.20
Emmamectin benzoate + lufenuron (V3, V6)	34.0-39.5	35.80-49.20
Variety+*Spinosad*	24.60-29.50	35.0-47.5
Habitat management +irrigation + *Bacillus thruringiensis* @ 1.5 g/L	28.00-32.50	30.5-35.5
Weeding + SNPV(V4_V6, R1)	25.8-31.5	13.0-16.21
ASEA + ETL based application of Volium Flexi/Virtako	35.5-47.0	31.5-58.50

The findings of the project were disseminated by training and field days at the Upazila Agriculture Training Centers in Alamdanga, Chuadanga and Dharmapur, Sundarganj and Gaibandha upazilas with the participation of more than 70 maize growing farmers, local elite, agricultural extension officials, NGO workers and input dealers. Two papers were presented at an international conference at ICRISAT, Hyderabad, India, which were published in IPPC proceedings.

Conclusions: The corn earworm and the Fall Army Worm (FAW) are becoming serious threats for the maize crop in Bangaldesh necessitating development of eco-friendly IPM based pest control measures. This project addresses the problem farmer participatory research on cultural, mechanical, bio-rational measures and chemical pesticides to develop new IPM packages for the control of major maize insect pests. The project work familiarized farmers with the harmful insect pests of maize, especially the cut worm, corn borer and FAW and new technologies for their management. The project continues to work for developing and fine tuning IPM measures to more effectively control the emerging insect pests of maize in Bangladesh.

23. Project Code and Title: TF-60-SBR/17. Improvement of agroforestry practices for better livelihood and environment in Charland area of the Tista River Basin

Implementing Organizations: Hajee Mohammad Danesh Science Technology University (HDSTU), Dinajpur and Rural Development Academy (RDA), Bogura

Principal Investigator: Prof. Dr. Md. Shafiqul, Bari Dept. of Agroforestry and Environment, HDSTU, Dinajpur

Locations: Kurigram, Gaibandha

Total budget: Tk. 49.00 lakh

Duration: Mar 2018 to Feb 2021

Introduction: Nilphamari and Rangpur districts of northern Bangladesh have vast *char* areas formed by the River Tista. During the pre- and post-monsoon seasons, scarcity of water becomes a big problem and restricts livelihood options available to the *char* inhabitants. Soil erosion and desertification, low soil fertility and productivity, low humidity and high air temperature are the major ecological problems in *char* areas. Char dwellers are very poor, yet they have to withstand extreme events such as, floods, droughts, storms, hail storms, char erosion, erratic rainfall, cold waves and climate variability off and on. Agriculture remains the only option for them to survive and sustain livelihood. Agroforestry may address the ecological problems in *char*s and improve livelihood of the inhabitants. This project attempts to introduce improved agroforestry production systems in the *char* areas of the Tista River Basin which may ensure sustainable environment friendly and climate resilient land use in the *char* areas.

Objective: Improvement of traditional and modern agroforestry systems practiced in farmlands and homesteads in the *char* areas of the Nilphamari and Rangpur districts of Bangladesh.

Materials and Methods: Several agro-forestry based experiments have been inintiated in Dimla upazila, Nilphamari and Gangachara upazila, Rangpur where the following systems are being tested: i) malta + chili, ii) moringa + maize, iii) gamar (tree) + sweet gourd, and iv) mango + potato. Baseline information was collected from 200 farmer households in *char* areas. Eight farmers were selected and different fruit (mango, guava, litchi and *malta*) and forest tree (mahogany and *gamari*) based agroforestry systems have been established. During the winter season, chili, potato, garlic, onion, red amaranth, maize, brinjal and sweet gourd are grown in an agroforestry-crop system.

Results and Discussion: Selected char lands have been surveyed in terms of demography, farmers' knowledge of agroforestry and communication status, plant diversity, etc. Eight new fruit and timber based agroforestry practices in different *char* lands are being tried and their economic and ecological benefits are being evaluated. Initial soil data in terms of physical, chemical, and biological characteristics have been collected. Plant biodiversity in char land is still less. Abundance of Eucalyptus tree is extreme. Fruit tree based agroforestry is promising in *char* areas. Some marketable vegetables like brinjal, cauliflower, okra can be successfully cultivated at the floor of the young malta, mango, litchi, guava, gamari and mehogony tree orchards/woodlots. Wider spacing for understorey vegetables/crops is recommended for less competition between crops and trees. Organic farming is possible in *char* land, but return is relatively low. New *char* land has low numbers of bacteria and fungus in soil compared with those in old *char* land. Farmers of *char* land who are using their land for agroforestry are etting more economic benefits than that farmers who practice mono-cropping of sweet gourd or chili or groundnut. Livelihood parameters of the selected char land farmers are being monitored and any changes due to the practice of agroforestry on their lands are being recorded. The Land Equivalent Ratios (LER) of the different *char* lands are being monitored.

Fig. 25. Litchi + taro in an agroforestry system on *char* land

Conclusions: Soil erosion and desertification, low soil fertility and productivity, low humidity and high air temperature are the major ecological problems in the *char* areas of the Rangpur and Nilphamari districts of Bangladesh. This project attempts to to address these problems introducing improved agroforestry which may help improve the ecological balance and ensure sustainable environment friendly and climate resilient land use in the *char* areas. Agroforestry is also seen as good agricultural enterprise to improve the the livelihood status of the poor *char* dwellers.

24. Project Code and Title: TF-61-C/17. Up-scaling of the rice-bean cropping system for increased yield, nutrients and soil productivity

Implementing Organization: BAU, Mymensingh

Principal Investigator: Prof. Dr. Md. Solaiman Ali Fakir, Dept. of Crop Botany, BAU, Mymensingh

Location: Field laboratory of the Crop Botany Department, BAU, Mymensingh

Total budget: Tk. 51.60 lakh

Duration: March 2018–February 2021

Introduction: Beans play an important role in crop rotation, maintaining soil organic matter, fertility and productivity through nitrogen fixation, but the long growth duration of most bean cultivars does not allow them to fit into the period between T. Aman and Boro, the two major rice growing seasons in the country. Short-duration vegetable legumes, such as, country bean, mungbean, cow pea, pea and French bean may be the suitable alternatives. Mature green seeds of French bean and country bean are popular in greater Chattogram and Sylhet areas, while tender young seeds of French bean have a high export market value. Lignosus bean, being non-conventional and wild in nature in Bangladesh, has very little or no pest or disease infestation/infection and its physiologically mature green seeds can be consumed as a vegetable which is excellent in taste and flavor with long shelf life. This project studies the

possibility of incorporating short duration vegetable legumes into the existing rice based cropping patterns.

Objective: To assess the feasibility of growing conventional and non-conventional vegetable bean species in a T. Aman-bean-Boro cropping pattern and to evaluate the improvement of soil fertility parameters.

Materials and Methods: An experiment was initiated in 2018 with a short-duration T. *Aman* rice variety (Binadhan-7) followed by beans (*Lignosus*-bean, French bean, dwarf cowpea, pea, soybean and mung bean) and Boro (Binadhan-14). Pre- and post-harvest soil samples were analyzed for organic C, Ca, Mg, P, S, Cu, Fe, Mn and Zn. In the first year of the project, experiments related to cultivation of T. Aman rice and beans in cropping patterns were conducted. Afterwards, validation trials in experimental fields and also in farmers' fields using the three best performing bean species were conducted. During July 2019-June 2020, beans and Boro rice were cultivated sequentially in experimental fields as well as in farmers'fields.

Fig. 26. Growing rice and bean in a T. Aman-bean-Boro sequence

Results and Discussion: In the experimental plots, the incorporation of pea in a T.Aman-bean-Boro sequence gave the best financial returns, followed by that of French bean, *felon*, mungbean and soybean. However, despite a high biomass yield, the pod yield obtained from *felon* or mungbean was negligible, so these beans were excluded from the validation trials in the farmers'fields.

During July 2019-June 2020, beans and Boro rice were cultivated sequentially in experimental fields as well as in farmers'fields. Unlike in the first year when T. Aman rice showed no significant variation in grain and straw yields among the three blocks, in the second year, significant variation in rice grain yield in Boro (4.52 to 6.32 t/ha) was observed. The highest Boro grain yield was observed in French bean plots with CFB (conventional fertilizer plus biofertilizer consortium) treatment (34.2% increase over control, i.e., no bean plots). After *Boro*, a short-duration T. Aman rice variety, Binadhan-7, was grown. The grain yield of Binadhan-7 varied between 3.92 and 5.69 t/ha under different treatment combinations. The highest rice grain yield increase was observed in *felon* plots with CF (conventional fertilizer) (26% increase over no bean plots).

In case of beans, species and fertilizer treatment both significantly influenced total pod and biomass yields. The total fresh biomass yield of bean ranged between 1 and 2 t/ha. As observed in the first year, soybean, French bean and pea were found to be best compatible with the two rice-and-one bean cropping pattern, whose pods could be safely harvested at physiological maturity before Bror rice transplanting, but the short time in between two rice crops was found to be insufficient for mung, lignosus beans and *felon* to mature and produce pods. *Felon*, although found unsuitable in terms of economic yield, gave the highest biomass yield among all the beans because of its heavy foliage. Unlike last year, CF was found to be the best fertilizer management option that increased plant biomass yield of *felon*, soybean or mungbean, but for French bean CFB, as found in the previous year was the best option. However, in terms of pod yield, CFM (conventional fertilizer plus micronutrients) was the best fertilizer manamgement practice for most beans.

Post-harvest soils analysis after each cropping season indicated an increase (ranged between 27.7% and 83.0% after Boro, and 1.8% and 58.2% after T. Aman) in soil organic carbon (SOC) in almost all bean plots compared with no bean plots. After Boro harvest, the highest SOC increase was observed in French bean plots with CFM treatment.

In farmer's field trials, after T. Aman the three promising beans (French bean, pea and soybean) that produced better pod and biomass in experimental plots were grown applying two fertilizer management schemes, one with CF and the other with CFB. There was a slight superior performance in both French bean and pea plots under CFB treatment compared with the CF. Surprisingly, no pod set was observed for the soybean in the farmers' fields, which needs further investigation.

After the completion of two years of the project, it was observed that apparently French bean, soybean and pea can be introduced in between T-Aman (short duration T. Aman variety such as, Binadhan-7) and Boro (late Boro like Binadhan-14) rice seasons. Introduction of these bean species not only increased the system productivity yield thereby increasing the annual return but also enhanced soil fertility.

Conclusions: Beans can be grown in a range of soil and climatic conditions and they can play an important role in crop rotation, maintaining soil organic matter, fertility and productivity through nitrogen fixation. However, the long growth duration of most bean cultivars does not allow them to fit into the period between T. Aman and Boro, the two major rice growing seasons in Bangladesh. This project demonstrated that short-duration legumes such as, French bean, soybean and pea can be introduced in between T-Aman (short duration T. Aman variety such as, Binadhan-7) and Boro (late Boro like Binadhan-14) rice seasons. The results were encouraging--introduction of these bean species not only increased the system productivity but also enhanced soil fertility.

25. Project Code and Title: TF 63-Char/17. Diffusion of innovative management practices for sustainable crop production in *char* lands of Bangladesh

Implementing Organization: Bangabandhu Sheikh Mujibur Rahman Agrcicultural University (BSMRAU)

Principal Investigator: Prof. Dr. Md. Safiul Islam Afrad, Dept. of Agricultural Extension and Rural Development, BSMRAU, Gazipur

Location: Field laboratory of the Crop Botany Department, BAU, Mymensingh

Total budget: Tk. 71.2115 lakh

Duration: November 2018 to November 2021

Introduction: *Chars*, with a total area of about 1,722 sq km in Bangladesh, are divided into five sub-areas: the Jamuna, the Ganges, the Padma, the Upper Meghna and the Lower Meghna rivers. There are other areas of riverine *char*s in Bangladesh, along the Old Brahmaputra and the Tista rivers, but compared with the *char*s in the major rivers, these constitute much less land area. *Char*s are vulnerable to erosion and floods. The sandbars remain unused and barren because of their infertile, sandy nature. Some proven technologies including organic amendments like biochar and household waste compost can be innovative practices for efficient utilization of the abandoned and

Fig. 27. *Char* land agriculture

underutilized *char* lands. Some crops like white gourd, bottle gourd, pumpkin, etc. can be grown profitably. These technologies need to be validated and disseminated for use in the *char* areas of Bangladesh.

Objective: To evaluate existing agricultural technologies and management practices and bring in new technologies for enhancement of productivity in *char* areas.

Materials and Methods: During the July 2019-June 2020 period, three sites were selected in Jamalpur Sadar, Sariakandi, Bogura and Kazipur, Sirajganj. Soil samples were collected from the three sites and analyzed for Zn, Mg, Ca and Cu and other nutrients. A benchmark survey was conducted on 150 respondents (50 from each location). The first famers' field trials were initiated with 54 participating farmers (18 farmers from each location) at the three project sites. Ninety farmers were trained on innovative soil and crop management practices at the three sites. The next year's field trials have been started at the three sites.

Results and Discussion: Baseline surveys indicated low cropping intensity, traditional crop production techniques in the *char* areas and poor socioeconomic profiles of the *char* dwellers. Chemical analysis indicated very low to medium levels of micronutrients in the *char* soils. Chemical fertilizers and organic amendments improved yield contributing characters and economic yields of different crops. As for example, in one field trial, fertilizers at recommended doses plus biochar as an organic amendment increased the yield of sweet potato to 43.4 t/ha from 36.1 t/ha with local farmers' traditional practice (Fig. 28). Other organic amendments also increased yield to various extents. Similar results were obtained with other crops such as, pumpkin and foxtail millet across *char*s.

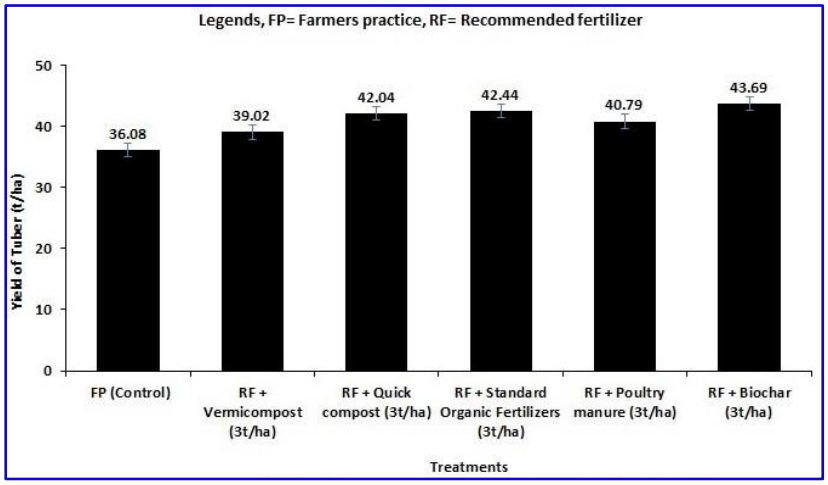


Fig. 28. Effect of fertilizers and organic amendments on the yield of sweet potato at Char Maijbari

Conclusions: Preliminary findings of the project indicated potential for improving crop yields in *char* areas with appropriate fertilizer application and addition of organic matter. Improving fertility of the soils may also possible with organic amendmends. There project is continuing for the validation of technologies suitable for the *char* lands.

26. Project Code and Title: TF-64-Fruit/17. Exploring and *in situ* development of under- utilized fruits to improve nutritional food security and livelihood of the poor communities of southern Bangladesh

Implementing Organization: Bangaldesh Agricultural University (BAU), Mymensingh

Principal Investigator: Prof. Dr. Md. Abdur Rahim, Department of Horticulture, BAU

Locatins: Bagherhat, Shatkhira, Khulna, Barisal and Patuakhali

Total budget: Tk. 34.99 lakh

Duration: January 2019 to December 2021

Introduction: In Bangladesh, many underutilized fruit trees grow without much care largely in homesteads, fallow and forest lands as well by the roadside and railway lines. These fruit trees are well adapted to the local climate, are nutritious and useful as herbal madicine and contribute to poverty

alleviation and household food security of rural people. Many tribal people are also dependent on such fruits and vegetables. Underutilized fruit trees like river ebony (*Diospyros peregrine*), velvet apple (*Diospyros discolor*), Cowa (*Garcinia cowa*) and ber (*Zizyphus mauritiana*), amlaki (*Phyllanthus emblica*) that grow naturally in the southern coastal zone protect the hinterland against natural disasters and balance the coastal ecosystem. Plantations of the underutilized fruit ber (*Ziziphus mauritiana* cv. BAU Kul 1) help reclaim coastal saline soils and also contribute to income generation for the poor people of the coastal region. Almost every year, Bangladesh faces floods and other natural disasters in about one third of its geographical area and people suffer food shortages and malnutrition. In the affected areas, underutilized fruit trees may contribute substantially as risk buffers ensuring household food and nutrition security. This research project aims to study the contributions of underutilized fruits to food security, nutrition, rural employment and women participation.

Objective: To assess and utilize under-utilized fruits for increasing production in southern and coastal areas of Bangladesh

Materials and Methods: Earlier, saplings of different targeted fruits grown at the BAU nursery were transferred to the project locations in different districts for plantation. A survey of underutilized fruit tree growers in Bagherhat, Shatkhira, Khulna, Barisal and Patuakhali was carried out. Ten growers were selected randomly from each district.

Results and Discussion: The maximum ratio of number of underutilized fruit trees to total land area was found in Bagherhat (11.6) and the lowest in Barishal (6.2). During the survey all the underutilized fruit trees belonging to each grower were counted. The highest number of underutilized fruit trees was found in Bagherhat (462) and the lowest in Patuakhali (182) (Fig. 29), while the species were almost the same in all districts (Table 8). In the survey it was found that fruit tree growers faced mainly three types of problems: (i) disease, (ii) insect and (iii) lack of management. The diseases were (i) leaf blight, (ii) leaf spot, (iii) fruit blight, (iv) leaf curl and (v) die back, and the insects were (i) mealy bug, (ii) caterpillar, (iii) fruit borer, (iv) ant and (v) leaf miner. Growers also faced a lot of post-harvest problems related mainly to (i) fruit abnormalities, (ii) shelf life, (iii) transport and (iv) storage.

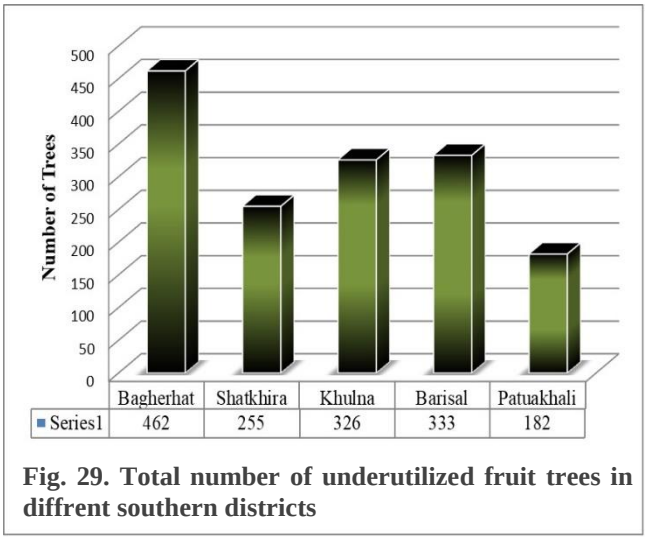


Fig. 29. Total number of underutilized fruit trees in diffrent southern districts

Some samples of leaves of *Bilati gab*, *sofeda* and *lotkon* showing symptoms of fungal disease were collected, causative fungi isolated and pure cultures prepared in different PDA media in petridishes. Three different fungal disease symptoms (Fig. 30) in *Bilati gab* leaves were noticed (a) whitish circular spots on green leaves, (b) black irregular spots on both sides of the leaves and (c) blight on leaves of *bilati gab*. The fungus is white in color and loose in texture. In sofeda, samples from leaves with two different fungal disease symptoms from (a) red circular spots with dark brown border on leaves and (b) white irregular spots with black color around. The fungus is white and also round in shape and the texture is loose.

Table 8. Species of underutilized fruit trees grown by farmers in differentsouthern districts of Bangladesh

District	Species of underutilized fruit trees
Bagherhat	Fig, Rever ebony, Hog Plum, Carambola, Anola, Olive, Elephant apple, Jamun, Longan, Bullock's Heart, Wax Jambu, Lime, Sapota, Hortoki, Karanda, Stone apple
Shatkhira	Fig, Hog Plum, Carambola, Anola, Longan, Wax Jambu, Lime, Sapota, Cowa, Monkey jack, Malay apple, Bilimbi, Tamarind, Pomegranate, Karanda
Khulna	Fig, Rever ebony, Hog Plum, Carambola, Anola, Olive, Elephant apple, Jamun, Longan, Bullock's Heart, Wax Jambu, Lime, Sapota, Stone apple, Tamarind, Rattan
Barisal	Fig, Rever ebony, Hog Plum, Carambola, Anola, Olive, Elephant apple, Jamun, Bullock's Heart, Wax Jambu, Lime, Sapota, Stone apple, Karanda, Custard apple, Rattan, Malay apple
Patuakhali	Rever ebony, Hog Plum, Carambola, Anola, Olive, Elephant apple, Wax Jambu, Lime, Sapota, Malay apple, Cowa, Pomegranate, Custard apple, Monkey jack, Tamarind

Samples from diseased leaves of lotkon with three symptoms from (a) blackish irregular spots, (b) blackblack spots at leaf tips and (c) yellowish coloration of the leaves were taken. The fungus is white in color and loose in texture. Morphological studies and molecular analysis will be performed to identify the fungi in the leaf samples collected from the three fruit species.

Fig. 30. Pure culture preparation of different fungi in diseased *Bilati gab* leaves

Conclusions: A survey of fruit trees in southern Bangaldesh showed that quite a large number of trees bearing various fruits reamain under-utilized, the number varying widely among districts. Fruit tree growers face three major problems such as, insect infestation, disease and lack of improved management techniques. The project scientists identified the major insects, symptoms of fumgal diseases in some important fruits. Work to identify the causative fungi is in progress.

27. Project Code and Title: TF 65-C/19. TF 65-C/19. **Post-harvest management, processing and marketing of jackfruits for loss reduction and value addition of jackfruit**

Implementing Organizations: Bangladesh Agricultural Research Institute (BARI), Gazipur and the NGO, New Vision Solutions Limited (NVSL), Dhaka

Principal Investigator: Dr. Md. Miaruddin, Chief Scientific Officer (CSO), Post Harvest Technology Division, BARI, Gazipur

Locations: BARI, Gazipur and 14 upazilas of 8 districts of Dhaka, Chattogram, Rajshahi and Mymensingh divisions

Total budget: Tk 248.68 lakh

Duration: May 2019 to January 2022

Introduction: Jackfruit (*Artocarpus heterophyllus* Lam.), the national fruit, is one of the most common, important and delicious fruits in Bangladesh. Both the pulp and seeds of ripe jackfruit are rich sources of carbohydrate, vitamins and minerals, and, thus, jackfruit is highly nutritious. Also, green jackfruit is popular in Bangladesh as a delicious vegetable dish. However, because of a lack of postharvest processing and management technologies, a staggering 30 - 35% loss of jackfruit occurs which costs about Tk. 500 crore per annum. With improved postharvest management and processing technologies to produce canned fruit, dried fruit and pulp, jackfruit jam, dehydrated jackfruit, chips, etc. and sound marketing this national fruit of Banglaesh can contribute significantly to the improvement of food security and income generation for the people and export earnings for the country. This project was designed to develop improved methods of postharvest management and processing technologies devise strategies and plans for profitable marketing of fresh and processed jackfruit products.

Objective: To develop a sustainable grower business model and strategic marketing plans for both fresh and processed jackfruit products.

Materials and Methods: Earlier, a baseline survey was conducted to evaluate the present status of jackfruit production, postharvest management and processing. Work on five value-added products (fresh-cut jackfruit, jackfruit chips, frozen jackfruits, dehydrated jackfruits and jackfruit jam) is in progress. Evaluation of the physiochemical properties of fresh cut jackfruit bulbs was conducted initially and at 2-day intervals for upto 6 days at different storage temperatures in terms of weight loss, external color and appearance of bulb and moisture, total soluble solid (TSS), total citric acid, ascorbic acid and carotenoids contents, microbial count and sensory characteristics was done. Processing parameters for jackfruit jam, attributes such as, color, flavor, moisture, water activity and taste, and total acidity, TSS, ascorbic acid and total carotenoid contents were evaluated.

A baseline survey of 727 jackfruit growers and 882 jackfruit intermediaries from 14 upazilas of 8 districts of Dhaka, Chittagong, Rajshahi and Mymensingh divisions was conducted.

Results and Discussion

A. Postharvest management and processing

The project research team is trying to develop high quality value-added products from jackfruits. Experiments on fresh-cut tender jackfruits stored in deep fridge using different treatment combinations are in progress and the experimental data on different parameters are being recorded. For standardization of processing, protocols for other products e.g. jackfruit chips, dehydrated jackfruit products have been developed on a trial basis and final experiments will be set up very soon.

Among the treatments for quality preservation of fresh-cut jackfruit bulbs after 6 days of storage, panelists gave the highest score (6.40) to treatment with 0.6% $CaCl_2$ and storage at 2±1°C for external appearance of bulb followed by (6.20) bulb treatment with 0.6% $CaCl_2$ and storage at 4±1°C. Similar trends were found for overall texture and flavor of jackfruit bulb. In case of overall acceptability after 6 days' storage, jackfruit bulb treatment with 0.6% $CaCl_2$ and storage at 2±1°C performed best with a score of 6.20. Panelists liked the treated the fresh-cut jackfruit bulb because of low tissue degra dation, fleshness of color and overall taste. This treated sample exhibited a total microbial count below the border line. This experiment will be repeated.

In the experiment on optimization of processing parameters for jackfruit jam, it was found that jam prepared using 10% lemon and 10% mango juice had acceptable nutritional quality and taste. However, most of the sensory attributes slightly changed throughout the storage period.

B. Jackfruit marketing

In the survey of jackfruit growers and marketing intermediaries in various upazilas, two types of jackfruit farmers in Bangladesh were found--homestead farmers who constituted the majority, i.e., 86% of the farmers surveyed and the remaining being jackfruit garden farmers. The major cost items in jackfruit farming are land, labor, inputs, fertilizers and pesticides. It was calculated that for the production of every 100 jackfruits a farmer/grower had to spend on an average Tk. 3,717, most of the expenditure being incurred due to land rent and labor. On an average, farmers had to spend Tk. 1,919 per 100 jackfruits for marketing. The estimated average total marketing costs of *bepari*, *foria*, wholesaler and retailer are Tk. 199, Tk. 158, Tk. 184 and Tk. 275. This analysis indicated that despite the highest marketing cost, the rate of return is also high, 11.80%, for jackfruit retailers compared with the other intermediaries. The *foria* and *bepari* earned 6% profit on their investments whereas the wholesalers gained 8.3%.

Fig. 31. Steps in the preparation of jackfruit jam (from top left to bottom right: Ripe fruit, de-seeding, blending, pulp making, jam preparation, sterilization of glass bottle in hot water, filling glass bottles with jam, storage of jam-containing glass bottles in ambient temperature

The survey revealed that approximately 43.94% of jackfruits, i.e., about 4.5 t went to waste every year, which was almost half of the total production.

Conclusions: The project work revealed that, with improved postharvest management and processing technologies, good quality, delicious and nutritious value-added products like canned fruit, dried fruit and pulp, jam, chips, etc. can be prepared from jackfruit, the national fruit of Bangladesh. This can reduce jackfruit wastage which is as high as 30-35% of the total production and contribute to the improvement of food security and income generation for the people and export earnings for the country. The project is continuing in an attempt to decelop improved methods of postharvest management and processing technologies and devise strategies and plans for profitable marketing of fresh and processed jackfruit products.

28. Project Code and Title: TF 66-C/19. On-farm validation and up-scaling of integrated pest and disease management packages for quality and safe country bean production in the Mymensingh region

Implementing Organization: Bangaldesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Dr. Md. Shahadath Hossain, Principal Scientific Officer, Entomology Section, Horticulture Research Center, BARI, Gazipur

Locations: Entomology Section, Horticulture Research Center, BARI, Gazipur

Total budget: Tk 122.16 lakh

Duration: April, 2019- March 2022

Introduction: In the Mymensingh region of Bangladesh, different vegetables, especially country bean (*Lablab purpureus* L. Sweet), are grown commercially as cash crops. Noldok, a famous bean variety of Bangladesh originating from the Sherpur district and some BARI released high-yielding varieties including summer country bean are cultivated commercially, but the bean yield is low and quality is poor due to insect and disease infestations. BARI, other research organizations and agricultural universities have developed a good number of integrated pest management (IPM) and integrated disease management (IDM) packages for safe and good quality country bean production, but these have not been properly disseminated among farmers through on-farm validation, refinement and demonstration especially in the Mymensingh region. This project seeks to disseminate and evaluate the performance of promising IPM and IDM packages.

Objective: To identify the best IPM and IDM packages for sustainable production of safe country beans in farmers' field conditions.

Materials and Methods: Farmers were given training on technologies of safe country bean production. Two experiments (i) On-farm validation of bio-rational integrated pest management (IPM) packages for quality and safe countrybean production and (ii) On-farm validation of bio-rational integrated disease management (IDM) packages for quality and safe countrybean production were conducted separately along with monitoring of insect and disease abundance during crop season in two upzilas of Mymensingh district (Mymensingh sadar and Nandail), two upzilas of Netrakona district (Durgapur and Kalmakanda) and two upzilas of Sherpur district (Nalitabari and Nakla) to reduce (1) yield losses caused by pests, (2) raise farmers' incomes, and (3) reduce environmental damage due to pesticides against major insect pests and disease of country bean following RCB design with ten replications (dispersed). Data on numbers of healthy and infested/infected plant, leaf, pod from whole plot were recorded weekly. Data were also recorded on the percent plant infestation/infection, leaf infestation/infection and pod damage (by visual estimation). Economic analysis was done, monetary returns were calculated on the basis of farm gate prices during November-March, 2019-20.

Results and Discussion

Insect pest control with IPM packages

The lowest aphid (2.71%) and pod borer (3.86%) infestations were recorded with the IPM measure consisiting of hand picking and destruction of infested flower/pods and shoot at 5-day intervals + installation of yellow sticky traps and sex pheromone trap + alternate spraying of azadirachtin (Phytomax) and Antario @ 1g/L of water at weekly intervals compared with maximum aphid (9.12%) and pod borer (9.98%) infestations in the untreated control plots. This IPM package also gave the highest average (mean of 6 locations) marketable yield of 21.7 t/ha compared with the yield of 17.0 t/ha from the farmers' practice and 14.9 t/ha achieved in the untreated control plots; this IPM package increased bean yield by 45.7% over the untreated control (Table 9).

Table 9. Effect of different IPM packages on marketable yield of country bean at different locations of Mymensingh division during the winter season, 2019-20

IPM package	Marketable yield (t/ha)						Avg. yield (t/ha)	% increase over control
	Mymensingh		Netrakona		Sherpur			
	Sadar	Nandail	Durgapur	Kalmakanda	Nakla	Nalitabari		
P_1	17.33ab	17.03b	18.62bc	19.12b	17.65b	18.75b	18.08	21.59
P_2	19.93a	20.23a	21.75a	22.56a	22.48a	22.98a	21.66	45.66
P_3	17.38b	16.80b	19.88ab	20.00b	18.38b	19.43b	18.65	25.42
P_4	16.25bc	15.88b	17.62bc	18.38b	16.50b	17.25bc	16.98	14.19
P_5	14.05c	13.28c	16.38c	16.13c	14.00c	15.38c	14.87	-
LS	**	**	**	*	**	**	-	
CV%	6.89	14.41	6.29	5.67	8.90	7.76	-	

(P1= hand picking and destruction of infested flower/pods and shoot at 5 days interval + installation of yellow sticky trap and sex pheromone trap + spraying of Azadirachtin (Phytomax) at weekly interval commencing from the first incidence; P2= Hand picking and destruction of infested flower/pods and shoot at 5 days interval + installation of yellow sticky trap and sex pheromone trap + alternate spraying of Azadirachtin (Phytomax) and Antario @ 1g/L of water at weekly interval; P3= Hand picking and destruction of infested flower/pods and shoot at 5 days interval + installation of yellow sticky trap and sex pheromone trap + alternate spraying of soap water @ 5g/L of water and Spinosad (Success 2.5SC) @1.25ml/L of water at weekly interval commencing from the first incidence, P4= (farmers' practice): Spraying of emamectin benzoate (Proclaim 5SG)+ spraying of chlorantraniliprole (Coragen) and P5= untreated control)

The marginal benefit cost ratio (MBCR) was the highest (11.08) for the P2 package compared with 4.73 for the farmers' practice.

Disease control with IDM packages

The lowest (9.70%) average *Cercospora* leaf spot disease infection was recorded for IDM package (P4) involving spraying of Amistertop325SC and Tilt250EC followed by the P1 package (11.01%) consisting of the application of Tricho-compost + seed treatment with Bordeux mixture + foliar spray of Tricho-leacete. On the contrary, the maximum *Cercospora* leaf spot disease infection (18.20%) was seen in the untreated control plots. The P4 and P1 IDM packages brought about reductions in the disease infection by 46.7% and 39.5%, respectively, from that in the untreated control plots. In case of the anthracnose disease, the lowest infection on an average (5.98%) was recorded for the P1 IDM (application of Tricho-compost + seed treatment with Bordeux mixture + foliar spray of Tricho-leacete) irrespective of location followed by package P4 (6.15%, spraying of Amistertop325SC and Tilt250EC). These packages reduced anthracnose infestation by 44.00% and 42.42%, respectively, from that in the untreated control plots showing an anthracnose disease infection of 10.68%. However, the different IDM packages were not found to be effective in significantly reducing the mosaic virus infections which might have been due to the seed-borne nature of this disease.

In terms of marketable yield of bean, the farmers' practice (spraying of Bavistin and Tilt) gave the best results (20.6t/ha) followed clodely by the P1 package (20.3 t/ha, application of Tricho-compost + seed treatment with Bordeux mixture + foliar spray of Tricho-leachate), while the lowest yield was acxhieved in the Untreated control plots.

Table 10. Effect of different IDM packages on marketable yield of country bean at different locations of Mymensigh division during the winter season, 2019-20

IDM package	Marketable yield (t/ha)						Avg. yield (t/ha)	% increase over control
	Mymensingh		Netrakona		Sherpur			
	Sadar	Nandail	Durgapur	Kalmakanda	Nakla	Nalitabri		
P_1	16.00b	15.32b	22.97a	22.50a	21.88a	23.31a	20.33	27.46
P_2	16.35b	16.13b	18.50b	18.25b	18.81b	18.50c	17.77	11.41
P_3	16.38b	15.62b	18.50b	19.25b	17.31b	17.43cd	17.42	9.22
P_4	21.75a	22.73a	21.00a	21.38a	16.50bc	20.40b	20.63	29.34
P_5	14.63b	14.70b	17.25b	18.25b	14.63c	16.25d	15.95	-
LS	**	**	**	**	**	**	-	
CV%	9.94	7.06	5.21	4.37	6.35	4.39	-	

P1= application of Tricho-compost in pit + seed treatment with Bordeaux mixture+ foliar spray of Tricho-leacete, P2 = applcation of rotten poultry refuse + seed treatment with Bordeaux mixture + alternate foliar spray of Amistertop325SC and Tilt250EC fungicides, P3=seed treatment with *Trichoderma harzianum* + application of Tricho-compost in pit + foliar spray of Tricho-leachete, P4 = farmers' practice (spraying of Amistertop325SC and Tilt250EC) and P5 = untreated control

Economic analysis for the different IDM packages revealed the highest MBCR of 10.53 for P_1 followed by 5.69 for P4.

Conclusions: The project so far has generated useful technical information on the integrated management measures for the control of insect pests and diseases of country bean in the Mymensingh region of Bangladesh. A few IPM and IDM packages appeared to be promising in the field validation trials of the project. The trials are being continued in an attempt to fine tune the technologies.

29. Project Code and Title: TF-67-C/19. Survey and integrated management of wilt and stem blight diseases of water melon

Implementing Organization: Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Dr. Md. Mahfuz Alam, Senior Scientific Officer, Plant Pathology Division, BARI, Gazipur

Locations: Different upazilas of nine major water melon growing districts of Bangladesh

Total budget: Tk 40 lakh

Duration: Oct 2019 to Oct 2022

Introduction: In Bangladesh, watermelon is cultivated in 11046 ha of land with an annual production of 2.49 lakh t. Two diseases, *Fusarium* wilt (FW) and gummy stem blight (GSB) seriously affect watermelon causing huge yield losses. The fungus *Fusarium oxysporum* f. sp. *niveum* is the causal agent of FW and *Didymella bryoniae* causes GSB. The wilt disease appears at different stages of plant growth from seedling to maturity and may even occur earlier to cause pre-emergence damping-off. Crown blight, leaf leasons, defoliation and fruit rot result from GSB infestation. This project was designed to develop integrated management practices consisting of the use pathogen-free seeds, selection of resistant varieties, spraying effective fungicides in the rhizosphere and foliar regions, increasing beneficial microbe populations and cultural practices against *Fusarium* wilt and gummy stem blight diseases of watermelon.

Objective: Survey, collection, isolation, preservation, pathogenecity tests of the pathogens of wilt and stem blight diseases of watermelon and development of integrated disease management (IDM) packages to control the diseases.

Materials and Methods: The project work entails: a) a field survey of deiseases of water melon in the fields of 4 major watermelon growing areas viz., Patuakhali, Chattogram, Noakhali, Bhola and Panchagar districts; in each district, 5 different locations and 10 commercial farmers fields was surveyed for the wilt and stem blight diseases, b) collection of samples of diseased roots, stems and leaves, c) collection of microbial isolates from these samples and their preservation for morphological studies, d) molecular identification of the pathogens carried out by DNA extraction, PCR analysis and nucleotide sequence analysis, e) seed health studies of commercial water melon varieties.

Results and Discussion: Among the 85 farmers' fields surveyed, 61 (71.76%) were found to be infected by FW and 34 by GSB. All the commercial water melon varieties and also advanced lines showed variable susceptibility to Fusarium wilt and GBD. The FW and GSB symptoms of water melon in farmers' fields varied in appearance and intensity (Fig. 32). So far more than 60 isolates have been collected from 142 samples of diseased roots, stems, and leaves of water melon, and pure cultures of those isolates are being maintained and preserved for future studies. Pathogenicity tests were performed for 9 isolates of *D. bryoniae* among which 7 isolates showed pathogenicity on detached leaves. In case of infection development, they showed difference in virulence. Out of 10 *Fusarium* sp. Isolates studied, only one was non-pathogenic to watermelon. Different isolates produced wilting symptoms on different dates.

Fig. 32. Leaf wilting (top) due to *Fusarium* wilt disease and petiole infection (bottom) due to gummy stem blight diseases of water melon

The morphologies of *F. oxysporum* and *Didymela bryoniae* showed variability among those isolates and indicated varying infection abilities. The colony color of *Fusarium* isolates showed huge variation in both case upper and lower surface on half Potato Dextrose Agar (PDA) plates. Mycelium spreading was mainly two types fluffy and flat and colony shape was regular and irregular. Some regular colonies showed tail like growth at the margin. The *Fusarium* isolates showed difference in colony growth on PDA, the colony diameters varying widely from 20 to 40 mm after 7 days of incubation. Isolates of *D. bryoniae* showed creamy white, white and milky white colony colors on PDA media. The reverse side color was light green to dark green. Both regular and irregular colony shapes were observed for the *D. bryoniae isolates*. Four type mycelial growth were observed on PDA after 7 days growth. The colony diameters varied widely after 7 days incubation on PDA.

DNAs of nine *Fusarium* and seven *D. bryoniae* isolates were extracted. For each isolate, two sets of 25µl PCR product werer amplified. In gel documentation, eight *Fusarium* and five *D. bryoniae* isolates produced bands.

In the seed health study, seed health status of five commercial varieties was tested. Among them, the variety "Sweet dragon" showed 100% germination and the lowest seed infection (13.33%). Both fungal and bacterial infections were observed in the commercial varieties. Fungi such as *Didymella bryoniae*, *Fusarium oxysporum* f.sp. nevium and other seed borne fungi were isolated from the incubated seeds of water melon and their cultures were maintained on PDA plates for the purpose of inoculation.

Conclusions: Prelminary findings of the project indicated substantial infestation of the *Fusarium* wilt and gummy stem blight diseases caused by fungi in water melon in different districts of Bangladesh. Morphological and molecular characterization of isolates of the causative agents continues. Virulent isolates are under experimentation for different studies and germplasms screening. Some promising lines of water melon have been selected which can be used for the development of resistant varieties in the future.

CGP Basic Research Projects

30. Project code andf title: BR 5- C/17. Identification and expression of heat tolerant genes at reproductive stage and their inheritance in wheat

Implementing Organization: Regional Wheat Research Centre (RWRC), BARI, Gazipur

Principal Investigator: Dr. Golam Faruq, PSO, RWRC, BARI, Gazipur

Locations: Gazipur, Dinajpur, Jashore, Rajshahi and Khagrachari

Budget: Tk. 199.98 lakh

Duration: Mar 2017 to Feb 2020

Introduction: High temperatures at the later growth stages are a key abiotic stress for wheat, the second major cereal crop in Bangladesh, which adversely affects a number of morpho-physiological processes during pollen development and grain filling and reduces grain yield. Genetic materials from wild crosses in the national wheat breeding programs of Bangladesh did not prove to be heat tolerant to desired level. Some intensive basic research is essential in this field, especially to elucidate the the presence of the major and candidate genes relevant to the tolerance of heat stress in wheat and their expression levels at critical wheat reproductive stages. It is also essential to understand the inheritance patterns of these genes. This research project, which integrates classical breeding and molecular techniques, aims to analyze information about the relevant genes, their expressions and inheritance patterns to help develop varieties tolerant of high temperatures.

Objective: Identifying the major heat tolerant genes and their expression analysis at reproductive stages in wheat and and development of early generation breeding materials for high temperature tolerance.

Materilas and Methods: In the first year of the project (2017-1820), 200 potential wheat genotypes were collected from different sources and 5 sets of these plant materials were readied for planting at 5 different locations, a) RWRC, BARI, Gazipur (Fig. 36), b) WRC, Nashipur, Dinajpur, c) RARS, BARI, Jashore, d) RWRC, Rajshahi, and e) Hill Agriculture Research Centre (HARC), Khagrachari, under two different growing conditions, i)irrigated and optimum sowing time (within 30th November), and ii) irrigated and late sowing (after 15th December). Wheat management practices recommended by WRC were followed. Sixty genotypes were selected based on their phenotypic markers in the wheat season of 2017-18. In the 2018-19 growing season, the same lines were grown again and their morpho-agronomic traits analyzed. A study on genetic diversity towards heat tolerance of 60 wheat genotypes was carried out in the experimental fields of different BARI regional stations. The mean data of each parameter from different stations were evaluated.

Results and Discussion: Sixty genotypes which were earlier selected at different locations in the last two wheat seasons based on their diversity analysis and phenotypic performances were screened by the thirteen different molecular markers (Fig. 33). Based on the molecular and field screening information a distinct crossing design was adopted in the 2019-2020 wheat season and several hundred F1s were obtained. Eight F2 families from 3 different targeted crosses raised in 2019-2020 wheat season were raised.

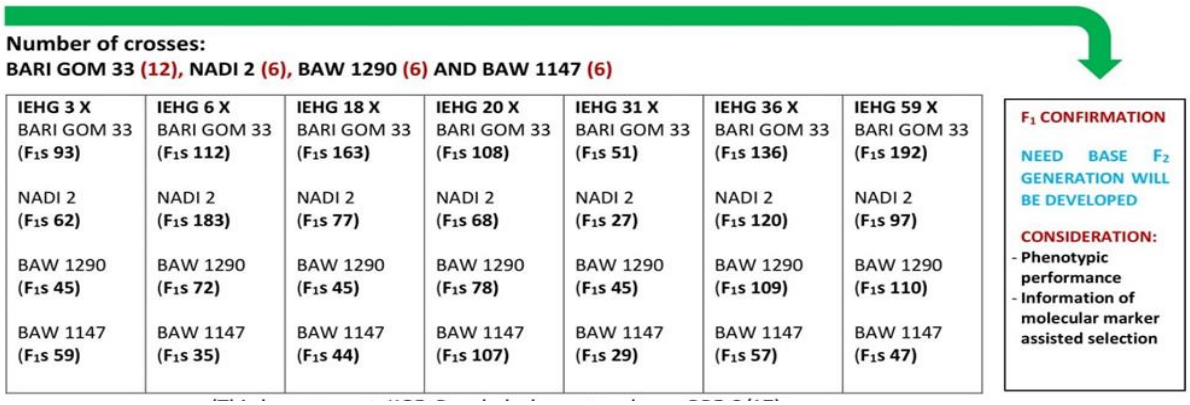


Fig. 33. Flow chart for obtaining F1s frommtarfeted crosses and F2 development

Conclusions: The project scientists identified, to date, six wheat genotypes as potential parents thrugh rigorous **f**ield and molecular screening for for different heat tolerant traits. A distinct breeding design as well as crossing plan was established using adaptable local cultivars and crosses were done which may be used in the development of much needed truly heat tolerant wheat varieties for growing in the rather short winter period in Bangladesh.

31. Project Code and Title: BR 8-C/17. PCR-based molecular characterization, fingerprinting and qtl analysis of salt, heat toletant and late blight resistant potato varieties

Implementing Organization: Bangladesh Agricuktural Research Institute (BARI), Gazipur

Principal Investigator: Dr. Md. Mosharraf Hossain, PSO, Tuber Crops Research Center (TCRC), BARI

Locations: BARI, Gazipur and Breeder Seed Production Center (BSPC), Debiganj

Budget: Tk.147.48 lakh

Duration: Mar 2017 to Feb 2022

Introduction: In Bangladesh, potato accounts for about 53% of the total edible vegetables. It has a great demand throughout the year, but production is concentrated during the months of January to March in Bangladesh. Biotic and abiotic stresses like soil salinity in the coastal region, high temperature, devastating diseases like late blight, etc. seriously affect potato production. Recently, TCRC, BARI has developed a few high yielding potato varieties like BARI Alu-46 and BARI Alu-53 (late blight resistant), BARI Alu-72 (heat and salt tolerant) and BARI Alu-73 (heat tolerant) with resistance to biotic and abiotic stresses. So far, genomic analysis of these varieties has not been done. Genomics studies using the chloroplast gene are very important. Moreover, use of molecular markers is of basic importance for the efficient exploration of a plant genome and to dissect quantitative traits.

Objective: To study the genetic makeup, genetic variation and phylogenetic relationships among potato varieties and locate the stress tolerant genes and genetic linkage QTL map

Materials and Methods: Heat tolerant (BARI Alu-72, 73), late blight resistant (BARI Alu-46, 53, 77) and susceptible potato varieties (BARI Alu-7, 8, 13 and 25) were used in this study. Protocols for chloroplast and chloroplast DNA (cpDNA) isolation were optimized. Chloroplast and cpDNA isolated

from BARI Alu-7, 25, 46, 72, 73 and 77 were tested using the NanoDrop Spectrophotometer 2000. The quality of cpDNA was tested through electrophoresis using cpDNA with 1% agaorse gel stained with ethidium bromide at 80v for 1 hr.

Results and Discussion: Bands in agarose gel revealed the presence of cpDNA. DNA isolated from BARI Alu- 46.53,72, 73 and 77 have been checked by NanoDrop Spectrophotometer 2000 (Table 11 and Fig. 34) and have been sent to Macrogen Co., South Korea to sequence the chloroplast genome.

Table 11: DNA quantification in heat tolerant potato genotypes by NanoDrop Spectrophotometer 2000

Sample ID	Nucleic acid (ng/µl)	260/280	260/230	Sample type
BARIAlu-46	1589.6	1.87	1.77	DNA
BARIAlu-53	1259.6	1.83	1.7	DNA
BARIAlu-72	1380.2	1.85	1.76	DNA
BARIAlu-73	3188.8	1.81	1.97	DNA
BARIAlu-77	2709.0	1.95	1.80	DNA

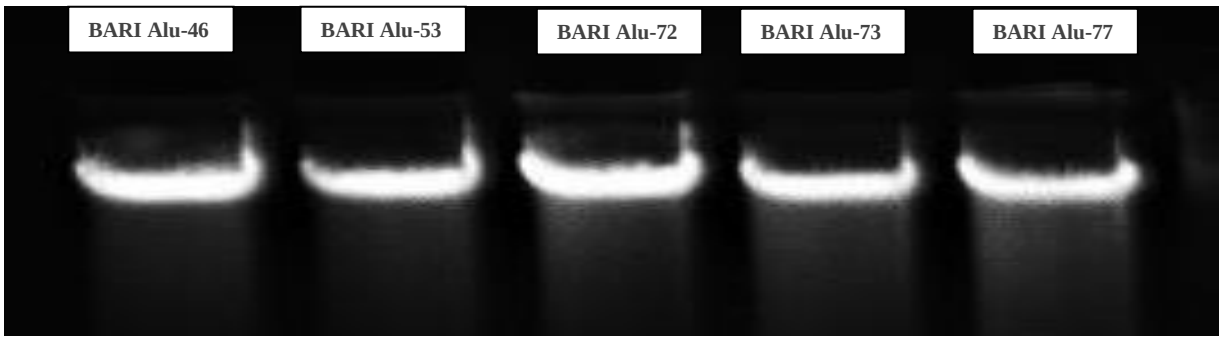


Fig. 34. DNA quality checking by gel electrophoresis

Bi-parental populations of heat tolerant (BARI Alu-72, 73) and late blight resistant (BARI Alu-46, 53, 77) potato varieties have been developed crossing with susceptible varieties (BARI Alu-7, 8, 13 and 25) for QTL mapping. Seventeen populations were developed through crossing between heat tolerant and late blight resistant potatoes. From each population, 250 lines have been developed. The late blight populations, TB08, TB10, TB17 and TB20 were planted at RARS, Rangpur on December 5, 2019. The plants were not sprayed with any fungicide to control late blight, they were unprotected. Only Admire was sprayed to prevent other diseases and insects. The lines showed a lot of variation in terms of late blight disease resistance. From the TB08 population, most lines were found susceptible to late blight. Only two lines (TB8-076 and TB8-079) showed good resistance. TB10-073, TB10-136, TB10-139 and TB10-162 showed moderate resistance to late blight. Resistance was measured by a susceptibility scale as well as rAUDPC. The rAUDPC will be used for QTL map development after genotyping with the SNP array to select resistance lines among the populations. Moreover, heat tolerant populations were planted at BSPC, Debiganj in the first week of December, 2019. Agronomic practices were followed properly according to TCRC recommendations except irrigation. Irrigation was stopped after 60 DAP to get crops wilted due to water scarcity/shortage. Before plant wilting other agronomic and yield data were taken. Watering was stopped for drought data recording, but due to heavy rainfall, wilting data recording was not possible. The tubers were harvested at full maturity. All the late blight resistant and heat tolerant lines will be planted in the 2020-21 crop season at BSPC, Debiganj and RARS, Rangpur.

Conclusions: Some promising late bight resistant and heat tolerant lines of potato have been developed which will undergo further laboratory evaluation and field tests in an attempt to breed stress tolerant potato.

4.1.3 Commissioned Research Program (CRP)

4.1.3A Completed Projects

31. Project Code and Title: CRP-1. Harnessing the potential of hill agriculture: Enhancing crop production through sustainable management of natural resources

Coordinator: Dr. Muhammad Nurul Alam, KGF

Locations: Bandarban, Khagrachari and Rangamati districts of the Chattogram Hill Tracts

Budget: Tk. 2141.2931 lakh

Duration: Oct 2013 to March 2020

Introduction: The Chattogram Hill Tracts (CHT), consisting of three hill districts, namely Bandarban, Khagrachari and Rangamati, situated in southeastern Bangladesh covers about 10% of the total land area of Bangladesh. This CHT region is composed mainly of hills and valleys. The traditional agricultural production system in CHT is the low-yielding, rather destructive slash-and-burn *"jhum"* system, a subsistence farming system practiced by the impoverished local farmers. The indigenous *jhum* system is a low-productivity, low-profit production system, but there is a great scope of enhancing land productivity and, thus, increasing local farmers' incomes and improving their livelihoods through interventions with suiable technologies. KGF initiated an interdisciplinary research and development program, "Harvesting the potential of hill agriculture: Enhancing crop production through sustainable management of natural resources" in 2013 in the CHT region to develop and disseminate suitable crop production technologies aiming at transforming subsistence farming in CHT into a market oriented agricultural production system. The program, which ended in early 2020, had five independent and interactive components: i) Watershed management, ii) Sustainable land management, iii) Technology development and delivery, iv) Entrepreneurship and value chain development, and v) Coordination and management support.Activities and achievements of these CRP-1 components in the final year, 2019-20 are presented in the following sections.

Component-I: Watershed management for sustainable agricultural production

Implementing Organization: Hill Agriculture Research Station (HARS), BARI, Khagrachari

Component Leader: Dr. Munshi Rashid Ahmed, CSO, HARS, BARI, Khagrachari

Locations: Selected watersheds in Bandarban Sadar, Rwangchari and Thanchi upazilas of Bandarban district; Khagrachari Sadar, Dighinala, Mahalchari, Ramgarh and Manikchari upazilas of Khagrachari district; Rangamati Sadar, Longodu and Kawkhali upazilas of Rangamati district

Budget: Tk. 555.6389 lakh

Duration: Oct 2013 to Mar 2020

Introduction: Most of the valleys in CHT are flat and broad where small streams, virgin forests and swamps can be found. The valleys and low hills are suitable for farming. Many streams in this region are silted up or have dried/disappeared as their watershed areas were improperly used in the past. Agricultural production in this region is seriously constrained by water scarcity throughout the year except a few monsoon months and severe soil erosion due to inappropriate farming practices. This

project studied the watershed characteristics and conditions and identified options of developing infrastructure and facilities to conserve surface water, harvest rainwater and harness runoff water to increase cropping intensity and water and land productivity in some selected areas of the three hill districts and also to improve supply of potable water for domestic use.

Objective: Infrastructure development and management of watersheds to augment surface water availability for irrigation of crops and domestic use.

Materials and Methods: Work included construction of RCC and earthen dams and resrvoirs, establishment of tube wells and irrigation water distribution systems at different locations. Studies on watershed characteristics were conducted including field surveys. Weather data on temperature, rainfall, humidity and evaporation were collected regularly.

Results and Discussion: Established three earthen dams at Cumilla tila, Noymile and Golakanapara in the Khagrachari district. Established three RCC submerged dams at Khagrabil, Ramgarh, Alutila, Matiranga and Ansar Camp, Sadar in the Khagrachari district. Constructed one culvert-cum-water retention structure at Perachara in the Khagrachari district. Established two rainwater harvesting reservoirs at Zero-Mile in Khagrachari and Balaghata in Bandarban district. Constructed one RCC water retention reservoir (Fig. 35) to collect water by diverting from the canal, supplied overhead tank and hose pipe for crop production at Halfchari, Rangamati. Established three deep tube wells and supplied overhead tanks and service pipes at Hafchari, Guimera; CDB, Matiranga and Eitchari, Sadar in Khagrachari Distributed 30 sets of pump with service pipes for crop production in three hill districts of CHT. Irrigation scheduling and water requirement of cabbage and tomato were Irrigation applied at the rate of IW/CPE= 0.8 for 10 days increased yield of the tomato variety, BARI Tomato-14 and the cabbage variety, Atlas 70. Delineation of 18 watersheds was completed and relevant maps and reports were prepared.

Fig. 35. RCC reservoir to preserve water for hill agriculture in CHT

Conclusions: The establishment dams and reservoirs and water supply systems will facilitate proper irrigation of crops in the dry season alleviating the problem of water scarcity throughout the year except a few monsoon months. The characterization and delineation of watersheds and the maps will be useful tools in irrigation and water management planning for crop agriculture in future in CHT.

Component-II: Sustainable land management

Implementing Organization: Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Sripur, Gazipur

Component Leader: Prof. Dr. A J M Sirajul Karim, Department of Soil Science, BSMRAU, Gazipur

Locations: Bandarban Sadar, Rwangchari and Thanchi upazilas of Bandarban district, Khagrachari Sadar, Dighinala, Mahalchari, Ramgarh and Manikchari upazilas of Khagrachari district and Rangamati Sadar, Longdu, and Kawkhali upazilas of Rangamati district

Budget: Tk. 388.452 lakh

Duration: Oct 2013 to Mar 2020

Introduction: The Chattogram Hill Tracts is very different from rest of the country in terms of physiography, soil conditions and agricultural practices. The productivity of hill soils is constrained by soil erosion, fertility depletion, strong acidity, inappropriate cropping and lack of proper management practices. *Jhum* cultivation is an age old, rainfed mixed crop cultivation method, practiced by the indigenous people on hill slopes of CHT. This shifting agriculture system involves the slash-and-burn clearing of large areas of the hillside. About 40,000 hill households are engaged in *jhum* cultivation in CHT. Traditionally, *jhum* has been practiced as a multi-crop system, where seed mixtures of assorted crops like rice, sesame, cotton, sweet gourd, marpha, etc. are dibble-sown in the field. However, at present 95-99% of *jhum* seed mixtures is rice. Soil fertility depletion is a major problem severely limiting the productivity of the *jhum* system. To restore soil fertility and increase the productivity of the *jhum* system, proper fertilizer doses and management are a must.

Fig. 36. *Jhum* farmers at work in CHT

Objective: Development of suitable fertilizer management practices for sustainable crop production on hill uplands

Materials and Methods: Thirty-two soil samples (16 disturbed and 16 undisturbed) were collected previously from two locations (Mrulongpara and Rameripara) of Bandarban district from two depths (0-15 cm and 15-30 cm) and from four spots of each location. The elevations of the four spots (1, 2, 3 and 4) from where the soil samples of Mrulongpara hill were collected were 1346 ft, 1330 ft, 1310 ft and 1284 ft, respectively, while the elevations of soil sampling for Rameripara hill were 1765 ft, 1745 ft, 1730 ft and 1710 ft, of the respective spots. The soil samples were analyzed at BSMRAU soil laboratories on chemical, physical and hydraulic properties of soils for 14 parameters of chemical properties (pH, OC, N, P, K, S, Ca, Mg, Fe, Mn, B, Zn, Cu and CEC) and 4 parameters of physical properties (texture, bulk density, particle density and porosity of soils) and hydraulic conductivity. Continuous *jhum* cultivation experiments were conducted on 10 hill slopes of Bandarban and Rangamati with the application of $N_{60}P_{20}K_{30}$ doses in 10 farmers' fields. NPK briquettes were used in the same doses in another experiment. Liming of soils with dolomite was done to increase soil pH to desirable levels.

Results and Discussion: Land management techniques for continuous crop production without fallowing in the *jhum* with the application of N60-P20-K30-S12 fertilizers or NPK briquettes by the dibbling method were developed. Cultivation of legumes (cowpea, yard long bean, country bean etc.) as relay crops to avoid fallowing was successfully tested and demonstrated to the *jhum* farmers. Soil liming with dolomite proved to be effective in sufficiently neutralizing strong soil acidity which substantially increased vegetable yields in the valleys. Several training sessions and field days were organised to train farmers, DAE and NGO workers. Booklet and leaflets were produced and distributed for technology dissemination.

Conclusions: Soil characterization in terms of physical and chemical properties and fertility will be of great help in fine tuning fertilizer doses and liming regime for various crops and cropping systems in the future. The introduction of relay legumes into the cropping patterns will improve productivity of the indigenous *jhum* system and increase hill farmers' incomes on the one hand and improve soil fertility and arrest soil erosion providing year round crop cover on the other.

Component-III: Development and delivery of intensive crop production technologies for hill agriculture

Implementing Organization: Bangladesh Agricultural Research Institute (BARI)

Component Leader: Dr. Mohammad Amin/Dr.Md.Khalilur Rahman Bhuyan, CSO, Regional Agricultural Research Station(RARS), BARI, Hathazari, Chattogram

Locations: Different upazilas of Bandarban, Khagrachari and Rangamati districts, and research stations at Bandarban, Khagrachari, Ramgarh and Hathazari

Budget: Tk. 724.9693 lakh

Duration: Oct 2013 to Mar 2020

Fig. 37. *Malta* production in CHT

Introduction: The CHT region has a good prospect of becoming agriculturally highly productive. In the harsh hill environment, *jhum* has been traditionally the major crop production system practiced by the indigenous people of CHT. With a view to improving the local production system, the present study was designed to improve the existing *jhum* cultivation system and develop and popularize suitable production systems. Research and development work on fruits, field crops including cotton, vegetables, spices, pest management, weed management was done hilly areas of the three CHT districts, Bandarban, Khagrachari and Rangamati.

Objective: To improve *jhum* system for enhancing production and reducing environmental degradation and to conduct strategic and applied research for developing appropriate crop production technologies suitable for uplands and valleys.

Materials and Methods: The BARI RARS, Hathazari unit of CRP Component-III continued the R&D work for six years involving fruits, field crops, vegetables, *jhum* cultivation, pest management, weed management and cotton development for CHT. Homestead gardens and orchards mango, litchi, banana, malta and papaya orchards, maize fields were established in three hill districts. Improved management practices for field crops, vegetables and fruit orchards were tested. The Modified Khagrachari Model for 12 BARI released vegetables and their production technologies were tested. The BSMRAU unit of Component-III established different winter vegetable fields with best weed management practices. An experiment was conducted in the three well established mango orchards with the best weed management practices. The SAU unit of Component-III established cabbage fields and brinjal fields with their best insect pest management practices as well as mango orchards in the three hill districts. Local land races (cereals, fruits and vegetables) were collected from the three CHT districts.

Progress: Improved management practices for mango and litchi resulting in higher and quality production in the existing orchards were developed. BARI Kola (Banana)-3, BARI Malta-1, BARI Dragon Fruit-1 and Red Lady Papaya showed good prospects for cultivation in CHT, which need to be piloted. The Modified Khagrachari Model for profitable homestead production of vegetables such as, BARI Shim-6, BARI Panikachu-2 and BARI Panikachu-6, BARI Lau-4, BARI Jharsheem-3, BARI Mishtikumra-1, BARI Borboti-1, teasle gourd, BARI Hybrid tomato-4, BARI Hybrid tomato-8 was developed and successfully tested. Integrated pest management (IPM) practices consisting of nappy trap+ clean cultivation+pesticide to control major insect pests of *jhum* crops were developed. One row cotton + two row rice configuration was identified as a viable planting configuration for intercropping. Improved *jhum* systems for rice (Cockroo), maize (BHM-9), cotton (CB-12), sesame (sada geisha), local pumpkin and marpha were developed. Forty-four (44) local landraces of 27 different crops like fruits, vegetables and cereals were collected from the three CHT districts. BARI RARS, Hathazari will preserve these in the germplasm bank and evaluate these in future research work.

Coclusions: This project developed and tested improved agronomic management practices for field crops, vegetables and fruit orchards which have the potentials to bring about substabtial crop productivity boosts in the CHT districts and enhance farmers' incomes. The development of the Modified Khagrachari Model of homeastead gardening with assorted vegetable species offer prospects of increasing small holder farm family incomes and also improve their nutrition levels through enhanced vegetable intake. The germplasm collected will be valuable in future R&D endeavors.

Component-IV: Entrepreneurship and value chain development for linking farmers with market

Implementing Organization: Bangladesh Agricultural Research Institute (BARI)

Component Leader: Dr. Md. Jamal Uddin, SSO, RARS, BARI, Hathazari, Chattogram

Locations: Different upazilas of Bandarban, Khagrachari, and Rangamati districts, and markets in Chattogram, Feni, Keranirhat and Dhaka

Budget: Tk. 124.6255 lakh

Duration: Oct 2013 to Mar 2020

Introduction: Agriculture in CHT can benefit from emerging market opportunities in the hill districts and outside CHT. Development of viable and sustainable value chain requires new relationships, networks, skills and coordination mechanisms to manage the flow of products among intermediaries and ensure that quality specifications are met. This project was planned and designed to assess, develop and upgrade existing supply/value chains of selected vegetables and fruits and linking hill farmers with markets, (ii) develop value added products using suitable post-harvest technologies and measure business performance, (iii) promote and develop entrepreneurship in agri-business for generating incomes for poverty alleviation in CHT, and (iv) follow up actions for entrepreneurs and value chain actors in CHT.

Objective: To promote and develop entrepreneurship in agri-business for generating income and reduction of poverty in CHT.

Materials and Methods: For entrepreneurship development in agri-business, the project scientists trained nursery groups for quality sapling production. The project team helped them get registered through DAE for nursery business. For value addition in mango and banana, fruit protection bags (brown paper bags) were supplied to the mango and banana farmer groups. Grower's organizations and farmers' marketing groups (FMG) were formed in the project areas, and the member growers/farmers trained on product quality maintenance, processing and value addition. Market linkages were established successfully through networking (setting up outlets) with local markets in CHT and also with external markets in Chattogram, Feni, Cumilla, Dhaka and Narshingdi. Value chain actors were trained up on different aspects of value chain development. A comprehensive socioeconomic study was carried out with a view to identifying the socio-economic impacts of the fruit bagging technology and value addition of mango at different locations of three hill districts namely, Chimbook, Dolopara and Meghla in Bandarban, Rangamati Sadar in Rangamati and Khagrachari Sadar, Panch Mile, Modhupur, Roapaya Para in Khagrachri.

Fig. 38. Bagging for safe and good quality fruits

Results and Discussion: Eleven fruit/vegetable growers' organizations were formed in Bandarban (9) and Rangamati (2) districts. The total targeted beneficiary households was 1018 in Bandarban and 200

in Rangamati. Moreover, hands on training was provided along with the distribution of 315 plastic crates for carrying produce and 95 BARI developed mango harvesters. Analysis of existing supply chain/value chains and upgrading of existing chains of selected fruits and vegetables in Bandarban and Rangamati were accomplished at 11 locations in Bandarban and Rangamati areas covering 330 sample farmers and 76 traders (*faria/bepari* 30, wholesalers 16, retailers 30) with a view to identifying post-harvest losses of the selected fruits (mango, litchi, jackfruit, banana and pineapple) and vegetables (yard long bean and teasle gourd. Five leaflets and two technology handouts were prepared and distributed. Two training manuals were developed.

Conclusions: This project helped develop value added products and upgrade existing supply/value chains of selected vegetables and fruits and linking hill farmers with markets and promoted and developed entrepreneurship in agri-business. This improved the prospects of raised incomes and profits of the largely impoverished hill farmers.

Component-V: Coordination and management support unit

Implementing Organization: Krishi Gobeshona Foundation (KGF), Dhaka

Objective: Coordinating and monitoring activities of 4 implementing components of CRP-1.

Achievements: One project inception workshop, one orientation and training workshop, nine coordination meetings, two PMC meetings and six annual progress review and planning workshops were organized. Farmers were trained in eight batches of training. A special evaluation was carried out by ICIMOD professionals.

32. Project Code and Title: CRP-III. Strengthening sugarcane research and development in the Chattogram Hill Tracts

Implementing Organization: Bangladesh Sugarcrop Research Institute (BSRI), Ishurdi, Pabna

Principal investigator: Dr. Amzad Hossain, Director General, BSRI, Ishurdi, Pabna

Locations: Khagrachari, Rangamati, Bandarban

Budget: Tk. 1026.86 lakh

Duration: Apr 2017 to Mar 2020

Introduction: Sugarcane does not flower in the larger parts of Bangladesh where it is usually grown. Sugarcane breeding is largely constrained by the non-flowering nature of the sugarcane genotypes maintained at the BSRI gramplasm bank. Of the 1100 clones in the BSRI germplasm bank, only 325 (29.54%) flower while the rest (70.45%) are non-flowering. Agro-climatic conditions of some parts of CHT present an excellent opportunity for sugarcane breeding, but but systematic research for adapting sugarcane to the hill region was not done in the past. For the first time BSRI started sugarcane R&D work in 2007 in three hill districts. It was very encouraging to find that some non-flowering varieties flowered at Bandarban and Kawkhali because of the close proximity of these two locations to the sea. Moreover, a huge number of *S. spontaneum* land races also flowered profusely in the natural environment of CHT. It was, thus, reasonable to expect that incorporation of *S. spontaneum* traits in future cane hybrids would add to stress tolerance, particularly against pest and disease. The ambient temperature and photoperiodic conditions in the southwestern part of Bandarban (Lama, Ali Kadam, Naikhangchari) and in Kawkhali of Rangamati of CHT favor sugarcane flowering. In the sugarcane mill zone the average yield of sugarcane is 50 t/ha whereas it was found to be more than double, i.e., over 100 t/ha in CHT. Also, disease and pest infestation in sugarcane is negligible in CHT in comparison with that in the sugar mill areas. This project sought to strengthen the research capability of BSRI and generate improved technologies including high- yielding varieties suitable for chewing and goor (molasses) manufacturing in the hill districts and establish sugarcane as a better alternative to the invasive tobacco in CHT.

Objective: Development of high-yielding disease resistant chewing and *goor* type sugarcane varieties suitable for growing in the Chittagong Hill Tracts.

Materials and Methods: The activities of the project were spread over nine upazilas of CHT include three upazilas of Bandarban (Bandarban Sadar, Lama and Rowangchari), two of Rangamati (Rangamati Sadar, and Kawhkali) and four of Khagrachari (Khagrachari Sadar, Dighinala, Panchari and Ramgarh). The construction of the crossing shed and fuzz processing building was completed. The existing photoperiod house (PH) at BSRI HQ, Ishurdi was renovated. Clones that are non-flowering at Ishurdi flowered at Bandarban. Crossing work was continued. Seedlings raised from pre-collected fuzz were transferred to fields. One germplasm plot with 160 clones was maintained at Lemujiri Para, Bandarban for making possible field and controlled crosses. Work on the development of high-yielding sugarcane clones was done and adaptive trials were conducted. Various Management practices for sugracane including time of planting, spacing, fertilizer application and intercropping with other crops were field tested with farmer participation. During the period under report, six adaptive trials were conducted in the three CHT project districts. The trials involved a) suitability assessment of chewing cane with intercrops and b) suitability assessment of *goor* cane with intercrops. Apart from this, sugarcane hybridization work, using the interim facilities developed at Bandarban, was continued with a view to developing varieties tolerant to pests and diseases.

Results and Discussion: Sixty clones that are of non-flowering nature at Ishurdi, flowered at Bandarban. Fifty-four bi-parented field crosses were made and in addition 6 clones selfed. The amount of fuzz obtained was 669 g that is currently being maintained in a freezer (-200^{0}C) at Bandarban prior to shipment to BSRI (Ishurdi) for further testing and field evaluation.

Trials conducted during the preceding seasons revealed superiority of BSRI Akh 42, BSRI Akh 41, Co 208 and China as chewing clones; and superiority of VMC 86-550, Ranangoan, Q 69 and BSRI Akh 41 as better *goor* cane varieties.

The Recommended Fertilizer Dose-2012 (RFD-2012) is being followed for sugarcane cultivation in CHT. Trials were set with 75%, 85%, 100% and 125% of RFD. Application of fertilizers @ 125% of RFD gave highest yield. Use of 125% of RFD was also found to be economically viable.

In the trials on suitability assessment for better ratooning potential of sugarcane, three sugarcane varieties viz., BSRI Akh 41, BSRI Akh 42 and VMC 86-550, were identified for ratooning of sugarcane. Among these, BSRI Akh 42 was found to be the most suitable one for ratooning in all the three hill districts. Other two varieties viz. BSRI Akh 41 and VMC 86-550 were also found to be good for ratooning in CHT.

Fig. 39. Sugarcane with soybean as a second intercrop

Sugarcane intercropping with high-value crop as second intercrop (after harvesting of the first intercrop) emerges as a profitable practice in Khagrachari region where soybean and lady's finger (okra) proved to be promising second intercrops (Fig. 39).

Physical facilities were created with KGF funding at Lemujiripara, Bandarban Sadar, Bandarban.

Conclusions: This project established that in the prevailing agro-climatic conditions in CHT, sugarcane along with assorted vegetables or legumes as intercrops can be grown profitably and the sugarcane system can agro-economically replace tobacco in CHT. A sugarcane breeding station has been established in Bandfarban which can facilitate the development of high-yielding disease resistant

chewing and *goor* type sugarcane varieties suitable for growing in CHT. The boost in the production of sugarcane and other crops along with sugarcane and production of sugarcane-based agro-products like *goor* can create employment opportunities for the hill people including women and enhance farmers' incomes.

4.1.3B Ongoing Projects

33. Project Code and Title: CRP-V. Development of upazila land suitability assessment and crop zoning system of Bangladesh

Implementing organization: BARC and Soil Resource Development Institute (SRDI)

Coordinator: Dr. Md. Aziz Zilani Chowdhury, Member Director (Crops), BARC

Locations: 300 upazilas of Bangladesh

Budget: Tk. 1742. 35 lakh

Duration: Jan 2017 to Dec 2021

Introduction: The agriculture sector of Bangladesh is facing various challenges like minimizing yield gaps, increasing resource use efficiency and developing resilience to climate change impacts. There is an urgent need to develop more efficient and sustainable agricultural production systems where the focus should be on identification of areas capable of producing high agricultural output and the areas where the soil and climate are best suitable for particular crop(s). Realizing the importance of proper utilization of agricultural land in the context of increasing food demand for the growing population, this project has been undertaken to assess the land potential for higher agricultural output under different crops/cropping patterns in selected upazilas of Bangladesh.

Objective: To update and validate land/crop suitability databases and create an online GIS based software to help design appropriate farming practices for sustainable agricultural and socio-economic development.

Materials and Methods: Two expert committees namely, (i) crop rules expert committee with 11 members, and (ii) socio-economic expert committee with 7 members were formed. The major roles and responsibilities of Committee (i) would be to prioritize crops to be selected for crop suitability analysis and identify bio-physical requirements of the selected crops. Land/soil parameters such as relief, soil consistency, soil moisture, soil drainage, soil reaction, soil texture, water recession, salinity along with climate and hydrologic parameters were assessed through crop rules (i.e. soil, climate, water requirements of crops)for determination of bio-physical suitability of crop(s). Three hundred upazilas for the crop zoning study were selected, soil surveys were done by SRDI. The methodology for land suitability assessment and crop zoning has been finalized. Eisting cropping pattern information by land type and AEZ was collected. Organizational focal points of BARI, BRRI, BINA and DAE were engaged with a view to establishing a platform for coordination among the major stakeholders for information sharing and dialogue relating to the issues toward development of an effective crop zoning system of Bangladesh.

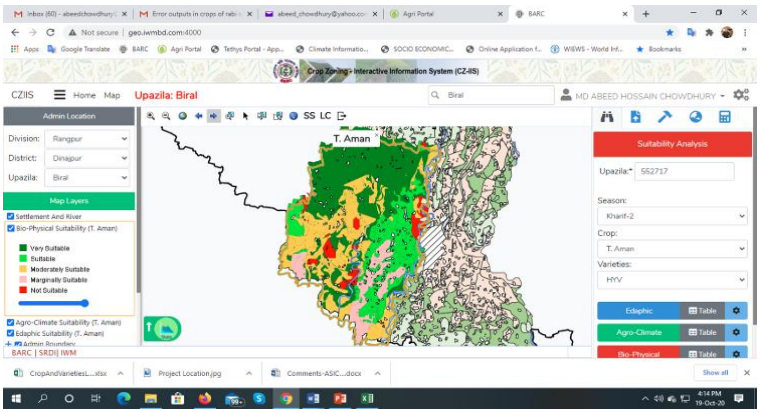


Fig. 40. The CZIIS software on crop zoning

Results and Discussion: An online GIS-based crop zoning interactive information system (CZIIS) software and related database have been developed for crop zoning and crop suitability delineation (http://geo.iwmbd.com:4000/). A mobile app "Khamari" has been developed for use by farmers and other stake holders, which can be downloaded from the Google Play Store. An agri-advisory web portal (http://geo.iwmbd.com:4001) has been developed to provide services and advice. Work on uploading soil fertility maps, agro-climatic maps, upazilla-wise cropping sequences data, etc. is in progress.

Conclusions: This project assesses the potential of land for higher agricultural output under different crops/cropping patterns in selected upazilas of Bangladesh and attempts to identify areas in the country capable of producing high agricultural output and the areas where the soil and climate are best suitable for particular crop(s). The database and farmer friendly software created by the project are expected to help develop more efficient and sustainable agricultural production systems in the country.

4.1.4 Capacity Enhancement Program (CEP)

4.1.4A Completed Project

34. Project Code and Title: CEP-III. Mitigating greenhouse gas (GHG) emissions from rice-based cropping systems through efficient fertilizer and water management

Implementing Organizations: Bangladesh Agricultural University (BAU), Mymensingh and Bangladesh Rice Research Institute (BRRI), Gazipur

Principal Investigators: BAU Component - Dr. Rafiqul Islam, Professor, Soil Science Division; BRRI Component - Dr. Jatish Chandra Biswas, CSO, Soil Science Division

Locations: BRRI and BAU

Budget: Tk. 88.0 lakh (BRRI) and 79.99 lakh (BAU)

Duration: Feb 2016 to Jan 2019 (BAU); Sep 2015 to Aug 2020 (BRRI)

Introduction: In Bangladesh, 80% of agricultural land is cropped to wetland rice which emits methane (CH_4) and nitrous oxide (N_2O), the two major GHG gases known to contribute to global warming. It is estimated that rice farming alone contributes 7.2% of total GHG emissions in Bangladesh. This estimate was made using default emission factors due to a lack of measured data. Fertilizer deep placement (FDP) is recognized as one of the best fertilizer management practices that saves N by 30% and increases rice yield by 15-20%. The alternate wet and dry (AWD) technology for irrigation is being promoted because it saves water by up to 38% and reduces costs. Although the government encourages both FDP and AWD technologies, their potential to mitigate GHG emission has not yet been fully measured. Research on GHG mitigation options, while increasing rice productivity, is crucial in the context of climate change (CC). This project assessed GHG emissions from rice-rice and rice nonrice cropping systems and studied the effectiveness of FDP and AWD technologies in reducing GHG emission from crop fields.

Objective: To quantify greenhouse gas (GHG) emissions from rice-based cropping systems and develop efficient nitrogen and water management technologies to minimize GHG emission.

Materials and Methods: Experiments were conducted to study the effects of N source and application methods on rice yield, nitrogen use efficiency (NUE) and to quantify ammonia (NH_3) volatilization, ammonium-N (NH_4^+-N) in floodwater, and emission of CH_4 gas under continuous standing water (CSW) and AWD irrigation regimes. Field experiments were conducted on rice under AWD and CSW conditions. Eight fertilization treatments with different N sources including integrated plant nutrient system (IPNS) based organic amendments were tested. Ordinary prilled urea (PU) and urea briquettes (UB) were the N fertilizers. PU was broadcast while UB was placed 7-10 cm below the soil surface (urea deep placement-UDP). Organic fertilizers, i.e., poultry litter (PL), vermicompost (VC) calculated on the basis of integrated plant nutrient system (IPNS) were used as the other treatments. Floodwater

samples were collected and NH_4^+-N content in them and ammonia (NH_3) volatilization from the rice field was measured. Measurements of the GHG emission from the rice field were made using standard methods.

Results and Discussion

Dynamics of NH_4^+-N and NH_3 volatilization in rice field

Results from Boro, T. Aus and T. Aman fields showed that broadcast PU and manure in rice fields produced higher NH_4-N in floodwater compared to UDP plots, which consequently caused higher N loss because ammonium present in floodwater is prone to losses through NH_3 volatilization and surface runoff. These results further confirm that the loss of N as NH3 volatilization will be within a week of urea broadcast, since ammonium-N in flood water was almost negligible after one week, irrespective of treatment. Ammonia volatilization varied among the N treatments (broadcast PU, UDP and PU+CD) under two cropping patterns (Boro-T. Aus-T. Aman and Mustard-Boro-T. Aman). The magnitude of NH_3 volatilization from the PU treatments (16.3 % of applied N) increased with increasing N rate and volatilization from the UDP treatment was negligible (0.45 % of applied N) irrespective of the N rate (Fig.41).

N_2O emission

Distinct emission peaks were observed after first, second and third topdressing of PU under AWD condition. Peaks of N_2O fluxes were observed for broadcast PU treatments after 2–7 days of topdressing. Some N_2O emission was also observed from the UB treatment. The N_2O fluxes among the treatments showed similar patterns during the fallow period for all the treatments indicating that there might be little residual N left in the fallow period (Fig. 42).

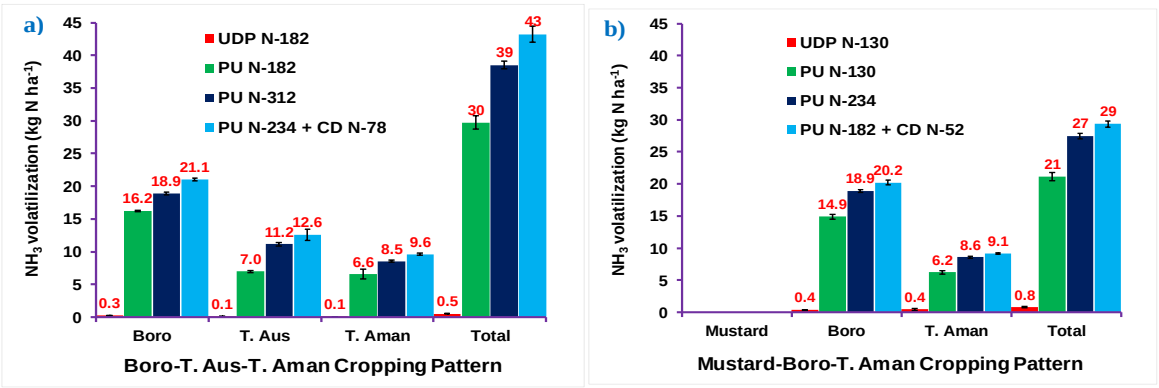
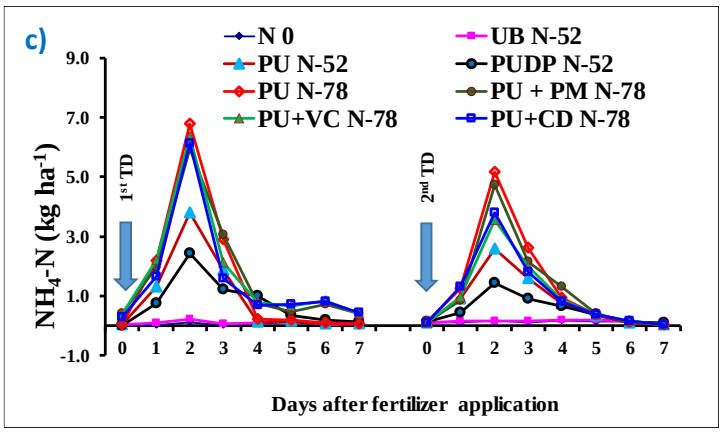


Fig. 41. Ammonia volatilization (kg N ha^{-1}) from crop fields in two cropping patterns (a. Boro-T.Aus –T.Aman) and b. Mustard-Boro-T.Aman) and under different N treatments during 2016-2019



UDP significantly reduced N_2O emission compared total total N_2O emission with broadcast PU. The total N loss as N_2O emission was about three times higher (833 g/ha/yr) in the broadcast PU treatment than UB treatment (254 g/ha/ya). The emission from the UDP plot was negligible and similar as that from the control plot. These results suggest lower GHG emissions (carbon dioxide equivalent, CO2 eq.) with UDP than with PU. The N_2O emission factors calculated for UB were 0.12, 0.14 and 0.17 in Boro, T. Aus and T. Aman rice, respectively and for PU these were 0.40, 0.46 and 0.55, respectively (Fig. 43).

CH_4 emission

The total CH_4 emissions in the Boro-T. Aus-T. Aman cropping pattern were estimated as 292, 385, 551 and 652 kg/ha/yr from control, UDP, PU and PU+CD plots, respectively (Fig. 44a), and in the mustard-Boro-T. Aman cropping pattern these figures were were 194, 266, 372 and 442 kg/ha/yr, respectively (Fig. 44b).

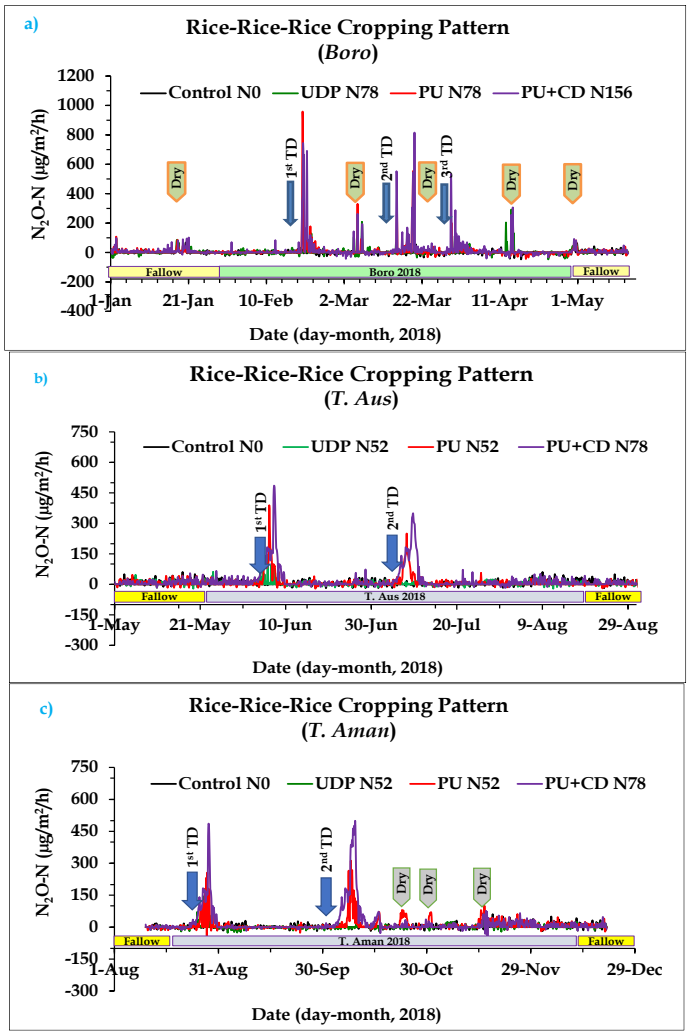


Fig. 42. N_2O fluxes (µgm^{-2} h^{-1}) from control (T1: N0), UDP (T2: N78), broadcast PU (T3: N78) and broadcast PU + CD (T8: N156) plots under AWD condition during a. Boro rice, b. T. Aus and c. T. Aman rice.

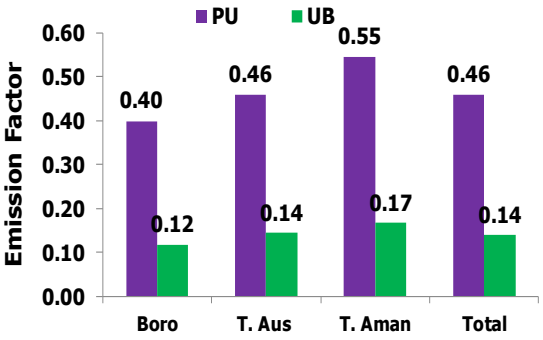


Fig. 43. N_2O emission factor in Boro, T.Aus and T.Aman rice (mean of three years)

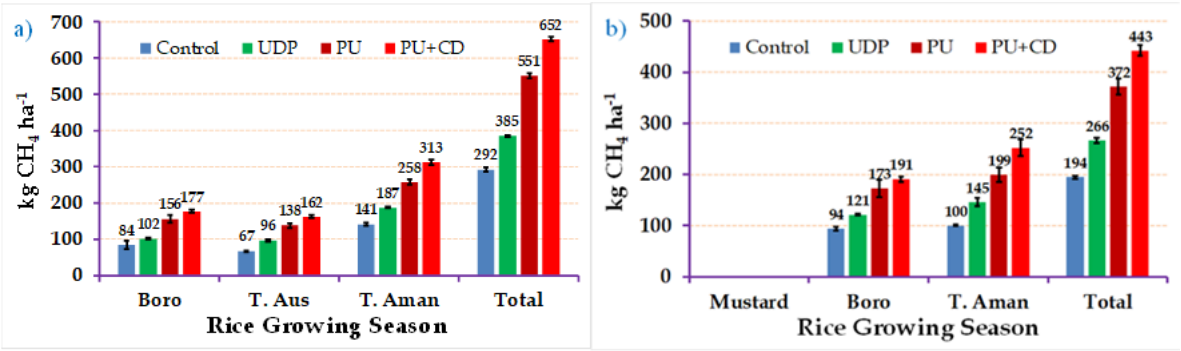


Fig. 44. CH_4 emissions from control, UDP, broadcast PU and broadcast PU+CD plots under two cropping patterns (a. Boro-T .Aus –T. Aman pattern and b. Mustard-Boro-T.Aman pattern) during 2016-201

The AWD irrigation regime for rice reduced CH_4 emission by around 10 % compared to the conventional continuous standing water (CSW) regime. UDP reduced GHG emissions compared to broadcast prilled urea (BPU). Ther emission factors for UDP in Boro, T. Aus and T. Aman rice was calculated to be 0.12, 0.14 and 0.17 and that for BPU to be 0.40, 0.46, and 0.55, respectively. Urea briquette (UB) deep placement reduced the use of prilled urea (PU) by 25%. UDP significantly reduced the amount of N in floodwater compared to BPU. Ammonia volatilization was negligible with UDP while volatilization from BPU treatments increased with increasing N fertilizer rate. Fertilizer response was similar between CSW and AWD water regimes. However, UDP either as PU or as UB increased rice yield by 3.99 - 31.20% over that obtained with PU. The reduction in GHG emissions (N_2O, CH_4) due to UDP and AWD practices would provide a good data set for carbon credits on the global carbon market. Therefore, UDP adoption should be promoted to achieve multiple benefits: Save N fertilizer, increase NUE and grain yields, and reduce losses of reactive N species to the environment.

In calculations of soil carbon dioxide equivalent (CO_2 eq) emission and carbon credit, it was estimated that, in the Boro season, the total CO_2 eq emission of CH_4 and N_2O gases under CSW at the BAU farm rice field were 2103, 2559 and 3953 kg/ha for T1 (control), T2 (UDP) and T3 (BPU) treatments, respectively, while under AWD, the figures were 1949, 2498 and 4235 kg/ha, respectively. The use of AWD water management reduced seasonal CO_2 eq emission by 0.28 t/ha and carbon credit by Tk 854/ha compared to CSW. The estimates for T. Aus were 1679, 2439 and 3546 kg/ha and for T. Aman 3540, 4697 and 6516 kg/ha, respectively. The US government has endorsed a 'central' estimate cost of $36 per ton of reduction of CO_2 eq from rice fields. Using this toll on carbon, the social cost of carbon (SCC) can be estimated by multiplying the reduction of CO_2 eq from 1 ha of land by area of the cultivated rice in a country (44,75,827 ha in Bangladesh) and may be claimed from the global carbon market. The estimated claims to the global carbon market due to adoption of AWD irrigation in Boro compared to CSW irrigation was Tk 3,821 million (Table 12). Similarly, adoption of UDP produced carbon credit of Tk 3,152 million in T. Aus and Tk 30,721 million in T. Aman compared to BPU.

Table 12. Average (2016 -2019) seasonal total GHG emissions in Boro and carbon credit estimation from different fertilizer treatments under different N fertilization and water management in Bangladesh

Treat	CSW			AWD			Carbon credit and claim due to AWD adoption		
	CH_4 (kg/ha)	N_2O (g/ha)	Total GHG (GWP) CO_2eq (kg/ha)	CH_4 (kg/ha)	N_2O (g/ha)	Total GHG (GWP) CO_2eq (kg/ha)	Carbon credit (t CO_2 eq reduction/ha)	Carbon credit (Tk/ha)	Total claimable amount (million Tk)
Control (N-0)	84	9	2103	77	46	1949	0.28	854	3,821
UDP (N-78)	102	40	2559	98	92	2498			
PU (N-78)	156	143	3953	164	311	4235			

Conclusions: This project, addressing the important issue of green house gas (GHG) emissions from crop fields, ended with some practically useful findings on crop, water and nitrogen fertilizer management to minimize the emissions. The use of alternate wetting and drying (AWD) method as an alternative to the conventional continuous standing water (CSW) method of irrigation and urea deep placement (UDP) instead of broadcasting of prilled urea (BPU) for wetland rice can minimize GHG emissions while maintaining crop productivity in rice-based cropping patterns. The estimated claims to the global carbon market due to adoption of AWD irrigation in Boro instead of CSW irrigation was Tk 3,821 million. Also, incorporation of mustard between T. Aman and Boro rice can reduce CH_4 emission compared with that in a yearly three-rice cropping pattern. The practices of AWD and UDP should be promoted to achieve multiple benefits in rice-based cropping patterns such as, saving nitrogen fertilizer, increasing nitrogen use efficiency and grain yields and minimizing the release of harmful GHG into the environment. Further research is needed throughout the country under diverse soil and environmental conditions for the calculation of default factors and claiming carbon credits from the global carbon market.

4.1.4B Ongoing Projects

35. Project code and title: CEP-I. Capacity enhancement of NARS through agricultural research management information system (ARMIS)

Implementing Organization: Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka

Principal Investigator: Dr. Md. Moslem Uddin Mia, Research Management Specialist

Locations: KGF, Dhaka, 13 NARS institutions and 5 public universities located in various parts of the country

Budget: Tk. 431 lakh

Duration: Jan 2018 to Dec 2021

Introduction: Timely availability and easy access to the agricultural research result/information are crucial for researchers both for enhancing efficiency in developing need based research proposals and for optimization of resource use. The role of ICT is prime in this respect as it enables instant access to the near-real time information for evaluating strengths and weaknesses of earlier work, identifying gaps, avoiding unnecessary repetition and, based on need analysis, beginning new research projects. The NARS institutions and the public universities have long been engaged in agricultural research, but the results and outcomes are scattered, not well organized and properly documented. Relevant information needs to be collected, organized and stored in a user friendly format so that research information can easily be retrieved by any interested person or organization and used as and when needed. In order to

develop a user friendly communication channel between the users and the information providers, BARC is implementing this project on agricultural research management information system (ARMIS).

Objective: Development and dissemination of ICT based research information.

Materials and Methods: The ARMIS project started in July 2013, was designed and implemented as an integrated online centric system in which information about research title, abstract, institution, researcher information, objectives, methodology, duration, major findings, keywords and so on are archived and can be used as per client need. Altogether, 25000 research entries from 250 sources were covered during Phase-I. The 2nd phase of the project started in 2019.

Results and Discussion: Since inception of Phase-II of the project, 1,670 new entries of research information were added to the databank. Up to March 2020, 19 hands-on training programs were completed at the institute levels and 455 users and focal points were trained. Linkages and active communications with 20 target organizations (NARS institutions and public universities) are being closely maintained to expedite data entries, editing and incorporation into the databank. The KGF web-site was redesigned adding a digital banner depicting the birth centenary of Bangabandhu Sheikh Mujibur Rahman. Updating of the ARMIS software to make them more user friendly is in progress.

Conclusions: This project collects, organizes and stores information on agricultural research and research findings in a user friendly format to facilitate timely availability and easy access for future researchers. The database being developed wil be useful in evaluating the strengths and weaknesses of earlier work, identifying gaps, avoiding unnecessary repetition and, based on need analysis, beginning new research projects.

36. Project Code and Title: CEP II. Capacity building for conducting adaptive trials on seaweed cultivation in coastal areas

Implementing Organizations: Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka and Bangladesh Agricutural Research Institute (BARI), Gazipur

Coordinator: Dr. Md. Aziz Zilani Chowdhury, Member-Director, Crops, BARC

Principal Investigators: BARI part: Dr. M. Akkas Ali, CSO, OFRD, BARI, Gazipur, (ii) BARC part: Dr. Kabir Uddin Ahmed, PSO, Planning and Evaluation, BARC

Locations: Cox's Bazar and Teknaf

Budget: Tk. 471.57 lakh

Duration: Jan 2018 to Sep 2021

Introduction: Seaweeds are a valuable marine resource. In many maritime countries seaweeds are used as human food items like sushi rolls, soups and stews, salads, etc. They are also useful in agriculture and horticulture as animal food, soil conditioners and manure, crop protectant against pests and diseases, and in industries as gums and chemicals. However, not much is known about seaweeds, their colletion from the Bay of Bengal and their utility and value in Bangladesh. Some people of Saint Martin's Island (SMI) and Nunia Chara, Cox's Bazar sporadically collect seaweeds from the sea shores nearby and sell them in the local markets. This project, dealing with the collection, characterization and processing of seaweeds, is being conducted in the southeastern coastal district of Cox's Bazar.

Objective: Developing techniques of seaweeds and their round the year cultivation and demonstration of their multipurpose uses.

Materials and Methods: In the previous years (1st and 2nd phases) project activities comprised collection of selected seaweeds from SMI and Inani Beach, cultivation and determination of nutritional quality of harvested seaweeds ensuring food quality and extraction of phycocolloids as sources of several industrial products including jam, jelly, chocolates, ice creams, etc. Indigenous seaweeds, *Hypnea börgesenii, Asparagopsis taxiformis, Chrysymenia agardhii* (reds), *C. racemosa* var. uvifera/furgusonii/chemnitzschia (greens), *Dictyota ciliolata/ robusta, Spatoglossum asperum,*

Dictyopteris australis, Sargassum flavicans/tenerrimum (browns) were collected from the St. Martin's Island (SMI), *Ulva linza* (green) from the Noapara on the west coast of the Naf river, *Gracilaria tenuistipitata* from Nuniachara sand-flat beside the Moheshkhali Channel, Cox's Bazar and *Ulva lactuca* (sea-lettuce) from Japan for adaptive trials. After successful completion of the 1st and 2nd phases of the project, and in view of the importance of seaweeds, a two-year 3rd phase, comprising adaptive trials on seaweed cultivation in coastal areas, was started in October 2019. Lunar cycle/full moon effect on the yield of the seaweed *Gracilaria tenuistipitata* var liui was evaluated at Nuniarchara, Cox's Bazar.

Results and Discussion: Seaweed yield may be increased by 10 to 15% if seeded 3 days before the full moon and harvested 3 days after the next full moon (24 days' field duration). Yield gradually increased from October 2019 to January 2020 with gradual increase in salinity and decrease of temperatures and turbidity. The green seaweed *Ulva lactuca* (sea lettuce) can be grown in open sea during January to March of the year. February is the best time to produce this seaweed. A performance study was conducted with *G. tenuistipitata* var. liui and *U. lactuca* in different areas along the coast of Cox's Bazar, and all the locations showed the possibility of large scale seaweed production. It is also possible to produce seaweeds in *ghers* (prawn producing ponds) with special management. Laboratory studies revealed that *Ulva lactuca* and *Gracilaria tenuistipitata* can grow *in vitro* under controlled conditions (Fig. 45). Preliminary trials are in progress for optimizing the procedure of agar extraction from *Gracilaria tenuistipitata*. Different seaweed recipes, e.g., seaweed pakora, soup, salad, jelly, etc. have been developed. Two fact sheets were developed regarding cultivation of seaweeds and post-harvest processing.

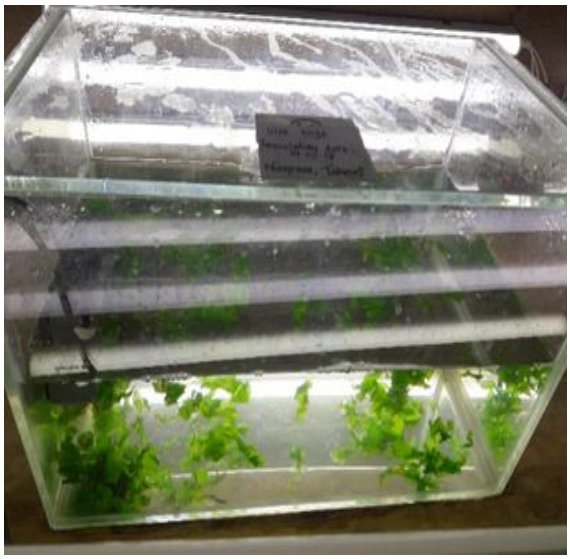


Fig. 45. Laboratory experiments on seaweed propagation

Conclusions: This project deals with a valuable and versatile natural resource—seaweeds available in the Bay of Bengal along the shoreline in southern Bangladesh. Practically and economically viable techniques of collecting seaweeds from the sea and cultivating them and using them as human food have been developed and work on fine tuning the techniques continues. Trials are in progress for optimizing the procedure of agar extraction from seaweeds like *Gracilaria tenuistipitata*. These findings hold promise for the commercial exploitation of a hitherto unutilized marine resource of the country.

4.1.5 International Collaborative Program (ICP)

4.1.5A Completed Project

37. Project Code and Title: ICP-I. Cropping system intensification in the salt affected coastal zones of Bangladesh and West Bengal, India

Implementing Organizations: Bangladesh Agricultural Research Institute (BARI); Bangladesh Rice Research Institute (BRRI); Khulna University; Institute of Water Modelling (IWM); Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia; ICAR-Central Soil Salinity Research Institute (CSSRI), Canning Town, West Bengal, India; Bidhan Chandra Krishi Viswavidyalaya (BCKV), Nadia, West Bengal, India; Tagore Society for Rural Development (TSRD), West Bengal, India

Principal Investigators (Bangladesh part): Dr. Md. Ansar Ali, Director (Research), BRRI, Gazipur and Dr. Abeda Khatun, Chief Scientific Officer and Head, Irrigation and Water Management Division, BARI, Gazipur

Locations (Bangladesh part): Dacope, Khulna and Amtali, Barguna

Duration: August 2016 to Jun 2020

Budget: Tk. 312.00 lakh

Introduction: The coastal zones of Bangladesh and West Bengal in India are home to millions of largely poor people, very vulnerable to the vagaries of nature. The people of the coastal zone depend mainly on agriculture, the productivity of which is low. Productivity constraints include prolonged water logging during the wet season, increasing soil salinity and the scarcity of low salinity irrigation water in the dry season. Thus, farmers primarily grow low-yielding late-maturing traditional varieties of rice during the wet season and much of the land lies fallow during the dry season. However, there are opportunities for intensification of cropping through efficient use and optimal management of fresh surface water and groundwater resources during the dry season, through improved polder water management, careful planning of the crop calendar, and improved agronomic practices that maximise water productivity. An international collaborative research project involving institutions from Bangaldesh, West Bengal (India) and Australia, with financial support from KGF and the Australian Centre for the International Agricultural Research (ACIAR), was initiated in the later half of the year 2016 which was aimed at increasing cropping intensity and productivity in the coastal areas through integrated soil, water and crop management.

Objective: To study salt and water dynamics and explore ways and means of cropping intensity in the coastal regions of Bangladesh and West Bengal, India.

Materials and Methods: There were four major activities of the project: (1) polder level water and salt balance modelling, surface water, groundwater and salinity interaction modeling, (2) conducting field experiments and demonstrations in farmers' fields, (3) Crop production modeling using Agricultural Production Systems sIMulator (APSIM), (4) study of socio-economic and community aspects of crop intensification. Field experiemnts involved the following braad areas:

- Selection of shorter duration, higher yielding T. Aman rice varieties for the wet season
- Growing vegetables after T. Aman rice
- Introduction of Aus and Boro rice and selection of suitable varieties
- Sowing dry season crops earlier (made possible by the shorter duration wet season crop)
- Crop diversification in the dry season with such crops as wheat, maize, barley, potato, garlic, tomato, garden peas, pumpkin, watermelon, mustard, sunflower, and other vegetable crops for their sowing time, salt tolerance, yield and profitability and overall suitability for the region
- Using several soil management techniques including zero tillage
- Use of different crop establishment techniques such as direct seeding, use of machinery, transplanting of seedlings, etc.
- Use of mulches to reduce soil evaporation and hence reduce salinity build-up in surface soil.
- Managing local canals and ponds to retain fresh water for use as irrigation in the dry season.

Results and Discussion

Outputs of the project over the last 4 years are summarized in the following:

- Introduction and evaluation of several high-yielding and early maturing newly released Aman rice varieties (BRRI dhan 53, 54, 66, 73, 76, 77, Bina dhan 7) in the farmers' fields.

- Introduced Aus and Boro rice in the project area which proved to be a good option for increasing crop intensification in the coastal zones.
- Rabi crops such as, wheat, maize, sunflower, potato, garlic, mustard, tomato, garden peas, pumpkin, watermelon, barley, and other vegetable crops were field tested. Among them zero tillage potato beame popular among the farmers rapidly. Farmers also found sunflower, maize, garden pea and spinach to be suitable and profitable.
- Several agro-economically suitable and profitable cropping patterns emerged from the project research work suchs, sunflower-rice-rice (Rabi-Kharif I-Kharif II), potato-rice-rice, maize-rice-rice, pumpkin-rice-rice, etc.
- Available water resources have been mapped and their volumes quantified and quakity assessed; farmers learned about storing freshwater in ponds and canals for crop irrigation in the dry season. Community-based water user groups were formed to equitably share the water resources in canals. The critical importance of rapid drainage of land after heavy rainfalls to facilitate Rabi crop establishment at the optimum time.
- A salt and water balance model and a detailed surface water, groundwater and salinity interaction model for the polders have been developed. These models have been used to analyse the impact of climate change and devise management strategies for cropping intensification.
- A new method has been developed for determining the combined impact of salinity and soil water content on the solute potential of the soil water of soils in the Ganges-Bramaputra Delta. The method is being used to modify factors in the APSIM model.
- The APSIM model has been calibrated and validated under saline soil conditions and a novel technique for simulating surface-soil salt build-up and the associated Rabi crop response was developed simply by providing the model with daily water table depth and salinity data, as well as daily climate. This empowers researchers to explore the performance of farmer management adaptations under both historical and future climate scenarios.
- Village- and field-scale soil salinity mapping using electromagnetic (EM) survey was introduced and a process to evaluate EM response in relation to yield at the trial plot scale was developed.

Conclusions: This project generated useful technologies to introduce new crops to increase cropping intensity and enhance productivity of the salt-affected marginal lands of the coastal zone. Initiation of a second phase for dissemination and large scale adoption of these technologies in the coastal zone is under consideration by KGF with co-funding from ACIAR.

38. Project Code and Title: ICP-II. Nutrient management for diversified cropping in Bangladesh

Implementing Organizations: BARC, Farmgate, Dhaka and Murdoch University, Australia

Project Coordinators: 1) Dr. Md. Baktear Hossain, PSO, BARC, and 2) Dr. Md. Enamul Haque, Adjunct Associate Professor, Murdoch University, Australia

Locations: Various sites in Mymensingh, Rajshahi, Dinajpur, Khulna and Barguna districts

Duration: Jan 2018 to Dec 2021

Budget: Tk. 312.00 lakh

Introduction: High intensity of cropping and increasing crop diversification, decreasing arable lands and raise questions about the profitability and sustainability of current crop nutrient management practices in Bangladesh. The challenge for the future is to develop nutrient management packages that will ensure improved, sustainable crop production maintaining current soil nutrient levels, avoid nutrient deficiencies and unbalanced doses or overuse of fertilizers. Recent evidences suggest that the yield gaps due to farmers' fertilizer rates and recommended rates equal yield increases of 15-40% for a range of crops including rice, wheat, maize, mustard, potato, etc. Nutrient management packages for emerging cropping systems based on minimum tillage and residue retention, are still to be developed. On the other hand, the major challenge for the southern region of the country is to increase cropping

intensity on waterlogged and saline lands and to develop fertilizer management packages for those difficult situations. This project aims to develop tools for sustainable nutrient management packages with greater fertilizer use efficiency for intensively cropped areas of the northwestern region and the southern coastal region of Bangladesh.

Fig. 46. Murdoch University/ACIAR (Australia) and Bangladeshi scientists visiting an experimental plot in the coastal district of Khulna

Objective: To increase the profitability and sustainability of intensive and emerging cropping systems in Bangladesh through improved nutrient management.

Materials and Methods: The project, "Nutrient management for diversified cropping in Bangladesh" (NUMAN) is an international collaborative project. Activities of the project can be categorized into five major areas: (1) socio-economic and gender aspects of fertilize use, (2) soil fertility and fertilizer management activities, (3) human resource development, (4) upscaling of the technologies, and (5) policy suggestions related for fertilizers. The focus areas and research hubs for intensive cropping and conservation agriculture (CA) cropping patterns are: Rajshahi (Durgapur- Agro-ecological Zone (AEZ)-11; Godagari (AEZ-25), Thakurgaon (AEZ-1), Mymensingh (AEZ-9). For the coastal zone research, focus areas and research hubs are: Dacope Upazila, Khulna (AEZ-13), Amtali Upazila, Barguna (AEZ-13). For socio-economic and gender studies, data were collected from primary and secondary sources using structured questionnaires. The major socio-economic data collected from the farmers through face-face interview were current fertilizer use according to farm types, cropping patterns, land typology, gender, data on fertilizer application time for different crops, availability, types and price of fertilizers, and extent of fertilizer adulteration in the local market. The research programs for the soil fertility and fertilizer management activities were developed on the basis of real field problems identified through field visits, discussion with farmers and rigorous discussion among the project team members, and designed for on-station, on-farm, and lab-based studies. For quality audit of fertilizers at the farm level, SRDI collected different fertilizer samples from six NUMAN project hub areas. To assess soil fertility status in the NUMAN project hub areas, soil samples from the project sites were collected and anlyzed in the partners' laboratories. For nutrient management and CA studies, the partner NARS institutions and universities conducted on-station field experiments and trials in farmers' fileds in the respective hub areas.

Results and Discussion: Socioeconomic surveys and analyses indicated that the fertilizer nutrient use gaps between current farmers' practice and scientific recommendation could be minimized through technical assistance and financial support in terms of awareness creation, technology development, strengthening extension services, assurance of input quality and supply.

Long-term experiments run by BARI at RARS, Ishurdi, by BAU at Mymensingh and by the PIO at Rajshahi (Durgapur and Godagari) have been incorporated into this project. Three of these long-term experiments including strip planting and increased residue retention are being used for comparison between conventional practice and conservation agriculture (CA) practices on nutrient budgets. Khulna University and PSTU, together with BARI and BRRI are conducting studies on the fertilizer requirements for rice and Rabi crops; and for double cropping patterns on saline and wet soils in Khulna and Barguna districts, respectively. The project activities started in Kharif-1 season 2018 and so far two years of the project have been completed successfully. In the northern region, recommended balanced NPKSZn and B fertilizer doses for various crops in diverse cropping patterns have been found to

significantly increase system productivity and profits over local farmers' practices. Nitrogen and potassium commonly, and in some areas phosphorus and sulfur have been found to be the limiting nutritional factors for crops in the northern region. Conservation agriculture practices appeared to be promising in comparison with the traditional intensive tillage practices in terms of land productivity, soil fertility maintenance and production cost savings. Sunflower appeared promising as an additional crop in the largely sole T. Aman cropping practice in the coastal saline areas. Optimum sowing dates and sowing methods and fertilizer doses were developed for sunflower on coastal saline land. For growing Rabi crops like maize in coastal areas with low pH soils soils, a combination of lime and phosphorus fertilizer was found to be a very good management option. Other nutrients like K, S and Zn should also be applield as maintenance doses.

Conclusions: The project activities are ongoing. So far, the project has yielded useful scientific information. The nutrient use gaps between current farmers' practice and scientific recommendation are influenced mainly by category of farmer, crop residue retention, crop rotation, fertilizer use in previous crop, distance of input/output market, fertilizer price, level of extension contact, number of cattle owned, and study region. In depth research on N, P, K and S dynamics and balance in the on-going long-term cropping pattern experiments is in progress. Introduction of a new crop, sunflower, into the existing single cropped pattern appears to be a promising technology for increasing cropping intensity and land productivity in the coastal saline areas. Conservation agriculture practices like minimum soil disturbance (strip planting, non-puddled transplanting of rice) and crop residue retention gave good results crop yields and improvement of soil properties.

39. Project Code and Title: ICP-III. Incorporating salt-tolerant wheat and pulses into smallholder farming systems in southern Bangladesh

Implementing Organizations: Bangladesh Agricultural Research Institute (BARI), Bangladesh Agriculture University (BAU), the NGO Agrarian Research Foundation (ARF), University of Western Australia (UWA) and Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia

Coordinator: Dr. Mohammad Hossain, Director, Pulse Research Center (PRC), BARI, Ishurdi

Locations: Khulna, Satkhira, Barishal, Pirojpur, Bhola and Barguna

Budget: 305.87 lakh

Duration: Jan 2018 to Dec 2021

Introduction: The coastal zone in southern Bangadesh is home to about 40 M people most of whom are poor. In southern Bangladesh, crop agriculture centers around the annual cropping of monsoon rice (T. Aman rice). The harvest of traditional long-duration T. Aman rice extends from December into February when the soils remain still wet from the monsoon rains (Kharif-II) and water stagnation to various extents. Rainfed dry season cropping on such lands is dominated by pulses – predominantly mungbean, grasspea and cowpea. About 0.3 M ha was cropped to pulses, cultivated with traditional production technologies in the Barishal Division in 2014. Where limited irrigation is possible, wheat is a profitable low-risk option, and potato and sunflower are also grown. In those restricted areas where extensive fresh water is available for irrigation, Boro rice is cultivated in the dry winter season. For saline lands, however, in marked contrast to the above, dry-season options are severely limited by the unavailability of salt tolerant cultivars of crops. To increase farm household incomes, this project aims to seize the opportunity presented by these extensive dry-season fallow lands to replace traditional, low-profit cropping practices with short-duration, more profitable, cropping options.

Objective: To evaluate wheat, pulse and forage genotypes tolerant of the salinity and submergence conditions in southern Bangladesh, and develop production technologies for dry season cropping.

Materials and Methods: The project started in June 2017 with ACIAR support, supplemented in November 2017 with co-funding by the Krishi Gobeshona Foundation (KGF). The project is led by the University of Western Australia (UWA) and CSIRO is the key Australian partner on wheat salinity. In Bangaldesh, BARI is the main agronomic research partner with the Bangladesh Wheat and Maize Research Institute (BWMRI), while the socio-economics research is being undertaken by BAU and ARF. BARI undertook agronomic research in Barisal Division of Southern Bangladesh during the 2017/18 and 2018/19 seasons. In response to a Mid-Term Review conducted in Sept. 2019, agronomic research was re-focused from specific trials toward the integration of project trial results into adoptable packages of practices for demonstration to growers. However, experiments on mungbean weed control and pest management have continued because improvements over standard practice have not yet been identified. Demonstrations were a major feature of the Yr3 (2019-20) crop program. In 2020 there were ~60 ha of mungbean demonstrations of production technology across Barisal Division with some also in Khulna. The demonstrated technology package comprised line sowing with cultivar BARI Mung 6 in late January with fertilizer and insecticide applied. For cowpea production, demonstrations were conducted in three districts of Barisal in the 2019/20 season. The package included a new cultivar, seed drilling - as opposed the usual hand broadcasting, and fertilizer with insecticide applied to control pod borer, as necessary. In the 2019/20 season grasspea demonstrations of an improved production package were conducted in five districts in Barisal. To identify wheat germplasm with salinity tolerance adapted to Southern Bangladesh, screening wheat collections for salt tolerance traits has been undertaken at both CSIRO in Australia and at BARI in Gazipur.

Results and Discussion: Weed control remains a problem in mungbean and in Yrs1 and 2, herbicide research gave no improvements on hand weeding. In Yr3, a further trial on weed management was conducted. The treatment with the highest benefit-cost ratio (BCR) of 3.01 from herbicide use was Quizalofop-p-ethyl (WeednilTM). For pest management in the first two seasons the effectiveness of IPM approaches using botanicals, synthetic insecticides and blue sticky traps were evaluated, but these eco-friendly approaches were costlier than current farmer pest management. In 2020 another approach to insect management was taken by testing micro and macro-nutrients in trials at Rahmatpur and Ishurdi. The application of sulfur (Thiovit 80 WG) significantly reduced thrip flower infestation and pod infestation by borers compared to the control. The BCR of sulfur application was 1.59 at Rahmatpur and 1.96 at Ishurdi. The trial will be repeated. In cowpea crop improvement an introduced line CPL-8-17 out-yielded the local cowpea variety and is clearly a candidate for release/rapid seed multiplication.

In 2020, the average yield of mungbean (BARI Mung 6) in the demonstration plots was 1280 kg/ha compared to 1070 kg/ha in neighbouring farmer-tended plots, indicating a yield gap of 210 kg/ha and a yield advantage of 20%. The BCR was highest in Patuakhali (1.79). The yield advantage of the package over farmer plots was 26% in 2019 and 44% in 2018.

In the 2019/20 season yields from the demonstrated production package for cowpea averaged 1.4 t/ha compared to nearby farmer plots (0.91 t/ha) showing a yield advantage of 54%. In the previous two years' demonstrations the percentage yield advantages were 45% and 71%. The benefit-cost ratio for cowpea production was 1.44 in Patuakhali, indicating the crop's potential as a dry-season cropping option.

Grasspea production is traditional in the southern region and relay sowing in November is the usual method of cultivation. Subsequent heavy rains are highly detrimental, as found in the 2017/18 season when the crop was destroyed due to unusual rainfall during the germination/early vegetative stage. In subsequent seasons production was not hampered. Over the last three seasons it was observed that the yield of pilot production plots was 54-60% higher than that in farmers' plots. Changing the variety and fertilizer are the probable reasons for the yield increase. Despite a BCR for relayed grasspea of more than 2.0 in Patuakhali indicating the crop's profitability, grasspea production remains risky in the coastal region.

Demonstrations of lentil and green pea production packages indicate that in upland pockets of Barisal both crops have potential with green pea production informally found favoured by female headed households.

At CSIRO, both a benchmark set of 24 diverse BARI wheat lines and a large diverse collection of 150 wheat lines - representing genetic diversity in the BWMRI breeding program - have been screened for the Na+ exclusion (salt tolerance) trait in leaves, resulting in the identification of useful broad genotypic variation for this trait. Similarly, genotypic variation for osmotic stress tolerance was identified in the benchmark set when screened on an automated glasshouse imaging platform used to non-destructively estimate seedling biomass.

To assist the Plant Physiology team at BARI in screening for salt tolerance in wheat and potentially other species, a supported hydroponics infrastructure was procured and assembled by the CSIRO team in Australia and sent to BARI (Gazipur). This was accompanied by a comprehensive PDF developed by CSIRO, detailing all the equipment and methods required to construct and run the supported hydroponics infrastructure was also and sent to BARI. This screening infrastructure has been established and tested by the Plant Physiology team at BARI and has recently been used to screen a large and diverse collection of 150 BWMRI wheat lines for a key salt tolerance trait in wheat – the capacity to exclude Na^+ and maintain high K^+ in leaves.

A benchmark set of 24 wheat lines from BARI was established to develop ranking parameters to eventually evaluate other wheat germplasm; and secondly, to be used to establish appropriate field trial design and characterisation methodology for the accurate assessment of salt tolerance and performance in saline field trials. Appropriate spatial trial designs together with EM mapping and soil coring (ECe measurements) have been used at multiple field trials across two seasons to evaluate and establish this methodology and to determine a salt tolerance performance ranking of the benchmark set of 24 wheat lines.

A breeding component for this project has focussed on incorporating CSIRO's salt tolerance Nax genes into adapted Bangladeshi wheat varieties for evaluation. This work has been largely undertaken by the BARI Biotechnology team led by Dr Yousuf Akhand with phenotypic validation of selected lines completed at CSIRO. This work has culminated in the selection and evaluation of 12 advanced wheat breeding lines containing either Nax1 or Nax2 in four salinity-affected field trials in southern Bangladesh over the 2019 / 2020 field season. Plans are underway to introgress the Nax genes into more current advanced breeding lines or varieties with a range of other adaptive and protective traits, particularly resistance to diseases such as wheat blast.

To identify germplasm of pulses and forages with tolerance to salinity and water-logging stress, an integrated plan of research was agreed at the July 2018 abiotic stress methodology workshop. At UWA in Yr3, a PhD student identified germplasm of mungbean with tolerance to waterlogging at germination and at the seedling stage. Systematic screening of the same mungbean mini-core germplasm collection for salinity tolerance is planned. Also, at UWA grasspea germplasm with tolerance to waterlogging at the seedling stage was selected with most of the tolerant accessions originating from Bangladesh and Ethiopia.

During Yr3 there were four PhD students engaged in project-related research at UWA, of whom three were John Allwright Fellows. A Masters student completed his thesis on project data at BAU.

Conclusions: The project found some varieties and genotypes of legumes like mungbean, cowpea and grasspea to be well adapted to the agroecological conditions of southern Bangladesh. Suitable crop-soil management practices for the cultivation of these legumes including insect, disease and weed management have been developed which are being fine tuned as more eco- and farmer-friendly options which may provide an opportunity to enhance land productivity and farmers' incomes in southern Bangladesh. Also, the overseas partners such as CSIRO and UWA conducetd basic research on the

physiological mechanisms of salt tolerance in wheat and shared the findings with their Bangladeshi counterparts, which will be helpful for BARI and BWMRI in breeding salt tolerant wheat for cultivation in the coastal saline areas of the country.

4.1.6 Technology Piloting Program (TPP)

4.1.6A Ongoing Project

40. Project Code and Title: P-17. Up-scaling of *Tricho*-compost and *Tricho*-leachate production for disease management in vegetables and spices (rhizome and bulb crop)

Implementing organization: Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Dr. Mosammat Shamsunnahar, PSO, Horticultural Research Center (HRC), BARI, Gazipur

Locations: Gazipur, Bogura, Jashore, Cumilla

Budget: Tk. 84.0 lakh

Duration: Jan 2018 to Dec 2021

Introduction: Soil borne plant pathogens—fungi, bacteria, nematodes--are some of the major constraints on crop production especially for vegetables resulting in serious yield losses. They cause foot rot, root rot, damping off, wilt, seedling mortality, etc. The common soil borne pathogenic species are: *Fusarium* spp. *Rhizoctonia* spp., *Sclerotium rolfsii*, *Pythium* spp. *Phytophthora* spp., *Ralstonia*, *Erwinia* and *Meloidogyne* spp. In comparison with foliar pathogens, soil borne pathogens are very difficult to control. Application of fungicides, bactericides and nematicides may suppress, to some extent, soil borne pathogens but this is neither economically viable nor environmentally sound. A better option would be to use biochemically effective and environmentally safe biological agents like *Trichoderma* to suppress soil borne pathogens. Very recently a KGF sponsored project on the use of *Trichoderma* products to suppress a wide range of soil borne pathogens of vegetable crops ended successfully. This TPP project was initiated to disseminate and popularize the eco-friendly technology among the vegetable growers of the country.

Objective: To enhance and expand the production technique of *Tricho*-compost and *Tricho*-leachate at farmers' levels to control soil borne diseases of vegetable crops.

Materials and Methods: In the research phase of the project during 2017-18 to 2018-19, the technology for the preparation of *Trichoderma* products (*Tricho*-compost and *Tricho*-leachate from a mother culture of *Trichoderma herzarium*) was developed. Seed treatment with *Tricho*-compost and foliar spray with *Tricho*-leachate were found to effectively suppress the *Phythium* rot disease, reduce plant mortality and improve yield of ginger. The technology is being disseminated under a KGF tevhnology pioting program. A total of 127.0 L spore suspension of *Trichoderma harzianum* was multiplied. By using this spore suspension, about 95.47 tons of *Tricho*-compost and 3250 L of *Tricho*-leachate were produced. In 2019-20, under TPP, 49 demonstrations/adaptive trials were conducted in three districts, out of which 28 were in the Rabi season and 21 in the Kharif-I season (Table 13).

Table 13. Demonstrations and adaptive trials on the effect of *Tricho*-products in suppressing diseases of vegetable crops in three districts of Bangladesh, Rabi 2019-20 and Kharif-I 2020

Crop	Demonstration/ Adaptive trials (no.)			Crop	Demonstration/ adaptive trials (no.)		
	Jashore	Bogura	Cumilla		Jashore	Bogura	Cumilla
	Rabi 2019-20				Kharif-I 2020		
				Pointed gourd	3	3	-
Cabbage	2	1	-	Indian Spinach	1	-	-
Cauliflower	3	1	2	Brinjal	2	1	-
Bottle gourd	3	-	-	Country bean	1	-	-
Tomato	-	2	6	Chilli	1	-	-
Brinjal	1	1		Bottle gourd	1	-	3
Country bean	-	4	-	Okra		-	1
Cucumber	1	-	-	Bitter gourd			2
Chili			1	Sponge gourd			1

Farmers' training was completed. Experiments with spices (onion in Rabi 2019-20 in Gazipur and Bogura and ginger in Bogura in Kharif-I 2020) were also conducted.

Results and Discussion: On an average, 50.55% disease reduced due to application of *Tricho*-compost and *Tricho*-leachate. Marketable yield and BCR increased by about 27.48% and 24.88%, respectively with *Tricho*-compost and *Tricho*-leachate treatments. Due to the application of *Tricho*-products, fruit damage was reduced to only 1.53-2.66% from 3.61-4.44% for the control treatment. Mean fruit damage reduction from control was 75.30% and 62.76% in Bogura and Cumilla, respectively. Mean yield increased from control was 35.62%. BCR increase over control was 34.14% in Bogura and

Fig. 47. A farmer's *Tricho*-compost production

31.11% in Cumilla. Application of *Tricho*-compost reduced disease and increased yield of brinjal at both locations. Disease reduction and yield increase were about 19.65% and 45.62%, respectively at the Jashore location and it was 54.95% and 41.06% at the Bogura location. BCR increased over control by about 41.81% and 37.37% at the Jashore and Bogura locations, respectively. Marketable yield of country bean from the *Tricho*-compost incorporated field was 21.25-26.19 t/ha, whereas it was only 16.80-20.14 t/ha in the non-amended control field.

Soil incorporation of *Tricho*-compost and foliar spray of *Tricho*-leachate reduced fruit damage in cucumber by 57.9%. The marketable yield increased by about 29.52%. The BCR was 2.58 was 2.58 for *Tricho*-plots and 2.0 for control plots. Fruit damage of cucumber was only 1.28% in *Tricho* treated plots and 2.54% in control plots.

The purple blotch disease of onion was reduced by *Tricho*-products in both research plots and farmers' fields. There was about a 51.43% disease reduction due to the application of *Tricho*-compost nd *Tricho*-leachate in farmers' fields. Single bulb weight and yield increased in the *Tricho*-compost field. Yield increase over control was about 42.94%.

Conclusions: This project generated a microbe-based environmentally safe and farmer friendly technology of disease management in vegetable crops. It is expected that farmers will find the process of preparation of the *Trichoderma* compost and leachate easy to handle and use in their fields and effective in suppression of diseases in vegetable crops.

Fig. 48. Vegetable crops in control plots (left) and in *Tricho*-treated plots (right), Jashore, Rabi 2019-20

Technical Progress
Livestock

Domestic animals comprise an essential component of farm economy being important sources of farmers' cash income. Today, livestock contribute about 1.5% to the GDP of Bangladesh. Over the last one decade, there has been a substantial boost in the livestock population of the country. On the other hand, livestock productivity increased spectacularly. This was made possible by research and development of animal husbandry and veterinary technologies. KGF has so far sponsored livestock research pertaining to animal health and husbandry services, breed up-gradation local genome conservation, training and technology dissemination, entrepreneurship development and value addition. In 2018-19, of the total of 58 on-going projects, 11 were on livestock, and considering the importance of livestock in human nutrition and food security in Bangladesh, KGF has plans to expand support for projects to address diverse problems in animal husbandry and veterinary services especially for marginal lands like the hill tracts and coastal saline areas and for the climate change adversity situation.

4.2 LIVESTOCK

4.2.1 CGP 3rd Call Projects

4.2.1A Ongoing Projects

41. Project Code and Title: TF 44-L/17. Livestock and human brucellosis: Molecular diagnosis, treatment and control

Implementing Organization: Bangladesh Agricultural University, (BAU), Mymensingh

Principal Investigator: Prof. Dr. Md. Siddiqur Rahman, Department of Medicine, Faculty of Veterinary Medicine, BAU, cell: 01918181550

Locations: Department of Medicine, BAU; Mymensingh Medical College, Mymensingh; Central Cattle Breeding Station and Dairy farm, Savar, Dhaka; Military Dairy Farm, Savar, Dhaka.

Budget: Tk. 75 lakh

Duration: Jan 2018 to Dec 2020

Introduction: Brucellosis is a zoonotic disease which is a human and animal health problem especially rural areas where people are engaged in livestock rearing and dairy production. In animals, brucellosis mainly affects reproduction and fertility, with abortion and reduced milk yield. In humans, the clinical picture resembles many other febrile diseases, but sacroilitis and hepato-splenomegaly are the most prominent. As an occupational zoonotic disease, infection of humans results from direct contact with infected animals and consumption of contaminated milk and milk products. Cattle ranchers/dairy farmers/milkmen, veterinarians, abattoir workers, meat inspectors, lab workers, hunters, travelers, etc. are at risk. Brucellosis is endemic in Bangladesh but there is still no vaccination program. Vaccination trials in animals with the is essential. Preparatory to vaccine development molecular characterization of the causal agent of Brucellosis and an epidemiological risk factor analysis are also very important.

Objective: Molecular characterization of the causal agent of Brucellosis and epidemiological risk factor analysis and development of vaccine for livestock.

Materials and Methods: A questionnaire was developed by the Project Team for collection of epidemiological data from different project areas. Project workers collected aborted cattle fetus and milk and sera the Military Dairy Farm (MDF), Savar, and the Central Cattle Breeding and Dairy Farm (CCBDF), Savar, and human serum samles from the Mymensingh Medical College Hospital (MMCH), Mymensingh and relevant data of the suspected cases during this reporting period. Suspected dairy cattle were screened for Brucellosis by the Rose Bengal Test (RBT), rapid test, Milk Ring Test (MRT), impression smear from aborted material and then modified Zeihl Neelsen staining, classical biotyping, guineapig inoculation, histopathology, polymerase chain reaction (PCR) and sequencing, Multi Locus Variable Number of Tandem Repeat Analysis (MLVA), CFT, SAT, were performed. A total 1003 cattle sera, (503 from the CCBDF and 500 from MDF) were screened with RBT, MRT and rapid kit test and 715 human sera were screened with RBT and rapid kit test in MDF and MMCH. Positive cases were re-tested with ELISA, conventional PCR with sequencing and construction of phylogenetic tree. Real time PCR and MLVA, Bruce ladder PCR, CFT and SAT were also performed.

Results and Discussion: Out of 1003 cattle sera 43 were positive with RBT, 14 in MRT and 14 in rapid kit test. And out of 715 human sera, 16 were positive with RBT. Positive human and cattle samples revealed 602 base pair bands in conventional PCR and amplifications of *B. abortus* specific DNA were recorded through real time PCR. Histopathology of naturally infected aborted fetus indicated lesions in different organs such as fibrinous pleuritic in lungs, focal hepatitis in liver, capsulitis with thickening of capsule in kidney, fibrinous pericarditis in heart, congestion and haemorrage in spleen. Experimentally *Brucella* infected guineapigs also revealed characteristic lesions in different organs such as granulomas, hemorrhages and necrosis in lungs parenchyma, hemorrhagic endocarditis, monocytes in heart, congestion, hemorrhage and multifocal accumulation of mononuclear cells in kidney. Hemorrhage, congestion and fatty change in liver and caseaus necrosis of splenic foci were also recorded.

Fig. 49. The milk ring test (MRT) for Brucellosis: Milk in the middle tube showing a ring of cream more intensely colored than the underlying milk indicates a positive test while the milk samples in the the two corner tubes showing reverse colorations tested negative

The histopathological study for the first time in Bangladesh using guineapig inoculation techniques successfully detectd pathological changes in major organs after inoculation with aborted fetal contents. On the basis of the different characteristics (CO_2 requirement for growth, production of H_2S in culture, biochemical test like oxidase, catalase and urease, growth in safranin, thionin and fuchsin and agglutination against anti A and Anti M antibody) and motility test, the *Brucella* species and biovar was determined as *Brucella abortus* biovar 3. The molecular technique (MLVA) indicated the strain to be similar as the Asian strain. The guineapig inoculation technique could be used as a good alternative to the culture method and for the confirmatory diagnosis of Brucellosis from contaminated clinical samples like placenta.

Fig. 50. *B. abortus* killed vaccine

A heat killed vaccine was prepared from the isolated *Brucella* organism and inoculated into guineapig subcutaneously at dose (4×10^{10}cfu/2ml). Serum samples were collected upto 9th week for observing the immune response. The antibody (Ab) level started to rise significantly ($p<0.01$) from the 2nd week (OD value 0.2287, reciprocal Ab titer 1:120), reached a peak level in the 4th week (OD value 0.2842, reciprocal Ab titer 1:800) and then started to decline significantly ($p<0.01$) up to the 9th week (OD value 0.1015, reciprocal Ab titer 0). Heat killed vaccine administered to indigenous cattle as an inoculum dose of 10×10^{10} cfu/5 ml) through a single subcutaneously (SC) injection. For comparison, the live attenuated commercial *Brucella abortus* strain RB51 vaccine (CZ Veterinaria, SA, Spain) @ 2.0 ml ($10\text{-}34\times10^{9}$) SC as a single dose was given to cattl of another set. The sera of heifer inoculated with heat killed vaccine were collected at 0, 7, 14, 21, 28, 40, 60 and 90 days post vaccination, whereas the sera of the commercial vaccine inoculated heifers were collected at 0, 7, 14, 21, 28, 60, 90, 120, 150 and 180 days

post vaccination. Evaluation of Ab titers of the two groups were done by RBT and ELISA. The Ab titer of cows inoculated with locally prepared killed vaccine started to rise significantly ($p<0.05$) from the14th day (OD value 0.2116 ± 0.0397, reciprocal Ab titer 1:120) and reached a peak level at day 28 (OD value 0.319 ± 0.172, reciprocal Ab titer 1:800) and then started to decline significantly ($p < 0.05$) from day 40 (OD value 0.234 ± 0.0415, reciprocal Ab titer 1:35) to 60 days (OD value 0.094 ± 0.0075, reciprocal Ab titer 0). On the contrary, mean Ab titer from the cow inocluated with the commercial RB51 vaccine started to appear insignificantly ($p > 0.05$) from day 7 (OD Value 0.094 ± 0.01603) and reached the peak level at day 60 (OD value 0.592 ± 0.398), the changes being very significant from day 0 ($p < 0.05$); after 60 days, the Ab level started to decrease and reach the lowest level at day 150 (OD value, 0.112 ± 0.0188), and the Ab level at day 180 was found to be similar as that at day 0 (OD value 0.0826 ± 0.00517) at 180 days (OD value 0.0822 ± 0.00249).

Univariant and binary logistic regressions were used to identify important risk factors of Brucellosis. Three variables (age, parity and abortion) were found to be significantly associated with *B. abortus* infection in lactating cows. *B. abortus* is the causal agent of bovine Brucellosis which was identified for the first time as an etiological agent of human Brucellosis in occupationally exposed dairy farm workers in Bangladesh.

Fig.51. Subcutaneous injection of *Brucella abortus* strain RB51 vaccine to an indigenous heifer by two Somalian MS students working with this project

Conclusions: *B. abortus* was detected as the causal agent of bovine Brucellosis which was identified for the first time as an etiological agent of human Brucellosis in occupationally exposed dairy farm workers of Bangladesh. Age, parity and abortion were found to be significantly associated with *B. abortus* infection in lactating cows. A heat killed vaccine was prepared from the local Brucella isolate of Bangladesh and without adjuvant it was found to induce immune response in guineapigs which persisted for a period of 6 weeks.

42. Project Code and Title: TF 45-L/17. Epidemiological investigation on tuberculosis and campylobacteriosis associated with dairy farming practices in the selected districts of Bangladesh

Implementing Organizations: Bangladesh Agricultural University (BAU), Mymensingh and International Centre for Diarrheal Disease Research, Bangladesh (ICDDR, B), Mohakhali, Dhaka

Principal Investigators: Dr. SM Lutful Kabir, Pofessor, Department of Microbiology and Hygiene, BAU and Dr. Md. Zeaur Rahim, Mycobacteriology Laboratory of ICDDR, B, Mahakhali, Dhaka

Locations: Selected municipal markets under Dhaka City Corporation, Central Cattle Breeding and Dairy Farm (CCBDF), Savar and selected upazilas in Mymensingh district

Budget: Tk. 260.00 lakh

Duration: Jan 2018 to Dec 2020

Intoduction: Among the zoonotic diseases, tuberculosis (TB) is important to cattle producers and public health authorities because of its economic and zoonotic implications. Bovine TB prevails in many developing countries including Bangladesh but remains mostly under reported. *Campylobacter* species have been reported to be involved in the Guelenbury syndrome (GBS), a deadly paralytic disease affecting humans. The occurrence of the organism (*Campylobacter* species) in dairy cattle has been reported recently in Bangladesh. A few studies from Bangladesh have documented the isolation of *Campylobacter* species from patients with diarrhea and from poultry. Along with the economic impacts,

the morbidity and mortality associated with Campylobacteriosis and bovine TB are relatively unknown or underestimated. The purpose of this study is to develop a screening and sanitation program in accordance with good farming practices (GFPs) that would involve local farmers in the control of TB and Campylobacteriosis.

Objective: Determination of potential risk factors for zoonotic tuberculosis and Campylobacteriosis and molecular characterization of the causal agents (*Mycobacterium* species and *Campylobacter* species).

Materials and Methods: A tuberculin skin test (TST) team carried out bovine tuberculosis (bTB) screening in selected dairy herds. The single comparative intradermal tuberculin test (SCITT) was employed to estimate the status of bTB. A total of 40 blood samples were collected from patients with neurological disorders for the investigation of Guillain-Barre´ Syndrome-Related *Campylobacter jejuni* in Bangladesh. Questionnaires were developed for assessing the economic of bovine Campylobacteriosis. A farmers' training module and a training manual were prepared. A pretested semi-structured questionnaire was used to capture herd and animal level data on risk factors, and analyzed through univarible and multivariable logistic regression models.

Results and Discussion: Among the risk factors, farms with a history of diarrheal symptoms was strongly associated with *Campylobacter* infection. Seasonal variation and vet health care facilities and management risk factors of Campylobacteriosis in bull are floor space, breeding service, ration, bedding and purpose of rearing bull. The other important risk factors are age and breed. Human Campylobacteriosis was associated with sex, age, poor hygienic practices and fast food consumption.

In dairy farms an overall prevalence of *Campylobacter* spp. was found to be 25.5%. On the other hand, the prevalence of *Campylobacter* in bull was 28.98%. The prevalence of *Campylobacter* in human diarrhoeal patients was 28.62%.

Serotyping using Penner's scheme was sufficient for identification of about 57% of the dairy *C. jejuni* isolates. On the other hand, serotyping using Penner's scheme was sufficient for identification of about 61% *C. jejuni* isolates of bull origin. However, serotyping using Penner's scheme was sufficient for identification of about 68% *C. jejuni* isolates of human origin.

Different virulence and toxin genes were identified in *C. jejuni*, *C. coli* and *C. fetus* isolates. The 16S rRNA gene sequences of *C. jejuni* (n=17), *C. coli* (n=1) and *C. fetus* (n=3) analyzed in this study have been registered with the GenBank. A considerable number of *C. jejuni*, *C. coli* and *C. fetus* isolates were multidrug resistant.

The project team accomplished TST activities in 1865 farming cattle of 79 herds in five districts (Dhaka, Mymensingh, Gazipur, Jamalpur and Munshiganj). The overall herd and animal level occurrences of bTB were estimated to be 45.6 % (95% CI= 34.3-57.2%) and 11.3% (95% CI=9.9-12.8%), respectively at >4 mm cut-off. At the herd level, farm size, bTB history in the farm and type of husbandry were significantly associated with bTB status in univariable analysis. Similarly, age group, sex, pregnancy status and parity were significantly associated with the cattle level bTB. However, in multivariable analysis only herd size at herd level and age group and pregnancy status in cattle level were found to be significantly associated with bTB. Compared with the herd size of 1-10, the odds of bTB were 22.8 (95% confidence interval [CI]: 5.2-100.9) and 45.6 times (95% CI: 5.0-417.7) greater in herd size of >20-50 and > 50, respectively. The odds of bTB were 2.2 (95% CI: 1.0-4.5) and 2.5 times (95% CI: 1.1-5.4) higher in cattle aged 3-6 years and > 6 years in comparison to cattle aged ≤1 year. Pregnancy increases the odds of bTB infection by 1.7 times (95% CI: 1.2-2.4) over compared with non-pregnant cattle. Older and pregnant cattle in larger herds (>20) should get highest priority for regular bTB screening. Control of bTB in high risk group of cattle will minimize the risk of transmission at animal-human interface.

The project has successfully applied the Gamma interferon assay (Bovigam®) (GIA) for the first time to detect bTB in Bangladesh as a parallel testing protocol along with TST. Among animals tested

(n=148), the ratings with TST for bTB were: positive (n=125), inconclusive (n=17) and negative (n=6); the same groups tested positive for bTB with GIA in the order 83.2% (n=104), 64.7% (n=11), and 16.67% (n=1), respectively. The agreement obtained between the two tests was substantial (Kappa agreement: 77.7%, 95% CI=70.9-84.5%, P=0.004). Since a considerable proportion of the TST-inconclusive animals (64.70%, n=11) presented as positive with the GIA test, it is recommend that parallel tests with GIA be done along with TST to increase the sensitivity of the bTB test protocol.

Of 1310 samples, 209 were sputum sample, 942 cattle samples (vital organs: lung, liver, spleen, lymphnode; milk and feces and pharyngeal swab) from slaughtered, TST positive and post mortem cattle and 159 wild species samples (deer, n=1; wildebeest, n=8; lion=8; goyal, n=5; common eland, n=1; impala, n=7; and monkey, n=128 and girrafe, n=1) that included vital organs collected during post mortem examination and fecal samples of wild species in zoological gardens. A total of 15 animals (cattle: 6 and wild species: 9) were found provisionary positive as MTBC through acid fast technique. Of 15 animals 11 (5 cattle and 6 wild species) were shown bacterial growth in culture media both in solid (LJ Slant) and liquid (MGIT). The culture organism were further genotyped via Line Probe Assay (LPA) and confirmed as *Mycobacterium africanum* (*M. orygis*). Of 209 sputum samples (cattle handers and butchers), 2 (two) were confirmed as *Mycobacterium tuberculosis* through genotypying. The project confirmed the causative agent of animal TB in Bangladesh (both in domestic animals and zoo species). The subculture of these isolates has been accomplished intended for whole genome sequencing from the collaborating laboratory in abroad.

43. Project Code and Title: TF 46-L/17. Study on zoonotic diseases of pets and assessment of risk factors of commonly occurringed zoonoses for better management

Implementing Organization: National Institute of Biotechnology (NIB), Ganakbari, Ashulia, Savar

Principal Investigator: Dr. Jahangir Alam, CSO, Animal Biotechnology Division, NIB

Location: Selected public and private veterinary hospitals and pet clinics in Dhaka and Chattogram metropolitan areas.

Budget: Tk. 82.15 lakh

Duration: Jan 2018 to Dec 2020

Introduction: Pets are lovely things, but but they can also transmit diseases. In Bangladesh, pet keeping is becoming popular, especially in the urban areas, and the commonest pets are dogs, cats and rabbits with some guinea pigs, birds and fish, and with this, the risk of infections with zoonotic diseases is rising. Pathogens of these diseases can be transmitted from animals to humans through direct contact and through fomite, aerosol, blood, saliva, urine, feces, food, water, scratches including different vectors. Several diseases/disease conditions/symptoms of pets, many of these with zoonotic potentials, have also been reported from Bangladesh. However, these reports are mostly based on clinical signs, symptoms and presumptive diagnosis, laboratory confirmation based on either serological and/or molecular diagnosis as well as pathogen isolation is important for proper identification of causal agents for the management of the diseases caused by them.

Objective: Investigation of the zoonotic diseases of pets prevailing in Bangladesh and assessment of risk factors for humans.

Materials and Methods: Various samples of animal organs were collected from the Central Veterinary Hospital (CVH) and the Blue Crescent Veterinary Hospital (BCVH), Dhaka and Chattogram Veterinary and Animal Science University (CVASU) pet hospital, Chattogram. The samples were tested by quick detection kit. Besides, data collection through a preformed questionnaire is going on to assess the risks.

Results and Discussion: Information was collectd regarding 300 animals (cat=174, dog=120 and bird=6) and 121 samples were collected from dogs, cats and birds in CVH, BCVH and CVASU pet hospital. Among the samples 70, 47 and 4 samples were derived from cat, dog and bird, respectively.

Of these 101 samples (54 for cats and 47 for dogs) were tested by quick detection kit irrespective of zoonoses and found 23 (39) and 9% (15) feline pan leukopenia virus (FPLV) and feline calicivirus (FCV), respectively. Besides, 45% (47) canine parvovirus (CPV) in dog samples were detected. Upon bacterial culture of 118 out of 121 samples, total viable counts were ound to range from $3.6x10^2$ to $6.04x10^7$/CFU/ml. On selective media *E. coli, Salmonella, Staphylococcus spp. Shigella, Campylobacter, Proteus* spp. and *Vibrio* spp. were detected from cat and dog samples. Portions of samples were sequenced to confirm bacteria. Virus detection is in progress.

Surveys revealed 10, 14, 9, 6 and 29% of viral, parasite, bacterial, fungal and others cases in cat samples and 14, 16 and 25% of viral, fungal and others cases in dog samples. In birds, 67 and 33% were bacterial and viral diseases. These figures were based on assumptions.

Besides, data collection through a preformed questionnaire is going on to assess the risk perception of pet owners as well as to assess the risk factors for human associated with commonly occurred zoonotic diseases in pet animals.

Conclusions: Zoonotic diseases in pets and causative pathogens have been detected in Bangaldesh. Theses diseases can be transmitted to humans. Good hygiene should be maintained and care taken in handling pets.

44. Project Code and Title: TF-47-L/17. Value addition to feeds and fodder through bioactive component-rich herbs for safe livestock production

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh

Principal Investigator: Dr. Mohammad Al-Mamun, Professor, Department of Animal Nutrition, Faculty of Animal Husbandry, BAU

Locations: Department of Animal Nutrition, BAU, Mymensingh; Modhupur, Mymensingh District; Military Dairy Farm; Central Cattle Breeding and Dairy Farm, Savar, Dhaka

Budget: Tk. 81.10 lakh

Duration: Jan 2018 to Dec 2020

Introduction: Feed additives are used for the purposes of improving animal health and production performance. Natural herbs are a very good alternative being biologically beneficial for animals in many ways. There are many natural herbs in Bangladesh, which have a century-long history of being used as traditional medicines in treating both humans and livestock. Plant extracts, such as, saponins, tannins and essential oils derived from yucca, chestnut, garlic, ginger, etc. have been used in ruminant feeds to modulate rumen fermentation. A growing awareness among people to consume antioxidant-rich foods necessitates production of antioxidant-rich milk and meat for human consumption. This study was designed to determine and characterize bioactive components of natural herbs available in Bangladesh, and to study their impacts on the milk fatty acid profiles in ruminants under local conditions.

Objective: Phytochemical profiling of herbs available in Bangladesh and determination of the effect of different storage conditions and processing stages on selected herbs in relation to nutrient digestibility, plasma metabolites, milk fatty acid profiles and milk yield in dairy cows.

Materials and Methods: On the basis of earlier results of this project especially regarding mineral contents, thin layer chromatography (TLC), 2,2-diphenyl-1-picryl hydrazyl (DPPH), Vitamin C contents and biomass yield, 8 herbs including moringa, pineapple, ivy-gourd, spear-mint, garlic, *neem*, plantain, and lemongrass were selected to determine the total flavonoids, total phenolic and Vitamin E contents. Initially the herb samples were collected from the Forage Herbs Bank established by this project. The samples were freeze- and shade-dried. Total phenolic, total flavonoids and Vitamin E contents were determined in the fresh, freeze- dried and shade-dried samples. *Neem* was later on excluded due to the bitter taste and coarseness. Specific bioactive components from the remaining 7

herbs were determined using high performance liquid chromatography (HPLC) and gas chromatography mass spectrometry (GC-MS) at Prof. Sano Lab in Japan. A herb mixture was prepared using moringa, pineapple waste, ivy-gourd, lemongrass, spearmint that were selected on the basis of biomass yield and availability (40%), level of bioactive components (40%), minerals profiles (10%), others (cows` preference, milk volatility) (10%). Pineapple waste was collected from Modhupur, Tangail. Finally, a feeding trial was conducted at BLRI regional station, Baghabarighat, Sirajganj using 20 mid lactating cows and 5 cows/treatment. The duration of feeding trial was 63 days and all samples including milk, blood, feces and feed were stored at -20^{0}C pending analysis.

Results and Discussion: In the phytochemical profiling of the herbs, novel bioactive components like total phenolic, flavonoid and Vitamin-E contents were determined in fresh, shade dried and freeze dried samples using gallic acid, quercetin and α-tocopherol standards. Specific bioactive components including kaemfperol, and myricetin (moringa), gallic acid and caffeic acid (pineapple wastes), alkaloids and saponins (ivy gourd), rutin and caffeic acid (spear mint), allicin and rutin (garlic leaves), limonene and citral (lemon grass), acteoside and aucubin (plantain) were determined in fresh, freeze and shade dried herb samples. The dairy cow feeding trial was completed using herbal mixes as dietary treatments, data of which are being processed.

Conclusions: Detailed chemical and biochemical analysis of the indigenous herbs offers a good opportunity to develop feed mixes for safe and nutritious feeding of cattle. This will improve cattle health and dairy product quantity and quality which in turn will benefit consumers.

45. Project Code and Title: TF-48-L/17. Improving lamb production potentiality of native sheep through selection and genetic enhancement

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh

Principal Investigator: Dr. Md. Munir Hossain, Professor, Department of Animal Breeding and Genetics, Faculty of Animal Husbandry, BAU

Locations: BAU, Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka, Bhuapur (Tangail)

Budget: Tk. 67.96 lakh

Duration: Jan 2018 to Dec 2020

Introduction: Sheep stand third in number among ruminant species in Bangladesh and are reared mainly for meat production. Bangladeshi sheep are very efficient users of low quality roughage, well adapted to hot and humid agro-climatic conditions, capable of bi-annual lambing with multiple births and tolerant to various common diseases. Considering the potential of the local sheep, this project addresses the issue of improving the lamb production potentiality of native sheep through a holistic breeding plan which includes enhancement of genetic merit by facilitating multitier gene flow from field to the farm level and using genomic information for higher lamb production through high throughput genotyping.

Objective: To adapt genomic information into conventional breeding schemes for improving lamb production potential of native sheep.

Material and Methods: Recording of productive and reproductive performance of sheep is being continued. A functional farmers' society in Bhuanpur, Tangail has been established. Selected rams based on their phenotypic characteristics have been distributed to sheep farmers. In addition, a trial ram station has been constructed at BAU. Isolation on of genomic DNA from blood samples of sheep is done. DNA samples were screened through ethanol precipitation, spectrophometry and gel electrophoresis and subsequently analyzed with Illumina 50K SNP beadchip.

Results and Discussion: Farmers' training programs have been organized for their capacity building and a functional farmers' society in Bhuanpur is in operation for the improvement of native sheep population. Selected rams based on the phenotypic characteristics have been distributed to farmers as good quality genetic materials for breeding. Selection of ewes and rams is continuously practiced for developing sheep breeding flock. In addition, a trial ram station has been constructed to support ram testing services for future ram selection and distribution programs. Genomic DNA from a total of 144 collected blood samples has been isolated. Quality and the quantity of the isolated DNA samples have been assessed to proceed with high throughput genotyping. Ninety-six DNA samples have been screened with quality pass and subsequently analyzed with Illumina 50K SNP beadchip for genome-wide genotyping and association studies. Analysis of 50K SNP bead chip results of the selected DNA samples for phenotypic and reproductive performance is in progress.

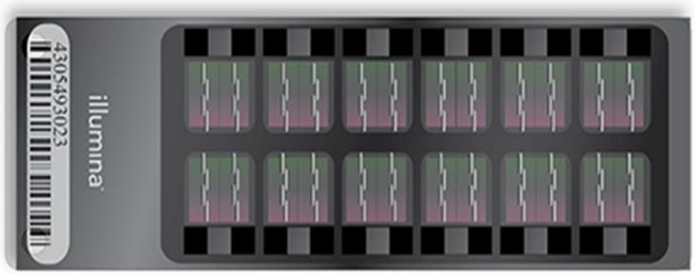


Fig. 52. OvineSNP50 Beadchip with 54242 SNPs used for genotyping of native sheep

Conclusions: Identification and characterization of native sheep will empower animal scientists to plan and implement strategies for genetic improvement of sheep, the third most important ruminants in Bangladesh. Array based Illumina's ovine 50K SNP beadchip analysis for the screened DNAs has produced interesting data which would improve the understanding of genetic architectures of different native sheep of Bangladesh and aid selection for improving lamb production potentiality.

46. Project Code and Title: TF-49-L/17. Value addition through pelleting and densifying of feed using crop residues for ruminants

Implementing Organization: Bangladesh Agricultral University (BAU), Mymensingh

Principal Investigator: Dr. Mohammad Mohi Uddin, Assistant Professor, Department of Animal Nutrition, Faculty of Animal Husbandry, BAU

Locations: BAU, Milk Vita Co. premises, Baghabari and selected areas of Sirajganj distirict

Budget: Tk. 60.00 lakh

Duration: Jan 2018 to Mar 2021

Itroduction: Feed and feeding management play the central role in improving milk and beef production. Productivity of milk and beef in Bangladesh has not yet reached the expected level due to shortage of quality feed throughout the year among other things. One good option for improving feeding management is to include in the daily ration nutritionally enriched rice straw, the most important source of roughage in Bangladesh. However, rice straw is rather poor in nutritive quality because of its high fiber and silica contents resulting in low intake by cattle and por digestibility. This study was designed to develop alternative feeding management which would be technologically and economically feasible and safe and nutritious or cattle and and conduct economic and market research for the development of a business model for value added rice straw marketing.

Objective: Ensuring year round availability of roughage and increasing milk production through providing value added straw to dairy cows.

Materials and Methods: The project implementation involves mainly 1) valued addition to straw, 2) manufacturing of densified rice straw blocks and baled straw, 3) storage and transportation of improved feed, 4) analysis of the nutritional quality of the value-added rice straw, 5) conducting feeding trial for evaluation of nutritional quality of the and economic performance of the dairy cattle an 6) adoption of rice straw blocks and rice straw bales at the farm level. In the feeding experiment, the parameters studied were: feed intake, feed DM intake, nutrient intake and daily milk yield. The feed material and faeces

were chemically analyzed for crude protein (CP), crude fiber (CF), ether extract (EE), ash and nitrogen free extract (NFE) AOAC 2004 methods. The neutral detergent fiber (NDF) and acid detergent fiber (ADF) of feedstuff were also analyzed. Hemicelluloses were estimated as the difference between NDF and ADF. The fat content of the milk was estimated using the Gerber analytical method (British Standard Institution, B.S., 696, 1955). The solid-not-fat (SNF) content in milk was determined by lactometer readings (LR) and the fat values of the milk.

The business model development considers the IPAO (I = input, P = process, A = assumptions, O = output) system.

Results and Discussion: Surveys and on-farm experimental feeding trials showed rice straw as the dominant feed used by dairy farmers of Bangladesh. The farmers, however, were found willing to adopt the technology of value addition to straw for use in the daily ration in their farms contingent upon easy access to the technology. The processed straw could also play a significant role in their budgeting.

Unfortunately, the machine for chopping straw in the required size was not available. The machines available in the country are suitable for chopping green fodder (grass) but not straw. Designing and fabricating a straw chopper are needed. Block and bale machines were successfully installed and they are in full operation.

The objective of this study was to evaluate the physical and chemical value addition to rice straw on nutritional quality improvement of rice straw and its effect on milk productivity and composition. The milking cow feeding treatments were: T_0 (control): loose rice straw + green grass + concentrate; T1: value addition to rice straw through chopping (physical) + green grass + concentrate; T2: value addition to rice straw through urea and molasses without chopping (chemical) + green grass + concentrate; and T3: value addition to rice straw through urea molasses with chopping (physical and chemical) + green grass + concentrate. The total DM intakes were 13.44± 0.26, 12.96±0.38, 12.47±0.16 and 12.06±0.31 for T2, T0, T3 and T1, respectively and the same trend was found for the crude protein content in feed. The daily milk yield was the highest with T3 (8.12±0.30 kg/day) followed by T0 (7.30±0.23 kg/day), T1 (6.61±1.35 kg/day) and T2 (6.78±0.09 kg/day), the differences were highly significant ($p<0.01$) among the groups. The treatments T0, T1, T2 and T3 gave fat content of 4.40, 3.97, 4.90 and 4.10%, protein 3.88, 3.69, 3.98 and 3.72%, SNF 8.42, 8.69, 8.49 and 8.13 and TS 12.57, 12.34, 12.96 and 11.90 in milk, respectively.

A well structured model for developing entrepreneurship is proposed and ready for testing and validation. The business model considers three different types of the entreprenurship: small, medium and large, are considered. The model considers the IPAO (I = input, P = process, A = assumptions, O = output) system where the input variables are the fixed costs of machinery and land plus the variable costs. The variable costs inlcude those for raw material, processing and overhead. The assumption is that the traditional model of straw markets is sporadic where there is no price and volume control. The business model targets young enterpreneurs.

Conclusions: The nutritional quality of rice straw, the dominant cattle feed in the country has been found to be rather poor in quality. Physical and chemical value addition to rice straw was found you improve the nutritional quality of feed and increase milk yield. A business model for young entrepreneurs for marketing value added rice straw is being developed by the project.

47. Project Code and Title: TF-62-L/17. Validation of good practices for on-farm lamb production systems

Implementing Organizations: Bangladesh Agricultural University (BAU), Mymensingh, Rajshahi University (RU), Bangladesh Livestock Research Institute (BLRI), Savar and SPS (NGO)

Principal Investigators: Dr. MA Hashem, Professor, Department of Animal Science, Faculty of Animal Husbandry, BAU; Dr. Jalal Uddin Sarder, Professor, RU, Dr. Sadek Ahmed, BLRI and Mr. Mannan Bhasani, SPS

Locations: Sherpur Sadar and Nalitabari upazilas, Netrakona; Paba and Godagari upazilas, Rajshahi; Companyganj and Subarna Char upazilas, Noakhali

Duration: January 2018 to January 2021

Budget: Tk. 51.595 lakh

Introduction: The yearly per capita intake of meat in Bangladesh is only 8.6 kg compared with 42.1 kg and 32.2 kg for the developed and developing countries, respectively. Different non-traditional species including sheep may be used as meat animals to increase meat consumption in the country. Bangladesh has 3.34 million sheep securing the 3rd position in number among the ruminant species. About 32% of the sheep are reared in the three ecological zones like Barind, Jamuna Basin and coastal areas in Bangladesh. Under traditional feeding systems, the sheep are raised on harvested or fallow lands, roads and canal sides, and the sheep also graze on aquatic weeds and grasses in knee-deep water without any supplementation. This system of production retards ruminant growth, hampers reproduction and is hardly profitable. Commercial lamb production from native sheep can be an alternative approach to meet the meat requirement in Bangladesh. This project seeks to develop lamb production farming communities in selected areas, popularize lamb production and optimize the land marketing system.

Objective: Development of lamb production farming community and marketing system for lamb meat in some selected areas of Bangladesh.

Materials and Methods: Previously, beneficiary sheep rearing farmers were selected and trained on sheep keeping. Sheep houses at farmers' homesteads were constructed. Ewes and rams were distribute to the farmers. Beneficiaries were provided with concentrate feed, management tools, medicines, vaccines, fodder cuttings, seeds, and fertilizers. BLRI developed technologies (feeding and other management like, medication, vaccination, de-worming, record keeping, marking, weighing, shearing, washing, castration, etc) were disseminated to the farmers. Data collection (pedigree record, birth, monthly body weight, etc.) and monitoring continue.

Results and Discussion: The total populations of sheep and lamb were found to be 1084 in the Jamuna Basin, 1295 the Barind area and 907 in the coastal region. Fourteen phenotypic characteristics were measured and analyzed in three components. The average body weights of grown up sheep Jamuna basin, Barind and Coastal areas were 2.28, 18.03 and 20.56 kg, respectively. Body weights of male and female lambs at 3 months of age in the Jamuna Basin were 6.77 and 6.51 kg whereas in Barind the figures were 6.22 and 5.8 kg and in the coastal region 6.89 and 6.62 kg, respectively. Season (winter and summer) had a significant ($p<0.05$) influence on the weight of 2 months old lambs in Sherpur and Nalitabari. Mother sheep mortality rates were 5.0, 3.8 and 3.69 % in the Jamuna Basin, Barind and coastal areas, respectively and the new born lamb mortality rates were 11.11, 18.52 and18.15 %, respectively. The numbers of new born lamb are increasing and mortality rate decreasing with time due to improved management.

Fig. 53. A female sheep farmer

PPR vaccine and ivermectin injection for de-worming (including internal and external parasites) are being continued. Mid-term surveys and calculations of calorie, protein and household diet diversified scores (HDDS) have been completed. Lambs have been sold at marketable ages (6, 9 and 12 month of age).

The RU component has already built a sheep slaughterhouse, and slaughterhouses SPS and BLRI are under construction.
A booklet on sheep rearing and a leaflet on lamb meat have been produced. Lamb has already been sold

Fig. 54. A model sheep slaughterhouse (left) and scientifically processed and packaged lamb meat for marketing

at marketable age (6, 9 and 12 months of age). PPR vaccine and ivermectin injection for deworming (including internal and external parasites) and continue. Midterm survey and calculation of calorie, protein and household diet diversified score (HDDS) have been completed. Lamb production performance was calculated up to 9 months by SPS.

Sheep farmers' society in Sherpur district has been formed. Farmers are taking collective steps to protectbtheis sheep from predators (jackal, dogs etc) attack and thieves.

Conclusions: Demonstration, promotion and extension of good rearing practices, management and health services have positively impacted sheep rearing and marketing in the Jamina Basin, Brind and coastal areas of the Bangaldesh. This offers the local sheep farmers a good opportunity to expand their flocks, maintain sheep health, produce good quality meat and increase earnings.

4.2.2 Commissioned Research Program (CRP)

4.2.2A Ongoing Projects

48. Project Code and Title: CRP-IV. Increasing livestock production in the hills through better husbandry, health services and improving market access through value and supply chain management

Implementing Organizations: Chattogram Vetrinary and Animal Science University (CVASU), Chattogram, Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka and Integrated Development Foundation (IDF), Mirpur, Dhaka

Principal Investigators: Dr. Md. Kabirul Islam Khan, Professor, Department of Genetics and Animal Breeding, CVASU, Dr. Paritosh Kumar Biswas, Professor and Director, Poultry Research and Training Center (PRTC), CVASU; Dr. Md. Abdul Jalil, PSO, BLRI; Mr. Shah Alam, IDF

Locations: Animal Nutrition and PRTC Laboratories, CVASU; Sadar and Naikhangchari upazilas of Bandarban; Sadar and Pan Chari upazilas of Khagrachari

Budget: Tk. 549.50 lakh

Duration: Apr 2017 to Mar 2022

Background: Chittagong Hill Tracts (CHT) differs from the plain lands of the country in terms of agro-ecology, landscape, biodiversity and anthropology. The ancestors of modern chickens, the red jungle fowl (*Gallus gallus*) can be found in CHT. Hilly chicken, a potential meat producing poultry genotype are available still in the hill districts. In spite of having considerable economic importance and potential for livestock development, little attention so far has been given to the study of livestock and its development in CHT. Increasing the productivity of the available livestock and poultry in the hills through introduction of proper feeding and nutrition, improved veterinary health care services, providing training and motivation on livestock rearing along with the development of marketing facilities for dairy and poultry products would help enhance incomes and improve the livelihood of the hill people.

Objective: Improvement of livestock health and nutrition and livestock product value chain development in the hill districts of Bangladesh.

Materials and Methods: The project activities are conducted in 4 upazillas of the Chittagong Hill Tract (CHT) districts. The main activities are :1) surveys on the status of livestock production amd marketing in CHT, 2) hands on training on livestock rearing for 208 farmers selected as project beneficiaries (sheep rearing group and hilly chicken rearing group) and 20 community livestock workers (CLW), 3) building of breeder sheep houses and chicken houses in the farmers' households and distributing livetock, 4) growing fodder crops and assessing their nutritional values, 5) regular vaccination drives and 6) studying opportunities of livestock entrepreneurs and value chain development.

Results and Discussion: This is a coordinated project being implemented by organization/institutes in four upazilas of CHT. Based on the baseline data and direct observation, 208 farmers were selected as project beneficiaries (sheep rearing group and hilly chicken rearing group) and 20 community livestock workers (CLW) were selected for hands on training on livestock and poultry health, production and marketing. The baseline survey data were generated in the first year and based on the information, research was undertaken and is ongoing. Building of breeder sheep houses in the farmers' households has been completed in the project area. Five sheep (01 ram and 4 ewes) were distributed to each of the 32 selected sheep breeder farmers by the CVASU and BLRI components. In addition, 16 sheep grower houses were built and 5 grower sheep distributed to each farmer by the same components. Twenty-four breeders' and 4 growers' chicken houses were built and a total of 928 breeders and 800 growers' hilly chickens were distributed by CVASU; and 16 breeder and 4 grower chicken houses were built and 640 breeders' and 600 growers' hilly chickens were distributed by BLRI. The survival, production and reproduction studies on sheep under hilly conditions are ongoing. The sheep are reared under traditional

Fig. 55. Hilly chickens and lamb in CHT

feeding and rearing systems. In addition, concentrate mixes are being supplied monthly to the sheep farmers as supplements (daily 200-300g/sheep). The weight of mature male sheep ranged from 24.67 to 26.63 and that of female sheep 24 to 24.63 kg, respectively, and it differed from location to location depending on the availability of green grasses and management. The survivability of male and female sheep was 60 to 75% and 70 to 78%, respectively. The prevalence of gastrointestinal parasitic infections in sheep and goat was 72.29% and 68.18%, respectively. The endo-parasitic infection rate was the higher in sheep aged >2 years than in the younger ones. Among the endo-parasites, *Haemophysalis* sp was more prevalent than *Boophilus* sp.

High-yielding varieties (HYV) of grass such as, Napier, Pakchang (*Penninsula purpureum*× *p. americanum)* and other plant species like maize (*Zea mays*), cowpea (*Vigna unguiculata*) and *shajna* (*Moringa Oleifera*) were planted in 16, 6, 9 and 3 plots, respectively. It was found that plant length, stem length, leaf length and stem diameter significantly differed among locations and with days to harvest (45 vs 75 days) after plantation. The fresh yield of Napier Pakchang varied from 91 to 167 kg/decimal at the first cutting (45 days) which was higher than that at the second cutting (75) days. Samples of some unconventional tree leaves and herbs such as, Ziga (*Odina woder*), Jujube (*Ziziphus mauritiana*), and *kumari lata* (*Smilax roxburghian*) were collected and their nutritional values are being determined with the aim of incorporating these as fodder in the rations of livestock and poultry. Dry matter, crude fiber, crude protein, ether extract of Ziga, Jujube and *kumari lata* were found to be 39.71, 12.89, 13.22, 3.34; 35.08, 11.04, 10.5, 4.2; and 11.65, 2.76, 2.25, 2.62%, respectively.

Fig. 56. Production of Napier grass as fodder for hill livestock

The weights at sexual maturity of spotted and reddish brown hilly chickens were similar (2400-2480 g for males and 1500-1580 for females). The feed conversion ratio (FCR, feed: growth) of hilly chicken were, 5.12: 1 and 5.08:1 for males and females, respectively at 20 weeks of age, FCR did not differ significantly among types. The net incomes observed per kg live chicken were Tk. 145 and 75 for male and female, respectively. The profit per kg broiler chicken ranges from Tk. 15 to 20 taka. If a farmer can run 4 batches of broiler in 20 weeks, s/he could earn Tk. 60-80 from broiler production. In comparison, rearing hilly chickens may fetch greater profits. The egg production performance, egg characteristics and blood constituent of hilly and their crossbred chickens were studied. The crossbred chickens showed better egg production and egg characteristics.

The blood glucose, triglyceride, cholesterol, calcium, protein, uric acid and alkaline phosphate values among chickens did not vary significantly. The genetic relationship and polymorphism of *BMPR1B* and *STAT5B* genes of hilly and crossbreds were studied, and the heterozygosity (H_E) and breed co-ancestry (Fij) and polymorphism information content (PIC) indicated that these chickens originated from a common ancestor.

Training of CLW and vaccination of animals are ongoing. Two hands on training for farmers on sheep rearing and fodder production and two on chicken rearing and feeding were conducted.

Conclusions: This project demonstrated that survival of sheep and improvement in production in the hilly environment can be substantially improved through introduction of good husbandry, feeding and management practices including regular vaccination and deworming with antihelminthics. The

incorporation of suitable unconventional tree leaves and herbs in the rations of livestock and poultry may reduce feed costs and enhance livestock productivity in CHT. Hilly chicken has been found to outperform broiler chicken as as an egg and meat producer since the former is greater adapted to the hilly environment. Egg production, egg characteristics and blood fatty acid constituents of Hilly and crossbred chickens were studied.

4.2.3 Capacity Enhancement Program (CEP)

4.2.3A Completed Projects

49. Project Code and Title: CEP-IV. Skill development training for scientists, field vets, livestock workers and poultry/dairy farmers

Implementing Organization: Chattogram Veterinary and Animal Science University (CVASU), Chattogram

Coordinator: Dr. Paritosh Kumar Biswas, Professor and Director, Poultry Research and Training Center (PRTC), CVASU, Chattogram

Locations: PRTC and SAQ Teaching and Veterinary Hospital, CVASU

Budget: Tk. 68.16 lakh

Duration: Mar 2017 to Feb 2020

Intorduction: Scientists working at different BLRI and DLS-based disease investigation laboratories and centers need to be trained on the use of high throughput, high-tech equipment for producing quality vaccines and proper disease detection. Again, for performing life saving surgery on domestic animals, veterinarians must be capable of using the correct surgical techniques and equipment including radiography and ultrasonography. On the other hand, poultry and dairy farming has an enormous potential for self-employment and income generation in Bangladesh. There is already a good number of people involved in commercial poultry and dairy many of whom lack adequate training and skills to operate livestock farms profitably. Advanced management for disease control, biosecurity and feeds can only be introduced to the commercial enterprises if the farmers are well-trained.

Objective: To train scientists on modern surgical techniques and dairy farmers on the operation of commercial farms in bio-secured, environmentally friendly ways.

Materials and Methods: Training programs were conducted community livestock workers (CLWs), poultry farmers, dairy farmers and animal and veterinary scientists of the Department of Livestock Services (DLS) and Bangladesh Livestock Research Institute (BLRI). The subjects of training for CLW and farmers were poultry and livestock management incuding fodder production, vaccination, farm biosecurity, artificial insemination, milking and milk storage, brooding, layer farm planning, marketing, etc. Training for the BLRI and DLS scientists was on the use of sophisticated techniques as DNA/RNA extraction, DNA sequencing analysis, real-time PCR testing, etc.

Progress: So far a total of 205 scientists, veterinarians and farmers have been trained in the relevant fields like the use of molecular techniques in microbiology, veterinary surgery and radiographic imaging techniques, advanced dairy farming, poultry farming and community livestock heath services. For the training on molecular techniques in microbiology, the trainees were exposed to techniques of using DNA extraction machine, PCR/real-time PCR machine and other molecular/DNA based equipment along with instrumental techniques like ultra high performance liquid chromatography (UHPLC), atomic absorption spectrophotometry (AAS), protein analysis, etc. In the training program on veterinary surgery and radiographic imaging techniques, the trainees were allowed to practice various difficult surgical and radiographic imaging procedures under the direct supervision of the surgery and radiographic imaging experts from Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), Chennai, India.

Conclusions: The training programs planned and implemented by this project greatly benefited livestock farmers, dairy and poultry entrepreneurs as they learned about advanced techniques of poultry and dairy farm management in terms of disease control, biosecurity and feeds. On the other hand, animal and veterinary scientists gathered valuable knowledge and developed their skills in the use of highly sensitive molecular/DNA-based testing equipment and modern surgical techniques which they can apply in their respective fields of work.

4.2.4 Technology Piloting Program (TPP)

4.2.4A Completed Projects

50. Project Code and Title: P-16/2017. Improving animal health and productivity through mobile veterinary services

Implementing Organizations: Bangladesh Agricultural University (BAU), Mymensingh and the NGO Socio-Economic and Environment Development Society (SEEDS)

Principal Investigator: Dr. Emdadul Haque Chowdhury, Professor, Department of Pathology, Faculty of Veterinary Science, BAU

Locations: Fulbaria upazila, Mymensingh and Nakla upazila, Sherpur

Budget: Tk. 111.043 lakh

Duration: May 2017 to April 2020

Introduction: It was evident from a previously implemented KGF funded project entitled "Calf mortality in large and small holder crossbred dairy cattle: Epidemiological and pathological investigation and mitigation" that farmers' door step veterinary services provided by mobile veterinary teams termed "Mobile veterinary service" could reduce calf mortality from 13.2% to 2% and improve the fertility of cows. This technology piloting is being implemented to disseminate the "Mobile veterinary service" package with a view to improving animal health and productivity in two more upazilas of Mymensingh and Sherpur districts. The "Mobile Veterinary Service" includes three service packages. The first package includes, i) surveillance on livestock diseases, ii) training on animal health management, iii) formation of community groups, and iv) linking with markets. The second package comprises delivery of preventive veterinary services and the third package provides clinical veterinary services to control calf and other livestock diseases.

Objective: Prevention of livestock diseases through better animal health and fertility management services provided by a mobile veterinary team

Materials and Methods: A total of 500 farmers from small and large holder private farms having at least 2 cattle each were selected for the project. All livestock as well as backyard poultry were included. During the past three-year period, the project area and beneficiaries were served regularly with veterinary services such as treatment, de-worming, vaccination, fodder cultivation, artificial insemination (AI) and other services when required. Continuous surveillance of diseases was done. Moreover, all the 500 farmers were thoroughly trained on livestock rearing, hygienic management of farm, deworming and vaccination, sign and symptoms of sickness and first aids. They were also provided thermometers, spray machines and health cards to maintain biosecurity in their farms.

Results and Discussion: A total of 1663 cattle, 479 goats and 1763 poultry suffered from different diseases, which were treated (Table 14). Moreover 2931 cattle and 1462 goats were de-wormed with different anthelmintics. AI (417) was performed at farmers' doorsteps and 362 calves (including 15 Brahma calves) were born during this study period. A toal of 192 farmers cultivated different types of fodder grass in their homesteads/fallow lands (Table 8). Mass vaccination was provided regularly against the fatal diseases of cattle and goat with special emphasis on FMD of cattle and PPR of goat. Calf mortality reduced from 8.1% to 1.2%, cattle morbidity gradually reduced from 72.74% to 20.21% and mortality reduced from 0.26% to 0.17%. Goat morbidity gradually reduced from 42.89% to 17.78%

and goat mortality reduced from0.67% to 0.47%. Milk yield per cow per day increased from an average 2.43 L/cow/day to 4.31 L/cow/day. Total livestock growth increased by 20.1% (Fig. 38). Age at first heat was reduced from 30.69 months to 21.85 months. Conception rate was increased from 53.47 % to 56.90 %. A drama on "Mobile Veterinary Clinic" has been produced and uploaded in YouTube which has had more than 2100 views so far.

Table 14. Summary of veterinary services provided and animal mortality

Activity	Fulbaria	Nakla	Total
Cattle treated	1005	658	1663
Goat treated	244	235	479
Poultry teated	1423	340	1763
Cattle dewormed	1217	1714	2931
Goat dewormed	561	901	1462
Cattle vaccinated	1130	2286	3416
Goat vaccinated	94	519	613
Poultry vaccinated	2027	1012	3039
Grass cultivation	79	113	192
AI done	212	205	417
Calves born	208	154	362
Calves died	03	02	05
Cattle Died	03	03	05
Goat died	04	03	07
Poultry Died	519	692	1211

Conclusions: The novel concept and operating system of "Mobile veterinary service" developed by this project can be very useful in providing veterinary services to the doorsteps of farmers especially those living far away from vet hospitls. This can protect livestock from serious and lethal diseases, improve livestock health and and quality and quantity of animal products for human consumption.

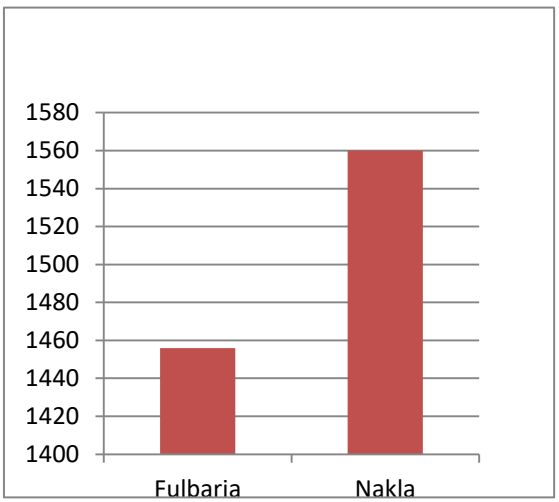


Fig. 57. Growth of livestock in the study area

Technical Progress Fisheries

Fish and the Bangladeshis are inseparable. Bangladeshis have traditionally been reputed as habitual and voracious fish- eaters. Fish is the major source of animal protein in the Bangladeshi diet. As a riverine country. Bangladesh has been historically well known the world over for producing and consuming fish. About whom 17 million people of the country, including 1.4 million women, depend on the fisheries sub- sector for their livelihoods comprising fishing, farming, fish handling and processing. Bangladesh for the first time has become self- sufficient in fish production, with a per capita fish consumption of 62.58 g/ day. The target set in Vision-2021 is to produce 4.55 million tons by 2021. As the people become prosperous, the demand for fish protein will increase making sustainable growth of fisheries essential with improved production technologies and management methods. For this, improved biological management of public water bodies, several socio-eco-friendly programs are being advocated which include community based fisheries management, establishment of beel nurseries, stocking of fingerlings, restoration of habitats, establishment and maintenance of sanctuaries, expansion of cage and pen farming in feasible water areas, adoption of climate smart technologies, etc. In recent years, KGF sponsored projects on fisheries have addressed some of these issues.

4.3 FISHERIES

4.3.1 CGP 3rd Call Projects

4.3.1A Ongoing Projects

51. Project Code and Title: TF 37-F/17. Development of health management strategy against bacterial diseases in the aquafarms of Bangladesh

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh

Principal Investigator: Dr. Gias Uddin Ahmed, Professor, Department of Aquaculture, BAU

Locations: BAU campus, Mymensingh and three districts, Mymensingh, Cumilla and Khulna, with high concentrations of commercial aquaculture

Budget: Tk. 76.76 lakh

Duration: Jan 2018 to Dec 2020

Introduction: Aquaculture has evolved as the fastest growing food-producing sector providing employment, income and nutrition to millions of farmers, input providers and consumers in Bangladesh. Mainly exotic fish like *Pangasius hypophthalmus*, *Oreochromis niloticus and Anabas testudineus* and a few indigenous catfish viz., *Clariasbatrachus*, *Heteropneustesfossilis* and *Ompok pabda* are grown by fish farmers in both monoculture and polyculture practices. Intensive aquaculture with these species often causes water pollution problems and disease outbreaks. Use of drugs, chemicals and antibiotics can lead to another set of problems like bacterial resistance and undesirable residual effects on human health and the environment. Therefore, the issue of fish health management is of considerable importance, which this project attempts to address.

Objective: To determine the status of biosecurity and assess the problems of commercial aquafarms and develop, validate and extend a model for fish health management.

Materials and Methods: In 2017-18, 12 commercial fish farms in 3 upazilas of the Mymensingh district were studied. In year 2 (20During July 2018 to June 2019, the study was carried out in 36 fish ponds from 3 divisions of Bangladesh where improved aquaculture is being practiced. To understand the baseline situation on health management, detailed data were collected through pond surveys using a pre-tested questionnaire. In the year underv report (2019-20), investigations were carried out in 15 ponds (prophylactic trials at BAU campus) and Alalpur Hatcheries and Fisheries, Alalpur, Shombhuganj, Mymensingh (off campus) to observe growth performance, bacterial load and blood parameters of tilapia fish. In the campus trial, there were 5 treatments viz., T_1 (soil probiotic), T_2 (gut probiotic), T_3 (soil+gut+water probiotics), T_4 (water probiotic) and T_5 (control). In the off-campus trial (Alalpur), treatments for the three ponds were T_1 (water probiotic), T_2 (soil probiotic) and T_3 (control). A one-day training program was conducted with 36 selected fish farmers, 12 from each of Mymensingh, Cumilla and Khulna divisions in late February 2020.

Results and Discussion: Net weight gain, % of weight gain, specific growth rate (SGR) and survival rate (%) of Tilapia in both on-campus and off-campus trials were better in probiotic treated ponds than in control ponds. However, the food conversion ratio (FCR) was higher in the control ponds than that in the probiotic treated ponds. The hematological study showed that probiotics increased immunity by increasing the hemoglobin, RBC and WBC levels of fish blood.

The training program focused on two topics--biosecurity issues in fish culture and probiotics for fish health. The presentations were lively and created lots of enthusiasms among the participants. Farmers took part in discussion stating their field and other problems in fish diseases and health management. The participating farmers were taught to maintain proper biosecurity measures and use probiotics for

fish culture and fish health management and cut down on the use of chemical drugs and antibiotics, encouraging them to develop model health management protocols for their aquafarms.

Fig. 58. Fish pickles: Value addition to fish

Conclusions: Since 1988, Bangladeshi fish farmers have been facing big problems of fish diseases that cause severe damage and mortality in both wild and cultured fish every year which ultimately impact the national economy. This project emphasized the application of preventive measures like biosecurity pracices, use of probiotics rather than use of chemical drugs and antibiotics in fish culture and health management.

52. Project Code and Title: TF 38-F/17. Post-harvest loss reduction and value addition of fresh water fish

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh

Principal Investigator: Dr AKM Nowsad Alam, Professor, Department of Fisheries Technology, BAU

Locations: BAU campus, Mymensingh and two study regions, such as, *haor* areas of Kishoreganj and floodplain areas in Daudkandi with natural fish landing and aquaculture fish landing

Budget: Tk. 235.00 lakh

Duration: Jan 2018 to Feb 2021

Introduction: Both natural fisheries and aquaculture fisheries suffer huge post-harvest losses (PHL), amounting to as high as 28-30 % in terms of quantity and 15% in terms of quality, after landing. It is, therefore, imperative to reduce fish PHL though improved fish handling, transportation, preservation and distribution methods and devices. Value addition to fish is an important tool in PHL reduction, which may be done by the adoption of different processing methods, utilization of the underutilized species, using accessories to maximize profits. This project encompasses studies on different improved fish handling, preservation and distribution techniques, devices and practices aiming to reduce PHL, and also on value addition measures like making fish fillets, frozen mince blocks, surimi, fish chatny, fish powder, fish soup, noodles, cookies, etc.

Objective: Development of technical skills in improved fish handling, preservation and production of different value added products from freshwater fish to reduce post-harvest loss.

Materials and Methods: The project activities included (i) baseline surveys, (ii) Post-harvest loss assessment, (iii) organizing beneficiaries' groups, (iv) training, motivation and awareness building, (vii) value added product development from freshwater fish. In 2019-20, ten landing centers were selected in five upazilas of Kishoregonj, namely, Karimganj, Tarail, Itna, Nikli and Kotiadi. Similarly, ten fish landing centers (FLC) were chosen from Daudkandi upazila.

Results and Discussion: Reconnaissance visits and community selection for social mobilization and skill development were done. Through participatory approach, several FGDs wre carried out for the site selection process. For both the regions, collection of baseline data has been completed. For the baseline study, necessary PRA tools and checklists were designed and field tested before field level data collection. The enumerators were trained before baseline data collection. Apart from site selection and

identification of target fishers' community and collection of baseline data, a two-day skill training workshop for the field staff and researchers including the NGOs was held. The main orientation of the skill training was towards post-harvest loss through improved fish handling, preservation, value addition and marketing of fish from the haor and floodplain landing sites. A hand operated ice crusher and self-powered water agitator were developed. The research team has developed good quality value added items, e.g., *Pangas* powder and *Pangas* pickle from *Pangas* fish, which can be produced commercially to create business as well as employment.

Fig. 59. Aerators in Pond of Aquamimicry culture systempond

Conclusions: Reducing post-harvest losses in fish through improved handling, transportation, preservation and distribution methods and devices is imperative to increase fish output and profits from fish business. In this respect, value addition addition through making fish fillets, frozen mince blocks, surimi, fish chatny, fish powder, fish soup, noodles, cookies, etc. may be an important tool. This project demonstrated the benefits of improved fish handling measures and value addition methods to fishing communites, fish handlers and traders.

53. Project Code and Title: TF 39-F/17. Adaptation of disease management strategy in the existing culture practices of shrimp through Aquamimicry system

Implementing Organization: Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur

Principal Investigator: Dr. S M Rafiquzzaman, Associate Professor, Department of Fisheries Biology and Aquatic Environment, BSMRAU

Locations: BSMRAU campus, Gazipur and Munshiganj, Satkhira

Budget: Tk. 69.84 lakh

Duration: Jan 2018 to Dec 2020

Introduction: Shrimp farming has emerged as a very profitable fisheries enterprise in Bangladesh. However, due to intensification and other reasons related to climatic adversities, management shortcomings, etc. various diseases are being frequently reported from across the shrimp farming areas of the country. There has been a gradual decline in production as well as shrimp exports over the last few years threatening the shrimp industry. To manage fish diseases farmers often use different aqua drugs, chemicals, feed additives and antibiotics which are unsafe for humans as well as for the environment. New culture techniques ensuring natural biosecurity and environment friendly and economically profitable management practices are required to address the disease problem and ensure sustainable shrimp production. Aquamimicry is a promising technology for stable production with a self-nitrification process within culture ponds and zero water exchange. This project was designed to adapt the aquamimicry system to existing cultural practices for brackish water shrimp production in the country.

Objective: To adapt and optimize the aquamimicry system for shrimp culture and monitor disease prevalence in the culture systems.

Materials and Methods: The Meghla Shrimp Farm in Shyamnagar, Satkhira was selected for conducting this research. To carry out this research, around 2.5 acre area comprising six ponds are being

used. The experiment was conducted with three treatments on pond design and feed application mode. The feeds used were commercial feed (CF) alone and combinations of CF and liquid fermented rice bran (LFRB). Two mechanical water aerators (Fig. 59) were settled in each pond of the Aquamimicry culture system. Sludge was removed regularly from the central pit of Aquamimicry pond with the help of suction pump. Water quality parameters (temperature, salinity, ammonia, alkalinity, transparencyandpH) were checked daily after stocking. Weight gain of the shrimp was recorded once a week, specific growth rate (SGR) and average growth rate (AGR) were was calculated. Quantities of plankton in the Aquamimicry and existing culture system ponds were as analyzed fortnightly. Microbial analysis of samples collected from water, soil and shrimp of Aquamimicry and existing culture ponds was done separately to isolate and characterize the microbes fortnightly. To study immunological parameters of shrimp, total haemocyte count (THC) and histological analysis were done on haemolymph and hepatopancreas samples, respectively.

Results and Dicussion

Pond water quality

The water quality parameters were found to be suitable for shrimp culture irrespective of treatment. Water transparency in the treatment ponds was lower than that in the control pond (Table 15). It could be due to the application of fermented rice bran in the Aquamimicry system, which might enhance phytoplankton growth. Transparency is a good indicator of the amount of nutrients and the overall health of a pond. However, pH was high (8.11±0.14) in the control pond compared to the Aquamimicry ponds. The high level of pH and transparency could create unfavorable condition for shrimp resulting rapid diseases infestation in the control pond with the existing culture practice.

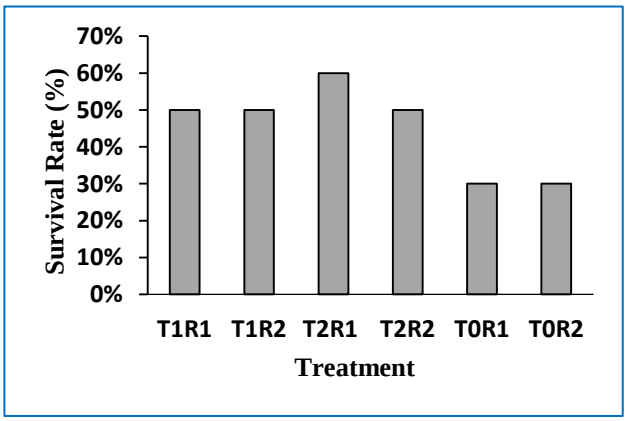
Table 15. Physico-chemical characteristics of water in the shrimp culture ponds

Treat	pH	DO (ppm)	Alkalinity	NH_3 (ppm)	Temp (°C)	Salinity (ppt)	Transparency (cm)
T_0	8.11 ± 0.14	5.74 ± 0.4	78.75 ± 3.56	0.0	33.3 ± 1.51	5.67 ± 0.37	54 ± 4.07
T_1	7.81 ± 0.07	5.88 ± 0.3	74.47 ± 2.94	0.0	33 ± 3.47	5.37 ± 0.50	48 ± 3.05
T_2	7.79 ± 0.08	6.01 ± 0.5	74.37 ± 3.07	0.0	31.8 ± 2.77	5.29 ± 0.72	45± 3.58

T_1 = 90% Commercial Feed (CF) + 10% Liquid Fermented Rice Bran (LFRB); T_2 = 70% CF + 30% LFRB and T_0 = 100% CF

Survivability of shrimp

The hapa survival rate of shrimp is shown in Fig. 60. the overall survivability in the control treatment was the lowest compared to the Aquamimicry treatments. Only 30% shrimp survived in the control pond while in one pond of treatment T_2 it was 60%. The higher mortality occurring in the existing ponds might be due to the presence of pathogenic strains *V. parahaemolyticus*, which was confirmed by microbial analysis.



Plankton Quantity

The quantity of plankton was higher in the Aquamimicry ponds than that in the existing culture ponds. During rainfall, the quantity of plankton decreases, but the quantity in Aquamimicry pond still remained higher.

Growth performance

The average weight gain of shrimp (Fig. 61), SGR and AGR of shrimp of Aquamimicry ponds were higher than those in the control ponds. The stock of the control ponds crashed within 45 days but the stock of treatment ponds specially 30% LFRB treatment gave the best result in case of survival rate and growth performance.

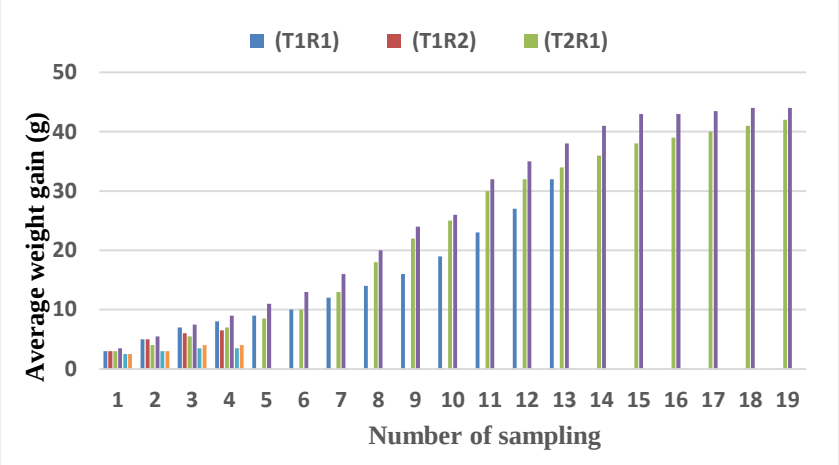


Fig. 61. Weekly growth performance of shrimp (sampling was started from the 4th week of stocking as at the beginning of stocking, sampling was not possible)

Fig. 62. Growth of shrimp in control pond (left) and Aquamimicry pond (right after 45 days of rearing

Microbial analysis

Several species of *Vibrio* and *Proteus* specieswere identified. Most importantly, control pond samples (soil, water and hepatopancreas of shrimp) had *Vibrio Parahaemolyticus*, which is usually responsible for EMS in *P. monodon*. On the other hand, in the treatment ponds, *Vibrio parahaemolyticus* was not found.

Total haemocyte count (THC)

A hemocyte is a cell that plays a role in the immune system of invertebrates. Hemocytes are phagocytes of invertebrates. The shrimp's mechanisms of defence against external agents such as viruses and bacteria include the production of hemocytes, the defence cells present in the blood of shrimp. Due to this reason, the survivability of shrimp in T_1 and T_2 was higher than the control (T_0) ponds. The higher amount of THC count indicates better immune performance of the shrimp in the treated ponds.

Histological analysis

The immune system protects the body against invasion by microorganisms, removes tissues damaged by trauma, and eliminates malignant growths. Regular and well developed hepatopancreatic tubules indicate that the shrimp is in good condition. Histology of the hepatopancreas of shrimp showed normal and well developed shape of hepatopancreatic tubule in T_1 and T_2 (where the shrimp of T_2 had the most regular shape), whereas T_0 showed irregular and undeveloped hepatopancreatic tubule. This result also indicated healthy condition of the shrimp in the Aquamimicry ponds.

Cost-benefit analysis

A cost-benefit analyses were done after the experiment; T_2 (70% CF + 30% LFRB) brought about higher profits. Some profit was derived from cultured shrimp with the Am treatment whereas there was no return from the traditional ponds. The Aquamimicry system appeared to be an attractive and sustainable option for the productive shrimp culture in Bangladesh.

Training program for farmers

A training program was arranged for the farmers on "Adaptation of Disease Management Strategy in the Existing Culture Practices of Shrimp through Aquamimicry System" in August 2019. Farmers shared their experiences regarding the challenges of shrimp culture. At the end of the training, farmers got clear information about the Aquamimicry technology, and some of them expressed keen interested in the Aquamimicry technology.

Conclusions: The Aquamimicry system tested by the project scientists offers a prospective, physico-chemically and biologically viable and productive system of shrimp culture. The new culture technique may ensure natural biosecurity and is prospective as an environment friendly and economically profitable management practice. It holds promise as a good alternative to the traditional practices of shrimp farming that often encounter disease infestations burdening the shrimp entrepreneurs with financial losses.

54. Project Code and Title: TF 40-F/17. Effects of dietary polyunsaturated fatty acids (PUFA) and beta glucan on broodfish (*Labeo rohita, Mystus cavasius* and *Ompok pabda*) immunity and fry quality

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh

Principal Investigator: Dr. Zakir Hossain, Professor, Department of Fisheries Biology and Genetics, BAU

Location: BAU campus, Mymensingh

Budget: Tk. 70.24 lakh

Duration: Jan 2018 to Dec 2020

Introduction: With the recent growth of aquaculture as a viable industry to support sustainable supply of fish for food and nutrition for the people of Bangladesh, it is important to maintain healthy brood stocks and their breeding. Supplementing brood stock diets with PUFA and BG is expected to produce immunized broods and increase spawning success, fecundity, total egg volume, individual egg weight, total egg lipid concentration, hatching success, immunized fry and ultimately boosts fish production securing steady supplies of quality fry to the farmers. The present investigation aims to study the effect of PUFA and BG on reproductive performance and immunity of three important fish species in aquaculture, namely, gulsha (*Mystus cavasius)*, pabda (*Ompok pabda)* and rohu (*Labeo rohita)* by determining gamete quality and plasma calcium (Ca^{+2}).

Objective: To formulate fish feed supplemented with polyunsaturated fatty acids (PUFA) and betaglucan (BG) using extracted phospholipids and BG from squid and mushroom

Materials and Methods: Eighty 80 ruhu (*Labeo rohita*), 400 gulsha (*Mystus cavasius*) and 400 pabda (*Ompok pabda*) fish were collected from different natural sources and stocked in the experimental ponds. The fish were fed with formulated feed enriched in PUFA and barley. A set of control ponds were maintained for comparison where fish feed was without PUFAs and barley. The formulated feed consisted of (i) barley flour 10%, (ii) wheat bran 15%, (iii) rice bran 20%, (iv) maize meal 13.5%, (v) fish meal 40%, (vi) Vitamin-B 0.5% and (vii) Vitamin-E 2.5 IU/g. Vitellogenesis, egg and sperm quality, immunological parameters (alternative complement activity, lysozyme activity, acetylcholinesterase activity and total immunoglobulin level in serum) in the brood fish were determined. The effect of PUFAs and BG on the survival and growth of fry was evaluated.

Fig. 63. Collection of blood sample from fish

Results and Discussion: Research is continuing. PUFAs improved the eggs and sperm quality of fish. Beta-glucan improved the immunological profile of fish. Hatching and survival percent of produced fry was higher in fry fed PUFAs and beta glucan enriched food.

Conclusions: The project demonstrated that supplementing brood stock diets with polyunsaturated fatty acids (PUFA) and beta glucan may improve immunity, increase spawning success and survival rate in fish.

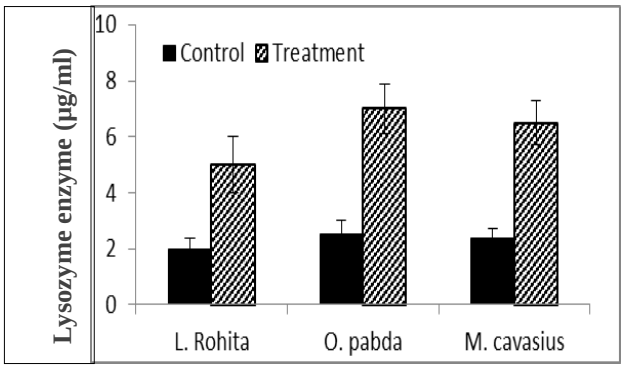
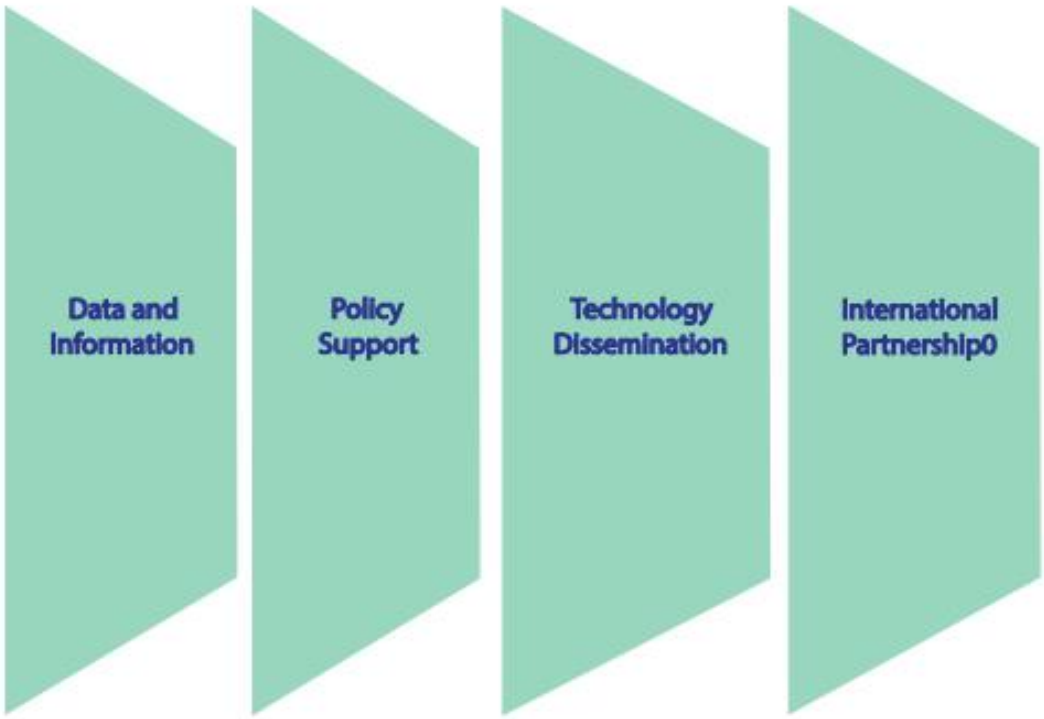


Fig. 64. Effect of beta-glucan on lysozyme enzyme activity in *L. rohita*, *O. pabda* and *M.*

Other Initiatives and Services



5. Initiatives and Services

5.1. Data and information services

KGF initiated work on policy issues and analysis to provide policy support and guidance to stake holders in agricultural R&D, entrepreneurship, planning and policy making and production. KGF's efforts in this respect so far have resulted in the following.

- Establishment of a free access data center with a digital data base on 40 years of work on various sectors of agriculture (crops, fisheries, livestock, etc.)—Agricultural Research Management Information Service (ARMIS)
- Initiation of analysis and policy briefs
- Assisting education-research-extension coordination

5.2 Technical support to policy makers

KGF had assigned agriculture experts to provide policy support to the Ministry of Agriculture on technical aspects of various agricultural R&D, production and contingency issues of national importance. Several policy papers were drafted to support Government policy initiatives:

i. National Agricultural Policy 2018 for the Ministry of Agriculture as Convener of an Experts Committee: Aapproved by the Cabinet after inter-ministerial consultations and feed backs. This policy has been developed after revising the policy of 2013. The policy brought forward newer and emerging areas including stress prone areas, agro-tourism, institutional development through skill and knowledge development, etc.

ii. National Agricultural Mechanization Policy 2018 for the Government--it paved the way to acceleration of farm mechanization in the country to reduce the production costs and save energy.

iii. National Extension Policy 2020 for the Ministry of Agriculture, focusing broadening of extension services to respond to diverse needs of growers and agro-entrepreneurs--approved by the Cabinet after inter-ministerial consultations and feed backs. The policy took into account diversification of extension services towards agro-business, mechanization, post-harvest management, water management, etc. It also focused supporting not only farmers but also entrepreneurs.

iv. Foreign Investment in Agriculture Policy 2020 for the Ministry of Agriculture-- several meetings with relevant departments and ministries have been organized for feedbacks on encouraging domestic investors to secure investments from friendly foreign countries in the fields of profitable agriculture including sharing of technological knowhow

KGF continues policy research and remains prepared to assists government planners and policy makers in the formulation of plans and policies related to R&D and production in the agriculture sector of Bangladesh.

5.3 Awareness building and technology dissemination

KGF initiated an awareness and technology dissemination drive through regular TV broadcasts, and to expedite this, signed an MoU with the TV channel "ATN Bangla' on 07 February 2019 for the dissemination of promising agricultural production technologies generated by R&D projects sponsored by KGF. Video clips of relevant project activities in farmers' fields and interviews of farmers/scientists/extension workers are recorded and

telecast as 25-minute ATN Bangla “KGF Sonalidin” episodes every Saturday at 6:25 pm and repeated the next morning (Sunday) at 6:30 am. In addition, ATN Bangla also organizes talk shows for the “KGF Sonalidin” program involving leaders in agricultural research, education and extension as well as development partners working in Bangladesh. Financial and technical support for the TV broadcasts are provided by KGF. The “ATN Bangla Sonalidin” telecast program continued through 2019-20 although a bit interrupted by the Covid-19 pandemic. In the year under report, 29 TV reports and 4 talk shows on various issues related to crop, livestock and fisheries production were telecast (Table 9).

Table 9. "KGF Sonalidin" telecasts by the TV channel ATN Bangla in 2019-20

ক্রমিক	প্রতিবেদন সম্প্রচার	সম্প্রচারের তারিখ
১।	তেলাপিয়ার সাথে দেশী মাগুর চাষ কৌশল এবং মাছের সংগ্রহ পরবর্তী ক্ষতি কমানো ও মাছের বহুমুখী ব্যবহার	০৩.০৮.২০১৯
২।	ভেড়ার মাংস জনপ্রিয় করণ	১০.০৮.২০১৯
৩।	ছাদ কৃষি	২৪.০৮.২০১৯
৪।	গাভীর ব্রুসেলা ও রিপিট ব্রিডিং	৩১.০৮.২০১৯
৫।	আইসিমোড ও বাউ-ব্রো চিকেন	২১.০৯.২০১৯
৬।	ভাসমান ধাপে বিষমুক্ত সবজি চাষের উন্নত কৌশল	২৮.০৯.২০১৯
৭।	ভাসমান ধাপে বিষমুক্ত সবজি চাষের উন্নত কৌশল এবং খাঁচায় মৎস্য চাষ ও বসত বাড়ীতে সবজি চাষ	০৫.১০.২০১৯
৮।	এ্যকুয়ামিমিক্রি	২৬.১০.২০১৯
৯।	শিসউক ঝনঝনিয়া	০২.১১.২০১৯
১০।	চাষ গবেষণা	০৯.১১.২০১৯
১১।	পাহাড়ের জীববৈচিত্র্য সংরক্ষণে মিশ্র ফলবাগান ও সাথী ফসল হিসাবে পেঁপে চাষ	১৯.১০.২০১৯
১২।	কাঁকড়া চাষ ও ACIAR-Strategic Consultation Meeting	২৩.১১.২০১৯
১৩।	ইউনিয়ন পর্যায়ে মৎস্য চাষ	৩০.১১.২০১৯
১৪।	কাঁঠালে উন্নত সুস্বাদু,এবং মৌসুমে ও অমৌসুমে উৎপাদনযোগ্য বারি উদ্ভাবিত কাঁঠালের তিনটি জাত কৃষক পর্যায়ে সম্প্রসারণ ও চাষ পদ্ধতি	০৭.১২.২০১৯
১৫।	বারি উদ্ভাবিত কাঁঠালের তিনটি জাত কৃষক পর্যায়ে সম্প্রসারণ ও শিল্পে কাঁঠালের ব্যবহার-২য় পর্ব	১৪.১২.২০১৯
১৬	বায়োফ্লক পদ্ধতিতে অধিক ঘনত্বে মাছ চাষ	২১.১২.২০১৯
১৭।	কৃষক সংগঠন, চুয়াডাঙ্গা	০৪.০১.২০২০
১৮।	চিংড়ি ও খুলনা ল্যাব	১৮.০১.২০২০
১৯।	শিসউক সিরাজগঞ্জ	০১.০২.২০২০
২০।	তাপ সহিষ্ণু গমের জাত উদ্ভাবন।	০৮.০২.২০২০
২১।	তাপ ও খরা সহিষ্ণু গমের জাত উন্নয়ন, এ্যকোয়াপনিক ও পেয়ারা চাষ	১৫.০২.২০২০
২২।	হাইড্রোপনিক পদ্ধতিতে সবজি চাষ কৌশল	২২.০২.২০২০
২৩।	বারি আলু রোপন ও উত্তোলন যন্ত্র	২৯.০২.২০২০
২৪।	বারিঃ মাটির স্বাস্থ্য ব্যবস্থাপনায় সারের বিভিন্ন মাত্রার সাথে বায়োচার প্রয়োগ	০৭.০৩.২০২০
২৫।	এসিআইএআর-কেজিএফ উপকুলীয় অঞ্চলের কৃষি	১৪.০৩.২০২০
২৬।	এসিআইএআর-কেজিএফ উপকুলীয় অঞ্চলের কৃষি	২১.০৩.২০২০
২৭।	নেট হাউসে সবজি চারা উৎপাদনের আধুনিক কৌশল, বগুড়া	২৮.০৩.২০২০
২৮।	বারি গবেষণা মাঠে জৈব কৃষি প্রযুক্তি মডেল	০৪.০৪.২০২০
২৯।	প্রাণিসম্পদ উন্নয়নে বিএলআরআই উদ্ভাবিত প্রযুক্তি ডিএলএস এর মাধ্যমে মাঠপর্যায়ে সম্পাসারণ	১১.০৪.২০২০
টকশো		
১।	এসিআইএআর	১৪.০৯.২০১৯
২।	ইরি ও কেজিএফ	১৯.১০.২০১৯
৩।	কৃষি উন্নয়ন পরিকল্পনাঃ ডিজি, ডিএই	২৮.১২.২০১৯
৪।	কৃষি উন্নয়নে বেসরকারি প্রতিষ্ঠানের অবদান ও সরকারের নীতি সহায়তা	২৫.০১.২০২০

5.4 International partnership: Information, knowledge and technology exchange

Having been authorized by Clause 15 of the Memorandum of Article of Association (MAA) "To obtain membership and pay fees for the membership of any national or international bodies, institutions, organizations and subscription to their publications, if any, for furtherance of the objects of the Foundation", KGF started partnering with a few international agricultural R&D organizations for information, knowledge and technology exchange:

- Asia-Pacific Association of Agricultural Research Institutions (APAARI), Thailand
- International Centre for Integrated Mountain Development (ICIMOD), Nepal
- Indian Society of Coastal Agricultural Research (ISCAR)
- International Centre for Climate Change and Development (ICCCAD), Bangladesh

5.5 International Visits/Delegations

5.5.1 International visits

The Executive Director and other professionals visited several countries to attend international conferences, workshops, seminars, consultation meetings during the period July 2019 to June 2020, as shown in the list below:

Country	Subject	Purpose
Nepal	Seminar on Cryosphere and signing of Letter of Intent between KGF and ICIMOD. HE High Commissioner of Bangladesh in Nepal, Director SAARC and DG ICIMOD attended the signing ceremony among others.	Attending seminar and signing LoI between KGF and ICIMOD during 28-29 August 2019
Turkey	Study of Bee keeping industry in Turkey. Value addition in bee keeping industry as medicine and commercialization of products. Visit was made in connection with MoU between Shere Bangla Agri University and honeybee keepers in Istanbul.	Attended Istanbul university and private sector collaboration in honey bee industry during 23-26 November 2019
Nepal	Invitation for Resilient Mountain Solutions Partners' Workshop in Kathmandu, Nepal, Dr. Shahabuddin and Dr. M. Nurul Alam Attended the workshop	The workshop provided input for KGF Hill project on development of research program during 28-31 January 2020.

Nepal	Participation in regional consultation meet ICIMOD. The Program was attended by Dr. M. Nurul Alam, Coordinator of Hill Project of KGF and Ms. Nasrin Akter, Communication Specialist of KGF	Workshop was organized with the ICIMOD partners on understanding HKH livelihood development during 15 November 2019.
Australia	The third international Tropical Agriculture Conference" at the Brisbane Convention and Exhibition Centre in Australia. Dr Tapan Kumar Dey of KGF attended the conference	ACIAR and CSIRO of Australia sponsored the conference during 11-13 November 2019

Organizational, Administrative and Financial Responsibilities

6. Organizational, Administrative and Financial Responsibilities

Besides supporting, overseeing and managing implementation of agricultural R&D programs like CGP, CRP, ICP, CEP and TPP, the Foundation has certain other, no less important, responsibilities to look after, such as, providing policy inputs to the Ministry of Agriculture, organizing functional, strategic and policy making meetings, national and international seminars, symposia, workshops Regular dissemination and diffusion of information and knowledge through assorted publications, promotional activities, media campaigns, etc. are also an important part of the KGF brief. In the year 209-20, KGF arranged seven (67th to 73rd) Board meetings, six (28th to 33rd) Technical Advisory Committee (TAC) meetings, one Annual General Meeting (AGM). In the year, 15 project coordination/review workshops participated in by working scientists of the KGF sponsored projects, KGF professionals and relevant reviewers and experts invited by KGF. In 2019-20, KGF organized and held 15 seminars/meetings attended by local and foreign dignitaries like the Minister for Agriculture, GOB, Agriculture Secretary and scientists from abroad. These meetings/workshops/consultative group discussions, etc. were held at different places of the country considering necessity, relevance and realities. All these events and activities were supported by BKGET funds. Besides, KGF responded to queries from different bodies like the Parliamentary Standing Committees, MoA, ADB, IMED, ERD, Planning Commission and also from KGF Board, through reports or presentations.

6.1 Training/Workshops/Seminars/Consultation Meetings

6.1.1 Training/workshops/seminars/coordination meetings and reviews

KGF organizes short- to medium-term training programs for capacity building of professionals engaged in agricultural research and extension work at NARS institutions, universities, DAE, NGOs, etc.

KGF regularly organizes internal workshops mostly in relation to monitoring of on-going projects and national workshops to strengthen coordination and support for work on agricultural research and development issues. The Foundation also assists in organizing international workshops to establish linkages and collaboration between national and international agricultural research organizations and universities. Several training sessions, national and international workshops/seminars/meetings were held in 2019-20 as listed below.

Table 10. Training/workshops/seminars/consultation meetings/KGF Board meetings during 2019-2020

Sl. No.	Subject	Date	Venue	Organizer	Remarks
KGF organized workshop/meeting					
08	Project Review Workshop	30.07.2019	KGF Conference Room	KGF	
10.	Annual Progress Review and Planning Workshop on CRP-1:Hill Agriculture	31.07.2019	KGF Conference Room	KGF	
12.	Meeting on Finalization of the Neem-Coated Urea Project Proposal	06.08.2019	KGF Board Room	KGF	
14	Meeting with ICIMOD	19.08.2019	KGF Office	KGF	
19	8th Coordination Meeting on CRP-1: Hill Agriculture Project	08.09.2019	KGF Conference Room	KGF	
23	TF 16-WM/15- PCR Review Meeting and APR for 2nd Year Review Meeting (TF 29-AM/15, BR1-C/17, BR3-C/17, BR5-C/17) of KGF	22.09.2019	KGF Conference Room	KGF	
30.	Experts Discussion Meeting on KGF and ICIMOD, Nepal	22-23.10. 2019	BARC Training Building	KGF	
34.	Project Management Committee (PMC) Meeting on ARMIS Project	27.10.2019	BARC Conference Room	KGF	
35.	Discussion Meeting of KGF Ongoing Projects	28.10.2019	KGF Conference Room	KGF	
49	শিশুক কর্তৃক বাস্তবায়িত পাইলট প্রকল্প পি-১৮ বাস্তবায়ন অগ্রগতি বিষয়ে আলোচনা সভা	12.12.2019	KGF Conference Room	KGF	
50	Project Review Workshop (BR-4-C/17, TF-61-C/17, CRP-V, TF-36-FP/15, TF-35-SF/15, TF-63-Char/17)	18.12.2019	KGF Conference Room	KGF	
51	Consultation Workshop on Livestock Sector Database for Development Planning: Present Status and Improvement Opportunities.	23.12.2019	BARC Training Building	KGF	
53	কেজিএফ কর্তৃক আয়োজিত কৃষি মন্ত্রণালয়ের সচিব জনাব মোঃ নাসিরুজ্জামান-এর সভাপতিত্বে "বর্হিবিশ্বে কৃষি বিনিয়োগ নীতিমালা ২০২০" পর্যালোচনা সভা	14.01.2020	BARC Conference Room	KGF	
24.	TF 30-AP/15 PCR Review Meeting and APR (TF 38-F/17, TF 49-L/17) (P-18) and (TF 31-VC/15, P-1, CRP-IV)- 2nd Year Review Meeting	23.09.2019	KGF Conference Room	KGF	
25	Workshop on Project Completion (CEP Seaweed Project)	28.09.2019	BARC Conference Room	KGF	
26.	Meeting on National Agricultural Mechanization Policy 2019	02.10.2019	KGF Office	KGF	
28	Training Program of ARMIS Project	07.10.2019	GIS Training Room, BARC	KGF	
38	Meeting with Prof. Richard W. Bell – Project Leader, NUMAN Project	07.11.2019	KGF Office		
KGF funding					
06.	Inaugural Session of the SAARC Regional Expert Consultation Program on Multi-Sectoral Program Development for the SAARC Agri Centre	16.07.2019	Hotel Golden Tulip, Banani, Dhaka	SAARC	KGF Funding
02.	North South University (NSU) Organized Symposium on Agribusiness Innovation : A Pathway to Sustainable Development in Bangladesh During (Financed Jointly by KGF and NSU)	07.07.2019	North South University	NSU	KGF Funding

Sl. No.	Subject	Date	Venue	Organizer	Remarks
16.	Inception Workshop: Postharvest Management, Processing and Marketing of Jackfruits Project	21.08.2019	BARI Conference Room, Gazipur		KGF Project
17.	Signing of MoU between KGF, ICIMOD and International Forum on Cryosphere and Society	27-30.08. 2019	Kathmondu, Nepal		KGF & ICIMOD
40	4th Innovations in Plant and Food Sciences-International Conference on Biotechnology in Health and Agriculture (4th IPFS-ICBHA)	11.11.2019	Senate Bhaban, Dhaka University		KGF Funding
41	Dinner and Cultural Program Organized by 4th IPFS-ICBHA Conference Committee	12.11.2019	Main Hall, Nabab Nawab Ali Chowdhury Senate Bhaban, DU		KGF Funding
44	KGF and ACIAR: Release of ACIAR Bangladesh 10-Year Strategy 2019-2028	19.11.2019	BARC Conference Room		
56	Weed Science Society of Bangladesh (WSSB): Parthenium Weed- A growing Concern in the Agro-ecosystems of Bangladesh	27.01.2020	BARC Conference Room		
60	বাউ অ্যালামনাই এসোসিয়েশন এর উদ্যোগে 'কৃষিবিদ দিবস ২০২০' পালন অনুষ্ঠানে যোগদান	12-13 Feb.2020	BARD, Mymensimgh		*KGF Funding*
61	BSAFE Foundation and BARC Jointly organize a Two-Day Conference on Safe and Nutritious Food for All: A Promise on the Eve of the 100th Birth Anniversary of Bangabandhu	25-26 Feb.2020	BARC Auditorium		KGF Funding
78.	Mid-Term Review of NUMAN Project (BARC-ACIAR)	04.02.2020	BARC Conference Room		
KGF Board meetings					
	67th	13.07.2019			
	68th	06.08.2019			
	69th	21.09.2019			
	70th	26.10.2019			
	71th	24.12.2019			
	72th	21.01.2020			
	73th	08.03.2020			
KGF TAC meetings					
	28th	02.07.2020			
	29th	01.08.2019			
	30th	17.09.2019			
	31st	06.10.2019			
	32nd	11.12.2019			
	33rd	09.02.2020			

6.2 Celebration of *Mujib Shoto Barsho*

KGF, along with the nation, is celebrating *Mujib Shoto Barsho* (the Birth Centenary Year) in honor of the 100th birth anniversary of Bangabandhu Sheikh Mujibur Rahman, Father of the Nation. The professionals, officers and staff of KGF, led by Dr. Wais Kabir, Executive Director, celebrated the auspicious day, March 17, 2020, with due respect and solemnity by placing a floral wrath on the foot of the statue of Bangabandhu at the BARC premises.

KGF celebrated the 100th birth anniversary of Bangabandhu Sheikh Mujibur Rahman, Father of the Nation, 17th March, 2020, BARC Campus

6.3 Monitoring and Evaluation

The Monitoring and Evaluation (M&E) program is meant for assessing and reviewing implementation status and outputs of projects sponsored and funded by KGF and providing, where and when necessary, required advice and suggestions on the relevant technical, administrative and financial issues. This helps project investigators/coordinators carry out smoothly and efficiently their activities towards successful completion of the projects. As a sponsoring and funding organization for strengthening agricultural research and development in the country, it is a key responsibility of KGF to ensure desired returns from its investments by way of successful completion of the financially supported and sponsored projects generating useful technologies and scientific information. The M&E program is a very important and potent tool in the hands of KGF to ensure that all goes well with the projects it is funding and sponsoring. At present, KGF employs two types of M&E like internal and external monitoring. KGF professionals regularly monitor on-going projects in two ways, i.e., (i) desk monitoring and (ii) field monitoring. KGF also evaluates these on-going projects through hiring external teams. Monitoring was interrupted in 2020 by the Covid-19 pandemic. However, all the project activities were continuing as per the schedule albeit with some hindrances caused by the pandemic.

6.3.1 Internal monitoring

Internal project monitoring is done by assigned desk officers (program specialists) through a) desk monitoring to ensure timely submission of reports on activities and documents related to i) inception workshops, ii) annual workshop, iii) timely submission of biennial and annual project reports, etc., and b) field monitoring for physical verification of trials at the planned sites. Each of the desk officers visited twice or at least once the project sites under their supervision. During the year under report, the KGF Executive Director visited a number of project sites and attended inception or other workshops arranged by the concerned PIs.

6.3.2 External monitoring

External project monitoring is done by hiring competent expert teams comprising senior officials from the national research institutes and professors of agricultural universities of the country. The monitoring teams independently visit the project sites and extensively interact with implementing scientist(s) at the concerned research stations and on-farm sites for two to three weeks and furnish detailed monitoring and evaluation reports to KGF. Based on these reports, the KGF management revises the project funding and work strategies. In 2020, external monitoring could not be done due to the Cobid-19 pandemic.

6.3 Reviewer Panel

In each year the reviewer panel of KGF is reformed/revised through adding eminent agricultural experts of the country. The list contains names of the reviewers, from Bangladesh and abroad, with full contact details including office and residential addresses, phone numbers, e-mail addresses, etc. and their fields of specialization, such as, crops, livestock, fisheries, forestry, agricultural engineering, agricultural economics and rural sociology, etc. Considering its volume (large numbers of experts) the list is not annexed with the report, however it is available at the KGF office.

6.4 Publications

Sl #	Booklet/book	Year
1.	Climate Change Impact Assessment on Crop Production in Bangladesh	2019
2.	Narrowing Skill Gap in Capturing Potential of Agricultural Science and Technology An Inventory of Programes Undertaken by KGF (2008-2018)	2019
3.	Krishi Projukti Barta 2008-2017	2019
4.	KGF Brochure	2019
5.	A Brief Review on Scope and Applications of Nanotechnology in Bangladesh Agriculture	2019
6.	Research on Impacts of Climate Change On Bangladesh Agriculture: A KGF Initiative	2019
7.	Proposed Education-Research-Extension Coordination for Bangladesh Agriculture	2019

6.4.1 Annual report

The annual report, published yearly, is a key document detailing major KGF activities, implementation status and progress statements related to projects sponsored and funded by KGF. This publication endeavor has been continued and maintained through the years following the inception of KGF in 2007. This annual report 2019 -20 is the 11th of the series of annual reports of KGF.

6.4.2 Booklets/leaflets

PIs of the KGF supported projects are supposed to prepare and publish booklets and leaflets in easily comprehensible language and terms detailing important aspects of the technologies generated and validated, and distribute these to the end users, so that they can apply and practice the new technologies/systems independently. KGF also has been periodically preparing booklets and leaflets on important technologies and distributing these to the stakeholders. Several booklets/leaflets have been prepared and distributed during the period under report.

7. Financial Management

7.1 Statement of expenditure (SOE)

In the reporting period, 2019-20, KGF received Tk. 3450.2781 lakh from BKGET and the expenditure was Tk. 3306.14341 lakh up to 30 June, 2020, which was 95.8% of the released fund. Progress was satisfactory in implementing different programs. The details of expenditure during fiscal 2019-20 are shown in the Annex-2.

7.2 Budget for Fiscal Year 2021-22

Annual work plan 2020-21

The Foundation has prepared the annual work plan. The detailed plan (gang chart) by items is given in the Annex-3.

Annual proposed budget 2021-22

The Foundation has prepared the annual proposed budget for the year 2021-22. The budget proposed for the fiscal year 2021-22 for approval of the Board of Directors and General Body of KGF is 4500.00 lakh. The detailed budget by items is given in the Annex-4.

Financial contributions to professional bodies

KGF receives request from different professional societies/associations including NGOs and daily/weekly/monthly magazines to subscribe for their events. Respecting the requests, KGF supports in celebrating different events of different professional societies related to agriculture. The beneficiaries used the KGF logo in their banners and placards, souvenirs/proceedings/books, advertisements, etc. So far, KGF has sponsored a good number of national and international conferences, workshops held in Bangladesh through financial contributions and organized collaborative workshops/seminars and published related to KGF sponsored projects and events.

8. Governance

8.1 The Board of Directors (BoDs)

The Board of Directors (BoDs) comprising 07 elected members from the General Body (GnB) who are reputed technical professionals in diverse fields of agricultural research and development. BoD has the authority to take any decision needed for the smooth functioning of KGF. The list of the members of BoD and GnB and their brief curriculum vitae are given in Annex-5.

Meetings of the Board of Directors

As per provisions of the Memorandum and Articles of Association (MAA), KGF is governed by its General Body (GnB) and a seven-member Board of Directors (the Board). The Board takes decisions pertaining to KGF functions, operations and projects. Generally, the Board meets bi-monthly with the provision of additional meetings, as and when necessary, called by the Member Secretary (Executive Director of KGF).

8.2 Annual General Meeting

The 11th Annual General Meeting (AGM) of KGF was held on 20 March 2018 at Radison Hotel, Dhaka. All members of the General Body attended the meeting. The meeting addressed six important agenda. Kbd. Dr. Kabir Ikramul Haque, Executive Chairman of BARC and Chairman, General Body and Board of Directors, KGF presided over the meeting.

8.3 Technical Advisory Committee (TAC)

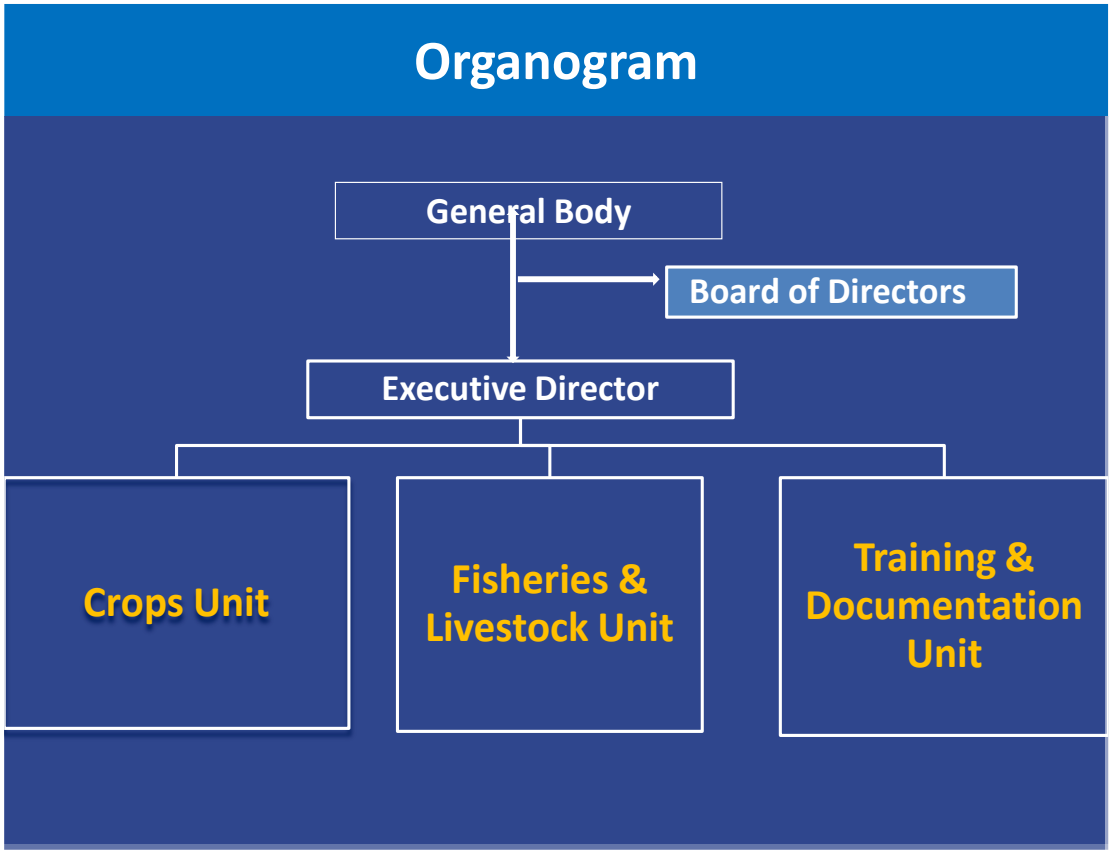
As per decision of the 31st Board Meeting of KGF in August 2012, a 14-member TAC was formed to provide strategic guidance ensuring the quality of research supported by KGF, to review BARC

prioritized researchable areas, and to select issues appropriate for inviting proposals for KGF funding, and to identify areas where new initiatives may be required and to recommend resource allocation to CGP and other projects. In fact, TAC holds the responsibility of selecting research themes and issues to be supported by KGF funding and to accomplish this, several TAC meetings were arranged by KGF.

8.4 Audit

The accounts and audit functions of the Foundation are regulated in accordance with Clause 78-89 of the Memorandum and Articles of Association of KGF. The General Body approved the balance sheet for the period ending June 2020 and fiscal year 2019-20. KGF finance and accounts were audited by Rahman Mostofa Alam & Co. The detailed audit report is presented in Annex-6.

9. The KGF Organogram



10. The KGF Team

Dr. Wais Kabir, Executive Director (up to April 12, 2020)
Dr. Tapan Kumar Dey, Senior Program Specialist (Crops):
Executive Director-in-Charge (April 13, 2020 to August 12, 2020)
Dr. Md. Hazrat Ali, Program Specialist (Field Crops)
Dr. Shahabuddin Ahmad, Program Specialist (Horticulture)
Dr. Mohibul Hasan, Technical Editor (Retired in December 2019)
Mr. Mohammad Nuruzzaman, Program Specialist (Fisheries)
Ms. Nasrin Akter, Communication Specialist
Dr.. Shahrina Akhtar, Technical Officer
Mr. Mehedi Hasan, Manager (Admin and SS)
Mr. Md. Salat Ahmed, Manager (Finance and Accounts)
Mr. A.T.M. Jashim Uddin, IT Manager
Ms. Tahsina Naznin, Graphic Design Manager/Audio Visual Associate
Md. Delowar Hossain, Assistant Manager (Audit and Accounts)
Ms. Mahmuda Begum, Audit and Accounts Supervisor
Ms. Fatema Parvin, Secretary to Executive Director, KGF
Mr. Md. Rafiqul Islam Akanda, Office Supervisor
Ms. Noormahal Begum, Logistics and Common Services Supervisor
Mr. Mohammed Abul Khair, Office Assistant cum Computer Operator
Ms. Jarin Tasmim, Cashier/Accounts Assistant
Mr. Aminul Islam Khan, Store Keeper

Annexure

A. List of the Board & General Body (GnB) Members

Annex-1

Sl	Name	Position	Picture
01	Dr. Md. Kabir Ikramul Haque Chairman, General Body, KGF, and Executive Chairman, BARC Farmgate, Dhaka-1215 Cell: E-mail:	GnB and BoD	
02	Dr. Shaikh Mohammad Bokhtiar Executive Chairman Bangladesh Agricultural Research Council Farmgate, Dhaka Cell: Email:ec-barc@barc.gov.bd , bokhtiarsm@yahoo.com	GnB and BoD	
03	Dr. Md. Abdus Sattar Mandal Emeritus Professor and Former Vice-Chancellor Bangladesh Agricultural University, Mymensingh Cell: 01713045654, Email: asmandal11@gmail.com	GnB and BoD	
04	Dr. Abul Kalam Azad Director General Bangladesh Agricultural Research Institute, Gazipur Cell: E-mail:dg.bari@bari.gov.bd	GnB and BoD	
05	Dr. Md Abdul Wohab Director General Bangladesh Agricultural Research Institute, Gazipur Cell: Email: dg.bari@bari.gov.bd	GnB and BoD	
06	Dr. Md Nazirul Islam Director General Bangladesh Agricultural Research Institute, Gazipur Cell: 01929338671, Email: dg.bari@bari.gov.bd	GnB and BoD	
07	Dr. Md Shahjahan Kabir Director General, BRRI Cell: 01712-280083 Email: dg@brri.gov.bd/kabir.stat@gmail.com	GnB and BoD	
08	Dr. Shaikh Abdul Quader Managing Director Agriconcern Ltd. Cell: 01713-015119 Email: shaikh@agriconcern.com	GnB and BoD	
09	Mr. Md. Manjurul Hannan Managing Director, Hortex Foundation Cell: 01711-565731 Email: manzurhannan@gmail.com	GnB and BoD	

10	Dr. F H Ansarey Managing Director and CEO ACI Agribusinesses Cell: 01711526289 Email: mdab@aci-bd.com/edab@aci-bd.com	GnB and BoD	
11	Dr. Md. Shah-E-Alam Vice Chancellor City University, Dhaka Cell: E -mail:	GnB	
12	Dr. Md Shahidur Rashid Bhuiyan Vice Chancellor Sher-e-Bangla Agricultural University Sher-e-Bangla Nagar, Dhaka Cell: 01552467945, Email: ipbscfc2009@gmail.com	GnB	
13	Dr. Md Abdul Muyeed Director General, DAE Khamarbari, Farmgate, Dhaka-1215 Cell: 01711247400, E-mail: dg@dae.gov.bd	GnB	
14	Dr. Shaikh Azizur Rahman Director, Animal Health and Administration Department of Livestock Services Cell: E-mail:	GnB	
15	Dr. Humnath Bhandari IRRI Representative in Bangladesh Cell: 1730700018 Email: h.bhandari@irri.org	GnB	
16	Dr. Kashfia Ahmed Chairman, Win Miaki Ltd. Cell: 01713-275366 & 01715104702 Email: kashfia.ahmed@miaki.co	GnB	

List of BKGET Funded Projects
CGP 1st Call

Annex-2

Sl	Project title, code no. and commencement date	Coordinator/PI/CI	Location
1	TF 01-C: Validation and Up-scaling of High Value Vegetable Crops production in Sylhet region. Date of commencement: May 13, 2013	Dr. Md. Shahidul Islam, Sylhet AU, Cell: 01916662421	Habiganj sadar, Bahubal, Nabiganj of Habiganj; Biswanath, South Surma, Sylhet sadar of Sylhet
2	TF-02-C: Development/ validation and up-scaling of dry direct seeded boro rice system for improving crop productivity in areas with limited water supply. Date of commencement: May 13, 2013	Dr. Md. Moshiur Rahman, BAU, Mymensingh, Cell: 01711072561	Godagari of Rajshahi and Rangpur sadar
3	TF 03-C: Adaptation of high yielding soybean in polder areas in Barguna and Patuakhali districts. Date of commencement: May 13, 2013	Dr. MA Mannan, BSMRAU, Gazipur. Cell: 01816020290	Amtali of Barguna and Kalapara of Patuakhali
4	TF 04-C: Screening and testing of Improved Aus Rice Varieties/ Genotypes Suitable for Rainfed Aerobic Soil Condition of Bangladesh Date of commencement: May 13, 2013	Dr. A S M Masuduzzaman, BRRI, Joydbpur. Cell: 01721964002	Manda of Naogaon, Mohonpur of Rajshahi, Habiganj sadar, Chunarughat of Habiganj, Fenchuganj of Sylhet, Rajnagar of Moulvibazar
5	TF 05-C: Year-round Production of Some Selected HYV and Hybrid Vegetable Varieties in Southern and Hilly Regions of Bangladesh Date of commencement: May 13, 2013	Dr. G M A Halim, BARI, Joydebpur. Cell: 01715179366	Bauphal, Dashmina, Galachipa of Patuakhali and Bandarban sadar
6	TF 06-C: Validation and up scaling of HYV brinjal, tomato, bottle gourd, ash gourd and pointed gourd in hilly areas of Moulvibazar. Date of commencement: May 13, 2013	Dr. Zashim Uddin, BARI, Moulovi Bazzar. Cell: 01554330576	RARS, BARI Moulvibazar
7	TF 07-C: Adaptation of newly released HYV oil seeds (Mustard, Groundnut, Soybean and Sesame) in Charland of Padma. Date of commencement: May 13, 2013	Dr. Md. Abul Khayer Mian, BARI, Joydebpur. Cell: 01914661801	Ishwardi of Pabna and Veramara, Daulatpur of Kushtia
8	TF 08-NR: Evaluation and Up scaling of Resource Conservation Technologies (RCTs) for Improving Productivity in the Drought Prone Areas.	Dr. Md. Ilias Hossain, RWRC, BARI Rajshahi. Cell: 01712632167	Godagari of Rajshahi and Nachole of Chapai Nawabganj

Sl	Project title, code no. and commencement date	Coordinator/PI/CI	Location
	Date of commencement: May 13, 2013		
9	TF 09-NR: Validation and up-scaling of Tricho-products for soil borne disease management in vegetable Crops. Date of commencement: May 13, 2013	Dr. Mossammat Shamsunnahar, HRC, BARI Gazipur. Cell: 01674876252	Jessore Sadar and Sherpur of Bogra
10	TF 10-F: Adaptation of Community Enterprise Approach for Intensification of floodplain fish production in Chalan beel. Date of commencement: May 13, 2013	Sakiul Millat Morshed, ED, SHISUK. Cell: 01713037796	Tarash of Sirajganj, Bhangura of Pabna and Singra of Natore
11	TF 11-C: Validation and up scaling of off-season jute seed production Technologies in different jute growing areas of Bangladesh. Date of commencement: May 13, 2013	Md. Abdul Alim, BJRI. Cell: 01911395624	Babuganj of Barisal disrtict and Patuakhali sadar
12	TF 12-L: Investigation on livestock diseases and development of appropriate control measures in hilly areas. Date of commencement: Sep13, 2013	Shonkor Kumar Das,BAU, Mymensingh. Cell: 01716-855186	Sadar, Lama and Rowanchari of Bandarban
13	TF 13-F: Production enhancement of aquaculture through innovative technologies in cage culture system in *haor* areas of Karimganj, Kishoreganj. Date of commencement: Dec 13, 2013	Dr. A.K.M. Nowsad Alam, BAU, Mymensingh. Cell: 01711446315	Karimganj (Hoar area) of Kishoreganj
14	TF 14-C: Sustainable management of flower and fruit dropping of mango. Date of commencement: Apr 14, 2014	Dr. Syed Nurul Alam, BARI, Joydebpur. Cell: 01711907886	Chapai N.Ganj; Rajshahi; Natore; Naogaon; Rangpur; Dinajpur; Thakurgaon; Jessore; Kushtia; Meherpur; Satkhira; Chuadanga; Mymen; and Gazipur

CGP 2nd Call

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
1	TF 15-SF: Improvement of Soil Fertility and Crop Yield through adoption of conservation agriculture in Mustard -Boro-T. Aman CP. Duration: Mar 2015 to Feb 2018	Dr. Jahiruddin, Soil Sc. BAU: 01718813889	BAU & Muktagacha Mymensingh; Dhanbari, Tangail
2	TF 16-WF: Collection, Evaluation and Introduction of White Maize for Human Consumption in Bangladesh. Duration: Mar 2015 to Feb 2018	Prof Jafar Ullah, SAU, Dhaka: 01552331605	Dhaka, Barisal, Rangpur, Dinajpur, Nilphamari, Bandarban, Rangamati and Khagrachari
3	TF 17-ARI: ARI Refining and Validation of BAU-Bro chickens.	Prof Ashraf Ali, BAU: 01675145096	BAU, Mymensingh

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
	Duration: Mar 2015 to Feb 2018		
4	TF 18-EM: Exploring epidemiology, anthelmintic resistance and genetic diversity of some common gastrointestinal nematodes of small ruminants in Bangladesh. Duration: Mar 2015 to Feb 2018	Prof Zahangir Alam, BAU: 01746611162	BAU, Mymensingh
5	TF 19-EM: Community engagement in biosecurity (CEB) for the prevention of infectious diseases of poultry based on epidemiological risk analysis. Duration: Apr 2015 to Feb 2018	Prof Rafiqul Islam, BAU: 01759674267	BAU, Mymensingh
6	TF 20-EM: Studies of pigeon diseases in northern Bangladesh. Duration: Apr 2015 to Mar 2017	Prof Jalal Uddin Sarder,Department of Animal Husbandry and veterinary Science , RU: 01556308564	Rajshahi, Natore and Pabna
7	TF 21-DL: Use of Probiotic to Improve Nutritional Value of Rice Straw and Its Impact on Dairy Cow Production. Duration: Apr 2015 to Mar 2018	Dr. Abu Sadeque Md. Selim: 01718370722	BSMRAU, Salna, Gazipur
8	TF 22-PS: Productivity Enhancement of Goor and Chewing type Sugarcane through management of Major Diseases in NMZ. Duration: Sep 2015 to Aug 2018	Dr. Shamsur Rahman, BSRI: 01716165669	Ishurdi, Shibgonj, Sirajgonj Sadar, Manikgonj, Narail
9	TF 23-AM: Improvement and validation of BARI seeder for grain crops under different cropping patterns and soil conditions. Duration: Mar 2017 to Feb 2020	Dr. Ayub Hossain, FMPE, BARI: 01716979034, Email:mahossin.fmpe@gmail.com	Gazipur, Patuakhali, Rajshahi
10	TF 24-EM: Epidemiological and patho biological investigation of repeat breeding syndrome and development of strategies for improving the fertility of repeat breeder dairy cattle. Duration: Aug 2015 to Jul 2018	Prof Nasrin Sultana Juyena, Vet Sc. BAU: 01759674267	Trishal, Mymensingh, Sahjadpur, Sirajganj, Potya, Chittagong
11	TF 26-ARI: Validation and Up-scaling of Bee Keeping Practices for Improving Yield and Quality of Bee Products'. Duration: May 2015 to Apr 2018	Dr. Sakhawat Hossain, SAU, Dhaka: 01716092747	Satkhira, Shirajgonj and Gazipur
12	TF 27-SF: Adaptation of Improved Soil Fertility Management Practices for Variable Soil Conditions under Intensively Cropping Systems. Duration : Jun 2015 to May 2018	Dr. Mustafizur Rahman, BSMRAU: 01718186642	Rajshahi, Kushtia, Tangail, Gazipur, Kurigram, Lalmonirhat, Faridpur, Chandpur, Jessore, Comilla

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
13	TF 29-AM: Design and development of two stage drying technique for drying high moisture grain. Duration : Mar 2017 to Feb 2020 (extended upto: Aug. 2020)	Md. Sazzad Hossain Sarker, HDSTU: 01713163347, mshsarker_hstu@yahoo.com	HSTU, Dinajpur
14	TF 30-AP: Sustainable Development of Aquaculture in the North-West Region of Bangladesh under Climate Changes scenario. Duration : Nov 2015 to Aug 2018	Prof Istiaque Hossain, RU, Rajshahi: 01726514232, Email:bitanrubd@yahoo.com	Rajshahi and Bogra
15	TF 31-VC: Market and value chain studies of selected fruits and vegetables with special references to post harvest losses and food safety in Bangladesh. Duration: Mar 2017 to Feb 2020 (extended upto: April 2020	Dr. Abdul Matin, Agril Economics, BARI: 01725694481, Email:matinecon61@yahoo.com Present: Dr. Kamrul Hasan, CSO, Economics Division, BARI, Cell: 01711244091, Email: khasan41@yahoo.com	Bogra, Rajshahi, Jhenaidah and Jessore
16	TF 32-SF: Integrated Nutrient Management for Intensive cropping in coastal and charland areas of Bhola District. Duration : Sep 2015 to Aug 2018	Md. Shahidul Islam, BARI, Bhola: 01718638771	Sadar, Daulatkhan, Charfashion and Monpura of Bhola
17	TF 33-ARI: Farm Productivity Improvement in Haor Areas through Integrated Farming Systems Approach. Duration: Aug 2015 to Jul 2018 (extended upto: Feb 2020)	Prof Dr. Md. Abul Kashem, Professor, Dept. of soil sc, Faculty of Agriculture, SAU, Sylhet: 01712213707, E-Maill : reem98k@yahoo.com; makashem.agri@gmail.com	Sunamganj
18	TF 35-SF: Integrated Nutrient management for sustaining soil fertility and crop productivity under intensive cropping system. Duration : Jul 2015 to Jun 2018	Previous (PI) Dr. Mahbubur Rahaman, OFRD, BARI: 01712598035, Present (PI) Dr. Akkas Ali, Cell : 017181637801, E-mail- ofrdjoy@yahoo.com, Personal- E-mail - akkasbari@gmail.com	Jamalpur, Sherpur, Mymensingh, Kishoreganj, Joypurha, Rangpur, Rajshahi
19	TF 36-FP: Maximizing forage production in saline prone areas of south -west coastal belt through improved management practices. Duration: Dec 2015 to Nov 2018	Prof Shafiqul Islam: 01711190798. Khulna University	Paikgacha of Khulna, Mollahat of Bagerhat, Tala of Satkhira

CGP 3rd Call

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
1	TF-37-F/17: Development of Health Management Strategy against Bacterial Diseases in the Aquafarms of Bangladesh. Duration: 13th Dec, 2017 to Nov 2020 (12th Dec 2020)	Dr. Gias Uddin Ahmed, Prof, Aquaculture, BAU, Mym, Mobile: 01712564528, Email: gias50@gmail.com	Chittagong, Khulna, Mymensingh

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
2	TF-38-F/17: Post-harvest loss reduction and value addition of fresh water fish. Duration : 18th Mar 2018 to Feb 2021 (17th March 2021)	Prof. Nowshad Alam Faculty of Fisheries, BAU, Mymen. Cell # 01711446315	BAU, Mymensingh, Kishoreganj, Comolla
3	TF-39-F/17: Adaptation of Disease Management Strategy in the Existing Culture practices of Shrimp through Aquamimicry System. Duration : 13th Dec 2017 to Nov 2020 (12th Dec 2020)	Dr. SM Rafiquzzaman, Dept of Fisheries Biology and aquatic environment, BSMRAU, Gazipur, Cell # 01754041311	BSMRAU and Satkhira
4	TF-40-F/17: Effects of dietary polyunsaturated fatty acid and beta glucan on broodfish (Labeo rohita, Mystus cavasius and Ompok pabda) immunity and fry quality. Duration: Dec 2017 to Nov 2020	Dr. Zakir Hossain, Prof, Fisheries, Biology and Genetics, BAU, Mymensingh. Cell # 01724939693	BAU, Mymensingh
5	TF41-SBR/17: Development and Adoption of Cotton-Based Cropping System for Drought-prone Highland of Chittagong Hill Tracts. Duration : Feb 2018 to Jan 2021	Dr. Md. Farid Uddin, ED, CDB, 6th Floor, Rear Building, Khamarbari, Dhaka-1215 Mobile: 01711020798	Bandarban, Khagrachari, Rangamati
6	TF42- E/17: Development and adoption of low cost small potato planter and harvester for profitable potato production. Duration : Nov 2017 to Oct 2020	Present PI- Dr.Md. Arshadul Haque , Cell : 01712635503 CSO, Farm Machinery & Postharvest Division, BARI, Gazipur, M: 01713363630, Email: mdisrail@gmail.com	Gazipur, Munshigonj, Debigonj
7	TF43-C/17: Livelihood improvement through farming system research and development in floating agriculture system. Duration : Nov 2017 to Oct 2020	Dr. M. Akkas Ali , PSO, OFRD, BARI, Gazipur. Cell: 01718637801, Email: alim.akkas@yahoo.com	Nazirpur of Pirojpur, Sadar, Tungipara Kotalipara og Gopalgonj, Mollarhat of Bagerhat
8	TF-44-L/17: Livestock and Human Brucellosis: Molecular diagnosis, treatment and control. Duration : Jan 2018 to Dec 2020	Dr. Md. Siddiqur Rahman, Prof, Department of Medicine, BAU, Mym; Mobile: 01918181550, msrahman4364@gmail.com	Dept of Medicine, BAU, Mymensing
9	TF-45-L/17: Epidemiological investigation on tuberculosis and campylobacteriosis associated with dairy farming practices in the selected districts of Bangladesh. Duration : Jan 2018 to Dec 2020	Dr. S.M. Lutful Kabir, Prof, Microbiology and Hygiene, BAU, Mym; Mobile: 01754987218, lkabir79@gmail.com	Dhaka & Mymen; Lab: Dept Microbiology/Hygine & Phermacology, BAU; Dept Microbacteriology lab of ICDDRB, Dhaka
10	TF-46-L/17: Study on zoonotic diseases of pets and assessment of risk factors of commonly occurred zoonoses for better management. Duration: Jan 2018 to Dec 2020	Dr. Jahangir Alam, CSO, Animal Biotechnology Division, National Institute of Biotechnology, Ganakbari, Ashulia, Savar, Dhaka-1349; Mobile: 01712819098, alamjahan2003@yahoo.com	Dhaka and Chittagonj

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
11	TF-47-L/17: Value addition to feeds and fodder through bioactive component-rice herbs for safe livestock production. Duration : Feb 2018 to Jan 2021	Dr. Al Mamun, Prof. Dept of Animal Nutrition, BAU, Mymensingh. Cell # 01715051093, Email:mamunshimu@yahoo.com	BAU, Mymensingh
12	TF-48-L/17: Improving Lamb Production Potentiality of Native Sheep through Selection and Genetic Enhancement. Duration : Feb 2018 to Jan 2021	Dr. Md. Munir Hossain, Prof, Animal Breeding and Genetics, BAU, Mym; Mobile: 01716540609, mmhabg@gmail.com	BAU, BLRI, Ghaibandha
13	TF-49-L/17: "Value addition to straw for enhancing dairy production in Bangladesh". Duration : Apr 2018 to Mar 2021	Dr. Mohammad Mohi Uddin, Assistant Prof, Animal Nutirtion, BAU, Mymensingh; Mobile: 01818429023, mohammad.uddin@bau.edu.bd	Animal Nutrition analytical lab, BAU, Dinajpur and Sirajgonj
14	TF-50-C/17: Management of wheat blast caused by *Magnaporthe oryzae* pathotype *Triticum* introduction. Duration: Jan 2018 to Dec 2020	PI 1: Dr. Naresh Chandra Barma, Director, WRC, BARI, Nashipur, Dinajpur. Cell: 01712226755, Email: ncdbarma@gmail.com Present PI 1: Dr.Asrail Hossain Director General, BWMRI, Nashipur, Dinajpur. Cell: 01713363630, Email: dg.bwmri@gmail.com	Jessore, Dinajpur, Mymensingh, Gazipur, Meherpur, Chuadanga
15	TF-50-C/17: Assessment of cropping patterns for sustainable intensification in drought and saline-prone ecosystems using remote sensing and geospatial modeling. Duration : Jan 2018 to Dec 2020	Dr. Md. Golam Mahboob, SSO, ASICT Division, BARI, Gazipur, Cell: 01816194986, Email: golam.mahboob@gmail.com	Rajshahi, Chapai, Nowga, Bogra, Nator, Sirajgonj, Gainbandha, Joypurhat, Dinajpur, Rangpur
16	TF-52-C/17: Adaptation of BARI released hyacinth bean varieties and up-scaling the farmer's innovation for productivity enhancement in Narsingdi region. Duration : Feb 2018 to Jan 2021	Dr. Syed Md Mizanur Rahman, PSO,RHRS, BARI, Shibpur, Narshingdi. Cell: 01819448805 Ex PI: Dr. Moshiur Rahman, PSO, RHRS, BARI, Shibpur, Narsingdi. Cell # 01716838586, Emai: moshiur.bari@yahoo.com	Shibpur, Belabo, Palash, Sadar of Narsingdi
17	TF-53-C/17: Production and dissemination of BARI released year round jackfruit variety and its management packages. Duration : Feb 2018 to Jan 2021	Dr. Md. Jillur Rahman, SSO, Pomology Division, HRC, BARI, Gazipur.; 01715082555, Email: jillurhrc@gmai.com	Gazipur, Mymensingh, Khagrachari, Narsingdi
18	TF-54-SBR/17: Improvement of cropping systems applying different agronomic management practices in salinity affected coastal zone of south-western part of Bangladesh for attaining food security and sustainability. Duration : Jan 2018 to Dec 2020	PI: Dr. Kawsar Uddin Ahammed, PSO,RARS,BARI, Gazipur Ex PI: Dr. Md. Sirajul Islam, CSO, RARS, BARI, Jessore-7400, Cell: 01712142042, Email:	Khulna, Satkhira

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
19	TF-55-AE/17: Development and adoption of a solar cabinet dryer for vegetable seeds Duration : Jan 2018 to Dec 2020	Dr. Nurul Amin, SSO, FFPE Division, BARI, Gazipur, Cell: 01717734248, Email:naminbari@gmail.com	Gazipur, Jessore
20	TF-56-C/17: Collection characterization of potential germplasm of rape seed-mustard and participatory salt tolerant short duration variety development for increasing cropping intensity in southern coastal Bangladesh. Duration : Jan 2018 to Dec 2020	Dr. Lulful Hasan, Prof GPB, BAU, Mymensingh. Cell: 01715091096, Email:lutfulhassan@yahoo.com	BAU, Mymensingh, BARI, Khulna, Satkhira, Bagherhat, Barisal, Patuakhali, Barguna
21	TF-57-C/17: Identification of Resistant Sources against gall midge and Development of Tolerant Advanced Breeding Lines. Duration : Feb 2018 to Jan 2021	Dr. Moffazzel Hossain, PSO, Entomology Division, BRRI, Gazipur. Cell #01731386113, Email:mofazzel70@yahoo.com	Kapasia (Gazipur), Natore (Sadar), Kaharul (Dinajpur, Chunarughat (Habiganj), Sadar (Cox's Bazar)
22	TF-58-C/17: Sustainable management of maize insect pests with special emphasis on the com borer, the emerging species through innovative, participatory and collaborative research. Duration : Feb 2018 to Jan 2021	Professor Dr. Khandakar Shariful Islam, Dept. of Entomology, BAU, Mymensingh 2202, Cell: 01716370731, Email:ksharif_bau@yahoo.com	BAU, Mymensingh; Chuadanga, Gaibandha
23	TF-60-SBR/17: Improvement of agroforestry practices for better livelihood and environment in Charland area of Tista River Basin. Duration : Mar 2018 to Feb 2021	Dr. Md. Shafiqul Bari, Prof, Agroforestry and Environment, HMDSTU. Cell: 01713163399, Email: barimdshafiqul@gmail.com	Kurigram, Gaibanda
24	TF-61-C/17: Up-scaling of Rice-Bean cropping system for increased yield, Nutrients and soil productivity. Duration : Mar 2018 to Feb 2021	Dr. Md. Solaiman Ali Fakir, Professor, Dept. of Crop Botany, BAU, Mymensingh-2202, Cell: 01715523202, Email: fakirmsa@gmail.com	BAU, Mymensingh
25	TF-62-L/17: Coordinated Project: Validation of good practices of on-farm lamb production systems. Duration : Feb 2018 to Jan 2021	Dr. M. A. Hashem, Prof, Animal Science, BAU, Mym; Mobile: 01721310621, hashem_mdabul@yahoo.com	Sherpur, Rajshari, Noakhali, and Feni
26	TF-63-Char/17: Diffusion of innovative Mgt. Practices for Sustainable Crop Production in Char lands of Bangladesh. Duration : Nov. 2018 to Oct. 2021	Dr. Md. Safiul Islam Afrad, Prof. Dept of Agricultural Extension and Rural Development , BSMRAU, Gazipur, Mobile No. 01972584820, Email: afrad69@gmail.com	Charlands of Ramgati, Raipur, Kamalnagar Upazilas under Lakshmipur District of Bangladesh.
27	TF-64-Fruit/17: Exploring and in situ development of under-utilized fruits to improve nutritional food security and livelihood of the poor communities of southern Bangladesh.	Prof. Dr. Md. Abdur Rahim, Department of Hoticulture, Mymensingh Agriculture University (BAU).	BAU,Khulna,Barisal,Patuakhali

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
	Duration : Jan 2018 to Dec 2019		
28	TF-65-C/19: Post-harvest Management , Processing and Marketing of Jackfruits loss reduction and value addition of fresh water fish. (Under Unsolicited) Duration : 27th May, 2019 to 26th January- 36 Months	Dr. Md. Miaruddin , Project Cordinator , & Chief Scientific Officer, Post Harvest Technology Division , BARI, Joydebpur.	Major areas Dhaka, Gazipur, Tangail, Khagrachhari, Rangamati, Mymensingh, Moulvibazar, Narsinghdi, Dinajpur and Rangpur,
29	-C/19: On Farm Validation and Up-Scaling of Integrated Pest and Disease Management packages for quality and safe country bean production in Mymensingh region. (Under Unsolicited) Duration : April, 2019- March 2022- 36 Months	PI- Dr. Md. Shahadath Hossain, Principal Scientific Officer, & Principal Investigator, KGF Funded Project , Entomology Section, HRC, BARI, Gazipur. CI- Dr. Latifa Yasmin, Senior Scientific officer, Plant Pathology section, HRC, BARI, Gazipur, PI- Dr Md. Akkas Ali, Chief Scientific officer, On-Farm Research Divistion , BARI, Gazipur. CI- Dr. Md. Samsur Rahman, Principal Scientific Officer, On-Farm Research Division , BARI, Sherpur. CI- Dr. Nargis Sultana, Senior Scientific officer, On-Farm Research Divistion , BARI, Mymensingh.	Two upazilas at Mymensingh District (Mymensingh Sadar & Nandail), Two Upazilas at Netrakona District (Durgapur & Kalmakanda) and Two Upazilas at Sherpur District (Nalitabari and Nokla) under Mymensingh Division.
30	TF-67-C/19: Survey of Water melon diseases and Integrated Management of wilt and stem blight disease. (Under Unsolicited) Duration : Nov. 2019-Oct. 2022	Dr.Md.Mahfuz Alam, SSO & PI, Plant Pathology Divisiton	Gazipur, Noakhali and Patuakhali

Basic Research Projects (BR)

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
1	BR 1-C/17: Study Of The Physical Mechanism Related To Water And Heat Stress Tolerance In Wheat Genotypes. Duration : Mar 2017 to Feb 2020	Dr. Imrul Mosaddek, BARI, Joydebpur. Cell : 01716458606, Email: imrulbau@gmail.com	BARI, Joydebpur
2	BR 2-C/17: Linkage and QTL mapping of Tungro resistance in rice. Duration : Mar 2017 to Feb 2020	Dr. Md. Abdul Latif, BRRI, Gazipur. Mob: 01715034004, Email: alatif1965@yahoo.com	BRRI Joydebpur
3	BR 3-C/17: Exploring new source of blast resistance and pyramiding blast resistant genes into boro rice Duration : Mar 2017 to Feb 2020	Dr. Tahmid Hossain Ansari, BRRI, Gazipur. Email: tahmidhansari@yahoo.com, 01716839404	BRRI Joydebpur
4	BR 4-C/17: Physiological Mechanism of waterlogging tolerance in sesame Duration : Mar 2017 to Feb 2020	Dr. A F M Shamim Ahsan, Scientific Officer, Cell: 01713311332, Email:shamim.agro@yahoo.com	RPRS, BARI Madaripur
5	BR 5-C/17: Identification and Expression of Heat tolerant genes at reproductive stage and their inheritance in wheat Duration : Mar 2017 to Feb 2020	Dr. Golam Faruque, RWRC, BARI Joydebpur. Cell: 01725444555, Email: faruqrwrc@gmail.com	BARI, Joydebpur; RARS Jessore; RARS Barisal; RARS Hathazari; HARC Khagrachari
6	BR 7-C/17: Rice physiological development through trait discovery for boosting rice yield in changing climatic conditions. Duration : Mar 2017 to Feb 2020	Dr.Md. Ansar Ali, BRRI, Gazipur. Cell: 01925053582, E-mail: maalibrri@yahoo.com, Present: Dr. Sazzadur Rahman, PSO, Plant Physiology Division, BRRI, Cell:01722210429	BRRI Joydebpur
7	BR 8-C/17: Chloroplast genome sequencing and QTL analysis of heat tolerant and late blight resistant potato varieties Duration : Mar 2017 to Feb 2020	Dr. Md. Mosharraf Hossain Molla, BARI. Cell: 01552403728, Email: mhmolla@hotmail.com	BARI, Joydebpur; RARS Burirhat, Rangpur; RARS Lebukhali, Patuakhali

B. Commission Research program (CRP)

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
1	CRP- I: Harnessing the Potential of Hill Agriculture Duration : Jul 2013 to Sep 2018	Dr. Md. Nurul Alam, Coordinator, KGF. Cell: 01911668399; 01711822586, Email: drmnalam@hotmail.com, crphilagri@gmail.com	Bandarban, Khagrachari and Rangmati
	Component – I: Watershed Management for Sustainable Agricultural Production	Dr. Munshi Rashed Ahmed, Chief Scientific Officer, RHARS, Khagrachari, BARI,	Selected watersheds in Bandarban (1), Khagrachari (3) and Rangamati

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
	Duration : Jul 2013 to Sep 2018	Cell phone: 01748717603, Email: munshirashid@gmail.com	
	Component – II: Sustainable Land Management Duration : Jul 2013 to Sep 2018	Prof. Dr. A J M Sirajul Karim, Department of Soil Science, BSMRAU, Gazipur; Cell phone: 01552601070, Email:alokpaulsau@yahoo.com	Selected locations at Bandarban, Khagrachari, and Rangamati
	Component-III: Development and Delivery of Intensive Crop Production Technologies for Hill Agriculture Duration : Jul 2013 to Sep 2018	Dr. Md Khalilur Rahman Bhuiyan, CSO, RARS, BARI, Hathazari, Chittagong. Cell: 01552410199, Email: csohathazari@gmail.com	Selected locations at Bandarban, Khagrachari, and Rangamati
	Component – IV: Entrepreneurship and Value Chain Development for Linking Farmers with Market Duration : Jul 2013 to Sep 2018	Dr. Md. Jamal Uddin, SSO, RARS, BARI, Hathazari, Chittagong; Cell: 01815425857, Email: jamaluddin1971@yahoo.com	Selected locations at Bandarban, Khagrachari, and Rangamati
	Component- V: Program Coordination Duration : Jul 2013 to Sep 2018	Dr.Md. Nurul Alam, Coordinator, KGF. Cell: 01911668399; 01711822586, Email: drmnalam@hotmail.com, crphilagri@gmail.com	Selected locations at Bandarban, Khagrachari, and Rangamati
2	CRP- 2 (2nd phase): Modeling Climate Change impact on agriculture and developing mitigation and adaptation strategies for sustainable agricultural production in Bangladesh Duration : 1st Dec, 2020 to 30th Nov 2023	Dr. Jatish C. Biswas, Coordinator, Climate Change, KGF. Cell: 01715332857	Gazipur, Mymensingh
3	CRP-3: Strengthening Sugarcane Research and Development in the Chittagong Hill Tracts. Duration : Apr 2015 to Mar 2019 (extended up to: June 2020)	Dr. Amzad Hossain, DG, BSRI, Ishurdi, Pabna, Cell: 01718426200, Kyachan-Senior Scientific officer, BSRI, Cell Phone: 01716-336712	Bandarban, Rangamati, and Khagrachari
4	CRP-4: Hill Livestock Development Duration : Apr 2017 to Mar 2022	Prof Dr. Kabirul Islam Khan, Dept of Genetics and Animal Breeding CVASU, Chittagonj, Cell: 01732986741, Email:kik1775@yahoo.co.uk	PRTC, CIVASU, Chittagonj, Bandarban (Sadar & Naikhongchari), Khagrachari (Sadar, Panghari)
5	CRP-5: Development of Upazila Land Suitability Assessment and Crop Zoning System of Bangladesh Duration : Jan 2017 to Dec 2019	Dr. Zilani, MD Crops, BARC. Cell: 01552355393; Dr. Moqbul Hossain, SRDI. Cell: 01710287841, Email: az.chowdhury@barc.gov.bd	300 Upazila of the country

C. Capacity Enhancement Program (CEP)

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
1	CEP-1: Capacity enhancement of NARS through Agricultural Research Management Information System (ARMIS) Duration : Jan. 2019 to Dec. 2021	Dr. Md. Moslem Uddin Mia, Research Management Specialist EX PI: H. M. Hamidur Rahman, Senior System Analyst, Computer & System Analyst, BARC, Dhaka.	BARC, Dhaka
2	CEP-II (3rd phase): **Seaweeds:** Capacity Building for Conducting Adaptive Trials on Seaweed Cultivation in Coastal Areas. Duration : 01 January 2016 to 30 Sep 2019 (18 months)	Coordinator: Dr. S M Bakhtiar, Member Director, Planning and Evaluation Division, BARC, Farmgate, Dhaka Dr. M. Akkas Ali, Chief Scientific Officer & Head, On-Farm Research Division (OFRD), BARI, Dhaka Dr. Kabir Uddin Ahmed, Chief Scientific Officer (Planning & Evaluation), BARC, Farmgate, Dhaka, Cell: 01771777993 kuahmed1970@gmail.com Ex PI: Dr. Md. Aziz Zilani Chowdhury, Member Director (Crops), BARC, Farmgate, Dhaka, Didarul Bashir, BARC, Farmgate, Dhaka, Cell Phone-01517141245, E-mail : didarbashir@gmail.com	Cox's Bazar, Chittagong.
3	CEP-III: Mitigating Greenhouse Gas (GHG) Emissions from Rice-based Cropping Systems through Efficient Fertilizer and Water Management. Duration : Sep 2015 to Aug 2019 (BRRI) & Feb 2016 (BAU) to Jan 2019	Dr. Rafiqul Islam, CSO, BRRI, Gazipur, Cell: --- & Dr. M. Rafiqul Islam, Prof, BAU, Mymensingh, Cell: 01711985414	BRRI On-stations and BAU Farm
4	CEP-IV: Training Program of PRTC in CVASU Duration : Mar 2017 to Feb 2020	Dr. Paritosh Kumar Biswas, Director, (PRTC), CVASU, Cell: 01718318926, Md. Moniruzzaman, BARI, Dinajpur, Cell Phone - 01725303399	CVASU, Chittagong

D. International Collaborative Program (ICP)

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
1	ICP- I: Cropping System Intensification in the Salt Affected Coastal Zones of Bangladesh and India Duration : Aug 2016 to Jul 2019	Dr. Md. Ansar Ali, Director (Research), BRRI, Gazipur; Cell: 01925053582; Dr. Md. Abida Khatun, CSO, IWM Division, BARI, Gazipur; Cell: 01712770880	Dacope, Khulna and Amtali, Barguna
2	ICP- II: Nutrient Management for Diversified Cropping in Bangladesh Duration : Dec 2017 to Nov 2020	Present: Dr. Baktear Hossain, CSO, Soil, BARC, Cell: 01711201441 Ex: Dr. MA Satter, MD, A & M,	Takurgaon, Rajshahi, Iswardi, Barguna, Khulna, Mymensingh

		BARC, Dhaka. Cell: 01716420890	
3	ICP- III: Incorporating salt tolerant wheat and pulses into small holder farming system in southern Bangladesh Duration : Jan 2018 to Dec 2021	Current: Dr. rais Uddin Choudhury, Director (Pulse), BARI, Gazipur EX. Dr. Mohammad Hossain, Director Pulse, BARI, Gazipur. Cell: 0175333679	Khulna, Satkhira, Jalokhati, Pirojpur, Barisal, Patuakhali, Barguna
4	ICP-IV: Development of short-duration cold-duration rice varieties for Haor areas of Bangladesh Duration : April 2020 to March 2025 (60 months)	Coordinator cum PI: Mohammad Rafiqul Islam, Scientist (Plant Breeder), IRRI Bangladesh, (Lead Organization), House#103, Road#1, Block F, Banani, Dhaka 1213 PI: Partha Sarathi Biswas, Principal Scientific Officer, Plant Breeding Division, BRRI, Gazipur (Component Organization)	Habiganj, Sunamganj and Kishoreganj

E. Technology Piloting Program (TPP)

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
1	C-HF-103: Validation of improved agricultural technologies at farmer's field in hill farming system. Implemented by BARI	Dr. Md. Mohabbat Ullah, Principal Scientific Officer, Hill Agril. Research Station, Bangladesh Agricultural Research Institute, Khagrachhari, Cell: 01550605727	
2	C-PHT-179: Increasing storability of potato in natural storage and income generation through small scale processing of potato. BARI	Dr. Md Azizul Haque, Former in charge, Tuber Crops Research Sub-center, BARI Munshiganj-1500. Currently Professor, BSMRAU. Cell: 01711488619	
3	C-CA-113: Adaptation of improved Sesame varieties in Khulna District optimizing sowing time and Nitrogenous fertilizer management. Khulna University	Dr. Md. Sarwar Jahan, Professor, Agrotechnology Discipline, Khulna University, Khulna-9208. Cell: 01712813106	
4	C-S-161: Water management practices for increasing cropping intensity in Chapai Nawabganj District of Bangladesh. BINA	Dr. Md. Asgar Ali Sarker, CSO (cc), Agriculture Engineering Division, BINA, P.O. Box-04, Mymensingh-2202. Cell: 01715998145	
5	P-1: Crop intensification in Barind area through effective drought management. BSMRAU	Dr. Md. Abdus Salam, Senior Scientific Officer On-Farm Research Division, Bangladesh Agricultural Research Institute, Rajshahi. Cell: 01712092122	
6	P-2: Management and control of mites in coconut through farmers' capacity enhancement. BARI	Dr. Md. Nazrul Islam, Principal Scientific Officer Regional Horticultural Research Station, Shibpur, Narshingdi. Cell: 01715855239	
7	P-3: Increasing rice production adopting improved production technologies in the tidal floodplain. BARI	Professor Dr. Md. Jafar Ullah, Department of Agronomy, Sher-E-Bangla Agricultural University, Dhaka. Cell: 01552331605	
8	P-4: Upscaling of mubgbean-rice pattern in the Charlands of Kurigram. BARI	Professor Dr. Md. Abdul Karim, Department of Agronomy Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706. 01716752414	
9	P-5: Upscaling improved jhum cultivation introducing intercropping rice with cotton.	Prof. Dr. Md. Farid Uddin, Additional Director Cotton Development Board Khamarbari. Cell: 01711020798	
10	P-6: Integrating crops and fish culture through land conversion into-ditch-dyke system	Professor Dr. Md. Mofazzal Hossain, Department of Horticulture, Bangabandhu	

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
		Sheikh Mujibur Rahman Agricultural University, Gazipur-1706. Cell: 01819433225	
11	P-7: Up-scaling and Validation of a proven technology on management of the major diseases of Brinjal and Tomato. BARI	Dr. Biresh Kumar Goswami, CSO, TCRC, BARI, Gazipur-1701. Cell: 01716519187	
12	P-8: Validation and piloting of improved production technologies in Gopalganj Basin. BARI	Dr. Ashraf Hossain, Principal Scientific Officer, Pulses Research Sub-station, BARI, Gazipur. Cell: 01712948871	Gopalganj and Madaripur
13	P-9: Validation of up-scaling of Improved Rice Based Cropping Systems incorporating Mustard and Potato in Northern Districts BARI	Dr. ASM Mahabubur Rahman, CSO, OFRD, BARI, Gazipur. Cell: 01712598035	
14	P-10: Up-Scaling and validation of Rhizome Rot Disease Management BARI	Dr. Atika Ayub, Chief Scientific Officer, Plant Pathology Division, Bangladesh Agricultural Research Institute (BARI); Cell:01716549366	Nilphamari, Rangpur, Bogra, and Tangail
15	P-11: Validation and scaling up of T.Aman - Potato/Mustard - Mungbean -T.Aus Cropping System in Northern districts of Bangladesh. BSMRAU	Prof. Dr. Md. Moynul Haque, Dept. of Agronomy; Cell: 01711908640	Dinajpur, Gaibandha and Nilphamari
16	P-12: Up-scaling of cost effective formula feeds and improved management practices for increasing milk and meat production from buffaloes. BAU	Dr. Md. Ruhul Amin, Prof Dept of Animal Science, BAU, Mymensingh. Cell: 01714217157	
17	P-13: Adaptation of Community Enterprise Approach in Tidal Floodplains for crop-fish culture - Jhalokathi Model. SHISUK Duration: February 2015 to April 2018	Mr. Zillur Rahman, Program Director, SHISUK, Dept. of Fisheries and Dhaka University	Jhanjhania, Pirojpur; Uttampur, and Bishnudia of Jhalakati
18	P-14: Pilot Project on "Up-scaling and Campaigning of Rice-Cotton intercropping in Bandarban and Khagrachari districts". CDP Duration: February 2015 to April 2018	Dr. Md. Farid Uddin, Executive Director, CDB, Dhaka	Chittagong Hill Tracts (CHT)
19	P-15: Upscaling of high value shing fish culture technology in homestead household ponds Duration : December 2015 to January 2017	Dr. Md. Jahangir Alam, Prof., Dept. of Fisheries Biology and Aquatic Environment, BSMRAU, Gazipur; Cell: 01715143521	Sadar, Palash, Shibpur, Raipura, Belabo, and Monohardi of Narsingdi
20	P-16: Improving the animal health and productivity through mobile veterinary services Duration : May 2017 to April 2020	Prof. Dr. Emdadul Haque Chowdhury, Department of Pathology, BAU, Mymensingh, Mobile no. 01712 017381	Fulbaria, Mym, Nokla, Sherpur and BAU
21	P-17: Upscaling of tricho-compost and tricho-leachate production for disease management in vegetable and spices (rhizome and bulb crops.	Dr. Mrs. Shamsunnahar, PSO, HRC, BARI	Gazipur, Jessore, Comilla and Bogra

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
	Duration : Jan 2018 to Dec 2020		
22	P-18: Scale up of Community Enterprise Approach (CEA) for Intensification of floodplain fish production in Chalan beel Duration : Apr 2017 to March 2020	SHISUK, Dept. of Genetics and Fish Breeding, BSMRAU, Gazipur	Pabna, Natore, Sirajganj
23	P-19: Validation and Dissemination of newly released high yielding and climate smart potato varieties. Duration : November 2017 to August 2018	Dr. Bimal Chandra Kundu, PSO, Tuber Crops Research Center, BARI, Joydebpur, Gazipur, Cell : 01712681181, Email- kundubc@yahoo.com	Borguna , Patuakhali, Barisal, Bhola, Madaripur, Gopalgong, Faridpur, jhenaidah , Hessor, Kushtia, Khulna, Satkhira, Cox's Bazar, Chittagong, Noakhali, Comilla, Brahmanbaria, Norsingdi, Gazipur, Tangail, Manikgong, Mymensingh, Jamalpur, sherpur, Kishoreganj, Bogra, Rajshahi, Rangpur, Joypurhat, Gaibandha, Dinajpur, Nilphamari, Panchagar, and Thakurgoan.
24	P-20: Piloting on Productivity Enhancement of Goor and Chewing type Sugarcane through Management of Major Diseases Duration: Jan, 2020 to Dec, 2022.	Dr. Md shamsur Rahman, PSO & Head, Pathology Division, BSRI	Tala of Sathkhira,Ishurdi of Pabna,Kalia of Norail, Kaligonj of Jhenaidah, singair of Manikgong, Dohar of Dhaka, Sadar and Kamarkhand of Serajgonj, Lalpur of Natore, Shibgonj of Chapainawabgonj, Sadar of Rajshahi, Sadar of Jypurhat, Sadar and Haripur of Thakurgaon

F. Technology Commercialization Program (TCP)

Sl	Project title, code no. and Duration	Coordinator/PI/CI	Location
1	TCP-1: BAU-Bro Chicken Conservation and Piloting their Producer-group Duration : 26 Dec 2019 to 25 Dec 2022	Dr. Md. Bazlur Rahman Mollah, Professor, Department of Poultry Science, Bangladesh, Cell: 01711304172, Email: mbrmollah.ps@bau.edu.bd	BAU, Mymensingh

Annex-3

KGF Work Plan and Implementation
FY: 2020-21 (Tentative)

Sl.	List of Activities/Programs	Performance Schedule (Tentative)											
		J	A	S	O	N	D	J	F	M	A	M	J
A.	Competitive Grants Program (CGP) and Basic Research (BR)												
1.	TAC evaluation and budget rationalization of projects												
2.	Board approval, MoU signing and grant awarding												
3.	Coordination, implementation and management of projects												
B.	Commissioned Research Program (CRP)												
1.	Coordination, implementation and management of projects												
2.	Formulation of new CRP projects based on national demand												
C.	Capacity Enhancement Program (CEP)												
1.	Coordination, implementation and management of projects												
2.	Coordination and implementation of upcoming training programs												
3.	Development and implementation of training on statistics/advanced breeding/ disease forecasting/ crop modeling/IPM/crop management/ molecular biology/IPR, etc.												
4.	Need based consultative meetings, seminars, workshops, etc.												
5.	Assistance to develop/improve physical facilities at NARS inst.												
6.	Work on national and international linkages and collaboration												
D.	International Collaborative Program (ICP)												
1.	Coordination, implementation and management of projects												
2.	TAC evaluation and budget rationalization of projects												
3.	Board approval, MoU signing and grant awarding												
E.	Technology Piloting/ Upscaling Program (TPP)												
	Implementation of the on-going and upcoming projects ; impact assessment studies of the completed pilot projects												
F.	Ongoing and Upcoming Projects												
	MoU signing and awarding, of upcoming projects												
G.	Monitoring and Evaluation												
1.	Concurrent M & E of on-going projects												
2.	Organizing annual/completion progress review and planning workshops												
H.	Other Activities												
1.	Mujib Barsha 2020: Observation of international/ national events												
2.	Board/AGM/EGM/other meetings												
3.	Preparation and printing of annual report (BKGET & KGF)/project briefs/data management /technical bulletins/need based fact sheets/other reports and publications /compilation of technical and scientific booklets, etc.												
4.	Preparation of action plan/implementation plan/activity plan												
5.	Misc. other activities												

KRISHI GOBESHONA FOUNDATION

Annex-4

Statement of Expenditure (SOE) for the Period from July, 2019 to 30 June, 2020

Fig. in Crore Tk.

Sources of Fund / Head of Income:		Approved budget by 12th AGM for 2019-20	Fund Received from BKGET, 2019-20	Quarterly expenditure (1st April,2020 to 30 June. ,2020)	Cummulative Expenditure Fiscal Year 2019-20	Un-spent Balance	Progress
Opening Balance 01/07/2019 (Cash at Bank Tk. 4.5413881 (Crore) + Petty Cash in hand Tk. 0.0025 (Crore)		**0.00000**	**4.5438881**				
Grants from BKGET Trust Fund.		**45.0367738**	**29.9588929**				
Total Fund for the period of July 2019 to June, 2020		**45.0367738**	**34.5027810**				
Sl. No.	**Line Items / Head of Expenditures**	**Approved budget by 12th AGM for 2019-20**	**Fund Received and with last year balance , 2019-20**	**Quarterly expenditure (1st April.2020 to 30 June ,2020**	**Cummulative Expenditure July'2019 to 30 June, 2020**	**Un-spent Balance (Tk.)**	**Achivement %**
1	**Program Cost:**						
1.1	**Research Grants Program (on-going):**						
	(a) Competitive Grants Program (CGP)						
	(i) CGP (2nd Call)	1.5300000	1.6047150	0.2047150	1.4212214	0.1834936	89%
	(ii) CGP (3rd Call)	8.8495700	8.6495000	2.0841932	8.6387380	0.0107620	100%
	(iii) Basic Research	2.1898678	0.9653634	0.1501303	0.7289495	0.2364139	76%
	Sub- total (CGP)	**12.5694378**	**11.2195784**	**2.4390385**	**10.7889089**	**0.4306695**	96%
	(b) Commissioned Research Program (CRP) :						
	(i) CRP-1: Hill Agriculture (i,ii,iii,iv,v)	3.5000000	3.2900000	0.0000000	3.2882225	0.0017775	100%
	(ii) CRP-2: Modeling Climate Change on Bangladesh Agriculture	4.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0%
	(iii) CRP- 3: Sugarcane RESEARCH AND DEVELOPMENT in CHT	1.0500000	0.8264850	0.1964850	0.8203850	0.0061000	99%
	(iv) CRP- 4: RESEARCH AND DEVELOPMENT on Hill Livestock	1.8715000	1.3400000	0.4000000	1.3357500	0.0042500	100%
	(v) CRP-5 Assessment of land suitability & Crop Zoning	3.5000000	3.0200000	1.0170250	3.0170250	0.0029750	100%
	Sub- Total- CRP	**13.9215000**	**8.4764850**	**1.6135100**	**8.4613825**	**0.0151025**	100%

Sources of Fund / Head of Income:		Approved budget by 12th AGM for 2019-20	Fund Received from BKGET, 2019-20	Quarterly expenditure (1st April,2020 to 30 June. ,2020)	Cummulative Expenditure Fiscal Year 2019-20	Un-spent Balance	Progress
	(C) Technology Piloting Program (TPP)	1.4258360	0.9855000	0.2369660	0.9767796	0.0087204	99%
	Sub-Total (TPP)	**1.4258360**	**0.9855000**	**0.2369660**	**0.9767796**	**0.0087204**	99%
	(d) International Collaborative Program (ICP)	0.0000000	0.0000000		0.0000000	0.0000000	0%
	(i) ICP- I : Cropping System Intensification in the Salt Affected Coastal Zone of Bangladesh & West Bangal, India. (ACIAR), Soil nutrition , Pulse and Wheat.	0.3600000	0.3048176	0.1348176	0.2952526	0.0095650	97%
	(ii) ICP-II : NUMAN	1.1600000	1.0400000	0.0000000	0.8306322	0.2093678	80%
	(iii) ICP- III- Incorporating Salt Tolernt Wheat and Pules into Small Holder farming system in Southern Bangladesh	1.1500000	0.9000000		0.5662269	0.3337731	63%
	Sub- Total-(ICP)	**2.6700000**	**2.2448176**	**0.1348176**	**1.6921117**	**0.5527059**	75%
	(e) Other Program:						
	(i) Mitigation of Greenhouse Gas (GHG)	0.6300000	0.6300000		0.3940834	0.2359166	63%
	(ii) RESEARCH AND DEVELOPMENT of Seaweed cultivation	0.0000000	0.6000000	0.4000000	0.5500000	0.0500000	92%
	(iv) Preparation of plan & other documents, management review & M&E cost (TA/DA), TAC Related Expenses, Honorarium (CGP/CRP/Pilot Projects), Expert Reviewer Honorarium, outsourching of expert/Technical staff etc..	1.8000000	1.5000000	0.0797530	1.4704458	0.0295542	98%
	Sub-Total (other Program)	**2.4300000**	**2.7300000**	**0.4797530**	**2.4145292**	**0.3154708**	88%
	Total Research Grants Program	**33.0167738**	**25.6563810**	**4.9040851**	**24.3337119**	**1.3226691**	95%
1.2	**Capacity Enhancement Program (CEP):**					0.0000000	
	(a) Human Resource Development (HRD) Program: Higher studies, Skill enhancement of scientists and RESEARCH AND DEVELOPMENT partners; National/ International training / visits, etc.; National /International resource person/ consultant / expert (remuneration, perdiem, fees, airfare, lodging and others cost); National /International linkage development program with KGF and RESEARCH AND DEVELOPMENT partners, Independant Monitoring Team.	1.3768000	0.9500000	0.2079103	0.9495020	0.0004980	100%

Sources of Fund / Head of Income:		Approved budget by 12th AGM for 2019-20	Fund Received from BKGET, 2019-20	Quarterly expenditure (1st April,2020 to 30 June. ,2020)	Cummulative Expenditure Fiscal Year 2019-20	Un-spent Balance	Progress
	(b) Institutional capacity enhancement: i) Strengthening/ creation of research facilities /renovation, etc. for NARS institute; ii) KGF capacity improvement: Office rent, procurement of KGF equipment, computer, 3 Vehicles, goods and logistics support and services, hiring of services and facilities, etc. for KGF.	1.3768000	0.8000000	0.0645420	0.7910351	0.0089649	99%
	(c) Preparation of plan & other documents: Fees for different studies/ publications / books, etc.; including logistics support and printing, publication, documents & video production cost, etc and hiring of National / Intenational experts / consultants / resource persons.	1.5000000	0.5000000	0.1126000	0.4937000	0.0063000	99%
	(d) ARMIS Program	2.1200000	0.8500000	0.2079500	0.8159000	0.0341000	96%
	Sub- total	**6.3736000**	**3.1000000**	**0.5930023**	**3.0501371**	**0.0498629**	98%
	Total Program Cost	**39.3903738**	**28.7563810**	**5.4970874**	**27.3838490**	**1.3725320**	95%
2	**Operational Support Cost:**						
2.1	**(a) Salaries:** i) Salaries of KGF Technical /Admin & Finance/Office and General Support Service Management Staff and support service Worker fees (ii) Remuneration of contractual services & other staff, etc	3.5000000	3.5000000	0.9228325	3.4937981	0.0062019	100%
	(b) Allowances: Allowances, service benefits, TAX/VAT, payments, etc. of KGF Technical/Admin & Finance /Office and General Support Service Management Staff and support service Worker	0.7500000	0.8000000	0.3381122	0.7786152	0.0213848	97%
2.2	**(c) General Operating Cost:** Utilities, hiring of vehicles, repair & maintenance/ renovation, supply & services, TA/DA , Audit fees/ financial/ technical services, AGM/EGM/Board Meeting and other costs, etc.	1.1629002	1.2129002	0.0764009	1.1877753	0.0251249	98%
	(d) Contingency/ Any other misc. cost (as per need)	0.2334998	0.2334998	0.0115000	0.2173965	0.0161033	93%
	Sub-total of Operational Support Cost	**5.6464000**	**5.7464000**	**1.3488456**	**5.6775851**	**0.0688149**	99%
		45.0367738	**34.5027810**	**6.8459330**	**33.0614341**	**1.4413469**	96%
Progress: Tk. 33.0614341 (crore) up to 30 June, 2020 against Total fund of Tk. 34.5027810 (crore)							

(As per need, line-item costs may be adjusted by the ED, KGF within the Total budget)

Trust fund grants Tk. 45.0367738 (Crore) will be utilized as per objectives of the BKGET Clause iv no.7 (page -10) and the provisions of the Memorandum of KGF.

(Dr. Tapan Kumar Dey)
Executive Director (In-charge), KGF

KRISHI GOBESHONA FOUNDATION

Proposed Budget for Financial Year 2021-2022

Figs. in lakh Tk.

Sources of Fund / Head of Income:		**Proposed budget for 2021-2022**	
Grants from BKGET Trust Fund			
Sl. No.	**Line Items / Head of Expenditures**	**Itemwise program cost**	**% of total budget**
1	**Programs Cost:**		
1.1	**Research Grants Program (on-going):**		
	(a) Competitive Grants Program (CGP)		
	(i) CGP (2nd Call)	-	0.00
	(ii) CGP (3rd Call)	177.335	3.94
	(iii) CGP (4th Call)	589.031	13.09
	Sub-total (CGP)	766.366	17.03
	(iv) Basic Research (BR)	35.000	0.78
	Sub- total (BR)	35.000	0.78
	(b) Commissioned Research Program (CRP) :		
	(i) CRP-1: Hill Agriculture	-	0.00
	(ii) CRP-2: Modeling Climate Change on Bangladesh Agriculture	293.760	6.53
	(iii) CRP- 3: Sugarcane R&D in CHT	-	0.00
	(iv) CRP- 4: R&D on Hill Livestock	125.620	2.79
	(v) CRP -5: Assessment of land suitability & Crop zoning	100.000	2.22
	Sub-total (CRP)	519.380	11.54
	(c) (i) Technology Piloting Program (TPP)	75.000	1.67
	(ii) Technology Commercialisaton Program (TCP)	116.080	2.58
	Sub-total (TPP)	191.080	4.25
	(d) International Collaborative Program (ICP)	-	
	(i) Cropping System Intensification in the Salt Affected Coastal Zone of Bangladesh & West Bangal, India. (ACIAR)	40.000	0.89
	(ii) ICP-II : NUMAN	90.000	2.00
	(iii) ICP-III : Incorporating Salt -Tolerent Wheat and Pulese into Small holder Farming Systems in Southern Bangladesh.	8.000	0.18
	(iv) ICP-IV-Development of short duration Cold Tolerant Rice Varieties in Haor Areas of Bangladesh	200.000	4.44
	Sub- total (ICP)	338.000	18.62
	(i) CEP-I : ARMIS Project	100.000	2.22
	(ii) CEP-II : R & D Seaweed Cultivation (2nd Phase)	70.000	1.56
	(iii) Mitigation of Greenhouse Gas (GHG)	-	0.00
	(iv) Global Institute for Food Security (GIFS), University of Saskatchewan Canada & Bangladesh Agricultural Research Council (BARC).	500.000	11.11

Sl. No.	Line Items / Head of Expenditures	Itemwise program cost	% of total budget
	(iv) Preparation of plan & other documents, management review & M&E cost (TA/DA), TAC Related Expenses, Honorarium (CGP/CRP/Pilot Projects), Expert Reviewer Honorarium etc.	120.000	2.67
	Sub- total	**790.000**	17.56
	Total (Research Grants Program on going)	**2639.826**	58.66
	(e) Other Program :		
2	**Research Grants Program (Up-Coming):** **CGP 4th call, CRP, ICP, CEP,Technology Piloting Program, etc.**	**694.174**	19.87
2.1	**Capacity Enhancement Program (CEP):**		
	(a) Human capacity (HRD Program): Skill enhancement of scientists and R&D partners; National/International training / workshops/ meetings/ visits, etc.; National/International resource person/ consultant/ experts perdiem, remuneration, fees, airfare, lodging and others cost; National/International linkage development program with KGF and R&D partners	120.000	2.67
	(b) Institutional capacity enhancement: i) Strengthening/ creation of research facilities/renovation, etc. for NARS institute; ii) KGF capacity improvement: Office rent, procurement of KGF equipment, computer, vehicles, goods and logistics support and services, hiring of services and facilities, etc. for KGF.	100.000	2.22
	(c) Preparation of Events : National/ International experts/ consultants/resource persons fees for different studies / publications / books, etc.; including logistics support and printing, publication, documents & video production cost, etc.	150.000	3.33
	(d) **MujibYear :** Observance of International/National events/Mujib year.	0.000	0.00
	Sub- total	**1064.174**	28.09
	1. Total Program Cost	**3704.000**	86.76
	Operational Support Cost:		
3.1	**(a) Salaries:** i) Salaries of KGF Technical/Admin & Finance/Office and General Support Service Management Staff and support service Worker fees (ii) Remuneration of contractual services & other staff, etc	550.000	7.78
	(b) Allowances: Allowances, service benefits, TAX/VAT, payments, etc. of KGF Technical/Admin & Finance/Office and General Support Service Management Staff and support service Worker	46.000	1.02
3.2	**(a) General Operating Cost:** Utilities, hiring of vehicles, repair & maintenance/ renovation, supply & services, TA/DA, Audit fees/ financial/ technical services, AGM/EGM/Board Meeting and other costs, etc.	150.000	3.33
	(b) Contingency/ Any other misc. cost (as per need)	50.000	1.11
	2. Sub-total of Operational Support Cost	**796.000**	13.24
	Total Budget for the Financial Year 2021-22	4500.000	100.00
In word : Taka 4500.00 (Forty Five Crore) only			

(As per need, line-item costs may be adjusted by the ED, KGF within the Total)

Trust fund grants **Tk. 4500.00 (forty-five crore)** will be utilized as per objectives s of the BKGET Clause iv no.7 (page-10) and the provisions of the Memorandum of KGF.

Jiban Krishna Biswas, PhD

Executive Director
KGF

Annex-6

PRIVATE & CONFIDENTIAL

AUDITORS' REPORT
&
FINANCIAL STATEMENTS
OF
KRISHI GOBESHONA FOUNDATION (KGF)

Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund

FOR THE YEAR ENDED 30 JUNE 2020

SUBMITTED BY

ATA KHAN & CO.

Chartered Accountants
67, Motijheel C/A, (1st Floor), Dhaka-1000,
Phones: 9560933, 9560716, Mobile: 01819228521
Email: maqbul.ahmed@yahoo.com
Website: www.atakhanca.com

ATA KHAN & CO.
Chartered Accountants
A PARTNERSHIP FIRM
.....since 1959

67, MOTIJHEEL COMMERCIAL AREA
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BANGLADESH
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Email: maqbul.ahmed@yahoo.com
Website:www.atakhanca.com

INDEPENDENT AUDITORS' REPORT

Report on the Financial Statements

Qualified Opinion:

We have audited the financial statements of **Bangladesh Krishi Gobeshona Endowment Trust (BKGET)** Fund of **Krishi Gobeshona Foundation** which comprise the statement of financial position as at 30 June 2020 the statement of Financial Position comprehensive income and expenditure, Statement of receipts and payments, for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, except for the possible effects of the matter described in the basis for qualified opinion section of our report, the accompanying financial statements give a true and fair view, in all material respects, of the financial position of **Bangladesh Krishi Gobeshona Endowment Trust (BKGET)** Fund of **Krishi Gobeshona Foundation** as at 30 June 2020 and of its financial performance for the year then ended in accordance with international financial reporting standards and other applicable rules and regulation.

Basis for Qualified opinion:

1. The evidence with respect to Advance and loan given during the year, refund during the year and adjustment thereof was limited as the document provided to us was not reliable and acceptable, As a result we could not confirm whether any adjustment was necessary which might have material effect on the financial statements.

2. Depreciation has not been charge on Fixed Assets.

We conducted our audit in accordance with International Standards on Auditing. Our responsibilities under those standards are further described in the auditors' responsibilities for the audit of the financial statements section of our report. We are independent of the company in accordance with the international ethics Standards board for Accountants' Code of Ethics for Professional Accountants (IESBA Code) together with ethical requirements that are relevant to our audit of the financial statements in Bangladesh, and we have fulfilled our other ethical responsibilities in accordance with the IESBA Code. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for audit opinion.

Other Information:

Management is responsible for the other information. The other information comprises all of the information in the Annual report other than the financial statements and our auditors' report thereon. The directors are responsible for the other information.

Our opinion on the financial statements does not cover the other information and we do not express any form of assurance conclusion thereon.

In connection with our audit of the financial statements, our responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the financial statements or our knowledge obtained in the audit or otherwise appears to be materially misstated.

If, based on the work we have performed, we conclude that there is a material misstatement of this other information; we are required to report that fact. We have nothing to report in this regard.

Responsibilities of Management and Those Charged with Governance for the Financial Statements and Internal Controls:

Management is responsible for the preparation and fair presentation of the financial statements in accordance with International Financial Reporting Standards and other applicable rules and regulations and for such internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, management is responsible for assessing the Company's ability to continue as a going concern, disclosing, as applicable, matters related to going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the Company or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the Company's financial reporting process

Auditors' Responsibilities for the Audit of the Financial Statements:

Our objectives are to obtain reasonable assurance about whether financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with ISAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with ISAs, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Company's internal control.

- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.

- Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Company's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the Company to cease to continue as a going concern.

- Evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

We also provide those charged with governance with a statement that we have complied with relevant ethical requirements regarding independence, and to communicate with them all relationships and other matters that may reasonably be thought to bear on our independence, and where applicable, related safeguards.

From the matters communicated with those charged with governance, we determine those matters that were of most significance in the audit of the financial statements of the current period and are therefore the key audit matters. We describe these matters in our auditor's report unless law or regulation precludes public disclosure about the matter or when, in extremely rare circumstances, we determine that a matter should not be communicated in our report because the adverse consequences of doing so would reasonably be expected to outweigh the public interest benefits of such communication.

Report on other Legal and Regulatory Requirements:

(a) we have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit and made due verification thereof;

(b) in our opinion, proper books of account as required by law have not been kept by the Organization so far as it appeared from our examination of those books; and

(c) The organization's financial statements dealt with by the report are in agreement with the books of account.

Dated: Dhaka,
05 January 2021

ATA KHAN & CO.
Chartered Accountants
DVC: 2101130587AS197102

ATA KHAN & CO.
Chartered Accountants

Krishi Gobeshona Foundation (KGF)
Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund

Statement of Financial Position
As at 30 June 2020

Particulars	Notes	Amount in Taka	
		30 June 2020	30 June 2019
Assets:			
Non-current assets:			
Property, Plant and Equipments	4.00	**37,256,601**	36,290,714
Current assets:			
Loans & advances	5.00	1,440,000	684,400
Security Deposits	6.00	1,110,000	1,110,000
Cash & Cash Equivalents	7.00	14,438,469	45,438,882
Total current assets		**16,988,469**	**47,233,282**
Total Assets		**54,245,070**	**83,523,996**
Fund and Liabilities:			
Fund Account (BKGET Fund)	8.00	54,245,070	83,523,996
Other Liabilities			-
Total Fund and Liabilities		**54,245,070**	**83,523,996**

The annexed notes form an integral part of these financial statements.

Manager (Finance & Accounts)

Md. Delwar Hossain
Asstt. Manager (Audit & Acc.)
KGF

Executive Director

Executive Director
Krishi Gobeshona Foundation
BARC Complex, Farmgate, Dhaka-1215

SIGNED IN TERMS OF OUR ANNEXED REPORT OF EVEN DATE

Dated: Dahka
05 January 2021

ATA KHAN & CO.
Chartered Accountants
DVC: 2101130587AS197102

ATA KHAN & CO. Chartered Accountants 18 Motijheel C/A, Dhaka

ATA KHAN & CO.
Chartered Accountants

Krishi Gobeshona Foundation (KGF)
Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund

Statement of Income & Expenditure
For the Year ended 30 June 2020

Particulars	Notes	Amount in Taka	
		2019-2020	2018-2019
Income:			
Grant	8.02	330,054,971	379,517,722
Interest Received	18.00	1,738,651	2,732,092
Other Received	18.00	48,320	-
Total Income:		**331,841,942**	**382,249,814**
Less : Expenditure			
Salaries and Allowances	10.00	53,511,214	50,535,507
Training, Workshop & CGP Related Expenses	11.00	16,129,200	19,197,486
Operational Cost	12.00	17,219,779	20,060,025
Competitive Grant Program CGP	13.00	114,568,185	136,412,580
Commissioned Research Project CRP-1	14.00	92,772,825	88,155,678
Pilot Project	15.00	9,767,796	11,832,087
Committed Expenditure CGP Grant		-	-
Basic Research BR)	16.00	19,420,418	44,368,226
Other Projects	17.00	8,452,526	11,688,225
Total Expenditure:		**331,841,942**	**382,249,814**
Excess of Income over Expenditure (Transferred to Fund Account)		-	-

The annexed notes form an integral part of these financial statements.

Manager (Finance & Accounts)

Md. Delwar Hossain
Asstt. Manager (Audit & Acc.)
KGF

Executive Director

Executive Director
Krishi Gobeshona Foundation
BARC Complex, Farmgate, Dhaka-1215

SIGNED IN TERMS OF OUR ANNEXED REPORT OF EVEN DATE

Dated : Dhaka
05 January 2021

ATA KHAN & CO.
Chartered Accountants
DVC: 2101130587AS197102

ATA KHAN & CO. Chartered Accountants Motijheel C/A, Dhaka

Krishi Gobeshona Foundation (KGF)
Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund

Statement of Receipts and Payments
For the Year ended 30 June 2020

Particulars	Notes	Amount in Taka	
		2019-2020	2018-2019
A. Receipts:			
Opening Balance:			
Cash at Bank		45,413,882	24,967,888
Cash in Hand		25,000	25,000
Fund Received	8.01	299,588,929	399,950,000
Refund of Unspent Balance against advance		551,012	1,225,389
Missc. Received	ANX-C	1,187,116	-
Other Received	18	1,786,971	2,732,092
Total		**348,552,910**	**428,900,369**
B. Payments:			
Salaries and Allowances	SCH-1	53,286,214	50,535,507
Acquisition of property plant and equipments	ANX-A	965,887	703,534
Training, Workshop & CGP related expenses	SCH-2	14,400,354	17,059,331
Operational Cost	SCH-3	16,067,215	15,630,324
Loans & advances	ANX-B	4,413,022	7,075,995
Competitive Grant Program CGP	13.00	114,568,185	136,412,580
Commissioned Research Project CRP-1	14.00	92,772,825	88,155,678
Pilot Project	15.00	9,767,796	11,832,087
Basic Research & CEP ii & iii	16.00	19,420,418	44,368,226
Other Projects	17.00	8,452,526	11,688,225
Total Payments		**334,114,441**	**383,461,487**
Closing balance:			
Cash at Bank	7.2	14,413,469	45,413,882
Cash in Hand	7.1	25,000	25,000
Total		**348,552,910**	**428,900,369**

The annexed notes form an integral part of these financial statements.

Manager (Finance & Accounts)

Md. Delwar Hossain
Asstt. Manager (Audit & Acc.)
KGF

Executive Director
Executive Director
Krishi Gobeshona Foundation
BARC Complex, Farmgate, Dhaka-1215

SIGNED IN TERMS OF OUR ANNEXED REPORT OF EVEN DATE

Dated: Dhaka
05 January 2021

ATA KHAN & CO.
Chartered Accountants
DVC: 2101130587AS197102

Krishi Gobeshona Foundation (KGF)
Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund
Notes to the Financial Statements
As at and For the year ended 30 June 2020

1.0 Reporting Entity

i) Organizations Profile:

The Krishi Gobeshona Foundation (KGF) was established by the Govt. of the People's Republic of Bangladesh in 2007 under the Companies Act 1994 having Reg. No. E- 684(05)07 dated September 19, 2007. The Foundation is an Association not for profit within the meaning of the section 28 of the said act.

The Foundation is set with its own General Body to manage the Competitive Grants Program CGP under the Bangladesh Krishi Gobeshona Endowment Trust (BKGET) with independence, objectivity and transparency. The General Body and the board of Directors have representative members from Government, Bangladesh Agricultural Research Council (BARC), eminent persons of Agricultural Research and Development under National Agricultural Research System (NARS), Consultative Group on International Agricultural Research (CGIAR), Agricultural Extension Service and Agricultural University/ Academic Institutes, NGO's Relevant Foundations/ Financial Institutions, Economists/ Rural Development Practitioners, Agribusiness Entrepreneurs and Private Sectors of Individuals.

ii) Objective and Activities:

KGF is responsible for management and implementation of the Competitive Grants Program (CGP) with objectivity and transparency. CGP is a sub-component of the research Component of the Bangladesh Krishi Gobeshona Endowment Trust (BKGET), Phase- 1 finance by the World Bank and IFAD. KGF through its CGP seeks to develop a more Pluralistic research system by opening the CGP to the NARS institutes, Universities, other research institutes, NGO's and privet sectors organizations. Agricultural research and development projects funded under CGP require having location-specific, pre-identified high priority area, multi-disciplinary approach short or medium term duration, demand driven, immediate benefit and problem-solving criteria. KGF funds the CGP projects that are crucial to bridge the yield gaps, respond to pre-identified problems and address other demand-based issues for improving productivity and farm income. Major focus is on-farm applied and adaptive research, including marketing, socio-economic aspects and value addition.

2.00 Basis of Presentation of Financial Statements

i) Basis of Accounting:

The financial statements have been prepared on the cash basis.

ii) Basis of Measurement:

The financial statements have been prepared on the historical cost convention and therefore do not take into consideration the effect of inflation.

iii) Accounting records:
Income has been recognized at the time when it was received and an expense has been recognized when it was paid.

iii) Fixed assets and Depreciation:

No depreciation has been charged on fixed assets continuously.

iv) Reporting Currency :

Reporting currency is Bangladeshi Taka .

3.00 Additional information on financial statements:

i) Components of the Financial Statements:

(a) Statement of financial position .

(b) Statement of income and expenditure.

(c) Statement of receipts and payments.

(d) Notes to the financial statements.

ii) Comparative:

Comparative information have been disclosed in respect of the previous year for all numerical information in the financial statements and also the narrative and descriptive information when it is relevant for understanding of the current year financial statements.

Previous year's figure has been restated and re-arranged wherever necessary, to confirm to the current year's presentation as per IAS-8 "Accounting Policies, Changes in Accounting Estimates and Errors".

iii) Reporting Period:

Financial statements of the company cover one year from 1 July 2019 to 30 June 2020.

iv) General:

Figures appearing in the Financial Statements have been rounded off to the nearest Taka.

			Amount in Taka	
			2019-2020	2018-2019
4.0	**Property, Plant and Equipments**			
	A. Cost:			
	As on 01.07.2019		36,290,714	35,512,180
	Add: Addition during the year		965,887	778,534
	Less: Adjustment during the year			-
	As on 30.06.2020		37,256,601	36,290,714
	Less:			
	B. Accumulated Depreciation:			
	As on 01.07.2019		-	-
	Add: Depreciation charged during the year		-	-
	Less: Adjustment during the year		-	-
	As on 30.06.2020		-	-
	Written Down Value (WDV) (A-B) as on 30.06.2019		37,256,601	36,290,714
	(Details have been shown in Annexure-A)			
5.00	**Loans & advances**			
	Tahsina Naznin		-	12,000
	Mojibor Rahman		40,000	100,000
	Abul Hasanat Khan		-	120,000
	Sahjahan		35,000	95,000
	Abul Khair		300,000	-
	Executive Chairman BARC		-	357,400
	Alam Mia		82,500	-
	Iqbal Hossain		97,500	-
	Faruque Hossain		100,000	-
	Zerin Tasnin		300,000	-
	Aminul Alam Khan		100,000	-
	Motaleb Hossain		100,000	-
	Pervin Begum		85,000	-
	Rehana Begum		100,000	-
	Salauddin Liton		100,000	-
	Total		1,440,000	684,400
6.00	**Security Deposits**			
	Deposit against office rent		1,080,000	1,080,000
	Security money for Trust Filling		30,000	30,000
			1,110,000	1,110,000
7.00	**Cash & Cash Equivalents**			
	Cash in hand	7.1	25,000	25,000
	Pubali Bank Ltd. Farmgate Br. A/C# 0522	7.2	14,413,469	45,413,882
	Total		14,438,469	45,438,882
8.00	**Fund Account (BKGET Fund)**			
	Opening Balance		83,523,996	63,091,718
	Add: Fund Received during the year **(Note - 8.01)**		299,588,929	399,950,000
	Missc. Received (Annexure-D)		1,187,116	-
	Add: Adjustment in advance amount (Fund refund)		-	-
			384,300,041	463,041,718
	Less: Transferred to grant income **(Note-8.02)**		330,054,971	379,517,722
	Add : Excess of Income over Expenditure		-	-
	Total		54,245,070	83,523,996
8.01	**Fund Received during the year:**			
	Fund received from BKGET Fund		299,588,929	399,950,000
8.02	**Transferred to grant income**		330,054,971	379,517,722

		Amount in Taka	
		2019-2020	2018-2019
10.00	**Salaries and Allowances**		
	Expert salary (Including CPF)	30,922,903	33,905,980
	Allowance/ Bonus	3,354,250	4,729,291
	Officer & Staff salary	282,581	74,242
	Contractual Service salary (Including Security Service Bill)	14,686,993	10,324,874
	Gratuity	-	1,501,120
	Employees Contribution(CPF Fund)	3,625,438	
	Security Service Salary	639,049	
	Total	**53,511,214**	**50,535,507**
11.00	**Training, Workshop & CGP Related Expenses**		
	CGP meeting, training fees & other	-	1,277,477
	Hiring of vehicle CGP monitoring	601,890	1,108,163
	Hiring individual monitoring exp.	-	26,000
	CGP TA/DA (review and M & E cost)	896,525	1,516,064
	Technical advisory committee fees	-	257,798
	ICP (International Collabration)	-	-
	Travel & Tour	-	55,686
	Honorioum	9,917,822	12,162,984
	CGP Training Workshop (CVASU)	-	2,616,350
	Resource person honorioum (International)	-	-
	Pre proposal activities of modeling climate change	-	-
	PHD Scholarship	2,984,117	-
	Advance Adjustment	1,728,846	-
	Workshop/Seminar/ Meeting expense paid/Remunaration	-	176,964
	Total	**16,129,200**	**19,197,486**
12.00	**Operational Cost**		
	Conveyance TA/DA	-	231,410
	Entertainment	29,957	54,957
	Board Meeting Expense	-	495,572
	Car Repair & Maintenance	593,621	704,088
	Other Repair & Maintenance	223,387	410,223
	Overtime Bill	806,785	-
	Bank Charge	61,627	8,080
	Electricity Bill	1,645,388	1,647,521
	AGM expenses	-	327,565
	Audit fee	185,438	62,500
	Printing and Publication/documents, video	4,445,921	3,986,806
	Software	-	896,000
	Miscellaneous Expenses	461,378	636,449
	Office Rent	2,820,208	2,890,111
	Gas, Fuel & Oil etc.	1,230,332	1,348,706
	Promotional advertisement	-	46,920
	Car Insurance Premium	528,717	588,770
	Telephone/ Mobile Bill, Courier, Internet & Website	750,892	708,787
	Office Supplies & Stationary	48,448	357,501
	Training workshop (National/International)	1,644,549	3,181,557
	National/ local Exerts/consultants	-	310,000
	Workshop/ Seminar/ Training	-	590,000
	Retention Fee	417,000	375,750
	Postage bill	8,567	54,908
	Internet bill	165,000	145,844
	Adjustment with advance	1,152,564	-
	Miscellaneous VAT	-	-
	Total	**17,219,779**	**20,060,025**

	Amount in Taka	
	2019-2020	2018-2019
13.00 Competitive Grant Program CGP		
1st Call:		
TF 01-C		-
TF 02-C		-
TF 03-C		-
TF 04-C		-
TF 05-C		-
TF 06-C		-
TF 07-C		-
TF 08-NR		-
TF 09-NR		-
TF 10-F		-
TF 11-C		-
TF 12-L		-
TF 13-F		-
TF 14-C		-
Total 1st Call		-
2nd Call:		
TF 15-SF	-	210,532
TF 16-WF	455,972	-
TF 17-ARI	600,000	439,003
TF 18-EM	-	-
TF 19-EM	295,633	1,209,055
TF 20- EM	-	-
TF 21-DL	-	687,702
TF 22- PS	-	764,783.00
TF23-AM	1,047,150	2,224,500
TF 24-EM	681,612	-
TF 26-ARI	2,750,040	-
TF 27-SF	321,635	-
TF 29-AM	1,768,500	3,069,500
TF 30-AP	-	-
TF 31-VC	3,573,700	7,662,600
TF 32-SF	155,072	169,073
TF 33-ARI	2,562,900	2,500,000
TF 35	-	1,604,208
TF 36-FP	-	1,575,176
Total 2nd Call	**14,212,214**	**22,116,132**
3rd Call		-
TF-37-F/17	1,185,000	3,080,800
TF-38-F/17	7,259,000	5,602,000
TF-39-F/17	1,534,000	2,762,500
TF-40-F/17	1,923,000	2,693,000
TF-41-SBR/17	1,939,500	4,125,000
TF-42-AE/17	1,915,677	1,324,000
TF-43-C/17	4,209,000	8,632,800
TF-44-L/17	2,171,000	2,792,000
TF-45-F/L/17	7,399,101	10,944,228
TF-46-F/L/17	2,921,000	1,772,500
TF-47L/17	1,406,250	2,927,000
TF-48-L/17	1,267,200	2,140,700
TF-49-L/17	1,663,175	657,000
TF-50-C/17	15,596,395	17,258,190
TF-51-SBR/17	-	1,602,280
TF-52-C/17	1,040,350	2,238,825
TF-53-C/17	1,001,950	2,183,325
TF-54-SBR/17	1,536,000	1,875,500
TF-55-AE//17	683,700	615,750

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	Amount in Taka	
	2019-2020	2018-2019
TF-56-C/17	3,720,590	4,254,705
TF-57-C/17	1,532,799	-
TF-58-C/17	3,001,550	1,840,775
TF-60-SBR//17	1,483,000	1,016,500
TF-61-C/17	1,604,000	1,221,500
TF-62-L/17	8,606,910	16,951,580
TF-63-Char/17	1,947,433	489,542
TF-64-Fruits/17	1,011,000	611,000
TF-65-C/19	2,904,000	1,936,000
TF-66-C/19	3,077,900	
TF-67-C/19	846,900	
Total 3rd Call	**86,387,380**	**103,549,000**
ICP- I	-	-
ICP-II (NUMAN)	8,306,322	6,748,008
ICP- III	5,662,269	3,999,440
Total	**114,568,185**	**136,412,580**
14.00 Commissioned Research Project CRP-1		
Components -I	-	-
Components -II	-	3,299,000
Components -III	-	8,575,501
Components -IV	-	3,180,936
Components -V	-	3,330,941
CRP-1 Hill Agriculture	32,882,225	
CRP-2:Modeling Climate Change	-	700,000
CRP-5 (Crop Zonning)	30,170,250	33,067,500
CRP-4 (Hill Live Stock)	13,357,500	12,162,000
CRP-3 (Sugarcane)	8,203,850	16,417,800
ARMIS (ICT)	8,159,000	7,422,000
Total	**92,772,825**	**88,155,678**
15.00 Pilot Project		
Pilot Project-3	-	-
Pilot Project-4	-	-
Pilot Project-5	-	-
Pilot Project-7	-	-
Pilot Project-8	-	-
Pilot Project-9	-	-
Pilot Project-10	-	-
Pilot Project-11	-	-
Pilot Project-12	-	-
Pilot Project-13	-	-
Pilot Project-14	-	-
Pilot Project-15	-	-
Pilot Project-16	1,430,550	3,493,600
Pilot Project -17	2,023,250	2,964,975
Pilot Project-18	4,669,660	5,188,512
Pilot Project -19	1,644,336	185,000
Pilot Project Honorioum (Abdul Baten)	-	-
Pilot Project Honorioum (Sochindra)	-	-
Pilot Project Honorioum (Liza Begum)	-	-
Total	**9,767,796**	**11,832,087**
16.00 Basic Research : With CEP ii & iii		
BR1-C/17	742,148	4,093,912
BR2-C/17	1,316,087	3,417,913
BR3-C/17	1,640,000	2,306,900
BR4-C/17	591,995	3,537,500
BR5-C/18	1,557,500	5,809,800
BR6-C/17	-	-
BR7-C/17	1,891,295	2,336,604
BR8-C/17	2,626,000	2,960,800
Total	**10,365,025**	**24,463,429**

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		Amount in Taka	
		2019-2020	2018-2019
	Capacity Enhancement Program (CEP)		
	CEP-Ii	-	8,433,875.00
	CEP-III	9,055,393	11,470,922
	Sub Total	9,055,393	19,904,797
	Total	**19,420,418**	**44,368,226**
17.00	**Other Projects**		
	Seaweed project	5,500,000	8,433,875
	CGP Mitigation Greenhouse Gas (GHG) BAU Component	-	-
	KGF ACAIR Grants (ICP- I)	2,952,526	3,254,350
	Total	**8,452,526**	**11,688,225**
18.00	**Other Received**		
	Revenue from sale of tender documents	-	-
	Fund Refund	-	-
	Receipt against loans and advances	-	-
	Interest Received	1,738,651	2,732,092
	Other Received	48,320	-
	Total	**1,786,971**	**2,732,092**

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Krishi Gobeshona Foundation (KGF)
Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund
Schedule of Fixed Assets
As at 30 June 2020

Annexure-A
Figures in Taka

Particulars	Cost				Rate %	Depreciation				Written down value as on 30.06.2020
	As on 01.07.2019	Addition during the year	Adjustment during the year	As on 30.06.2020		As on 01.07.2019	Charged during the year	Adjustment during the year	As on 30.06.2020	
Vehicles	27,850,065		-	27,850,065	0%	-	-	-	-	27,850,065
Misc Equipment & Materials	64,609		-	64,609	0%			-	-	64,609
CGP Equipment	17,034		-	17,034	0%	-	-	-	-	17,034
Computer Accessories	1,324,922	17,200	-	1,342,122	0%	-	-	-	-	1,342,122
Multimedia Projector	95,680		-	95,680	0%	-	-	-	-	95,680
Office Equipment	4,159,181	856,707	-	5,015,888	0%	-	-	-	-	5,015,888
Furniture & Fixtures	1,987,224	-	-	1,987,224	0%	-	-	-	-	1,987,224
Electric Equipments	791,999	91,980	-	883,979	0%	-	-	-	-	883,979
Total	**36,290,714**	**965,887**	**-**	**37,256,601**		**-**	**-**	**-**	**-**	**37,256,601**

Note: Depreciation has never been charged on fixed assets during the year and previous years.

KRISHI GOBESHANA FOUNDATION

Schedule of Advance
For the year ended 30 June 2020

Annexure-B
(Amount in Taka)

SL	Name	opening (01-07-2019)	During the year	Refund	Adjusted	Closing (30-06-20)
1	Tahsina Naznin	12,000	-	-	12,000	-
2	Mojibor Rahman	100,000	-	-	60,000	40,000
3	Abul Hasanat Khan	120,000	919,804	194,168	845,636	-
6	Sahjahan	95,000	-	-	60,000	35,000
9	Abul Khayir	-	300,000	-	-	300,000
10	Executive Chairman BARC	357,400	-	165,629	191,771	-
11	Alam Mia	-	150,000	-	67,500	82,500
12	Iqbal Hossain	-	120,000	-	22,500	97,500
13	Faruque Hossain	-	100,000	-	-	100,000
14	Zerin Tasnin	-	300,000	-	-	300,000
15	Aminul Alam Khan	-	100,000	-	-	100,000
16	Motaleb Hossain	-	100,000	-	-	100,000
17	Pervin Begum	-	100,000	-	15,000	85,000
19	Rehana Begum	-	100,000	-	-	100,000
20	Salauddin Liton	-	100,000	-	-	100,000
22	Nurmohol Begum	-	496,500	55,136	441,364	-
26	Dr. Wais Kabir	-	45,000	-	45,000	-
27	Md. Sazzadur Rahman Sarker	-	20,000	1,033	18,967	-
28	Md. Nurruzzaman	-	50,000	-	50,000	-
31	Nasrin Akter	-	30,000	11,305	18,695	-
32	Tahsina Naznin	-	14,500	477	14,023	-
41	Habibur Rahman Kondokar	-	50,000	-	50,000	-
42	Topon Kumar dey	-	15,000	-	15,000	-
43	Fatema Pervin	-	28,000	11	27,989	-
44	Rafiqul Islam Akanda	-	1,249,218	123,253	1,125,965	-
47	Abul khaiyer	-	25,000	-	25,000	-
	Total	**684,400**	**4,413,022**	**551,012**	**3,106,410**	**1,440,000**

Annexure-C

Missceleneous received

01	Fund received (Refund)	452,753
02	CEP-11(Seaweed Project)	456,318
03	Other Received (transport)	74,044
04	Bank Credit Due	1
05	Dr. Kundu,Bari, Gazipur	150,000
06	Cheque Cancelled	54,000
	Total	**1,187,116**

During the year the amounting taka **1,187**,116 credited to bank account but the reason for crediting the amount is Unknown, based on the **assum**ption this amount recognised as fund as the assumption is made that the amount refund from **previous**ly disbursed research amount.

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Schedule of cash use for Adjustment and Expenditure

Schdule-1

Salaries & Allowances	Amount in Taka
Salaries & Allowances(Notes 10)	53,511,214
Less: Adjustment with related expenses	225,000
Cash use for Salaries & Allowances	**53,286,214**

Schedule-2

Training, Workshop & CGP Related Expenses	Amount in Taka
Training, Workshop & CGP Related Expenses (Notes 11.00)	16,129,200
Less: Adjustment with advance	1,728,846
Cash use for Training, Workshop & CGP Related Expenses	**14,400,354**

Schedule-3

Operational Cost	Amount in Taka
Training, Workshop & CGP Related Expenses (Notes 12.00)	17,219,779
Less: Adjustment with advance	1,152,564
Cash use for Operational Cost	**16,067,215**

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About KGF

Krishi Gobeshona Foundation (KGF) is an institutional innovation to sponsor agricultural research and development (R&D) in Bangladesh. The Foundation was established in 2007 to provide funds and guidance to a) foster and sustain, in a pluralistic manner, a competitive environment for agricultural R&D initiatives by public institutions, private enterprises and NGOs, and b) act as a common platform for interactions, cooperation and collaboration among them in the fields of agricultural technology generation, validation and uptake. The mission of KGF is: To facilitate capacity improvement, technology generation and adoption for enhancing productivity and quality of crops, fisheries and livestock under a competitive and pluralistic research environment.

KGF is governed by a fifteen-member General Body through a Board of Directors consisting of seven members elected from among the members of General Body, who are eminent personalities with expertise in different disciplines of agriculture representing both the public and private sectors of Bangladesh. The funding of KGF is maintained by the Bangladesh Krishi Gobeshona Endowment Trust (BKGET) with an endowment fund created by the Government of Bangladesh. KGF is closely linked with mainstream agricultural research through the Bangladesh Agricultural Research Council. KGF operates various programs covering crops, livestock, fisheries, natural resources, value chains, various cross cutting issues, etc. The Executive Director, appointed by the Board of Directors, is the Chief Executive of KGF.

Contact Us

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