Annual Report 2020-21

KRISHI GOBESHONA FOUNDATION

A non-profit Foundation for sustainable support to agricultural research & development

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List of Contents

List of Contents

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

Message

Since the independence of Bangladesh in 1971, agriculture has been playing a key role in the nation's initiatives and endeavors to achieve food and nutrition security for the populace, alleviate poverty and sustain economic development. The contemporary story of agriculture in Bangladesh is a story of fast growth and remarkable accomplishments in all sub-sectors like crops, fisheries and livestock. This has been possible through concerted and dedicated efforts of agricultural researchers and extension experts and toil and sweat of the hardworking farmers of the country with strong support from an agriculture and farmer friendly government. However, the key actors in the agricultural production arena in small, land hungry Bangladesh has to make do with a diminishing per capita resource base due to an ever increasing population density and, that, too, in the face of escalating natural disasters exacerbated by global climate change. Agricultural researchers and extension specialists will have to address the challenges of achieving higher agricultural productivity and profitability through the development of high-yielding yet resilient crop varieties and livestock and fish breeds, climate smart production practices, sustainable intensive integrated farming systems etc. Research and extension services will need to be oriented in line with government policies, strategies and action plans envisioned in Vision 2041, 8th Five Year Plan, National Agriculture Policy 2018, National Agricultural Extension Policy 2020, National Agricultural Mechanization Policy 2020, Master Plan for Agricultural Development in the South, Sustainable Development Goals, Bangladesh Delta Plan 2100 etc. This will require new thoughts, new ideas, new R&D paradigms.

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.

Technologies and useful scientific information generated by KGF sponsored programs and projects need to be documented and published. I am happy to know that the results and impacts of the agricultural research and development projects and programs are regularly monitored, recorded and documented by KGF in assorted quarterly and annual publications, such as, newsletters, technical bulletins, annual reports, etc. The KGF annual report, regularly published each year is one such publication. I appreciate the efforts of KGF colleagues for the publication of the 12th Annual Report (2020-21). 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 Chairman, BARC, and
Chairman, Board of Directors, KGF

Executive Directors, KGF

Preface

In the last decade, the Bangladesh agriculture sector has grown substantially despite dwindling arable land area and intensifying natural adversities like climate change. Research and technology generation and dissemination by agricultural scientists and extension specialists and use of technology by farmers coupled with agriculture friendly Government policies and strategies have been instrumental in this impressive growth. The Krishi Gobeshona Foundation (KGF), through sponsoring and supporting agricultural research and technology dissemination endeavors of NARS institutions, universities, DAE, NGOs and private enterprises, continues to play an important role as a key partner in the agricultural research and development arena of Bangladesh.

To achieve the desired goal of sustained agricultural production in the country, KGF has been involved, over the years, in addressing complex production constraints and post-production processes where many actors such as researchers, extension experts, farmers, agribusiness entrepreneurs etc. with diverse interests and purposes are involved. Fruitful collaboration among these key partners in the programs and projects sponsored by KGF generated a number of promising technologies pertaining to crop, livestock and fisheries production in Bangladesh which may well become the major drivers of agricultural production in the country. However, in order to actually generate value, the technologies and relevant scientific information need to be effectively transferred to farmers' fields and entrepreneurs' chains and 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 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, 2020-21, 12th in the series, presents a brief account of the initiatives, activities and achievements of KGF during the fiscal year July 2020 to June 2021. Results of research and development work on crops, fisheries, livestock, agricultural engineering, farming systems, socioeconomics, agroforestry and enterprise development during this period are documented in the annual report. Also, this report provides insights into governance, human resources and finance and accounts of KGF. 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
Executive Director, KGF

Abbreviations and Acronyms

ACIAR	Australian Center for International Agricultural Research
ADP	Annual Development Program
AEZ	Agro-ecological zone
AIS	Agriculture Information Service
Aman	Monsoon rice
APSIM	Agricultural production systems simulator
Aus	Summer (pre-monsoon) rice
AWD	Alternate wetting and drying
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BAURES	Bangladesh Agricultural University Research System
BCR	Benefit cost ratio
BINA	Bangladesh Institute of Nuclear Agriculture
BKGET	Bangladesh Krishi Gobeshona Endowment Trust
BLRI	Bangladesh Livestock Research Institute
Boro	Winter rice
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
CERES	Crop estimation through resource and environment synthesis
CDB	Cotton Development Board
CEB	Community engagement biosecurity
CEP	Capacity Enhancement Program
CGP	Competitive Grants Program
CGR	Crop growth rate
CHT	Chattogram Hill Tracts
CRP	Commissioned Research Program
CSO	Chief Scientific Officer
CVASU	Chattogram Veterinary and Animal Science University
DAE	Department of Agricultural Extension
DLS	Department of Livestock Services
DoF	Department of Fisheries
DSSAT	Decision support system for agro-technology transfer
ED	Executive Director
ETL	Economic threshold level
FAO	Food and Agriculture Organization of the United Nations
FGD	Focal group discussion
FMD	Foot and mouth disease
GHG	Green house gas
GIS	Geographical information system
GnB	General Body
GO	Government organization
GoB	Government of Bangladesh

Abbreviations and Acronyms

HARS	Hill Agricultural Research Station
HRC	Horticulture Research Center
HYG	High yield goal
HYV	High yielding variety
ICP	International Collaborative Program
IRRI	International Rice Research Institute
KGF	Krishi Gobeshona Foundation
KII	Key informant interview
KSSL	Krishibid Somobay Samity Limited
LAI	Leaf area index
LED	Light-emitting diode
M&E	Monitoring and evaluation
MAA	Memorandum and Articles of Association
MHAT	Moist and hot air treatment
MoA	Ministry of Agriculture
MODIS	Moderate resolution imaging spectroradiometer
NAR	Net assimilation rate
NARS	National Agricultural Research System
NATP	National Agricultural Technology Project
NGO	Non-government organization
OFRD	On-Farm Research Division
OLI	Operational land imager
PCR	Project Completion Report
PGR	Plant growth regulator
PKSF	Palli Karma-Sahayak Foundation
PRTC	Poultry Research and Training Center
PSO	Principal Scientific Officer
R&D	Research and development
RB	Repeat breeder
RCP	Representative concentration pathway
RCT	Resource conservation technology
RFV	Relative feed value
RGR	Relative growth rate
RS	Remote sensing
SAU	Sher-e-Bangla Agricultural University
SNPs	Single nucleotide polymorphisms
SO	Scientific Officer
SSO	Senior Scientific Officer
TAC	Technical Advisory Committee
T. Aman	Transplanted Aman
T. Aus	Transplanetd Aus
TCP	Technology Commercialization Program
TDN	Total digestible nutrient
TPP	Technology Piloting Program
UAO	Upazila Agriculture Officer
UNDP	United Nations Development Program

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 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 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.

Krishi Gobeshona Foundation (KGF)

Annual Report 2020-21

1. Executive Summary

Established in 2007 under the Companies Act 1994 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 (R&D) 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 R&D 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) and a Technology Commercialization Program (TCP) to accelerate the dissemination, uptake and, where possible, commercialization of potentially useful technologies generated by the R&D 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.

Fourteen BKGET funded CGP projects were awarded following the 1st call. These projects were initiated in May 2013. One out of the 14 projects was completed and the completion report submitted in 2015, 12 projects were completed in 2016 and one was completed in 2017. The results and findings of CGP 1st call projects were presented in KGF annual reports for 2017-18 and 2018-19). Sixteen projects from among the proposals submitted in response to the CGP 2nd call were awarded, the implementation of which began mostly in March 2015. Another three projects under CGP 2nd call were awarded in March, 2017 with three-year durations. All of the 2nd call projects were completed by 2019-20 and reported in earlier annual reports (up to 2019-20).

Out of the 36 selected projects under the CGP 3rd call, grants were awarded for 27 projects and another three were awarded as coordinated projects. Among the 3rd call projects 22 have been completed by June 2021 and the remaning 8 projects are ongoing and expected to end by June 2022. Results of the the 3rd call CGP projects have been presented in this annual report for 2020-21. In addition, 8 basic research projects (BR) were awarded in 2017-18 to BRRI and BARI. One of these Basic Research projects was terminated due to technical reasons, and of the remaining seven projects, five were completed and reported in the last year's (2019-20) annual report. The remaining two BR projects are ongoing and the findings have been reported in this annual 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, socio-economics-21 and cross-cutting issues-44) were received out of which KGF shortlisted 252 projects for the rigorous process of reviews, overviews and selection by KGF program secialists, members of the Technical Advisory Committee (TAC) of KGF and invited experts in the relevant disciplines. In the process, 72 were accepted ad interim 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) were screened out for review by special sub-committees. The selected proposals with the sub-committee's observations, remarks and comments were summarized and placed to TAC. These 55 proposals were 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 on-going research activities by others. Finally, 29 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 mainly to address agricultural production issues in marginal areas of the country where the natural resources have hitherto remained unutilized or under utilized. The CRP projects attempt to develop appropriate technologies and interventions to boost agricultural productivity in these agro-ecologically challenged areas of the country. 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 and CRP-III have been completed. The first three projects ended by 2019-20 and the remaining two projects are ongoing. The first phase of the CRP project on the impact of climate climate change on Bangladesh agriculture has been completed and the second phase is ongoing.

Out of the four projects under the Capacity Enhancement Program (CEP), two are in progress in their second phases 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, and (b) Adaptive Trials on Seaweed Cultivation in Coastal Areas. The other two, i.e., (1) Mitigating Greenhouse Gas Emission from Rice-Based Cropping Systems through Efficient Fertilizer and Water Management, and (2) Skill Development Training for Scientists, Field Veterinarians, Livestock Workers and Poultry/Dairy Farmers ended last year (2019-20).

KGF also sponsors international agricultural R&D programs in financial and technical collaboration with overseas universities, research organizations and international agricultural development agencies under the International Collaborative Program (ICP). Out of the past ICP projects (until 2019-20) viz., (a) ICP-I: Cropping Systems Intensification in the Salt Affected Coastal Zones of Bangladesh and West Bengal, India, (b) ICP-II: Nutrient Management for Diverse Cropping in Bangladesh, and (c) ICP-III: Incorporating Salt Tolerant Wheat and Pulses into Small Holder Farming Systems in Southern Bangladesh, ICP-I was completetd and reported out in the 2019-20 annual report. The other two are continuing, being implemented in collaboration with Murdoch University, Australia and University of Western Australia funded jointly by KGF-BKGET and ACIAR. A new, five-year ICP project (ICP-IV), "Development of Short-Duration Cold-Tolerant Rice Varieties for Haor Areas of Bangladesh" was launched in 2020-21 which is being implemented jointly by the Bangladesh Office of the International Rice Research Insitute (IRRI) and the Bangladesh Rice Research Insitute (BRRI) funded by BKGET-KGF and IRRI.

Six lump sum grants (LSG) were made in 2020-21 to study special contemporary problems or emerging issues of regional or national importance in Bangladesh agriculture. These grants (LSG) are meant for short-term (6-12 months) intensive studies. Results and findings of these studies may be helpful in developing and designing full research projects in the future.

In order to expedite dissemination and uptake, KGF pilots promising technologies generated earlier by CGP projects. All except one pilot projects ended by 2019-20, one ended in 2020-21 while a new three-year pilot project began in February 2020. In 2018-19, KGF took a novel initiative for technology dissemination, uptake and commercialization, namely, the Technology Commercialization Program (TCP). The first TCP project involves upscaling of 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 technology inventors and KGF is ongoing. In addition, to help build awareness and expedite technology dissemination, KGF continues TV broadcasts on innovations and technologies developed or being developed through the KGF sponsored agricultural R&D projects. In 2021, KGF continued this media intitiative in collaboration with the TV channel "Channel 24"; video clips of

relevant project activities in farmers' fields and interviews of farmers/scientists/extension workers are recorded and telecast in weekly episodes titled "KGF Rupantorer Krishi". Three episodes were telecast in June, 2021.

Research institutes, universities, some government organizations such as, BARI, BRRI, BJRI, BAU, BSMRAU, HSTU, Rajshahi University, CVASU, Sylhet Agricultural University, National Institute of Biotechnology (NIB), DoF, and NGOs, private entrepreneurs, etc., as recipients of KGF grants, are involved in the implementation of agricultural R&D projects. The Project Coordinators/PIs prepare their respective project briefs and inception reports following prescribed formats and regularly submit technical and financial progress reports to KGF.

Achievements and highlights of the completed projects and implementation progress of the ongoing projects in 2020-21 are presented briefly in this annual report.

In addition to regular activities like management of on-going projects, monitoring, reviewing and evaluation, KGF organized meetings of the Board of Directors and held research review workshops. In the year 2020-21, KGF arranged four Board meetings (74th to 77th), two meetings (34th and 35th) of the Technical Advisory Committee (TAC), two (13th and 14th) Annual General Meetings (AGM) and one (7th) Emergency Gerneral Meeting (EGM). In the year under report, KGF organized and held 22 workshops on project inception/coordination/annual review/completion report out participitated in by working scientists of the KGF sponsored projects, KGF professionals and relevant reviewers and experts invited by KGF. Also, during the year, two more workshops were organized by KGF attended by the Honorable Minister for Agriculture, Senior Secretary, Ministry of Agriculture (MoA), Executive Chairman, BARC, eminent agriculture experts of the country and KGF professionals. All these events and activities were supported by BKGET funds. Besides, KGF responded to queries from different bodies like MoA, BARC, KGF Board, etc. through reports or presentations.

A list of members of the KGF Board of Directors and General Body, a list of completed and on-going projects under CGP (1st, 2nd, 3rd and 4th Calls) and Basic Research, CRP, CEP, ICP, TPP and TCP, KGF statement of expenditure (SOE) for 2020-21, tentative work plan for 2021-22, proposed budget for 2021-22 and the audit report for 2020-21 are presented in Annex-1, 2, 3, 4, 5 and 6, respectively.

2. Introduction

2.1 Background

The Krishi Gobeshona Foundation (KGF) is a grants awarding organization established in 2007 under the Companies 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 (R&D) 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 (BoD) 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. The Executive Director, appointed by the BoD, is the Chief Executive of KGF. The Foundation

sponsors various R&D programs covering crops, livestock, fisheries, natural resources management, climate change adaptation, unfavorable ecosystems, socioeconomic issues, commercialization, marketing, value chains and other cross cutting issues.

2.2 Programs of KGF

KGF usually awards agricultural R&D projects to eligible professionals and institutions under four research programs viz., a) Competitive Grants Program, b) Commissioned Research Program, c) Capacity Enhancement Program, and d) International Collaborative Program. In addition, the Foundation implements technology piloting and technology commercialization projects to disseminate and commercialize technologies generated by sponsored research projects. Very recently KGF initiated a "Lump Sum Grants" program to encourage researchers to conduct short-term research to generate information on contemporary problems or emerging issues in Bangladesh agriculture.

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, have been 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 approved by TAC and the KGF Board:

a. CRP-I. Harnessing the potential of hill agriculture: Enhancing crop production through sustainable management of natural resources

b. CRP-II. Modeling climate change impact on agriculture and developing mitigation and adaptation strategies for sustaining agricultural production in Bangladesh

c. CRP-III. Strengthening sugarcane research and development in the Chattogram Hill Tracts

d. CRP-IV. Hill livestock: Increasing livestock production in the hills through better husbandry, health service and improving market access through value and supply chain management

e. CRP-V. Development of upazila land suitability assessment and crop zoning system of Bangladesh.

CRP-I and III ended and were reported out in last year's (2019-20) annual report. The first phase of CRP-II ended in June 2019 and the project outputs were reported in the KGF annual report for 2018-19. The second phase of CRP-II began in 2020 and is ongoing along with CRP-IV and CRP-V.

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 facility development. Out of the four projects under the Capacity Enhancement Program (CEP), two are in progress in their second phases 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, and (b) Adaptive Trials on Seaweed Cultivation in Coastal Areas. The other two, i.e., (1) Mitigating Greenhouse Gas Emission from Rice-Based Cropping Systems through Efficient Fertilizer and Water Management, and (2) Skill Development Training for Scientists, Field Veterinarians, Livestock Workers and Poultry/Dairy Farmers ended last year (2019-20).

2.2.4 International Collaborative Program (ICP)

KGF also sponsors international agricultural R&D programs in financial and technical collaboration with overseas universities, research organizations and international agricultural development agencies under the International Collaborative Program (ICP). The Foundation, until 2019-20, jointly sponsored four ICP projects viz., (a) ICP-I: Cropping Systems Intensification in the Salt Affected Coastal Zones of Bangladesh and West Bengal, India, (b) ICP-II: Nutrient Management for Diverse Cropping in Bangladesh, and (c) ICP-III: Incorporating Salt Tolerant Wheat and Pulses into Small Holder Farming Systems in Southern Bangladesh. ICP-I was completetd and reported out in the 2019-20 annual report. The other two, i.e., ICP-II and ICP-III, are continuing, being implemented in collaboration with Murdoch University, Australia and University of Western Australia funded jointly by KGF-BKGET and ACIAR. A new, five-year ICP project (ICP-IV), "Development of Short-Duration Cold-Tolerant Rice Varieties for Hoar Areas of Bangladesh" was launched in 2020-21 which is being implemented jointly by the Bangladesh Office of the International Rice Research Insitute (IRRI) and the Bangladesh Rice Research Insitute (BRRI) funded by BKGET-KGF and IRRI.

2.2.5 Technology Piloting Program (TPP)

Projects under TPP are implemented 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.

2.2.6 Technology Commercialization Program (TCP)

TCP was initiated in 2018-19 with a project entitled, "BAU-Bro Chicken Conservation and Piloting Producer Group Farming" designed for technology commercialization. The legal framework for this project consists in a tripartite agreement among BAURES (on behalf of BAU), the technology inventors (two professors of BAU) and KGF. The organizations involved in this technology commercialization initiative are BAU, Palli Karma-Sahayak Foundation (PKSF) and Protein Mart BD Ltd. (private enterprise). This is the first initiative in Bangladesh to commercialize technology to fetch returns from research investment through a legal framework.

2.2.7 Lump Sum Grants (LSG)

Lump sum grants are meant for short-term (6-12 months) intensive studies on special contemporary problems or emerging issues of regional or national importance in Bangladesh agriculture. Results and findings of these studies may be helpful in developing and designing full research projects in the future. This program was initiated in 2020-21.

2.3 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 with members from among highly reputed and experienced experts in different fields of agriculture. The main tasks of TAC are to: i) provide strategic guidelines ensuring the quality of research and its relevance to the country's goals and objectives, ii) review priority researchable areas and select issues appropriate for calling proposals under KGF funding, iii) recommend resource allocations for CGP projects/programs, iv) identify areas for new initiatives, and v) overview the proposals reviewed by peer reviewers and make recommendations to the KGF Board.

2.4 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.

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

2.5 Accomplishments during 2020-21

This 12th Annual Report of KGF covers activities carried out during the period July 2020 to June 2021. During this period, a total of 68 projects were in operation under different programs related to crops, livestock and fisheries. Various 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 2020-21

Programs		Total projects (No.)	Sector-wise project (No.)		
			Crops	Livestock	Fisheries
CGP	3rd Call	27	16	07	04
	Interim-1	03	03	-	-
	4th Call	18	11	04	03
	Basic Research	02	02	-	-
	CGP total	**50**	**32**	**11**	**07**
CRP		03	02	01	-
CEP		02	02	-	-
ICP		03	03	-	-
LSG		06	04	01	01
TPP		03	02	01	-
TCP		01	-	01	-
Grand total		**68**	**45**	**15**	**08**

2.6 Financial progress

In the reporting period of 2020-21, KGF received Tk. 45,78,76,000 from BKGET and the expenditure made was Tk. 43,91,34,000, i.e., 98% of the funds. Thus, the progress in program implementation, finance-wise, was satisfactory.

2.7 Other activities

For the management of ongoing projects under different programs, KGF performed regular desk and field monitoring and evaluation of the projects, arranged review workshops, consultation meetings, etc. KGF also organized 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 Collaborative Program (ICP)

Technology Piloting Program (TPP)

Technology Commercialization Program (TCP)

Lump Sum Grants (LSG)

Crops

Livestock

Fisheries

3. Research Highlights

3.1 CROPS

3.1.1 Competitive Grants Program (CGP)

- In the Chattogram Hill Tracts (CHT), alternative cropping systems such as, rice-maize and cotton-maize strip cropping substantially outperformed the indigenous jhum farming system in terms of land productiveity and farm incomes.
- The modified BARI potato planter and harvester machines showed great advantage over the traditional manual field operations in potato cultivation: The machine reduced planting labor requirement by 90% and cost by 75%, and, likewise, harvesting by the machine required 60% less labor and cut down the cost by 57%.
- Floating agriculture showed competitive advantages over soil-based agriculture in terms of management that excluded irrigation tasks and pest control and in terms of productivity in flood prone areas. It holds promise as a climate smart technology.
- Two blast resistant/tolerant wheat varieties were released in 2020 which would be helpful in mitigating wheat blast severity in blast-prone areas of Bangladesh. In addition, some promising resistant sources were also identified which could be used for developing blast resistant varieties in the future. The moist blotter technique combined with the PCR protocol can be employed for getting blast-free seed lots. The application of silicon, boron and zinc together to soil during land preparation may reduce blast infection in wheat. Two S-genes were edited in wheat genome and four non-transgenic mutant lines moderately tolerant to the wheat blast fungus were developed.
- An algorithm was developed to delineate dry season crops in the Godagari upazila of Rajshahi using Sentinel-2 imageries. The classified map of Godagari upazila shows that Boro rice and lentil dominated in the study area and occupied one-third of the total upazila in the 2020-21 Rabi season. Besides, a series of agro-environmental geo-database has been derived for further analysis, which will help achieve the objective of recommending location-specific suitable cropping patterns for sustainable intensification of agriculture.
- The BARI developed hyacinth bean varieties were found suitable for relay cropping with eggplant in the Narsingdi region. The production cost was less in the relay cropping system than in sole cropping as old eggplants could be used as trellis for hyacinth bean saving the cost of erecting new trellis.
- Performances of BARI Kanthal-1, BARI Kanthal-2, BARI Kanthal-3 and exotic jackfruit germplasm were evaluated. Trials on production practices of jackfruit were carried out in farmers'fields in Gazipur, Khagrachari, Narsinghdi and Mymensingh districts. From the newly established mother orchards saplings could be produced through vegetative propagation. Promising off-season and year round jackfruit genotypes were identified which could be important genetic resources for varietal development in the future.
- Ten agro-economically viable cropping patterns and suitable tillage and cultural practices for the salinity affected coastal areas were developed. Some examples of the new cropping patterns are zero tillage potato or mustard (Rabi)-mungbean/sesame (Kharif-I)-short-duration, high-yielding, moderately salt tolerant T. Aman rice variety, T. Aman rice-fallow-bottle gourd/bitter gourd/sweet gourd, T. Aman rice-maize-fallow, etc. Piloting of these cropping patterns across the coastal saline zone was recommended.
- Two solar cabinet dryers, one large and one and small, were designed and fabricated at the Farm Machinery and Postharvest Process Engineering Division, BARI, Gazipur for drying of 10-12 kg and 2-6 kg per batch of moist vegetable seeds, respectively. They were fabricated with locally available

materials. The dryer is economically viable, environment and women friendly.

- Three short-duration, high-yielding genotypes of rapeseed mustard with phenotypic and metabolic attributes enabling them to grow and yield well on moderately to strongly saline lands were developed. These three genotypes were ultimately released as new varieties of rapeseed mustard suitable for cultivation in the southern coastal zone.
- One hundred and two genotypes were identified with varying degrees of resistance/susceptibility to the rice gall midge (GM) insect pest. Out of them, 40 were HR (including BRRI dhan33), 25 R, 22 MR and 15 MS donor parents (HR= highly resistant, R= resistant, MR= moderately resistant and MS= moderately susceptible). The genotypes with GM resistance are presently being used in BRRI's GM resistant rice varietal development program.
- Corn Borer and Fall Armyworm were identified as emerging pests causing significant damage to the maize crop in Bangladesh. Cost-effective technologies and IPM packages were developed to reduce pest infestation by about 40% resulting in a 25-47% yield increase of maize. A training manual was developed as a guideline of maize pest management for farmers.
- Appropriate tree species selection, adjustment of tree-crop combinations, using proper spacing for understory crops, adequate management practices like fertilization and manuring and training of farmers can replace the traditional low-productivity farming systems with climate resilient vertical farming systems with agroforestry on *char* lands of the Tista Basin.
- Improved soil and crop management practices like combinations of chemical fertilizers, manure, biochar etc. increased the production of vegetables and fruits and at the same time improved soil fertility in the *char* areas of Jamalpur Sadar, Sariakandi (Bogura) and Kazipur, (Sirajganj) upazilas. Poultry manure was most effective in this respect followed by biochar and quick compost.
- French bean, soybean and pea can be introduced in between T. Aman rice (short-duration variety such as, Binadhan-7) and Boro rice (late Boro like Binadhan-14) seasons. Introduction of these bean species can not only increase the system productivity thereby increasing the annual return but also improve soil fertility. An improved rice-bean cropping pattern, T. *Aman* (Binadhan7)-pea (BARI motor 3/French bean, BARI jharsheem 2)-*Boro* (Binadhan-14) was developed. Also, a biofertilizer consortium was formulated and validated, which was effective in increasing the rice-bean system productivity and improving the nutritional quality of the produce.
- In a survey of underutilized fruit trees in southern districts, diseases such as, leaf blight, leaf spot, fruit blight, leaf curl and die back were found to affect fruit plants. Twenty-two isolates of pathogens from leaves of different underutilized fruit plants were collected for laboratory studies. Topral 52.5 WP, Autostine 50 WDG, Dithane M-45 and Potent 250 EC were found to be most effective in the inhibition of the pathogen isolates *in vitro*.
- Three value-added jackfruit products such as, fresh cut jackfruit bulb (ripened), fresh cut tender jackfruit and jackfruit jam have been developed and their nutritional and sensory qualities evaluated. Introduction of newly developed value-added jackfruit products to the domestic markets as well as to international markets may contribute to the GDP of the country.
- Integrated pest management (IPM) and integrated disease management (IDM) packages developed by different research organizations and universities for safe and quality country bean production were tested in farmers' fields for validation, refinement and demonstration in the greater Mymensingh region with a good amount of success.
- 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. Morphologies of the *F. oxysporum and Didymella bryoniae* isolates showed variability and indicated

varying infectiveness. Seed treatment with Provax, soil drenching with Decoprima, use of ridge beds with bio fumigation and black plastic sheets, foliar sprays, Companion for wilt and Amister Top for GSB were recommended for growing watermelon.

- As high as 47% bacterial wilt infection in eggplant and 20% infection in tomato were detected in Narsingdi, Bogura and Thakurgaon, the vegetable growing regions. Eighteen genotypes of eggplant and 16 of tomato showed resistance to bacterial wilt. Burning of rice husk was found to be effective in minimizing bacterial wilt. As a biocontrol agent, *Bacillus* sp. 38 proved its potential against bacterial wilt of eggplant and tomato.
- Good quality lilium bulbs were successfully produced from bulblets using cocodust+sawdust+perlite+soil+cowdung at the same ratios. Removal of spikes may be recommended for producing quality bulb as well as flower production of lilium using small, medium and large sized lilium bulbs.
- Morphological characteristics of lisianthus cultivars may be affected differentially depending on the light spectrum. The quality of seedlings grown under the red LED light spectrum was generally better in terms of seedling height, leaf number, leaf length, root number and survival percentage. Using LED light to improve plant growth in controlled environments is a viable option in lisianthus culture.
- A simple green synthesis of silver, copper oxide, zinc oxide and silica nanoparticles using *neem, dholkalmi and tulshi* leaf extracts was tried and tested. The bio-synthate has a good potential for use in management of major rice diseases like blast, sheath blight and bacterial blight in the future.
- Field trials on three tillage methods viz., raised beds (RB), zero tillage (ZT) and relay croping as climate smart conservation technology system (CSTCS) options in comparison with conventional tillage (CT) were conducted. With CSTCS, cropping intensity could be increased as it permitted growing three crops in a year comapred with a single crop with CT. Production costs were reduced by 45-80% in CSTCS compared with CT as the machines used for conservation tillage could perform four operations in a single pass and relay cropping was possible. Irrigation water requirement was 35% less in CSTCS than in CT.
- In biochar production from sawdust in slow pyrolysis kilns, the temperature was found to increase with time reaching up to 800°C and then go down suggesting that good quality biochar can be produced in slow pyrolysis kilns. The production of biochar was higher when the sawdust biomass was loaded with minerals.
- Based on phenotypic and molecular screening, five outstanding genotypes were selected as potential parents for breeding wheat for heat tolerance. A breeding design was developed and 37 crosses made to derive heat tolerant progenies. Early generation materials have been selected from several crosses.
- F1 populations of late blight resistant and heat tolerant potato varieties have been developed, and 145 kg tubers of heat tolerant and late blight resistant lines were harvested. From these tubers, a total of 447 progenies of 22 late blight resistant and heat tolerant populations were evaluated for phenotype. QTL maps will be developed from the data.

3.1.3 Commissioned Research Program (CRP)

- Projections based on 40 models and the modified Mann-Kendall test under RCP4.5 and RCP8.5 emission scenarios indicated that there could be a significant increase in precipitation in the months of March, May, June, July, August, September and October during 2011-2040 and 2041-2070 periods under RCP4.5. Studies based on the CERES-Rice model in DSSAT indicated that the growth duration of BRRI dhan28 could be reduced by 30 days in Moulvibazar because of a 4°C rise in temperature. Rice grain yield reduction could be 0-17%, 16-35%, 31-49% and 39-61% from the normal condition if the seasonal mean temperature increased by 1°C, 2°C, 3°C and 4°C, respectively. Irrigation water management greatly contributed to indirect GHG emission (29.82%) followed by fertilizer application (6.46%). Fish egg number and its diameter increased with augmented water temperature up to a certain limit.

- An online GIS based software 'Crop Zoning Information System (CZIS)' has been developed and hosted into the government National Data Center cloud. A mobile app named 'Khamari' has been developed as a handy tool to empower farmers and other stakeholders with much needed information relevant to agricultural productivity. The app/software can be downloaded and installed from the Google Play Store or from the website www.cropzoning.gov.bd. Users of CZIS/mobile app will get location-based information on suitable crops, profitable cropping patterns, crop varieties with their yields and growth durations, crop-specific fertilizer recommendations and information on upazila-wise crop zoning and upazila-wise cropping patterns including profitability indicators like gross margins and benefit cost ratios.

3.1.2 Capacity Enhancement Program (CEP)

- The total number of entries into the database of the agricultural research database project (ARMIS) reached 34,928 by 2020-21, new entries numbering 8,428. This database is readily available and accessible at http://armis.barcapps.gov.bd for any interested user from anywhere in the world.
- Maintaining the lunar cycle for seeding and harvesting can prevent 10-15% seaweed yield losses. The seaweeds *Ulva lactuca* and *Gracilaria tenuistipitata* can be grown and maintained in indoor conditions using the von Stosch enriched seawater medium under controlled temperature and light intensity for around six months. *Gracilaria tenuistipitata* and *Ulva lactuca* were selected for release as BARI seaweed varieties.

3.1.4 International Collaborative Program (ICP)

- In detailed field experiments of an international collaborative project being jointly implemented by a few NARS organizations and universities of Bangaldesh and Murdoch University of Australia, co-funded by KGF and the Australian Center for International Agricultural Research (ACIAR), it was observed that, with proper management, including mulching, dry season small scale supplemental irrigation with fresh water, use of salt tolerant crops/varieties and recommended fertilizers, satisfactory yields of both wetland and upland crops could be obtained in the southern coastal saline areas of the country. The effects of appropriate fertilization in enhancing yields of various crops and build-up of soil fertility were obvious in fertilizer management trials in farmers' fields in the northern districts. Conservation agriculture practices like strip cropping and minimum tillage showed promise as a method of facilitating crop establishment at optimum times, resource conservation and maintenance of soil fertility without significant crop yield penalties.
- In another ICP project being implemented jointly by BARI and University of Western Australia and and co-funded by KGF and ACIAR, a significant genotypic variation in pulse and wheat crops with regard to adaptation ability in saline and waterlogged land was found. In the adaptive trials, the pulse varieties BARI Mung-6, BARI Felon-1, BARI Khesari-3, BARI Motor-3 and BARI Masur-7 performed better than local cultivars. The wheat varieties BARI Gom 27, BARI Gom 29, KRL 1-4, KRL 19, BAW 1290, BARI Gom 33, BAW 1147 and BAW 1272 performed better in saline areas of southern Bangladesh. Wheat lines derived from crosses, BioW 6, BioW 12, BioW 31, BioW 50 and BioW 65, performed better than their parents, BARI Gom 25 and BARI Gom 26, in saline areas.
- In a recently initiated ICP (KGF-IRRI-BRRI) on the development of short-duration, cold-tolerant rice varieties for the *haor* regions of Bangladesh, 17 lines and 250 entries from the BRRI Gene Bank were screened for cold tolerance at reproductive and seedling stages. Results indicated that the IRRI lines, IR100723-B-B-B-B-61 and IR100722-B-B-B-B-11, having acceptable grain quality and high yield potential across the sites under both cold and non-stress conditions, could be promoted to the variety release pipeline. Advanced breeding lines that were found promising and tolerant to cold stress at the reproductive stage will be evaluated further to identify suitable lines for the *haor* ecosystem.

3.1.5 Lump Sum Grants (LSG)

- Hoarding, manipulations by business syndicates, etc. were identified as the main reasons behind the unusual price hikes of rice, potato and onion in 2020. Some policy measures suggested to stabilize prices were: production cost minimization, modernization of the government's domestic stock maintenance policy, fixing government purchase prices at suitable profit margins against farmers' costs of production, government purchase-stockpiling of at least 10% of the produce and strong market monitoring and interventions, establishment of a price commission and preventing manipulations by traders' syndicates.
- In terms of area per super hive, maximum honey yield was obtained with the comb cassette method utilizing bee hives. The comb cassette method increased honey yield by 74.77% over that obtained with the traditional method during the litchi blooming period.
- During 2020-2021, barley, millets viz., foxtail millet (*kaon*), proso millet (*cheena*), pearl millet (*bajra*) and oats were the noticeable minor cereals that occupied 4813 ha in Bangladesh. Foxtail millet alone occuppied 63% of the area, grown mainly in 38 upazilas of which Shariakandi (Bogura), Ulipur (Kurigram), Munshiganj Sadar, and Saghata and Fulchari of Gaibandha districts were the major ones. Varietal improvement, market chain development and value addition are essential for increasing production of these crops. Creating farmers' and consumers' awareness about the health and nutritional benefits of minor cereals is also necessary.
- Some biological aspects of the exotic Rugose spiraling whitefly (RSW) in coconut (native and dwarf) and guava saplings under normal temperature and humidity (30.0 ± 1.2°C, RH: 77.0 ± 4.5%) conditions were studied. Forty-two host plants were identified including fruit, forest, crop, ornamental and flowering plants in 20 districts in 7 agricultural regions where coconut, banana, betel nut and guava are widespread.

3.1.6 Technology Piloting Program (TPP)

- The bio-control agent *Trichoderma harzianum* was multiplied in the laboratory using yeast enriched Richards's solution and supplied to participating farmers in different areas. One commercial farmer-entrepreneur alone produced about 95 tons of *Tricho*-compost, sold about 80% of the product and used the remaining in his vegetable fields. The use of *Tricho* products enhanced farmers' economic returns from vegetable production.
- The sugarcane production technology, moist and hot air treatment (MHAT) of setts, developed by BSRI, gave better control of major diseases and higher yield of sugarcane. Sustainable sugarcane production with high yield and disease-free seeds can be achieved by using certified seeds. Production of foundation and certified seeds is essential to increase sugarcane yield and enhance farmers' incomes.

3.2 LIVESTOCK

3.2.1 Competitive Grants Program (CGP)

- *Brucella 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. A heat killed vaccine was prepared from the local isolate of Bangladesh.
- Many pet animals may carry virulent pathogens that may cause zoonotic diseases in humans. Among the pathogens, *E. coli, Salmonella* spp., *Staphylococcus* spp., *Streptococcus* spp., *Campylobacter* spp. were notable. A new pathogen, *Raoultella planticola*, hitherto unknown in Bangladesh, was isolated from cat oral swab samples.

- Seven herbs (pineapple, garlic, *neem*, moringa, spearmint, lemon grass, and ivy gourd) were selected for cattle feed development. A mixture was developed with these herbs which was fed to dairy cattle at various doses. The herbal feed mixture boosted milk yield and improved milk quality, showing prospects of increased milk production in the country and growth of the antioxidant fortified milk chain market.
- There is a good scope of using sheep genetic resources for livestock keepers and animal breeders. Systematic selection and breeding enhanced the productivity of the selected sheep populations. Molecular genetic diversity of the sheep populations enabled researchers to understand the origin of different sheep breeds of Bangladesh and differences in their genetic architecture as well as identify causative single nucleotide polymorphisms (SNPs) for the production traits to support a sustainable sheep breed improvement strategy.
- Adding nutritional value to rice straw as a cattle feed through physical manipulation such as, chopping into pieces, densification with the help of baler machine and mixing of urea increased the crude protein level of the feed without any negative effect on the blood nitrogen concentration of the cattle. Medium scale entrepreneurs can establish a feed straw business with a return on investment (ROI) of 16% while the bank interest rate is only 5%.
- Out of 50 cloacal swab samples from backyard chickens, 17 were found to be positive for hemagglutinating viruses. These 17 samples were then screened for the presence of the Newcastle disease virus (NDV) and 13 samples tested positive. RNAs will be extracted from these 13 samples and RT-PCR will be performed to differentiate between virulent and avirulent NDV.

3.2.2 Commissioned Research Program (CRP)

- 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 in the hilly environment of CHT. Napier, Pakchong and maize can be cultivated on dry and partially irrigated land as feed grass for sheep. After applying routine vaccination against infectious diseases and de-worming, animals became immune. The nutritive value, meat and egg quality of hilly chickens were similar as those for non-descriptive deshi (ND) chickens and the hilly chicken meat is softer and more pliable than either broiler or ND chicken meat.

3.2.3 Lump Sum Grants (LSG)

- Lead (Pb) poisoning of domestic animals and humans resulting from the toxic wastes of a factory in the Barasia village and surrounding areas of Magura Sadar upazila was detected. Analysis of postmortem samples from dead animals, vegetation and agricultural crops showed Pb concentrations over 1,000 to 100,000 times that of the maximum permissible limit. Community based awareness building programs among the villagers were organized and environmental and agricultural measures for safety against Pb poisoning suggested.

3.2.4 Technology Piloting Program (TPP)

- Veterinary services, such as treatment for diseases, deworming, vaccination, fodder cultivation, artificial insemination (AI) were provided on a regular basis in a technology piloting program in Fulbaria upazila of Mymensingh district and Nakla upazila of Sherpur district. Fertility of cows was improved due to timely diagnosis and veterinary care of the infertile cows. A significant increase in milk production was observed due to transformation of indigenous cows to crossbred cows. The per capita annual income of farmers was increased by 112% in four years. These data indicate that doorstep veterinary services could play a very important role in improving livestock health and productivity at the farmer household level.

3.2.5 Technology Commercialization Program (TCP)

- A "BAU Poultry Conservation and Research Center (BPCRC)" is being established by utilizing the infrastructure (feed mill, hatchery, renovated sheds, laboratory etc.), developed previously through a KGF CGP-I project (TF-17-ARI/15) and the ongoing project. To ensure an uninterrupted supply of BAU-Bro chicks conveniently at reasonable price to farmers, a forward linkage (BAU-Bro Conservation Center → local hatchery → farmers) will be developed with local hatcheries and farmers by providing BAU-Bro parents to the local hatcheries. By this time 30,000 BAU-Bro commercial chicks have been distributed among selected farmers. Processed BAU chicken is now available at Mina Bazar, Chaldal.com and other shopping centers in the Dhaka City.

3.3 FISHERIES

3.3.1 Competitive Grants Program (CGP)

- A combined (gut, soil and water) probiotics regimen was developed for fish culture and the project research showed that regular probiotics feeding in aquafarms may increase fish production and significantly minimize the risk of diseases in fish, especially bacterial diseases.
- 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 *chatni*, 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. The project developed entrepreneurship to process and market value added products (VAP) from fish.
- Growth of shrimp was better in Aquamimicry ponds than that in the traditional culture ponds. Disease infestation and mortality of shrimp in the Aquamimicry system were lower than those in the traditional ponds. The new culture technique may ensure natural biosecurity and is prospective as an environment friendly and economically profitable management practice. Comprehensive, multi-location research is needed in different ecological zones like Khulna, Satkhira, Bagherhat, Patuakhali and Cox's Bazar to test, optimize and disseminate this technology among advanced shrimp farmers.
- Chopped squid as a source of polyunsaturated fatty acid (PUFA) and mushroom powder as a source of beta glucan (BG) were provided in the fish diet. PUFA and BG influenced fish physiology, especially reproduction and the immune system, respectively. Diet supplementation with PUFA and BG produced broods with a high immune profile and increased spawning success, fecundity, total egg volume, individual egg weight, hatching success and health which ultimately boosted production ensuring a steady supply of quality fry to the fish farmers.
- A survey showed that 88 different probiotic products from 36 companies are being used in aquaculture farms of Bangladesh supposedly to promote growth, control disease and for water treatment. Two probiotics were selected and their characterization at the microbiology laboratory of BAU is in progress.

3.3.2 Lump Sum Grants (LSG)

- Data regarding Biofloc were collected from online websites and respondent interviews directly from the fields. The initial observation indicated that media created a hype on Biofloc and people took it as a means of quick earning easily without scientific knowledge or any hands-on experience. Many people invested lots of money depending solely on social media news or blogs and incurred big losses. A 'cautionary message' for the neo-entrepreneurs against adopting unknown technology and investing money and time is in order.

Technical Progress

CROPS

Crop agriculture in Bangladesh has grown fast through the integrated efforts of researchers, extension experts, policymakers and farmers. This made possible the transition from the huge and recurrent shortfalls of the 1970s and 1980s to today's self-sufficiency or near self-sufficiency in food 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 2007, has been a proud partner in agricultural R&D in Bangladesh, through sponsoring and supporting agricultural research and technology dissemination projects of NARS institutions, universities, DAE, NGOs and private enterprises. In the year 2020-21, with KGF sponsorship and involvement, 68 projects were ongoing, 66% (44) of which were related to crops. In these projects, some up-and-coming technologies for the production of cereals, legumes, vegetables and fruits not only in the favorable ecological systems but also in the marginal ecosystems like the coastal saline lands, Chattogram Hill Tracts, *haor and char* areas and low-lying perpetually waterlogged 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 the KGF sponsored projects.

4. Technical Progress

4.1 CROPS

4.1.1 Competitive Grants Program (CGP)

CGP 3rd Call

4.1.1A Completed Projects

1. 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, Executive 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 the CHT land area is suitable for agriculture. Two major agricultural systems are observed in the CHT region: (i) intensive cropping in the valleys and (ii) seasonal cropping in the sloping uplands, mostly *jhum*, the dominant system which depends primarily 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 in place of the traditional *jhum* cultivation practice in CHT. The project also studied value chain linking indigenous farmers with markets in three hill districts.

Objective: Development of 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 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. In the third year (2020-21), field trials were continued (Fig. 2).

Fig. 2. Intercultural operations in an experimental strip-cropping rice-maize field at Khagrachari of CHT

Results and Discussion: Consistently wider differences in rice and cotton yields between strip cropping and *jhum* were observed across locations, with strip cropping giving higher yields. Rice and cotton gave consistently higher yields in the strip cropping system than in the *jhum* system. In the third year (2020-21) incomes derived from the various cropping systems amounted to Tk 52,535, Tk 61,420, Tk. 104,655 and Tk. 113,230 in the *jhum*, strip crop rice, maize-rice and cotton-rice, respectively. Averaging over the three

years of the project, the farm income from any of the alternative rice-maize and cotton-maize strip cropping systems was about double that derived from *jhum* farming.

Paddy not being a trading item in Bandarban and most areas in other districts of CHT, value chain analysis of rice was not conducted. The cotton value chain, farmer (producer)-CDB (seed supply) and input vendors (for herbicides, fertilizers and pesticides)–(middle man)-traders (Chattogram)-ginner-textile mills, was found to be similar in both Bandarban and Khagrachari districts.

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.

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

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

Principal Investigator: Dr. Muhammad Arshadul Hoque, SSO, Farm Machinery and Postharvest Process Engineering (FMPPE) Division, BARI, Gazipur

Locations: Gazipur, Bogura (Gabtali and Shibganj upzilas) and Jashore (Sadar and Jhikargacha upazilas)

Budget: Tk. 44.42 lakh

Duration: October, 2017 to October, 2020

Fig. 3. BARI developed potato planter (top) and harvester (bottom) machines

Introduction: Potato is very important in terms of production and multipurpose use in Bangladesh. Potato farming is a profitable agricultural enterprise in the country due to the short field duration yet high productivity and market value of the crop. Timely planting is a prerequisite for a good harvest of potato. In Bangladesh, potato planting is done manually which is time-consuming. Moreover, labor shortages often delay potato planting and harvest. Delayed planting reduces yield and cuts down profits. In the traditional potato cultivation system (tillage with power tiller and planting and harvesting manually) fuel consumption, labor requirement, etc. are relatively high resulting in a high cost of production and narrowing down of the profit margin. Mechanization of the planting and harvesting operations may remove these shortcomings and increase production and profits from potato cultivation. In view of the fact that the power tiller is available everywhere in the country and is the main tool for tillage in agriculture now, BARI developed a power tiller operated small potato planter and harvester (Fig. 3) which functioned well in on-station and on-farm trials and gained good farmer acceptance. However, adoption of the potato mechanization technology has not been as expected so far. This project was designed to popularize the potato planter and harvester machines with farmers through adaptive trials and building capacity of manufacturers and machinery service providers.

Objective: To test the efficacy of the small potato planter and harvester machines in potato growing areas of Bangladesh and build capacity of manufacturers.

Materials and Methods: Some technical problems of the machines were identified and taken care of to improve operation. The transmission belt of the potato cup was changed and a chain was placed instead. The seed hopper was modified for efficient seed picking. The bed shaper was redesigned to increase the bed height and improve earthing of the potato seed. A furrow opener was incorporated to place the seed potato into a deeper position below the soil surface. Modification of the potato harvester was done by reducing the length and speed of the conveyer belt, adding a separator at the delivery end, reducing the dimensions of the cutting shovel and modifying the wheel rim of the Sifeng power tiller. Field experiments were conducted in farmers' fields in the Gabtali upazila of Bogura and Jhikargacha and Sadar upzilas of Jashore. Two on-station experiments were conducted at the Tuber Crops Research Substation (TCRS), Bogura and Regional Agricultural Research Station (RARS), Jashore. In the field trials, efficacy of the BARI potato planter and harvester machines was compared with the traditional manual methods of potato planting and harvesting.

Results and Discussion: The effective field capacity and efficiency of the potato harvester ranged from 0.101 to 0.117 ha/hr and 72.66 to 81.25%, respectively in farmer's fields. The effect of machine planting on potato yield (varieties BARI-36, BARI Alu-41) was not consistent across the trial locations. In both on-station (BARI, Gazipur, TCRC, Bogura and RARS, Jashore) and farmers' field trials, at some locations machine planting gave a yield advantage over manual planting while at others there was no such effect, but nowhere did machine planting cause any yield penalty vis-à-vis the traditional farmers' practice of manual planting. The most important positive effect of machine planting was that, irrespective of location and potato variety, it gave substantial financial benefits by way of reduction in labor requirement and cost of labor and, hence, reduction in the cost of production. The potato planter machine reduced labor requirement and labor cost by more than 80% compared with manual planting.

The potato harvester, on the other hand, saved 59.4% cost and 65% labor compared with the manual harvesting method at BARI, Gazipur. The lifted tubers were 42.1% and 39.8% higher in mechanical harvesting than that by the manual method in Bogura and Jashore, respectively. Potato harvesting by mechanical harvester caused less than 1.5% tuber damage. Potato tubers found during the second harvest for mechanical harvesting and manual methods were 1.35% and 5.67% in Bogura and 1.29% and 5.53% in Jashore, respectively. The potato harvester saved 56% labor, 48% cost and 55% time compared with the manual potato harvesting method. An economic analysis showed that the net returns from the use of the BARI potato planter and harvester were Tk. 1,11,693 and 1,26,092 per year, respectively. The payback periods for the potato planter and harvester were 1.61 and 1.35 years, respectively. The benefit-cost ratios (BCR) for the BARI potato planter and harvester were 1.2 and 2.0, respectively.

At the project locations (4 upazilas), 60 operators and farmers were trained on the operation, repair and maintenance of the potato planter and harvester machines through two practical training sessions. Ten manufacturing mechanics from ten different workshops were also trained. Two booklets were printed in Bangla on "The introduction and use of the BARI potato planter" and "The introduction and use of the BARI potato harvester".

Conclusions: The Bangladesh Agricultural Research Institute (BARI), Gazipur developed two simple power tiller driven machines for more productive and profitable potato cultivation—a potato planter and a potato harvester. This project tested the efficacies of these machines in researchers' and farmers' fields in potato growing areas of Bangladesh and found them to be suitable for potato farmers. The machines reduced the production costs for potato by reducing the labor requirement and labor cost for potato planting and harvesting by 80-90% and increased profits compared with the traditional planting and harvesting methods. The project scientists recommended large scale farmer adoption of these machines in the major potato growing areas of the country to reduce the cost of production of potato and, thus, enhance profits.

3. 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 or dhap chash*) to cope with flooding. The floating agriculture system has the potential to enhance food security and incomes for the millions of small households living close to large bodies of water and having little or no access to land. However, productivity and diversity are low due to lack of modern technologies and farmers' knowledge. Farmers of this region traditionally do not practice integrated farming comprising forage cultivation, homestead gardening, modern livestock rearing 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: Experiments on screening of vegetables, spices and forage under floating bed conditions, standardization of bed size, nutrient management, cage culture, homestead gardening, pest control and effect of different management practices were conducted in five upazilas of Gopalganj, Pirojpur and Bagerhat districts. The different components of floating agriculture based IFS tested were i) crops (floating and mainland) cropping patterns and production technologies for floating beds and mainland, ii) fisheries, iii) livestock, iv) homestead, v) composting and vi) off-farm occupations. The project activities consisted of year round production of vegetables and fruits and HYV seeds, de-worming and vaccination of livestock, mono-sex tilapia fish culture, etc. The residues of water hyacinth used to prepare the floating beds were used as a good source of compost for crop production inland. The experiments were conducted for three years.

Results and discussion:

Crops

Among the four rabi vegetable crops viz. brocolli, cabbage, cauliflower and knolkhol tested on floating beds, cauliflower gave the highest BCR in each project area. Among the *kharif* vegetables viz., bottle gourd, bitter gourd, sweet gourd, okra, bottle gourd outperformed the others in respect of yield and profitability. The BARI released turmeric varieties viz. BARI Holud-3, BARI Holud-5 and a local variety were tested and among them BARI Holud-5 performed the best on floating beds (Fig. 4). Between Napier and Pakchong tested as forage crops on flating beds, the former with a yield 619.87 kg/bed/year) performed better than the latter.

Fig. 4. Growing vegetable crops and turmeric on floating beds

Broccoli, cabbage, cauliflower, knolkhol red amaranth and spinach were tested on residues of floating beds on land (Fig. 5) where cauliflower and broccoli performed best in respect of profitability. Okra (variety-Chayanika) gave the highest yield of 58 kg/bed and a gross return of Tk. 2030/bed when N-P-K-S-Zn-B @ 75-21-15-5-1-0.5

kg/ha were applied, whereas yield (43 kg/bed) and gross return were much lower, 43 kg/bed and Tk. 1505/bed, respectively, with the farmers' practice of no fertilizer application.

Fig. 5. Growing different vegetable crops using residues from floating beds

A cropping pattern *boro*-floating bed-fallow was tested as a better alternative to the traditional fallow-floating bed-fallow pattern at Kondorpogati, Kotalipara and Tungipara in Gopalganj and at Nazirpur in the Pirojpur district. The improved pattern gave a higher gross return and BCR than those from the traditional pattern. The intercropping system bottle gourd + red amaranth was found to be suitable in respect of profitability. During November 2017-May 2021, about 1500 saplings of mango (var. BARI Aam-4), guava (var. BARI Peyara-2) and malta (var. BARI Malta-1) were distributed among selected households and their neighbors to encourage homestead gardening. The fruit trees survived and were growing healthily. Also, year round vegetable production in homesteads was mostly successful.

Livestock

Vaccination of 250 calves was done in different upazilas of Gopalganj, Bagerhat and Pirojpur and also 1800 cattle were vaccinated against the food and mouth disease. De-worming was done in about 1800 calves. The vaccination and de-worming programs generated interest among farmers who adopted these practices for improving health of their livestock. Besides this, 600 chickens were distributed among 60 farmers and 60 ducklings among 12 farmers. Three different vaccines viz., BCRDV (Baby Chick Ranikhet Disease), RDV (Ranikhet Disease Vaccine) and duck plague vaccine were administered to chickens and ducks which significantly minimized the mortality rates to below 4.8, 3.2 and 5% from the high rates of 20, 25 and 20%, respectively before vaccination.

Cage fishery with floating beds

For improvement of livelihood, fish cultivation was introduced in floating bed areas with the release of 20 kg monosex tilapia fingerlings in each 20 x10 x 6 feet cage. The average amount of captured fish catch per cage was 51.6 kg and the gross return was Tk. 6199.20.

Integration among different sectors and components

The component enterprises of integrated farming like crops on floating beds and mainland, poultry, fishery, dairy, home gardening, composting etc. are interrelated. The end product and waste of one enterprise may be used as inputs for others. The residue of water hyacinth used to prepare floating beds is a good source of compost, which can be used for crop production on the mainland. Cattle wastes like dung, urine, refuse etc. can be used in the preparation of farm yard manure (FYM), which is an important input for cropping systems. The straw obtained from the crops can be good fodder for cattle. The water of the ponds or other water bodies is home to the floating beds as well as fish which again, thrives on phytoplankton feeding and proliferating on compost from the floating beds. These interrelationships are schematically depicted in Fig. 6.

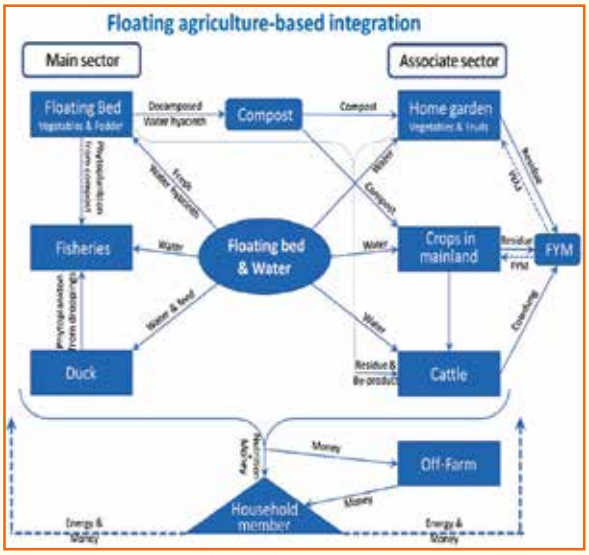


Fig 6. Integration among different sectors and components of integrated farming in a floating agriculture system

Conclusions: The project demonstrated that there are good opportunities of enhancing agricultural production on floating beds, homesteads and water bodies in IFS 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-cage culture could substantially enhance farmers' incomes in the rather unfavorable flood ecosysytems of the low-lying basin areas of southern Bangladesh. The competitive advantages of floating agriculture over soil-based agriculture consisting in easier management that excludes irrigation, better pest control than conventional farming and in terms of productivity make floating agriculture an interesting option to mitigate the impact of climate change in flood prone areas.

4. 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; Bangladesh Agricultural University (BAU), Mymensingh and Bangabandhu Sheikh Mujibur Rahman Agricultural University (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 southern and southwestern 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. By then the disease incidence had become significantly widespread affecting approximately 15% (about 15,000 ha) of Bangladesh's total wheat area 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 given the magnitude of crop loss incurred by small farmers and that wheat is the second most important cereal crop of Bangladesh. 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) resistant sources are limited worldwide and their durability is questionable, 6) the disease develops very rapidly, giving little time for remedial measures, 7) known fungicides are partially effective under moderate to low disease pressure, and fungicide resistance has been observed, and 8) there are knowledge gaps regarding 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 halt or at least rein in its spread to south Asia and other wheat growing regions with similar climates. The major focus of this multi-institute (BWMRI, BAU and BSMRAU) coordinated project includes variability in MoT population, its epidemiology, field diagnostics, agronomic manipulation, fungicide efficacy and development of durable blast resistant wheat varieties through classical breeding and genome editing.

Objective: 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 included 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, (MoT), and development and field testing of management methods to contain wheat blast.

BWMRI: In 2020-21, an intensive field survey was conducted in 107 farmers' fields and trial sites of major wheat-growing areas in 24 districts of Bangladesh. As in the past, disease rating was done based on a 0-100 scale. Blast incidence and severity was 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 then the disease severity was calculated using the formula, disease severity (%) = (incidence x severity)*100. During 2020-21, 17 isolates were cultured from infected samples of wheat and preserved on sterilized filter paper in a deep fridge for future studies. Pure cultures of the isolates were characterized up to molecular level using PCR analysis. Pathogenic potentiality (virulence of isolates) was tested and standardized through artificial inoculation on wheat seedlings and adult plants. In field screening of germplasm during 2020-21, 250 entries including susceptible/resistant checks were screened against wheat blast under inoculated conditions in a Precision Phenotyping Platform (PPP) at Regional Agricultural Research Station (RARS), Jashore and in field conditions at BWMRI, Dinajpur. Forty elite wheat genotypes from diverse sources including susceptible/resistant checks were evaluated against wheat blast under MoT inoculated conditions at Regional Station (RS), BWMRI, Jashore during the 2020-21 crop cycle.

BAU: Fifteen experiments were carried out on wheat during the cropping seasons of 2018-2021 in the BINA nethouse and farmer's fields of Meherpur. The experiments included identification of healthy seed lots through seed health tests, determining the seed to plant transmission pathway of MoT, developing field diagnostics for early stage forecasting of the blast disease, detection of critical growth stage of wheat for MoT infection, detection of MoT in wheat stubble, identification of alternative host/s of MoT, crop rotation cycle for reducing inoculum level of MoT, soil supplementation and foliar spray of nutrients and *Trichoderma*, developing an effective fungicide spray schedule and IPM packages and seed irradiation for developing blast resistant wheat.

BSMRAU: Four potential bacterial antagonists were evaluated in a field experiment in the wheat blast hotspot district of Meherpur by using both seed priming and spraying of bacterial suspension in plants. Fungal spore suspension was applied in wheat fields just after the flowering stage of wheat. Blast disease assessment was done. CRISPR/Cas genome editing technology was used to introduce mutations in the candidate orthologs of the S-genes into wheat varieties to generate non-transgenic blast resistant plants and pathogenicity assay was carried out at the heading stage.

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

In 10 districts, 17% of the 107 wheat fields surveyed were blast infected. Among these 10 districts, two, Kurigram and Chapai Nawabganj, were newly affected (Fig. 7). Wheat planted at the optimum time (Nov. 15-30) mostly escaped blast infection or had a very low disease severity while late planted wheat suffered a higher disease pressure. Blast incidence was most frequently observed in susceptible cultivars like BARI Gom 26, Prodip, Bijoy etc. The overall disease severity of the affected districts was lower (<1%) than that in the previous year (2020).

Different isolates MoT showed different morphological behavior. Decision tree analysis indicated that the wheat blast isolates were identical to those from Brazil, Paraguay and to previous isolates collected from Bangladesh.

The resistant variety, BARI Gom 33, the advanced lines Borlaug 100, BAW 1280 and BAW 1286 showed resistance to wheat blast at the seedling and adult plant stages while the susceptible checks, BARI Gom 26 and

Prodip, were found to be highly susceptible under a high disease pressure. Nine alternative hosts of *Magnaporthe* spp. were identified. Cross infections among the wheat, triticale, barley and durum hosts occurred.

Among the 250 entries of wheat evaluated, 17 were selected based on the least blast severity, 1000-grain weight, grain yield and other agronomic characters assessed across locations. A significant variation in disease severity was observed among the genotypes evaluated. The percentages of disease severity in the selected lines ranged from 0.60 to 5.60, while those in the check varieties disease severity were found to be up to 75%. The resistant variety, BARI Gom 33, showed very low (<2%) disease severity while the susceptible variety, BARI Gom 26, showed 75% infection. Grain yield of the selected entries varied from 521 to 768 g/plot and that of the check varieties from 559 to 714 g/plot.

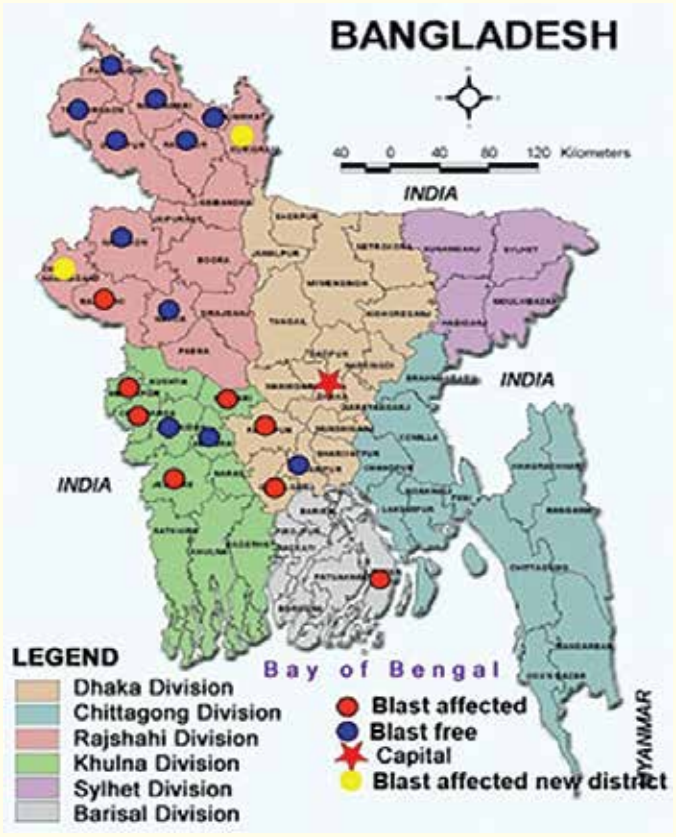


Fig. 7. Bangladesh map showing wheat blast disease status during the 2020-21 cropping season

Out of 40 elite entries evaluated, 18 genotypes were graded as resistant (R), 7 moderately resistant (MR), 1 moderately susceptible (MS), 11 susceptible (S) and the remaining 3 highly susceptible (HS). The R variety, BARI Gom 33, showed 8.8% disease severity, while in the most affected the HS variety, BARI Gom 26, disease severity was 85.2%. The recently released varieties WMRI Gom 3 (resistant) and WMRI Gom 2 (tolerant) showed highly resistant (3.7%) and tolerant (28.5%) reactions against wheat head blast infection, respectively. Some other test genotypes appeared promising with less than 10% blast severity.

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

The moist blotter technique has been developed as a quick and economic method (costing Tk. 500/sample) of screening wheat seeds for the presence of MoT within 72 hours to evaluate the suitability of a seed lot for sowing by farmers. Three sprays of a cocktail of fungicides (Tebuconazole + Propiconazole + Pyraclostrobin) beginning at the booting stage of wheat reduced blast severity by 97% in susceptible wheat which ultimately yielded >4t/ha with a BCR of 1.45. Soil application of Si, Zn and B together can reduce the blast disease in wheat to an acceptable level (Fig. 8); this method is inexpensive and environment friendly. Also, a preventive spray of selenium starting at the booting stage was effective in reducing the incidence and

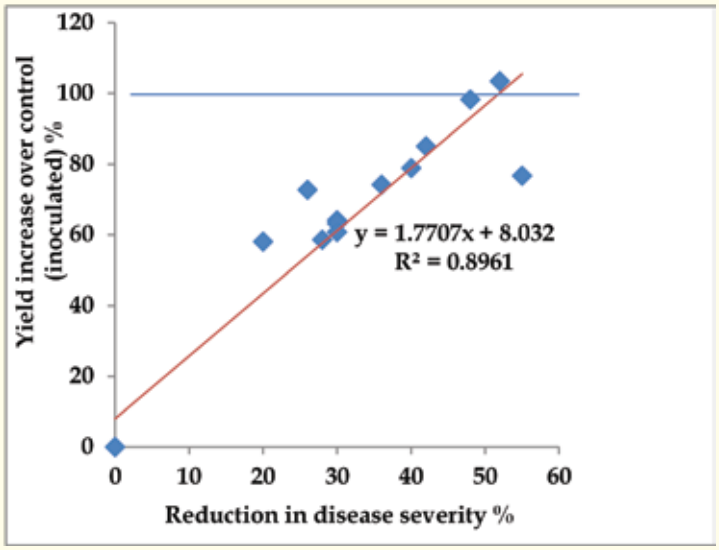


Fig. 8. Soil supplementation of Si, Zn and B: Relationship between percent reduction in wheat blast severity and percent yield increase

severity of wheat blast. An eco-friendly foliar spray of *Trichoderma* reduced blast incidence by 42.48% and severity by 39.67% from no-spray control.

The transmission pathway of MoT from seed to plant to seed was confirmed. Destruction or removal of wheat stubble was recommended as it was found to harbor MoT which could cause a spread of the pathogen in the plant in the succeeding year. MoT may decline in two to three years if wheat is rotated with non-host crops like lentil, chili, mustard and potato.

Twelve wheat mutant families have been developed which may be released as blast resistant varieties in a period of three years.

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

Out of the 650 probiotic bacteria screened against a virulent isolate (BTJP4-5) of the wheat blast fungus, four isolates viz., *Bacillus subtilis* sub-sp. *subtilis* BTS-3, *Bacillus velezensis* BTS-4, *Bacillus velezensis* BTLK6A and *Staphylococcus saprophyticus* BTS-5, markedly suppressed the wheat blast fungus in both a growth chamber and in field conditions. The percentage of blast disease suppression by the bacterial isolates was 60-75% in field conditions (Fig. 9). Moreover, application of these bacterial isolates enhanced grain yield of wheat indicating the potential of these isolates as biological control agents as well as growth promoters.

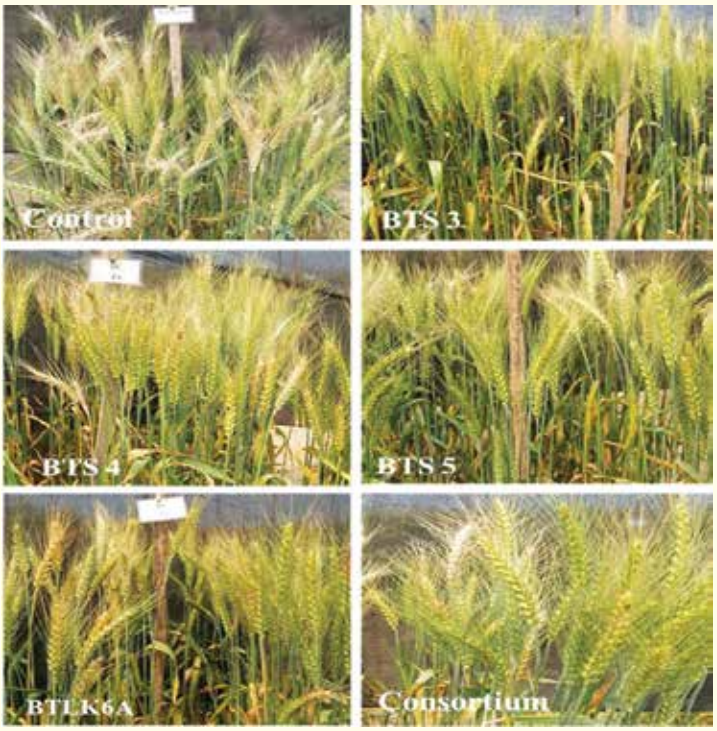


Fig. 9. Photographs showing suppression of wheat blast disease by biocontrol bacteria; affected wheat heads showed partially or fully bleached/faded color while unaffected heads remained green

Fourteen rice orthologus S-genes namely, ERF922, Dja6_1, Dja6_2, Rac4, Rac5, HDT701, sHMA1, sHMA7, 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. Among them, four (sHMA1-gene mutant) lines viz., Crwt8, Crwt6, Crwt9, and Crwt4 showed partially resistant (disease incidence: DI=32.67 to 39.33 %.) to wheat blast pathogen at heading stage in growth room conditions. Findings of this research indicate that precisely editing hexaploid wheat for disease resistance is a complicated task. Further methogological improvement is needed to generate other S-gene mutant lines using CRISPR-Cas technology for resistance in wheat against the MoT fungus.

Conclusions: The wheat blast disease has emerged as an increasingly serious biotic constraint to wheat production in Bangladesh. The magnitude of damage to wheat in the country has been assessed and some pioneering work on molecular characterization and genome sequencing of the causative agent, *Magnaporthe oryzae* pathotype *Triticum*, 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. Two blast resistant/tolerant varieties, WMRI Gom 3 and WMRI Gom 2 have been released in the country in 2020. In addition, some promising resistant sources have been identified which could be used for developing more blast

resistant varieties in the future. Three IPM packages have been developed as cost-effective measures for the management of blast in farmers' wheat fields. Four bacterial strains have been identified, for the first time, which can act as biocontrol agents against the wheat blast pathogen employing chemical weapons and inducing systemic resistance to wheat under field conditions. Two S-genes in the wheat genome were edited and four non-transgenic mutant lines moderately tolerant to wheat blast developed.

5. 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 Narsingdi 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 Narasingdi district

Budget: Tk. 67.5 lakh

Duration: Feb 2018 to Jan 2021

Introduction: A few farmers' innovations in vegetable production are practiced in the Narasingdi region and farmers achieve relatively 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, the traditional costly practice 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 aimed 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 Narsingdi.

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

Materials and Methods: Winter hyacinth bean varieties released by BARI were tested at RHRS, Shibpur, Narsingdi and in farmers' fields in the Sadar and Shibpur upazilas of Narsingdi through relay cropping of the bean with eggplant for up-scaling the farmers' innovation. Adaptive trials on the two BARI eggplant varieties, BARI Begun-8 and BARI Begun-10, were conducted in farmers' fields and at RHRS. 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 (Fig. 10) compared with the normal practice of erecting bamboo trellis. The growth and yields of hyacinth bean and eggplant as well as profitability were studied and analyzed.

Fig. 10. Growing hyacinth bean using old eggplant stands as trellis

Results and Discussion: The eggplant varieties took 84 to 96 days to reach the 1st harvest stage starting in the 2nd week of June. The number of fruits per plant ranged from 22 to 30. The heaviest fruits (129.0 g) were harvested from BARI Begun-10 at RHRS, Narsingdi followed by BARI Begun-10 (125.5 g) in Shibpur upazila and BARI Begun-10 (125.5g) in Belabo upazila. The highest yield (34.0 t/ha) of eggplant was obtained from

BARI Begun-10 at RHRS, Narsingdi, followed by BARI Begun-10 (34.5 t/ha) in Shibpur and Belabo, while the lowest yield (26.2 t/ha) was recorded for the local variety, Bholanath in Polash and Shibpur upazilas. After harvest, the eggplant stands were left intact in the fields for use as trellis for hyacinth bean in the succeeding season. The maximum gross return of Tk. 8,18,640/ha and net return Tk. 4,83,740/ha (Table 2) were obtained from BARI Begun-10 which also gave the maximum BCR of 2.44.

Table 2. Cost and return analysis for trials on eggpant varieties in farmers' fields in Shibpur, Sadar, Belabo and Polash upazilas of Narsingdi and in a research field at RHRS, BARI, Narsingdi

Variety	Gross return (Tk/ha)	Total cultivation cost (Tk/ha)	Net return (Tk/ha)	BCR
BARI Begun-8	715530	334900	380630	2.14
BARI Begun-10	818640	334900	483740	2.44
Bholanath	648000	334900	313100	1.93

(Average price of BARI Begun-8: 23 Tk/kg, BARI Begun-10: 24 Tk/kg and Bholanath: 24 Tk/kg)

Among the hyacinth bean varieties, BARI Sheem-7 flowered at the earliest (days to first flowering: 60) under relay cropping, Sikribi Sheem-1 was late-flowering (80 days to first flowering) under the relay cropping system. BARI Sheem-7 also matured the earliest, in 86 days under sole cropping and in 89 days under relay cropping system. The Sikribi varieties matured 3-5 weeks later. The highest yield of 12.0/ha was obtained from BARI Sheem-7 in sole cropping system followed by the same variety (9.82 t/ha) under relay cropping system while Sikribi Sheem-2 under relay cropping system gave the lowest yield (7.63 t/ha). Among the summer varieties, BARI Sheem-7 performed better in both cropping systems than either Sikribi Sheem-1 or Sikribi Sheem-2. The maximum net return of Tk. 4,81,080/ha was obtained from BARI Sheem-7. The highest BCR was recorded for BARI Sheem-7 (2.78) under relay cropping with eggplant which was due to the fact that the production cost was relatively low in the relay cropping system as the old brinjal plants were used as trellis which saved costs.

Table 3. Performance of hyacinth bean varieties under sole and relay cropping systems

Variety	Cropping system	Yield (t/ha)	Net return (Tk/ha)	BCR
BARI Sheem-1	Sole	16.68	93690	1.34
	Relay	15.86	163490	1.88
BARI Sheem-6	Sole	16.37	135980	1.50
	Relay	13.36	148570	1.80
Local (Kartika)	Sole	13.87	31870	1.12
	Relay	11.75	73070	1.39

In the trials on upscaling of farmer's innovation, BARI Sheem-1 or BARI Sheem-6 outperformed the local hyacinth bean variety, Kartika in sole or relay cropping systems both agronmically and economically (Table 3).

Conclusions: Use of modern eggplant and hyacinth varieties released by BARI and novel agronomic practices such as, growing hyacinth 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 Narsingdi 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.

6. Project Code and Title: TF 53-C/17. Production and dissemination of BARI released year round jackfruit varieties and their 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 drop, along with proper 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: Five experiments were conducted at the Fruit Research Farm, BARI, Gazipur during 2018 to 2021. Performances of BARI Kanthal-1, BARI Kanthal-2, BARI Kanthal-3 and exotic jackfruit germplasm were evaluated. The experiments included effect of time of grafting on grafting success and response to split application of fertilizers. Surveys on year round/off-season jackfruit germplasm and production practices of jackfruit were carried out in Gazipur, Khagrachari, Narsingdi and Mymensingh districts during the entire project period. Adaptive trials were conducted in farmers' fields in the four districts.

Results and Discussion: Orchards of BARI developed jackfruit varieties were established at the research station and in farmers' fields of Gazipur, Khagrachari, Narsinghdi and Mymensingh. About 2000 grafted plants of these jackfruit varieties were planted for the first time in Bangladesh. Moreover, saplings were distributed among selected farmers of Joydebpur. From the established mother orchards saplings could be produced through vegetative propagation. January was found to be the most suitable grafting time for jackfruit, grafting could also be done in February and October although with a lower success rate. Valuable off-season and year round jackfruit germplasm were identified which could be important genetic resources for future varietal development work. Growth performances of BARI Kanthal-1, BARI Kanthal-2 and BARI Kanthal-3 were evaluated during 2018-2021. In August, 2018, plant heights of BARI Kanthal-1, BARI Kanthl-2 and BARI Kanthal-3 were 1.03 m, 0.40 m and 0.44 m which increased sharply to 4.03 m, 4.00 m and 3.96 m (Fig. 11), i.e., by 291%, 900% and 800%, respectively, in about two years and a half later in January, 2021. Female inflorescence occurred in BARI Kanthal-1 in 2021. Male inflorescence started in all the exotic genotypes of jackfruit from the fourth week of July, 2020 indicating off-season and year round behaviour. The highest grafting success (82.9%) was found in the month of January followed by that in February (69.8%) and October (66.3%). The high grafting success found in January might have been due to the availability of more suitable dormant scion.

Fig. 11. Increase in plant height of three BARI developed jackfruit varieties over time during 2018-2021

In field surveys, eight off-season jackfruit germplasm were identified in Gazipur, three year round germplasm in Khagrachhari, one year round jackfruit germplasm in Narsingdi and three year round jackfruit germplasm were identified in Mymensingh.

In the adaptive trials in 10 farmers' fileds at Sreepur, Gazipur, in 2021 (planted in 2018), plant height varied from 2.50 m to 4.60 m in BARI Kanthal-1, 2.10 m to 4.75 m in BARI Kanthal-2 and 2.10 m to 4.50 m in BARI Kanthal-3, the averages being 3.19 m, 2.99 m and 2.89 m, respectively (Table 4).

Table 4. Growth parameters of BARI developed jackfruit varieties in farmers' fields in Gazipur district

Farm	Plant height (m)			Base girth (cm)			Plant spreading N-S (cm)			Plant spreading E-W (cm)		
	V1	V2	V3	V1	V2	V3	V1	V2	V3	V1	V2	V3
F1	3.60	4.00	3.60	25	27	37	270	350	370	200	330	370
F2	4.60	4.75	4.50	23	34	19	230	360	230	210	300	240
F3	3.00	2.10	2.10	14	8	8	90	70	70	95	90	65
F4	2.95	2.70	2.90	18	23	22	150	130	180	240	150	200
F5	2.65	2.30	2.60	15	10	14	150	95	120	100	120	150
F6	2.80	3.40	2.50	17	27	16	155	265	166	150	280	130
F7	3.00	2.25	2.50	18	24	14	140	200	120	150	260	120
F8	2.90	2.50	2.60	15	12	14	120	100	120	100	110	150
F9	3.90	2.80	3.10	20	20	15	300	300	100	330	250	120
F10	2.50	2.70	2.50	15	17	14	180	200	150	190	190	160
Mean	3.19	2.95	2.89	18	20.2	17.3	178.5	207	162.6	176.5	208	170.5
SD (±)	0.65	0.85	0.70	3.68	8.40	7.82	67.3	107.8	85.6	73.9	86.9	84.5
CV (%)	20.4	28.9	24.2	20.5	41.6	45.2	37.7	52.1	52.7	41.9	41.8	49.6

V1= BARI Kanthal-1; V2= BARI Kanthal-2; V3= BARI Kanthal-3

Conclusions: 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.

7. 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 (RARS), 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 the coastal region of Bangladesh. For improving the food and nutrition security situation in this region it is imperative that the conventional cultivation practices and methods be replaced by improved, agro-economically viable and profitable techniques. 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 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/Kharif-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, watermelon and sunflower and two Kharif crops namely mungbean and sesame (Fig. 12) 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. Several improved cropping patterns involving salt-tolerant crops and varieties in various Kharif-I-Kharif-II-Rabi combinations were tested. Soil salinity (soil EC) was measured for each plot during the crop growing period starting from sowing time.

Fig. 12. Growing sesame in a T. Aman-potato-sesame cropping pattern in a farmer's field in the costal district of Khulna

Results and Discussion: Ten improved cropping patterns were developed for the target coastal saline areas. All the test cropping patterns were rice-based, T. Aman rice, a BRRI developed short-duration variety, BRRI dhan75, in the monsoon season (Kharif-II) being the common crop. Across the project locations and cropping patterns, T. Aman rice yield varied narrowly from 4.43 to 4.90 t/ha (Table 5) compared with 4.62 t/ha in farmers' monocrop practice. Potato and mungbean were the two major crops following rice as components of the test cropping patterns. Potato was a component crop in 10 test cropping patterns, its yield varying within the narrow range of 22.7 to 26.3 t/ha while mungbean was a component in 9 cropping patterns and its yield, except at one location where it failed, varied from 0.6 to 0.9 t/ha. The other crops were grown only at 1 to 3 locations. The highest total rice equivalent yield (TREY) of 27.13 t/ha was obtained from the pattern T. Aman-fallow-watermelon which was six times higher than the meager 4.62 t/ha from a single crop of T. Aman rice in the farmers' practice (FP). The inclusion of potato in the cropping pattern increased cropping intensity and the TREY from these patterns was also relatively high, 16 to 20 t/ha (Table 5).

Table 5. Yields of component crops, total field durations of different crops and TREY (t/ha) of different cropping patterns at project locations in Satkhira and Khulna districts (means of of 2018-19 and 2019-20 cropping seasons)

Cropping pattern	Yields of component crops (t/ha)													
	T. aman rice	Mustard	Wheat	Potato	Grasspea	Maize	Mungbean	Sesame	Watermelon	Sweet gourd	Bitter gourd	Bottle gourd	TREY (t/ha)	Duration (days)
T.aman-fallow-watermelon	4.60	-	-	-	-	-	-	-	45.1	-	-	-	27.13	183
T.aman-potato-sesame	4.88			24.2				1.1	-	-	-	-	19.73	235
T.aman-potato-mungbean	4.70	-	-	22.9	-	-	0.7	-	-	-	-	-	18.25	258
T.aman-fallow-sweet gourd	4.90	-	-	-	-	-	-	-	-	6.7	-	-	8.25	208
T.aman-potato-sesame	4.43	-	-	26.0	-	-	-	1.1	-	-	-	-	20.18	259
T.aman-potato-mungbean	4.55	-	-	26.3			0.8	-	-	-	-	-	20.08	263
T.aman-grasspea-mungbean	4.90	-	-	-	1.25		0.8	-	-	-	-	-	11.05	303
T.aman-maize-mungbean	4.70	-	-	-	-	7.6	0	-	-	-	-	-	10.78	208
T.aman-fallow-bitter gourd	4.65	-	-	-	-	-	-	-	-	-	7.6	-	10.37	196
T.aman-potato-mungbean	4.52	-	-	22.90	-	-	0.8	-	-	-	-	-	18.39	239
T.aman-fallow-bitter gourd	4.60	-	-	-	-	-	-	-	-	-	11.83		13.47	180
T.aman-fallow-bottlegourd	4.63	-	-	-	-	-	-	-	-	-	-	30.5	12.25	184
T.aman-potato-mungbean	4.45	-	-	23.25	-	-	0.9		-	-	-	-	18.78	240
T.aman-potato-sesame	4.55	-	-	23.17	-	-	-	0.9	-	-	-	-	18.26	271
T.aman-maize-mungbean	4.45	-	-	-	-	7.8	-	-	-	-	-	-	10.69	206
T.aman-potato-mungbean	4.70	-	-	26.0	-	-	0.7		-	-	-	-	19.80	252
T.aman-potato-sesame	4.55	-	-	25.6	-	-	-	0.9	-	-	-	-	19.60	219
T.aman-wheat-mungbean	4.50	-	4.1	-	-	-	0.6	-	-	-	-	-	9.34	232
T.aman-mustard-mungbean	4.57	1.2	-	-	-	-	0.7	-	-	-	-	-	9.67	235
T.aman-potato-mungbean	4.55	-	-	22.75		-	-	-	-	-	-	-	15.93	186
T.aman- grasspea- mungbean	4.65	-	-	-	0.9	-	-	-	-	-	-	-	7.35	168
T.aman-mustard-mungbean	4.70	0.8	-	-	-	-	-	-	-	-	-	-	6.70	182
Farmers' practice (FP)	4.62	-	-	-	-	-	-	-	-	-	-	-	4.62	115

Prices per kg of rice, wheat, mustard, potato, grasspea, maize, mungbean, sesame, watermelon, sweet gourd, bitter gourd and bottle gourd were Tk. 20, 15, 50, 10, 50,15, 60, 50, 10, 10, 15 and 05, respectively; TREY= total rice equivalent yield

In terms of economic returns and sustainability index, too, the T. Aman-fallow-watermelon pattern was the best performer netting Tk. 4,16,825/ha and giving a system profitability of Tk. 1142/ha/day which was 2-10 times higher than that of the other patterns (Table 6), an income increase of 91% over FP and and a high sustaibaility index of 80%. Considering the total rice equivalent yield, net income, production efficiency and system profitability, the following improved cropping patterns are recommended for the different upazilas of the coastal districts:

Dacope, Khulna: T. Aman- fallow- watermelon, T. Aman- potato-sesame, T. Aman–potato-mungbean, T. Aman-fallow-sweet gourd

Table 6. Economic returns, land use efficiencies and sustainability indices of different cropping patterns tested in coastal saline areas (means of 2018-19 and 2019-20)

Cropping pattern	Gross margin (Tk/ha)	Production efficiency (kg/ha/day)	Systems profitability (Tk/ha/day	Land use efficiency (%)	Sustainable yield index (%)	Income increase over FP (%)
T.aman-fallow-watermelon	416825	148	1142	50.14	79.81	91
T.aman-potato-sesame	183318	84	502	64.38	52.51	80
T.aman-potato-mungbean	134255	71	368	70.68	47.07	73
T.aman-fallow-sweet gourd	49125	40	135	56.99	10.22	27
T.aman-potato-sesame	175575	78	481	70.82	54.19	79
T.aman-potato-mungbean	170755	76	468	71.92	53.80	79
T.aman-grasspea-	103395	37	283	82.88	20.54	65
T.aman-maize-mungbean	91575	52	251	56.99	19.54	61
T.aman-fallow-bitter gourd	82725	53	227	53.56	18.01	56
T.aman-potato-mungbean	139675	77	383	65.48	47.57	74
T.aman-fallow-bitter gourd	144875	75	397	49.32	29.46	75
T.aman-fallow-bottlegourd	131325	67	360	50.41	24.96	73
T.aman-potato-mungbean	144755	78	397	65.62	49.01	75
T.aman-potato-sesame	137175	68	376	74.11	47.11	74
T.aman-maize-mungbean	89775	52	246	56.44	19.21	60
T.aman-potato-mungbean	165255	79	453	69.04	52.79	78
T.aman-potato-sesame	163975	89	449	60.00	52.05	78
T.aman-wheat-mungbean	50320	40	138	63.42	14.22	28
T.aman-mustard-mungbean	63420	41	174	64.25	15.45	43
T.aman-potato-mungbean	124160	86	340	50.82	38.50	71
T.aman-grasspea-	65800	44	180	45.89	6.90	45
T.aman-mustard-mungbean	40425	37	111	49.86	4.50	11
Farmers' practice (FP)	36103	40	99	31.51	-3.16	-

Batiaghata, Khulna: T. Aman- potato- sesame, T. Aman –potato- mungbean, and T. Aman- grasspea–mungbean

Batiaghata, Khulna: T. Aman- potato- sesame, T. Aman –potato- mungbean, and T. Aman- grasspea–mungbean

Dumuria, Khulna: T. Aman –potato- mungbean, T. Aman-fallow-bitter gourd and T. Aman- fallow-bottle gourd

Sadar, Satkhira: T. Aman –potato- mungbean and T. aman- potato- sesame

Kaliganj, Satkhira: T. Aman –potato- mungbean and T. Aman- potato- sesame

Conclusions: Eleven salt tolerant varieties of different Rabi crops developed by BARI and two Kharif-1 crops were grown using relay, zero tillage, dibbling and mulching techniques in various cropping patterns in farmers' fields to demonstrate the probability of increasing cropping intensity and land productivity in the salinity affected Dacope, Batiaghata and Dumuria upazilas of Khulna and Shyamnagar, Kaliganj and Sadar upazilas of Sathkhira where growing only a single crop of T. Aman rice has been the traditional practice so far. The project ended with the development of 10 agro-economically viable cropping patterns and suitable tillage and cultural practices for the salinity affected coastal areas where scarcity of sweet water for irrigation and high soil salinity especially in the dry winter season have so far restricted farmers to growing only one monsoon rice crop a year in the traditional fallow-T. Aman-fallow cropping pattern in the salt-affected Khulna, Bagerhat and Satkhira districts of the southwestern coastal saline zone of Bangladesh. These interventions substantially increased land use efficiency, production efficiency, systems profitability, sustainable yield index and farmers' net incomes in the agro-ecologically challenged coastal saline region of Bangladesh.

8. 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 Division (FMPPED), 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. Moreover, continuous rains for a few days may restrict traditional seed drying and whole lots of seeds may be 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: Two solar cabinet dryers (Fig. 13), one large and one small, were designed and fabricated at the FMPPED, BARI, Gazipur with locally available materials such as, mild steel (MS) box, MS flat bar, MS angle bar, MS sheet, galvanized sheet, stainless steel net, insulation materials, DC fan, photovoltaic module, polyethylene sheet, cork sheet, etc. for drying of 10-12 kg and 2-6 kg per batch of moist vegetable seeds, respectively. The dryers were designed to generate desirable temperature (<45°C) from solar radiation suitable for vegetable seed drying. Performance of the vegetable seed dryer was evaluated with red amaranth, tomato and sweet gourd seeds.

Results and Discussion: A special feature of the dryer is that it can be operated on a sunny day using solar

radiation and on a rainy or cloudy day or at night using auxiliary electric heaters. The moisture content of amaranth seeds was reduced from an initial moisture content of about 20.78% on weight basis (wb) to the final moisture content of about 7% (wb) in 6 hours maintaining an air temperature of 42.8°C and relative humidity (RH) of 30% when the mean global solar radiation (MGSR) was 550 kW/m^2. The moisture content of BARI Tomato-14 was reduced from 58% to 7.8% on a weight basis (wb) in 9 hours maintaining an air temperature of 42.3°C and 35% RH when MGSR was 600 kW/m^2. The moisture content of sweet gourd seeds was reduced from 41.59% to 9.23% (wb) in 6 hours maintaining air temperature of 42.70 °C and 40% RH when only 4 kW electric heaters were used. It was observed that the moisture content of seeds in the bottom tray was 1.13% lower than that in the upper tray. In total, 2 kWh electric energy was consumed for drying of 600g sweet guard seeds (41.59% moisture) for 6 hours which cost Tk.12.00. The germination of amaranth seeds was 81% on filter paper media after drying to 7% moisture content (wb) (Fig. 14). Likewise, the germination% of BARI Tomato-14 seeds, dried to 7.8% moisture in the dryer, was 85% on the filter paper media and sweet gourd seed germination was 98% in sand media after drying to 9.23% moisture content.

Fig. 13. Solar cabinet dryer developed by BARI for drying vegetable seeds

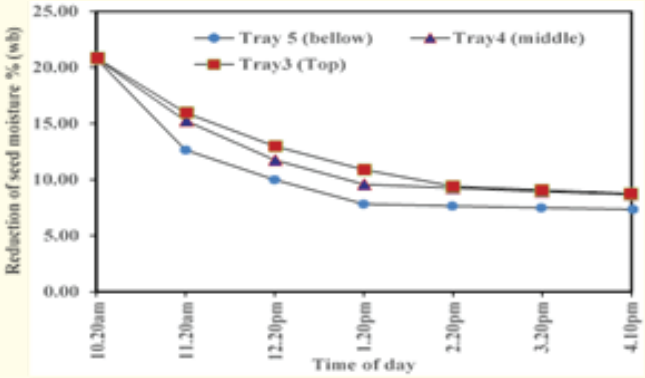


Fig. 14. Reduction of moisture content of amaranth seeds with drying time in the solar powered seed dryer

Table 7 shows the economic aspects of operation of the dryers. The costs of seed drying were 117.00 Tk/kg and 163.00 Tk/kg, respectively, for the large and small dryer. The payback periods of the dryers were 75 days and 64 days and the benefit cost ratios (BCR) were was 1.14 and 1.04, respectively.

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 seed 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 seed

Table 7. Operational costs of the solar cabinet dryers

Cost item	Taka	
	Large size	Small size
Fixed cost (FC)		
1. Capital consumption (CC), Tk/yr	18967.00	11566.00
2. Shelter (T), Tk/yr	410.00	250.00
Sub-total (Tk./yr)	**19377.00**	**11816.00**
Tk/hr	**16.00**	**10.00**
Variable cost (VC)		
Labor (Tk/hr)	62.5	62.5
Electricity (Tk/hr)	36.00	24.00
Repair and maintence (Tk/hr)	2.40	1.46
Sub-total	**101.00**	**88.00**
Total cost (FC+VC), Tk/hr	**117.00**	**98.00**
Tk/10 hr	**1170.00**	**980.00**
Capacity of the dryer, kg/10 hr	10	6
Drying cost (total cost/capacity), Tk/kg	117.00	163.00
Payback period of the dryer (days)	75	64
BCR over net return	1.14	1.04

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 and cheaply dry their produce, prevent seed damage and increase incomes and profits.

9. Project Code and Title: TF 56-C/17. Collection and characterization of potential germplasm of rapeseed 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/person/yr) of edible oil. As per PPB, the estimated demand for edible oil would be 14.94 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 especially in the dry winter season 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 region. This project addressed the issues of development and adoption of salt tolerant rapeseed 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 in laboratory, greenhouse and field experiments at BAU for salt tolerance out of which 5 were selected. They were evaluated for determining genetic divergence at molecular level based on simple sequence repeat (SSR) marker. 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 levels of soil salinity (6, 8, 10 and 12 dS/m) on seed yield and yield contributing characters. Training camps were organized for the participating farmers of the project areas to train them on the aim of the project work, ways and means of better livelihood, effect of salinity on crop production 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: Genetic divergence was found among the five promising genotypes of rapeseed mustard namely, BD-6950, BD-7104, BD-10115, Jun-536 and BJDH-12. Molecular analysis revealed diversity among these genotypes in different locii related to salinity tolerance. The agronomic parameters, days to flowering and maturity and yield of these advanced lines, salt tolerance levels, biochemical parameters such as, reactive oxygen species (ROS) and scavenging role of antioxidants against salt stress, H_2O_2 metabolizing enzymes such as catalases (CAT), ascorbic peroxidases (APX), peroxidase reductases (POD), economic analysis, etc. were reported in KGF annual reports for 2018-19 and 2019-20 and mass media (Fig. 15). Overall,

the genotypes BD-6950, BD-7104 and BD-10115 were found to be salt tolerant (able to complete their life cycle at a soil salinity level of 6 to 12 dS/m), high-yielding (30% higher yield than the check variety BARI Sarisha-14), medium statured (plant height around 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 Agriculture for release as new mustard varieties such as, BAU Sarisha-1, BAU Sarisha-2 and BAU Sarisha-3. Some important information regarding these varieties is furnished in Table 8 below:

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. 15. Newspaper report on the development of three high-yielding mustard varieties at BAU

Table 8. Characteristics of three newly released slat tolerant mustard varieties

Test genotype: BD-6950, *Brassica juncea*
Proposed variety: BAU Sarisha-1

Characteristics
1. High yielding (25-30% higher than BARI Sarisha-14)
2. Salt tolerant upto 12 dS/m
3. Life duration 83-85 days
4. Can be sown up to 1st week of December
5. Average plant height 90-110 cm
6. *Alternaria* blight susceptibility less than BARI Sarisha-14

Test genotype: BD-7104, *Brassica juncea*
Proposed variety: BAU Sarisha-2

Characteristics
1. High yielding (25-30% higher than BARI Sarisha-14)
2. Salt tolerant upto 12 dS/m
3. Life duration 84-85 days
4. Can be sown up to 1st week of December
5. Average plant height 85-105 cm
6. *Alternaria* blight susceptibility less than BARI Sarisha-4

Test genotype: BD-10115, *Brassica juncea*
Elite line: BD-10115
Variety: BAU Sarisha-3

Characteristics
1. High yielding (25-30% higher than BARI Sarisha-14)
2. Salt tolerant upto 12 dS/m
3. Life duration 82-85 days
4. Can be sown up to 1st week of December
5. Average plant height (104-111) cm
6. *Alternaria* blight susceptibility less than BARI Sarisha-14

Conclusions: This project researched the probability of 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.

10. Project Code and Title: TF 57-C/17. Identification of resistant sources against gall midge 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 south and southeast Asia and Africa. In Bangladesh, gall midge incidence is more severe in the T. Aman rice season than in any other season. Gall midge 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, Cumilla, Brahmanbaria, Sylhet, Chattogram, 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 gall midge is available in Bangladesh except BRRI dhan33. Identification of a resistant source is a prerequisite for resistant variety development. This project emphasized screening of a large number of rice cultivars for the identification of resistant sources that could be used in developing gall midge resistant varieties.

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

Materials and Methods: Rice germplasm/varieties/lines were screened against gall midge (Gm) in screening trays in the net house (Fig. 16). Validation experiments of Gm resistant sources/donors were conducted. "Onion shoots" (OS) of gall midge affected rice plants (having maggot or pupa inside) and emerged Gm adults were collected from the rice fields of Gm endemic areas for experiments. Gall midge was reared in the greenhouse for egg laying. The infested seedlings were kept in the rearing house providing high temperature (28-30^{o}C) and high humidity (RH 85-90%) for hatching eggs and to establish maggot inside the growing points of the susceptible seedlings. Rice germplasm (released varieties, advanced lines, land races etc) collected from national and international sources were grown in Yoshida culture solution. Scores (resistant/susceptible) were made on the basis of OS% according to the Standared Evaluation System (SES).

Fig. 16. Tray for screening rice germplasm against gall midge

Results and Discussion: A total of 1616 rice germplasm/varieties/lines were screened against Gm during the three years of the project. Among them, Shampakatari (Singra, Natore) was recorded as resistant (0% OS) against Gm. Among the BRRI lines only BR8693-17-6-2-1 was found resistant against Gm. Exogenous genotypes namely, Mudu Kiriyal, Sudurvi305, Warrangal culture 1263, RD4 (Bkn6805-22-13) showed resistant reactions; and Horanamawee (IRRI) and RD9 (IRRI) showed moderately resistant reactions to the test Gm population.

Ten different groups of germplasm (e.g., BR cross materials/lines, IR materials, RYT, RYT1, RYT2, ZER, local germplasms, BR(path), BR(bio) and IRBPHN (SVIN) were screened against rice Gm. Among the 82 BR cross materials, two lines, BR11035-4R-72, BR11035-4R-190 and BR11035-4R-135, were recorded as highly resistant (HR) and resistant (R) respectively, another two entries, BR11033-4R-158 and BRRI dhan74, were moderately resistant (MR) and only one (Habu Balam-RLR) was moderately susceptible (MS) to Gm. Out of 49 IRBPHN19 germplasms, IRBPHN19, R-1, S-4 were found HR against Gm. The remaining test entries belonging to RYT, RYT1, RYT2, local germplasm, BR(path) and BR(bio) showed susceptible (S) to highly susceptible (HS) reactions.

In addition, 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 conditions to complete their life cycle. These genotype(s) were used in breeding programs for hybridization between two parents, and Rapid Generation Advance (RGA) studies to develop high yielding Gm resistant line(s)/varieties.

Experiments with Gm resistant donors were conducted again in T. Aman, 2020 season in Gm endemic areas in Gazipur, Natore, Pabna, Dinajpur, Gaibandha, Habiganj and Cox's Bazar districts based on earlier survey information. The test entries were late transplanted due to early floods in the northern parts of Bangladesh. Unfortunately, the test entries were not infested with the desired level of Gm under field conditions.

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.

11. 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 University (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 addressed.

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 (Fig.17) 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 in the management of major maize insect pests were conducted to develop new IPM packages.

Fig. 17. Field trial on corn borer control with biocontrol agents

Small scale farm level validation trials of different IPM technologies were conducted in farmers' fields in Mymensingh, Chuadanga and Gaibandha districts in collaboration with the Department of Agriculture Extension (DAE). Detailed training programs and field days were conducted for capacity building of 600 farmers and extension workers. Bioassay of selected insecticides and bio-pesticides against cut worm, corn borer and Fall Armyworm (FAW) were done and validated. IPM packages were developed for the control of corn borer and FAW and disseminated through communication materials like training manual, leaflets and media coverage.

Result and Discussion: Intensive cropping, human intervention, and climate change are playing key roles in increasing insect populations in maize. Among a dozen of major insect pests (Fig. 18) 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 in Bangladesh.

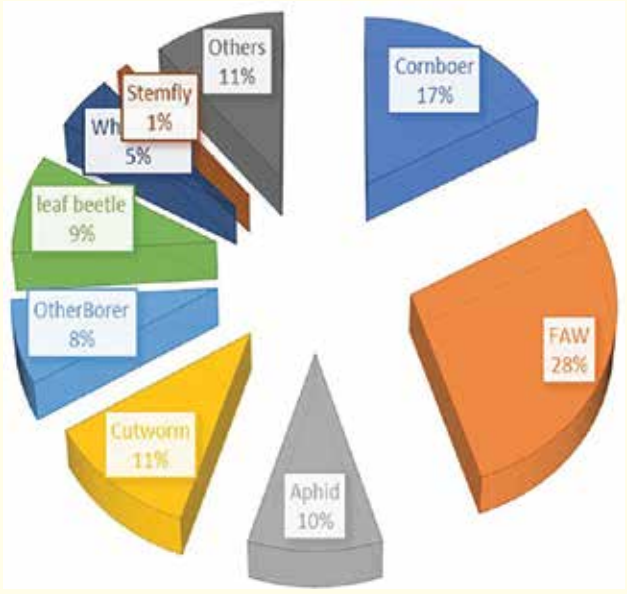


Fig. 18. Insect pests of maize in Bangladesh

A comprehensive guideline was developed involving cultural and biological control along with insecticides of biological origin for eco-friendly management of major maize pests in Bangladesh. Corn may be protected effectively from the attack of two major insect pests if insecticides are applied at or before the silking stage, the corn growth satge most preferred by CB and FAW. The technologies were disseminated widely, with great success, across Chuadanga and Gaibandha supported by a ToT program and demonstration of IPM technologies including massive release of parasitoids and organizing field days. Six IPM packages namely i) clean cultivation + pheromone trap + *Bracon hebetor*, ii) pheromone trap + Metarhizium, iii) emmamectin benzoate + Lufenuron, iv) habitat management + irrigation + *Bacillus thruringiensis* @ 1.5 g/L v) clean cultivation + SNPV @ 0.3 g/L and vi) ASEA + ETL based application of chlorantraniliprole were developed for maize pest management. Diamide pesticide was found less disruptive to the natural enemies. Awareness and confidence of farmers in maize pest management were increased through arrangement of training, field days and workshops.

Conclusions: The corn borer, cutworm and Fall Army Worm (FAW) are becoming serious threats to maize production in Bangaldesh necessitating development of eco-friendly IPM based pest control measures. This project addressed the problem through 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 cutworm, corn borer and FAW and new technologies for their management.

12. 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. *Char* lands are very promising areas for introducing agroforestry systems, but there is still absence of crop and garden based agroforestry practices in *char* areas of Bangladesh. Agroforestry may address the ecological problems in *chars* and improve livelihood of the inhabitants. This project attempted 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 there.

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

Fig. 19. Field trial on corn borer control with biocontrol agents

Materials and Methods: Selected *char* lands and 200 farmer households were surveyed in terms of demography, farmers' knowledge of agroforestry and communication status, plant diversity, etc. Several agro-forestry based experiments were conducted in Dimla upazila, Nilphamari and Gangachara upazila, Rangpur where the following systems were tested: i) *malta* + chili, ii) moringa + maize, iii) *gamar* (tree) + sweet gourd, and iv) mango + potato. Eight farmers were selected and different fruit (mango, guava, litchi and *malta*) and forest tree (mahogany and *gamari*) based agroforestry systems were established (Fig. 19). During the winter season, chili, potato, garlic, onion, red amaranth, maize, brinjal and sweet gourd were grown in an agroforestry-crop system.

Results and Discussion: Plant biodiversity is still low in the *chars* compared with that on the main land. The project survey showed an extreme abundance of eucalyptus trees in the Tista *char* areas. Government extension

services in the *char* areas were found to be very weak. The *char* farmers had poor knowledge of agroforestry. Fruit tree based agroforestry, especially mango, *malta* and litchi based agroforestry, was found to be promising for the Tista *char* lands. Moringa was not found to be a suitable tree species for *char* land. Mango (var. Harivanga) and *malta* (var. BARI Malta 1) could survive monsoon flooding for at least two months on an island *char*. Litchi (var. China 3) can be used as an agroforestry component on settled (attached to main land) *char* land. Some marketable vegetable and spice species like brinjal, cauliflower, okra and garlic could be successfully cultivated on the floor spaces of the young *malta*, mango, litchi, guava, *gamari* and mahogony tree orchards/woodlots. Taro is also a promising kharif vegetable crop for *char* land as an understory crop in an agroforestry system. The performance of four BARI garlic varieties was tested, the variety BARI Rashun-4 with a yield of around 7 t/ha was the best in terms of yield (Fig. 20). Wider spacing for understory vegetables/crops is recommended. Organic agroforestry farming is possible in *char* areas, but the economic return is comparatively low compared with chemical fertilization. New *char* soil has a smaller number of bacteria and fungus than that in older *char* soil. Farmers of *char* land who are using their land for agroforestry are getting greater economic benefits than farmers practicing mono-cropping of sweet gourd or chili or groundnut. Livelihood parameters of the selected *char* land farmers need to be monitored and any changes due to the practice of agroforestry on their lands recorded in the future. The Land Equivalent Ratios (LER) of the different *char* lands also need to be monitored.

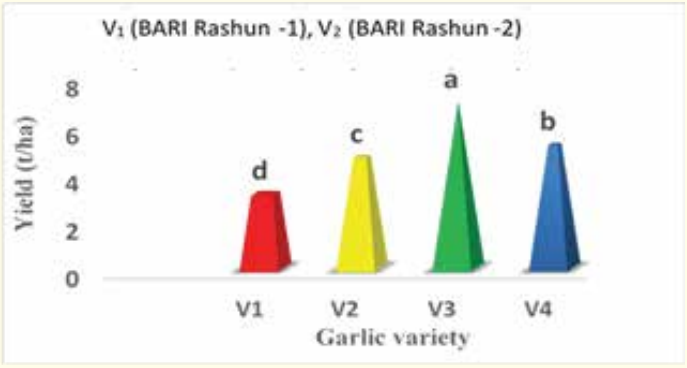


Fig. 20. Yield of four garlic varieties in mango based agroforestry on an island *char* in Dimla, Nilphamari of the Tista River Basin

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 attempted 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 a good agricultural enterprise to improve the livelihood status of the poor *char* dwellers.

13. 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, cowpea, 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 a long shelf life. This project studied 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 mungbean) and Boro (Binadhan-14) to examine the feasibility of incorporating short-duration vegetable beans in between two rice crops and to evaluate the efficiency of different fertilizers. 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.

Result 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 farmers'fields. Following this, 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 Boro 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 in 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 management practice for most beans.

Post-harvest soils analysis after each cropping season indicated an increase (ranging from 27.7% to 83.0% after Boro, and 1.8% to 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 the CFM treatment. In farmers' 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 CF. Surprisingly, no pod set was observed in soybean in the farmers' fields, which needs further investigation.

Fig. 21. Annual returns from rice-fallow-rice and rice-bean rice cropping patterns; the trend line on the yellow bars represents the gross return from an annual crop sequence

After completion of the third year of the project, it was concluded that French bean and pea can be introduced in between a short-duration T. Aman rice crop such as, Binadhan-7 and Boro (late Boro like Binadhan-14) rice. Introduction of these bean species not only increased the system productivity but also improved soil fertility. Trials in farmers' fields corroborated this. Incorporation of bean biomass into soil increased Boro and T. Aman grain yields by 19 and 13%, respectively. Apart from the agronomic gains, introducing beans into the rice-rice system enhanced farmers' incomes (Fig. 21).

Conclusions: Beans can be grown in a range of soil and climatic conditions and they can play an important role in soil fertility and productivity through nitrogen fixation and organic matter addition. 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 of Bangladesh. The results were encouraging--introduction of these bean species not only increased the system productivity and improved soil fertility but also enhanced rice farmers' incomes.

4.1.1B Ongoing Projects

14. 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, Agricultural Statistics, Information and Communication Technology (ASICT) Division, BARI

Locations: Drought prone Barind Tract regions of Rajshahi, Chapainawabganj, 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 assess crops and cropping patterns in the High Barind Tract covering 11 upazillas of Chapainawabganj, Naogaon and Rajshahi districts. Two reconnaissance surveys were conducted in March 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 was 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 such as, Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI) and Global Muscular Vascular Index (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 2020-June 2021), 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/) for the dry season (October-March) which were analyzed using desktop based geospatial software tools and the Google Earth Engine (GEE) platform.

Results and Discussion: An algorithm was developed to delineate dry season crops in the Godagari upazila using Sentinel-2 imagery. The maximum likelihood classification (MLC) technique was employed to classify the NDVI composite image and final classified images. 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 areas were 2,087.89 (4.24%), 1,731.55 (3.52%), 798.76 (1.62%) and 658.58 ha (1.34%), respectively during the 2019-2020 Rabi season. Other areas (water bodies, other crops, orchards, settlement, etc.) shared the maximum area coverage with 27,052.42 ha (54.92%). The overall accuracy of the classified map was 75% relative to the ground truthing data, which was considered satisfactory. During the reporting period, i.e., July 2020-June 2021, extensive field work was conducted to collect representative reference data for the same crops to improve the accuracy of the crop type mapping. Besides, a set of agro-environmental resources geo-database from image analysis was developed including the digital elevation model, slope map, aspect map, soil map, topsoil texture, soil reaction, waterbody, soil consistency and land type of the Godagari Upazila (Fig. 22) to be used as input data in further analysis towards achieving the final objective of location-specific cropping pattern modeling in GIS environment. Moreover, the digitized land use/land cover map (1:1000) of the study area is under development through digitizing the Google Earth base maps.

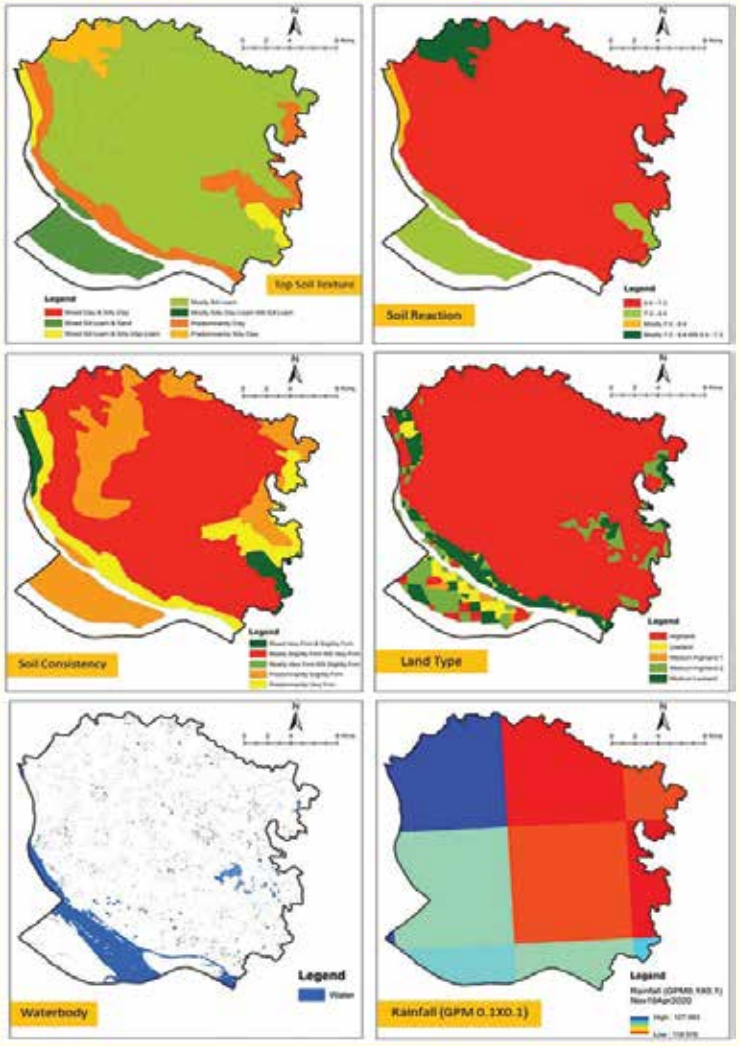


Fig. 22. Agro-environmental maps of the Godagari upazila of Rajshahi

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 offers 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. Digitization of land use/land cover map (1:1000) of the study area is in progress. Besides, a series of agro-environmental geodatabase has been derived for further analysis towards achieving the objective location-specific suitable cropping pattern for sustainable intensification of agriculture.

15. 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 Agricultural 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 *chars* in Bangladesh, along the Old Brahmaputra and the Tista rivers, but compared with the chars in the major rivers, these constitute much less land area. *Chars* 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 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: 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). Farmers' field trials were conducted on nutrient management with combinations of recommended chemical fertilizers (RF) and organic matter like poultry manure (Pm), vermicompost (Vc), quick compost (Qc) and biochar (Bc) for vegetable crops such as, snake gourd, Indian spinach, okra, pumpkin and yellow sweet potato. There were 54 participating farmers (18 farmers from each location) at the three project sites. *Char* farmers were trained on innovative soil and crop management practices at the three sites.

Fig. 23. A yellow sweet potato experimental field on a *char* land

Results and Discussion: Chemical-organic combinations of nutrients markedly influenced yield components and yields of the vegetable crops across the experimental sites on the three *chars*. Polutry manure was most effective in this respect followed by biochar and quick compost. For example, snake gourd gave a high yield of around 29 t/ha with the (RF+Pm) or (RF+Vm) combination

while the yield was only about 17 t/ha in control. The Indian spinach yield ranged from about 50 t/ha (control) to 74 t/ha with (RF+ Pm) or (RF+Vm). Okra, too, gave the highest yield of about 21 t/ha with Pm compared with 15 t/ha in control. For pumpkin and yellow sweet potato (Fig. 23), Pm, Vm, Qc or Bc was equally effective.

Conclusions: Findings, so far, of the project indicated good prospects of improving crop yields in *char* areas with appropriate fertilizer application and addition of organic matter. Improving fertility of the soils may also be possible with organic amendmends. The project is continuing for the validation of technologies suitable for the *char* lands.

16. 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 as by the roadside and railway track side. These fruit trees are well adapted to the local climate, are nutritious and useful as herbal medicine 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*), 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 under-utilized fruits for increasing production in southern and coastal areas of Bangladesh

Materials and Methods: A baseline survey was done to assess the status of underutilized fruit trees, fruit production and barriers to fruit tree establishment in coastal areas of Bangladesh. For survival and adaptation experiments, 30 farmers were selected from Jashore, Khulna and Satkhira (10 farmers each) and fruit trees were planted in their homestead gardens. In the laboratory, isolation and identification of some fungal pathogens were done through mycelial growth test, PCR amplification of DNA and pathogenicity test. Disease management experiments through the application of fungicides are ongoing.

Results and Discussion: 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 are (i) leaf blight, (ii) leaf spot, (iii) fruit blight, (iv) leaf curl and (v) die back, and the insects are (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. About 80% farmers from Khulna were found facing the problem of leaf blight, 90% farmers from Shatkhira were facing the leaf spot problem. Fruit losses due to disease, insect, harvest and transport occurred. The greatest loss, >10-20%, was found in Barishal. *Sofeda* (sapota) was found to be more adaptive than *lotkon*. After 16 months, the highest percentage of mortality was

found in Satkhira. *Sofeda* had the lowest mortality (36.8%) closely followed by *jambura* (40%), while the highest mortality was found in *lotkon* (66.5%). Twenty-two different pathogens were isolated from fruit plant leaves from different locations. Topral 52.5 WP, Autostine 50 WDG, Dithane M-45 and Potent 250 EC were found to be most effective in controlling the pathogens isolated.

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

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

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. 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.

Objective: To develop improved methods of postharvest management and processing technologies to produce assorted food items from jackfruit and devise strategies and 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. Immature jackfruit (6-7 weeks) was considered for fresh-cut, ready-to-cook, frozen and pickles and matured *Gala* type jackfruit were used for processing fresh-cut, jam, and leather. Similarly, matured *Khaja* type jackfruit (golden yellow flesh) were utilized to prepare dehydrated chips and seed powder. Besides, nutritional quality such as contents of minerals, vitamins, bioactive compounds were determined, antioxidant activities were studied and sensory evaluation during storage was done. Surveys were conducted amomg farmers, intermediaries and consumers. F2F, KII interviews, workshops were organized among stakeholders and key market players to develop market and value chain of jackfruit.

Results and Discussion: Several value-added jackfruit products such as fresh-cut, jam, dehydrated products, chips, leather, ready to cook products, pickles and seed powder were developed. These products exhibited good nutritional quality with considerable amounts of different bioactive compounds like total phenols, carotenoids,

beta-carotene, ascorbic acid and significant antioxidant activity. Furthermore, consumers' perception indicated an excellent sensory quality of the processed products. Low-temperature storage (3-6°C) of fresh-cut tender jackfruit prolonged the shelf life (3 days) and improved edibility while fresh-cut ripe jackfruit prepared using 0.6% $CaCl_2$ and keeping at 2 ± 1°C can be stored for up to 6 days. Jackfruit jam prepared using 10% lemon juice showed high nutritional quality and sensory acceptance. The sugar concentration of 50° brix is the best option for preparing dehydrated jackfruit. Lemon juice (7-10%, v/w) can be added to jackfruit pulp during preparation of leather (Fig. 24), which could boost up different nutritional compounds. Freeze drying at -56°C, and cabinet drying at 60°C maintained good nutritional quality of jackfruit seed powder retaining bioactive compounds and antioxidant properties. Frying at 110ºC for 25 minutes and at 120ºC for 20 minutes made good quality jackfruit chips with adequate nutritional and sensory properties.

Fig. 24. Processing steps for preparing jackfruit leather

Post-harvest losses of jackfruit amount to a staggering 40-45%. Eight farmers groups, entrepreneurs and small and mid-size enterprises (SMEs) at eight locations in the project areas were formed. BARI and NVSL jointly provided hands on training to 16 batches (20 participants/batch) of small and medium scale processors and entrepreneurs from the project areas for the preparation and marketing of jackfruit products. Different promotional and motivational activities were conducted to highlight the health benefits of jackfruit and promote post-harvest processing of jackfruit.

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 presently 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 fine tune methods of postharvest management and processing technologies and strategies and plans for profitable marketing of fresh and processed jackfruit products.

18. 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 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 the 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 diseases of country bean. The IPM/IDM packages tested were, (i) P1: seed treatment with Bordeux mixture @10g per kg seeds + application of Tricho-compost in pit + foliar spray of Tricho-leachate (Trichomax @10ml/L) + hand picking and destruction of infested flowers/pods and shoots at 5-day intervals + installation of yellow sticky trap and sex pheromone trap for Maruca + alternate spraying of Azadirachtin (Fytomax @ 1.5ml/L) and Bt + Abamectin (Antario @ 2g/L of water) at weekly intervals, (ii) P2: farmers' practice-- spraying of emamectin benzoate (Proclaim 5SG) and chlorantraniliprole (Coragen18.5SC) + spraying of Amistertop325SC and Tilt250EC commencing from the first incidence, and (iii) P3: untreated control. Data on numbers of healthy and infested/infected plant, leaf, pod from whole plot were recorded weekly. Data were also recorded on the per cent 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. The best identified IPM and IDM packages and farmers' practices (FP) were evaluated in comparison with untreated control. Farmers' training and field day programs were organized to build up the capacity of growers and beneficiaries.

Results and Discussion: The lowest aphid and pod borer infestations (4.56%) and (5.24%), respectively, were achieved with P1 irrespective of location. In respect of disease control, too, P1 was the most effective package which resulted in the lowest disease infection (4.25%). Being the most effective insect and disease control package, P1 helped plants of country bean grow normally which resulted in the highest marketable yield of 19.5 t/ha while farmers'practice (P2) gave 16.8 t/ha and the untreated control gave only 11.4 t/ha (Table 9). Also, the marginal benefit cost ratio (MBCR) was the highest (10.11) for P1.

Table 9. Effect of different IPM/IDM packages on marketable yield (t/ha) of country bean at different locations, Rabi 2020-21

Package	Mymensingh		Netrakona		Sherpur		Avg. (t/ha)	% increase over control
	Sadar	Nandail	Durgapur	Kalmakanda	Nakla	Nalitabari		
P1	19.90a	18.70a	20.55a	20.15a	18.10a	19.30a	19.45	68.85
P2	16.90b	15.80b	17.40b	18.10b	15.05b	17.30a	16.76	46.63
P3	11.60c	10.85c	11.85c	12.25c	11.10c	10.90b	11.43	-
LS	**	**	**	*	**	**	-	
CV%	6.85	8.45	5.02	4.41	5.15	6.24	-	

P1: seed treatment with Bordeux mixture @10g per kg seeds + application of Tricho-compost in pit + foliar spray of Tricho-leachate (Trichomax @10ml/L) + hand picking and destruction of infested flowers/pods and shoots at 5-day intervals + installation of yellow sticky trap and sex pheromone trap for Maruca + alternate spraying of Azadirachtin (Fytomax @ 1.5ml/L) and Bt + Abamectin (Antario @ 2g/L of water) at weekly intervals; P2: farmers' practice-- spraying of emamectin benzoate (Proclaim 5SG) and chlorantraniliprole (Coragen18.5SC) + spraying of Amistertop325SC and Tilt250EC commencing from the first incidence; P3: untreated control

Conclusions: The project so far has generated useful technical information on 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.

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

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 watermelon growing districts of Bangladesh

Total budget: Tk 40 lakh

Duration: Oct 2019 to Oct 2022

Introduction: In Bangladesh, watermelon is cultivated in 11,046 ha of land with an annual production of 2.49 lakh tons. 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, from seedling to maturity, of the watermelon plant growth and may even occur earlier to cause pre-emergence damping-off. Crown blight, leaf lesions, defoliation and fruit rot result from GSB infestation. This project was designed to develop integrated management practices consisting of the use of pathogen-free seeds, selection of resistant varieties, spraying effective fungicides in the rhizosphere and foliar regions, increasing beneficial microbe populations and cultural practices against FW and GSB diseases of watermelon.

Objective: Survey, collection, isolation, preservation of the pathogens causing FW and GSB diseases in watermelon, pathogenecity tests and development of integrated disease management (IDM) packages to control the diseases.

Materials and Methods: The project work entails: a) a field survey of diseases of watermelon in the fields of major watermelon growing areas viz., Patuakhali, Chattogram, Noakhali, Bhola, Panchagar, Gopalganj, Khulna, Pabna and Sylhet districts, b) isolation and preservation of the fungal pathogens from collected diseased samples, c) pathogenicity test of isolates of wilt and gummy stem blight (GSB) pathogens, d) characterization of the isolated pathogens at morphological and molecular levels (Fig. 25), e) study of efficacy of fungicides *in vitro* and *in vivo* for management of wilt and GSB diseases of watermelon, and f) evaluation of bio-control agents *in vitro* and *in vivo* and cultural practices for the management of the FW and GSB diseases of watermelon, g) seed health studies of commercial watermelon varieties.

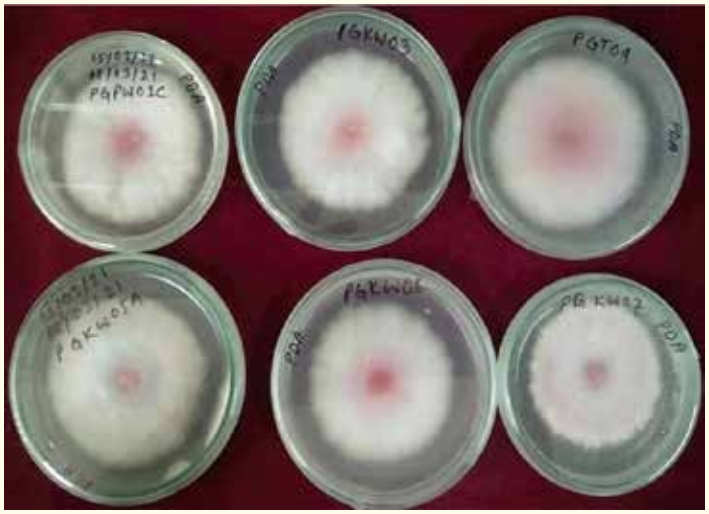


Fig. 25. Colony characteristics (growth, color and texture) *Fusarium* isolates on potato dextrose agar (PDA)

Results and Discussion: Among the 126 farmers' fields surveyed, 35 (27.78%) were infected with FW and 74 (58.73 %) with GSB. The maximum FW infected (40.67%) field was found in Patuakhali. GSB was most prevalent in Sylhet (50.67%) and the least in Panchagar (5.33%) (Table 10). In field experiments with diseased

plots at the Regional Horticultural Research Station (RHRS), BARI, Lebukhali, Patuakhali and in farmers' fields of Subarna Char, Noakhali during 2020-21, the lowest wilt and GSB incidences were obtained with Provax and Autostin seed treatments. In case of foliar spray, the lowest FW/GSB incidence and the highest plant canopy diameter were obtained with Companion and Amistar Top, respectively. In bio-control and cultural methods, antagonistic fungi and endophytic bacteria have been reported as bio-control agents against plant diseases and plant growth promoters. Under green house (inoculated) and diseased field (natural) conditions, the highest reduction in FW incidence and GSB severity were observed in watermelon plants treated with commercially formulated Decoprima (74.4%) containing cellulolytic, ligninolytic and proteolytic microbes, followed by *T. harzianum*, *B. subtilis* PTB001 and *E. nigrum* ESJ002, while seedling treatment with pesiticide was least effective. The study confirmed that the four fungal bacterial species can be used as suspensions or formulations as eco-friendly alternatives to synthetic fungicides for controlling the FW and GSB diseases of watermelon.

Table 10. Incidence and severity of the Fusarium wilt and gummy stem blight diseases of watermelon in different districts, 2021

District	Disease incidence (%)					
	Fusarium wilt			Gummy stem blight		
	Max	Min	Avg	Max	Min	Avg
Noakhali	15.67	5.67	11.08	30.33	15.33	22.8
Patuakhali	**40.67**	15.33	**24.84**	19.33	5.67	15.15
Panchagar	25.33	15.67	20.44	25.33	15.33	20.42
Bhola	40.33	15.33	22.46	22.33	5.67	13.97
Khulna	15.67	13.67	13.17	18.67	8.33	13.81
Chattogram	9.33	**4.67**	**7.56**	15.33	**5.33**	**10.74**
Pabna	25.87	20.33	24.67	25.33	10.33	17.92
Gopalganj	16.57	10.33	13	25.33	15.33	20.5
Sylhet	15.67	10.33	13.78	**50.67**	15.33	**35.49**

Conclusions: The project findings indicated substantial infestation of the *Fusarium* wilt and gummy stem blight diseases of watermelon caused by the fungi *Fusarium oxysporum* f. sp. *niveum* and *Didymella bryoniae*, respectively in different districts of Bangladesh. Work on the morphological and molecular characterization of isolates of the causative agents is ongoing. Virulent isolates are under experimentation for different studies and germplasm screening. Foliar sprays of fungicides appeared to be effective in controlling FW and GSB incidence. Bio-control agents like Decoprima containing cellulolytic, ligninolytic and proteolytic microbes, *T. harzianum*, *B. subtilis* PTB001 and *E. nigrum* ESJ002 were found to be promising as eco-friendly control measures against wilt and blight diseases of watermelon. Earlier, one commercial watermelon variety (Sweet Dragon) was found to be least infected indicating the possibility of identifying promising germplasm that can be used for the development of wilt and blight resistant watermelon varieties in the future.

CGP Basic Research Projects

20. 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 Center (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 constraining the production of wheat, the second major cereal crop in Bangladesh. This 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 the 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 development of early generation breeding materials for high temperature tolerance.

Materials and Methods: The project work was designed to poroceed in four steps: 1) collection of potential breeding stock (200 genotypes) based on their pedigree history and also consultation of senior local and international wheat breeders, 2) phenotypic selection through field screening at 5 locations for a period of two years, 3) genotypic selection through marker assisted screening (MAS) using selected molecular markers, identifying genes/QTLs, selection of potential parental stock and establishing an authentic breeding design, crossing among selected potential parental stock and establishing varieties/advanced lines, raising of early generation breeding materials and 4) inheritance studies and gene expression analysis.

Results and Discussion: In the first two years of the project, a total of 200 genotypes were screened at 5 different locations under two different growing conditions viz., irrigated-timely sowing and irrigated- late sowing. In year 2 at Joydebpur and Jashore, the condition was irrigated-very late sowing. Sixty genotypes were selected based on their morphological traits as well as phenotypic markers towards heat tolerance considering leaf curl, waxiness, faster grain filling period, single kernel weight and stay-green features. Using 13 molecular markers across 60 wheat genotypes, an average of 13.38 alleles were found of which Xcfa2129 and Gwm11 showed the highest number of alleles (17). On the other hand, Xcfd43 had the least number of alleles (9). The frequency of the most common allele at each locus ranged from (0.57) Xgwm294 to (0.87) Xcfd43. On an average, (0.71) of the 60 genotypes shared a common major allele at any given locus. Seven genes/QTLs were identified. The highest maximum 5 markers' presence was observed in 5 genotypes, 4 in 7 genotypes and 3 in 15 genotypes. In the second year, a few selected crosses were made based on only phenotypic markers. However, in the third year based on the findings of phenotypic and molecular screening, five outstanding lines were selected as potential parents. A breeding design was developed and a total of 37 crosses made to derive heat tolerant progenies. Transitory genotypic information is provided in Fig. 26. In the fourth year (2020-21), better early generation materials have been selected from several crosses (Table 11). Work on relevant basic genetic analysis is in progress.

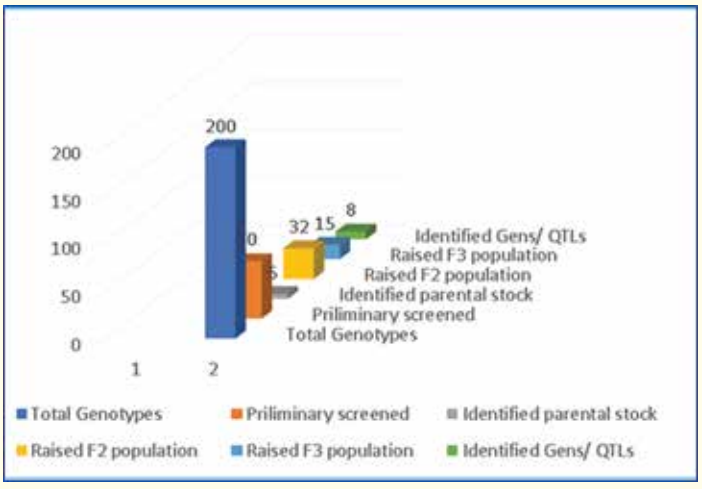


Fig. 26. Brief genotypic information regarding the wheat germplasm studied

Table 11. Selected outstanding parental stock, obtained progenies and identified genes/QTLs

Selected genotype	Developed population	Phenotypic performance	QTL/gene confirmed
IEHG 03	F2 (7); F3 (4)	1. Leaf curl	1. *Gwm291*
IEHG 06	F2 (5); F4 (3)	2. Waxiness	2. *Xbarc137, Gwm484*
IEHG 18	F2 (5); F3 (2)	3. Faster Grain-filling	3. *Gwm 11, Xcfd43*
IEHG 48	F2 (9); F3 (4)	4. HSI- kernel weight	4. *Gwm264. Xcfa2129*
IEHG 29	F2 (6); F3 (2)	5. Stay Green	5. *Gwm325*

Conclusion: The project scientists identified, to date, five wheat genotypes as potential parents through rigorous field and molecular screening 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.

21. 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. 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. Genomi 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: Stress tolerant potato (*Solanum tuberosum*) varieties such as, heat tolerant (BARI Alu-72, 73), late blight resistant (BARI Alu-46, 53, 77) and susceptible (BARI Alu-7, 8, 13 and 25) varieties have been used in this study. Genomic DNA, chloroplast (cp) and cpDNA have been isolated from BARI Alu-7, 25, 46, 53, 72, 73 and 77. Quality and quantity have been checked using a NanoDrop Spectrophotometer 2000. Electrophoresis was performed using genomic and cpDNA with agarose 1% gel stained with ethidium bromide at 80v for 1 h for quality checking. Good quality DNA has been sequenced. True Seq Nano DNA Kit (Illumina San Diego, United States) was used to assemble the library after DNA fragmentation. The genomic DNA of five *Solanum tuberosum* species was sequenced on 150bp paired ends on an Illumina NovaSeq 6000 by Macrogen Inc., Korea. Trimmomatic v 0.36 (Bolgeret al.2014) was used for raw data processing, and the resulting clean data were used for assembly and post-analysis. Fastqc v0.11.5 was used to evaluate the quality of the data visually. SPAdes was used to assemble the clean data, and the complete chloroplast genome sequence was obtained after gap closing. Prokka was used to annotate the cp genomes and predict the rRNA/tRNA of BARI Alu-46, BARI Alu-53, BARI Alu-72, BARI Alu-73, and BARI Alu-77 with EggNOG v5.0. The circular cp genome maps were drawn using the Organellar Genome DRAW (OGDRAW) program. Approximately 2G of data for each cp genome was obtained with a 150 bp read length. Gap closing was based on the sequence of the complete cp genome from *Solanum tuberosum* cultivar Desiree chloroplast (DQ386163.2).

Results and Discussion: The chloroplast genome sequences of the five genomes ranged from 176,021 bp (BARI Alu-46) to 176,301 bp (BARI Alu-77) (Fig. 27, Table 12). The same typical quadripartite structure was displayed in the five cp genomes. Two IR regions (44,606 - 44,999 bp) were separated by an LSC region (85,738 - 85,986 bp) and an SSC region (690 - 717 bp) (Table 12). The variation of the IR/LSC and IR/SSC borders was considered to be the primary mechanism causing the length differences of angiosperm cp

genomes. The GC content ranged from 36.81% to 35.77% for the five cp genomes (Table 12). These five *Solanum tuberosum* cp genome data will be sent to the National Center for Bitotechnology Information (NCBI). The five genomes contain genes ranging from 152 (BARI Alu-77) to 161 (BARI Alu-53) and protein-coding genes ranging from 118 (BARI Alu-77) to 127 (BARI Alu-53) (Fig. 27, Table 13). All of them also contain 30 tRNA and 4 rRNA (Table 12).

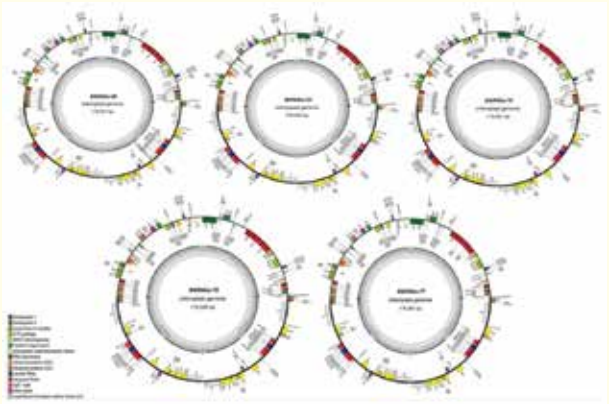


Fig. 27. Gene maps of the five *Solanum tuberosum* cp genomes

Table 12. Summary of the sequencing data for the five Solanum tuberosum species

Spec.	Gene no.	Protein coding genes (no.)	tRNA genes (no.)	rRNA genes (no.)	Cp genome length (bp)	LSC length (bp)	IRa length (bp)	SSC length (bp)	IRb length (bp)	GC (%)
A	154	120	30	4	176,021	85,738	44,965	700	44,618	36.35
B	161	127	30	4	176,060	85,738	44,999	717	44,606	36.59
C	153	119	30	4	176,041	85,738	44,971	690	44,642	35.77
D	155	121	30	4	176,028	85,738	44,979	694	44,617	36.81
E	152	118	30	4	176,301	85,986	44,996	702	44,617	36.63

A= BARIAlu-46, B= BARIAlu-53, C= BARIAlu-72, D= BARIAlu-73, E= BARIAlu-77

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 progenies were developed through crossing. Some lines were found promising for late blight resistance. Their distribution to late blight resistance was skewed and major genes were involved in maintaining their resistance to late blight. Also, some promising lines showed tolerance to heat. The lines TB11-009=red, TB11-029=pale red, TB11-056=red, TB11-095= white, TB11-073= white, TB11-002= dark green leaves having very minor infections of LB, TB11-060, TB11-065, TB11-097, TB11-058= white, TB11-005= white, TB11-020= red, TB11-046= white, TB10-085 and TB10-134 showed very good resistance to late blight. The lines TB15-030, TB15-105, TB15-023, TB15-026 = red skin and high yield, TB15-016, TB15-143, TB15-037, TB15-144, TB15-011, TB15-0171, TB15-118= red skin and long tuber, TB15-025= large, oval flat tuber, TB15-019= red skin, rounded, russet and looks like Hugrai (local potato), TB15-045= deep red, flat and looks like Hugrai (local potato), TB15-145= deep red, round and looks like Hugrai (local potato) showed good performance in respect of heat tolerance (Fig. 28). QTL maps will be developed from the data of these lines. A total of 145 kg tubers of heat tolerant and late blight resistant lines were harvested

Fig. 28. Field views of phenotypic evaluation of heat tolerant and late blight resistant potato lines at BARI OFRD, Rangpur during 2020-2021

during 2020-21. From these tubers, a total of 447 progenies of 22 late blight resistant and heat tolerant populations have been evaluated.

Conclusions: Some promising late bight resistant and heat tolerant lines of potato have been developed which are undergoing further laboratory evaluation and field tests. Genomic DNA and cpDNA isolation protocols have been refined. F1 populations of late blight resistant and heat tolerant potato varieties have been developed. Project findings will be helpful in future attempts to breed potato varieties tolerant to such biotic and abiotic stresses like late blight and high temperature.

CGP 4th Call

4.1.1C Recently Initiated Projects

Presented under this category are findings of projects which were initiated less than a year ago. This covers projects under CGP 4th Call, CRP-II and ICP-IV and Lump Sum Grants (LSG) programs.

22. Project Code and Title: TF 68-C/20. Molecular characterization of biovars of *Ralstonia solanacearum*, the causal agent of bacterial wilt of solanaceous crops and integrated management of the disease

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

Principal Investigator: Dr. Mafruha Afroz, Senior Scientific Officer (Plant Pathology), Horticulture Research Center (HRC), BARI, Gazipur

Locations: HRC, BAI, Gazpur, Tuber Crop Research (TCRC) Sub-Center, BARI, Seujgari, Bogura and Agricultural Research Station, BARI, Thakurgaon

Budget: Tk. 80.00 lakh

Duration: December 2020 to Novemebr 2023

Introduction: *Ralstonia solanacearum*, the causal agent of bacterial wilt (BW), is an economically devastating pathogen of solanaceous vegetable crops worldwide. If the bacterial pathogen attacks at an early stage of the crop, yield is reduced drastically. Conservative estimates of yield loss due to bacterial wilt in eggplant are around 30%, but sometimes 100% yield loss may occur if the crop is grown in a previously BW infected field. In Bangladesh, previously some integrated disease management (IDM) recommendations against BW were made, but they are no more popular now. This project is designed to test new IDM measures involving biological control.

Objective: To asses the occurrence and severity of the bacterial wilt disease of eggplant and tomato in Bangladesh, molecular characterization of biovars of *R. solanacerum* and to develop an IDM package to control the disease.

Materials and Methods: A comprehensive survey was conducted during the January-May, 2021 cropping season in three major eggplant and tomato growing districts such as, Narsingdi, Bogura and Thakurgaon to record the incidence of bacterial wilt (BW) of eggplant and tomato. The survey covered 128 farmers' fields and trial sites. Data on area surveyed, variety grown, wilt incidence (%), etc. were recorded. Twenty-six germplasm of eggplant and 18 of tomato were screened against BW through artificial inoculation in sickbed. Management methods tested against BW were: (a) cultural: burning of rice husk and treatment with biochar @ 3t/ha and @ 2t/ha and rice ash @ 2t/ha, (b) use of biological agents: *Bacillus* spp. 38, *Pseudomonas* spp. 1, *Bacillus* spp. 38 and *Pseudomonas* spp. 2 and (c) use of chemicals: stable bleaching powder @ 25 kg/ha, Ulka 35 SC @ 0.5ml/L, Timsen-TM @ 2 g/L, bleaching powder @ 100 kg/ha, Bactaf 50EC @ 1.5 g/L and Sunvit 50W @ 6.8 g/L.

Results and Discussion: As high as 47% BW infection in eggplant and 20% infection in tomato were detected (Table 13). Eighty isolates of *Ralstonia solanacearum* were collected and preserved. Eighteen genotypes of

eggplant and 16 of tomato showed resistant to BW. In the experiment on cultural management practices, among the treatments, burning of rice husk was most effective reducing wilt incidence by 80% from control (no treatment), followed by biochar @ 3t/ha, biochar @ 2t/ha and rice ash @ 2t/ha. All the four biological agents reduced BW at both the locations. Among the treatments, *Bacillus* spp. 38 was most effective in reducing wilt incidence followed by *Pseudomonas* spp. 1, *Bacillus* spp. 38 and *Pseudomonas* spp. 2.

Table 13. Incidence of bacterial wilt of eggplant in three major eggplant growing districts of Bangladesh

District	Upazila	Incidence (%)		Area (ha)
		Mean	Range	
Thakurgaon	Sadar	11.58	0.0-30.0	4.0
	Baliadangi	13.26	0.0-47.0	1.56
Bogura	Shahjahanpur	1.66	1.0-2.0	1.0
Narsingdi	Belabo	1.90	0.0-7.0	1.81
	Raipura	2.0	0.0-2.0	0.13
	Shibpur	0.9	0.0-2.0	1.18
Total				**9.68**

Yield of tomato was significantly increased due to the application of biological agents. In respect of chemical management, all the chemicals were effective and significantly reducing the disease incidence at Bogura and Thakurgaon. The maximum wilted plants were observed in control plots and the minimum in plots receiving stable bleaching powder @ 25 kg/ha followed by Ulka 35 SC @ 0.5ml/L, Timsen-TM @ 2 g/L, bleaching powder @ 100 kg/ha, Bactaf 50EC @ 1.5 g/L and Sunvit 50W @ 6.8 g/L in that order.

Conclusion: This project deals with bacterial wilt which, in field surveys, was found to be a devastating disease of eggplant and tomato. In experiments, a few promising chemicals, cultural practices and biological agents have been identified which may be useful in mitigating the disease. Future work is expected to confirm these findings.

23. Project Code and Title: TF 69-C/20. Adaption, validation, multiplication and maintenance of lilium genotypes in Bangladesh

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

Principal Investigator: Dr. Farjana Nasrin Khan, Floriculture Division, Horticulture Research Center (HRC), BARI, Gazipur

Locations: Dhaka (Savar), Gazipur (Gazipur Sadar), Rangpur (Rangpur Sadar), Jashore (Jhikargacha)

Budget: Tk. 116 lakh

Duration: December 2020 to Novemebr 2023

Introduction: Lilium is a new exotic flower crop in Bangladesh which is recently being imported to meet user demand. Considering the local demand and profitability, farmers are much interested in cultivating this flower, but due to unavailability of lilium bulbs, commercial cultivation could not begin yet. On-farm validation, demonstration and dissemination of proven technologies of lilium flower production are necessary. Moreover, technologies need to be standardized for multiplication of lilium bulbs. Besides, bulb preservation and maintenance are important issues for the continuation of lilium cultivation. BARI has developed lilium technologies which can be disseminated. Simultaneously, research should be carried out for standardizing the multiplication methods of lilium bulbs and facilities should be developed for flower production in the future.

Objective: To validate and disseminate developed technologies of lilium flower production and bulb preservation among growers.

Materials and Methods: On-station field, laboratory, green house research and demonstrations are being carried out. A cold room (temperature -20° C, RH 80-90%) with pre-cooling facilities will be developed. A total of 16 demonstrations will be conducted at four places. In addition to the use of previously obtained bulbs from HRC, BARI, required quantities of bulbs will be purchased from various sources for demonstrations and on-station experiments. Concurrently, new lilium germplasm are also being collected for enriching the lilium collection. An experiment on bulb production of lilium from bulblets as influenced by growing media was

carried out using cocodust +sawdust+ perlite+ soil + cowdung at the same ratios. Another experiment on the effect of management practice such as spike removal and bulb size for quality lilium bulb production was conducted.

Results and Discussion: In addition to previously obtained bulbs from the Horticulture Research Center (HRC), BARI, ten new lilium genotypes have been collected for the study so far from various sources. An experiment on bulb production of lilium from bulblets as influenced by growing media was carried out and quality lilium bulbs were successfully produced from bulblets using cocodust +sawdust+ perlite+ soil + cowdung at the same ratios. Cocodust (50%) + soil (25%) +cowdung (25%) also performed well for bulb production from bulblets. Another experiment on the effect of management practice and bulb size for quality lilium bulb production was conducted in which large sized lilium bulbs combined with removal of spikes showed very good performances in respect of quality lilium bulb production as well as flower production (Table 14). Removal of spikes may be recommended for producing quality bulb as well as flower production of lilium using small, medium and large sized lilium bulbs.

Table 14. Bulb and bulblet production of lilium influenced by management practice and bulb size

Treatment	Bulb no./plant	Single bulb wt. (g)	Bulb diameter (cm)	Bulblet no./plant	Bulblet wt./plant (g)
Management practice					
Without spike removal	1.22b	21.46b	3.73b	1.27b	4.40b
Spike removal	1.41a	26.02a	4.47a	1.81a	6.88a
Level of significance	**	**	**	**	**
Bulb size					
Large	1.51a	27.80a	4.67a	1.98a	7.92a
Medium	1.34b	23.37b	4.17b	1.49b	5.58b
Small	1.10c	20.05c	3.47c	1.16c	3.43c
Level of significance	**	**	**	**	**
CV (%)	9.03	6.61	5.41	13.37	20.40

Conclusions: Lilium is a new exotic flower crop in Bangladesh which is recently being imported to meet user demand. This project deals with on-farm validation, demonstration and dissemination of proven technologies of lilium flower production. Preliminary work has been done on bulb production of lilium from bulblets as influenced by growing media was carried out and quality lilium bulbs is in progress and dissemination to growers will follow.

24. Project Code and Title: TF 70-C/20. Technology development for lisianthus (*Eustoma grandiflorum*) production and its varietal improvement for flower industry development in Bangladesh

Implementing Organization: Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka

Principal Investigator: Dr. A F M Jamal Uddin, Department of Horticulture, SAU

Locations: SAU

Budget: Tk. TK. 76 lakh

Duration: December 2020 to Novemebr 2023

Introduction: The project was designed to work on sustainable technology development for quality seedling production using light spectra for emergence and growth of lisianthus (*Eustoma grandiflorum*) cultivars.

Objective: Varietal improvement, sustainable technology development and dissemination for lisianthus production.

Materials and Methods: An experiment was conducted in a controlled growth room at the Horticulture Innovation Laboratory (Plant Factory), Department of Horticulture, SAU, Dhaka to study the effect of different LED light spectra on seedling emergence, growth, and development of different lisianthus cultivars for technology development for rosette free quality seedling production. The study comprised three different LED light spectra: white LED (W), blue LED (B), red LED (R) and four lisianthus cultivars: Arena Type 1 pure white (V1), Double III pure white (V2), Arena Type I light pink (V3), Super Magic Type Blue (V4). Coco pellets were used as growing media which had an EC of about 0.5 dS/m and a pH of 6.5. Seed trays were kept in the Plant Factory where temperature was maintained at 20° C ensuring light for 16 hours of the day. Data were collected on days to 80% germination, days to reach 80% of 4-leaf stage, seedling height, root length, leaf length, leaf number, number of roots, leaf width, rosetting and survival %.

Results and Discussion: Morphological characteristics of lisianthus cultivars were affected differentially depending on the light spectrum (Fig. 29). The quality of seedlings grown with red LED light spectrum was generally better in terms of seedling height, leaf number, leaf length, root number and survival percentage. Under red light, the Arena Type Pure I light pink (V3) seedlings displayed the best quality. The emergence of seedlings was improved by the red light spectrum. Plant growth inhibitors and other height-suppressing physiological processes can be eliminated by the development of LED lighting systems with effective spectra. Furthermore, seedling morphology does not always indicate whether or not a seedling will survive transplantation. Combining morphological measurements with a suitable measure of physiological quality could lead to improved transplanting performance. So, using LED light to improve plant growth in controlled environments is a viable option.

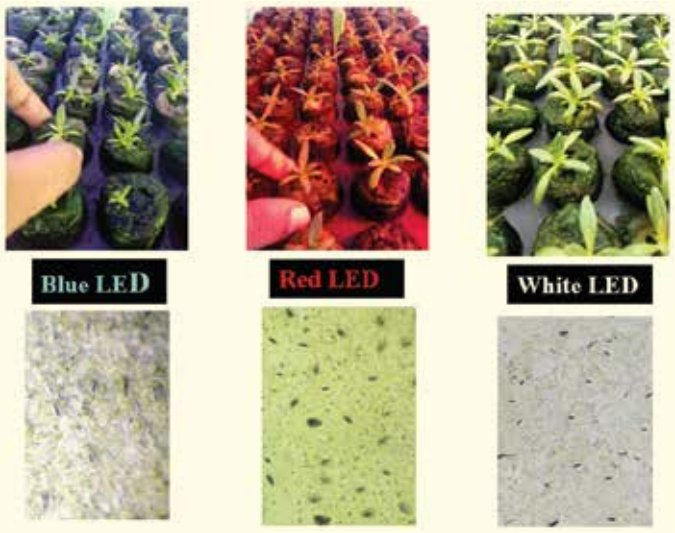


Fig. 29. Seedling growth of lisianthus under different LED light spectra

Conclusions: Preliminary results showed that morphological characteristics and quality of seedlings of different lisianthus cultivars may be affected by light spectrum, the red light spectrum appearing to be generally better. Combining morphological measurements with a suitable measure of physiological quality could lead to improved transplanting performance. Using LED light to improve plant growth in controlled environments may be a viable option.

25. Project Code and Title: TF 71-C/20. Sustainable management of blast, sheath blight and bacterial blight diseases of rice through nano-particles (NPs)

Principal Investigator: Dr. Md. Abdul Latif, CSO and Head, Plant Pathology Division (PPD), BRRI, Gazipur

Location: PPD, BRRI, Gazipur-1701

Budget: Tk. 39.73 lakh

Duration: December 2020 to December 2023

Introduction: Blast (Bl), sheath blight (ShB) and bacterial blight (BB) are serious diseases of rice in Bangladesh which are, at present, managed mainly by adopting cultural practices and using chemicals due to the absence of resistant varieties. Chemicals adversely affect the environment and human health which necessitates the search for alternative options. Green methods comprising nanoparticles prepared with plant extracts may be a simple, convenient, and eco-friendly option to fight rice diseases. This project tests green

syntheses of silver (Ag), copper oxide (CuO), zinc oxide (ZnO) and silica (SiO_2) nano-particles (NPs) as potential tools against the three major rice diseases in Bangladesh.

Objective: Bio-synthesis of nano-particles for the management of three major diseases (Bl, BB and ShB) of rice.

Materials and Methods: Finely washed and air-dried leaves (*neem, dholkalmi, tulshi*) were cut and put in a beaker containing 300 ml distilled water and boiled for 30 min at 80^0C. The extract was cooled down and filtered with a Whatman No. 1 filter paper. Four nanoparticles were extracted following standard methods. Two ml *neem* leaf extract was mixed with 10 ml of 1 mM silver nitrate ($AgNO_3$) and color change was observed from colorless to dark brown, which indicated the formation of AgNPs. *Dholkalmi* leaf extract (15 ml aliquot) was mixed with 40 ml of 15mM aqueous copper sulphate pentahydrate ($CuSO_4.5H_2O$) solution and a change in the color from light green to dark green was the indication of copper nanoparticles formation. Neem leaf extract (4 ml) and 20 ml of an aqueous solution containing $ZnSO_4.7H_2O$ (100 mM) were mixed with vigorous stirring and then then 5 ml NaOH (1M) was mixed. White precipitates confirmed the formation of ZnO nanoparticles. Ethanol extract of *tulshi* (10 ml) was mixed with 20 ml $Na_2O_3Si.9H_2O$ (100 mM) and aged for 1 hour, centrifuged and washed with distilled water.

Results and Discussion: Fig. 30 shows the UV-visible spectra of nanoparticles formed by the reactions. Addition of plant extract of *neem* into the beakers containing aqueous solution of silver nitrate led to the

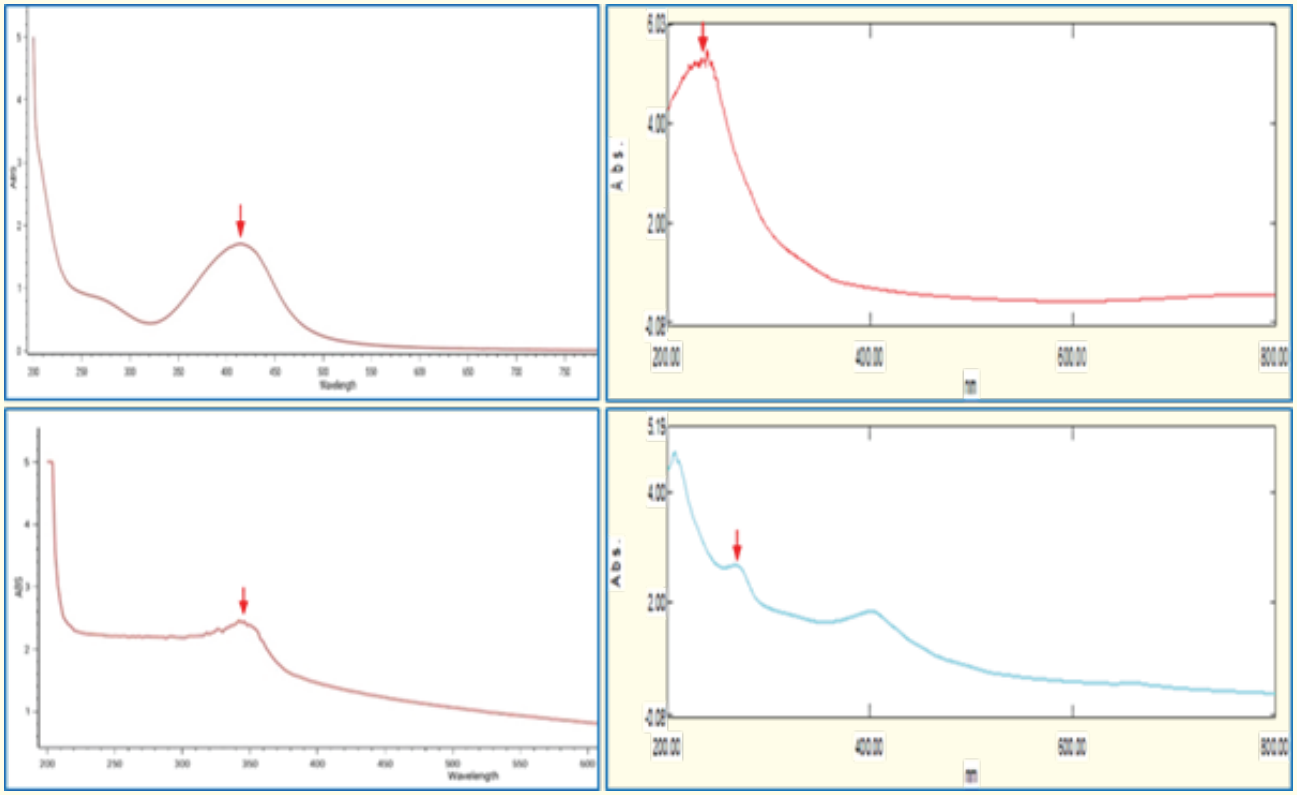


Fig. 30. UV-visible spectra of nanoparticles, clockwise from top: silver nitrate, copper oxide, silica and zinc oxide

change in the color into reddish brown within reaction duration due to the excitation of surface plasmon in silver nanoparticles. The formation of silver nanoparticles was examined and confirmed by obtaining its absorption at 415nm. The UV-visible spectrum of the synthesized CuO nanoparticle showed a strong absorbance of the UV rays at the wavelength of 240nm revealing the presence of CuO nanoparticle in the sample. The zinc nanoparticles were formed by the bio-reduction of metal ions in the salt solution. UV-Vis spectroscopy analysis was carried out as a function of time for the prepared ZnO NPs at room temperature using UV spectrophotometer. The bio-reduction of Zn^{2+} to Zn^0 ions was mainly due to the phytochemicals

present in the *neem* leaf extract. The maximum absorbance peak was obtained at 343nm which confirmed ZnONPs formation. The UV-visible spectrum of the synthesized silica nanoparticle showed strong absorbance at the wavelength of 265nm. This revealed the presence of silica nanoparticle in the sample.

Conclusions: A simple green synthesis of silver, copper oxide, zinc oxide and silica nanoparticles using *neem*, *dholkolmi and tulshi* leaf extracts was tried and tested. The bio-synthesis procedure was found to be efficient in terms of reaction time as well as stability of the synthesized nanoparticles which excluded external stabilizers/reducing agents. The bio-synthate could be a competitive alternative to the conventional physical/chemical methods used for synthesis of silver, copper oxide, zinc oxide and silica nanoparticles and thus has a potential for use in management of major rice diseases like blast, sheath blight and bacterial blight in the future.

26. Project code and title: TF 72-NRM/20: Evaluation of profitable and agro-ecologically suitable cropping patterns considering soil fertility for increasing cropping intensity in the northern region of Bangladesh

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

Locations: Rangpur Sadar, Rangpur and Gabtali, Bogura

Coordinator: Dr. A K. M. Zakir Hossain, Professor, BAU

Budget: Tk. 89.00 lakh

Duration: December 2020 to November 2023

Introduction: The most common cropping pattern in northern Bangaldesh is Boro-fallow-T. Aman. A vast land area remains fallow between T. Aman and Boro rice, the fallow period being 75-80 days during November to February. There is room for increasing cropping intensity by incorporating short-duration crops like mustard, mungbean, potato, maize or Aus rice in the rice based cropping pattern. Farmers should gradually reduce their dependence on the use of chemical fertilizers to maintain soil fertility. Combined applications of inorganic fertilizers with organics helps increase the availability of nutrients and crop yield. This project attempts to introduce new crops by adjusting the planting times and other management options.

Objective: To evaluate cropping patterns using agro-ecologically suitable and profitable crop varieties for increasing cropping intensity and maintaining soil fertility in the northern region of Bangladesh.

Materials and Methods: In year 1, an experiment on evaluation of three new agro-ecologically suitable and profitable T. Aman rice based cropping patterns (no Boro) was conducted. In year 2, suitable combinations of organic and inorganic fertilizers in the three new cropping patterns will be tried. In yr 3, validation trials of the three cropping patterns with suitable packages of organic and inorganic fertilizers will be conducted.

Results and Discussion: In the first year of the project, one field experiment was conducted in farmers' fields with cereal, vegetable, tuber, legume and green manure crops in Rangpur Sadar and Gabtali (Bogura) upazilas where four different cropping patterns were tested. It was evident from the preliminary results that the rice variety, BRRI dhan75, can be popularized and successfully incorporated in the cropping pattern as a short-duration crop in the northern region. Farmers appeared to have accepted this variety because of its short duration, aromatic grains and low fertilizer, insecticide and pesticide requirements.

Conclusions: The project was initiated less than a year ago, different cropping patterns with cereal, vegetable, tuber, legume and green manure crops were tried. Detailed analysis of the collected data is in progress.

27. Project Code and Title: TF 73-NRM/20/402. Increasing crops and soil productivity through climate smart conservation technologies (CSCTS) in drought and non-traditional areas of Bangladesh

Implementing Organization: Bangladesh Wheat and Maize Research Institute (BWMRI)

Principal Investigator: Dr. Md. Ilias Hossain, Principal Scientific Officer and Head, Regional Station, BWMRI, Shyampur-6212, Rajshahi

Location(s): Paba and Godagari upazilas of Rajshahi and Narail Sadar and Lohagora upazilas of Narail

Budget: Tk.68 lakh

Duration: December 2020 to November 2023

Introduction: Farmers' livelihood in the drought prone areas of Bangladesh depends largely on rainfed agriculture which is recurrently affected by water scarcity. About 8340 ha of land remains fallow after the Kharif-II season in Narail and Rajshahi where wheat, maize, mungbean, lentil, sesame, grass pea etc. can be grown instead of Boro rice. Soil fertility in these areas is affected by continuous rice cultivation. Incorporation of pulses into the cropping patterns making use of conservation agriculture (CA) tools will improve soil fertility. This can also increase cropping intensity and farmers' incomes.

Objective: Increasing cropping intensity and system productivity and preserving natural resources like soil and water, saving energy, fuel, labor, biodiversity in drought prone and non-traditional areas.

Materials and Methods: Field trials were conducted in farmer's fields of four upazilas viz., Godagari and Paba of Rajshahi district and Narail Sadar and Lohagara of Narail district. Three tillage options (1) raised bed (Fig. 31), (2) zero/relay and (3) conventional tillage were studied. Soil moisture regimes of the experimental plots were recorded at a 0-15 cm depth at 15-day intervals. Yield and yield component data of different crops were recorded and benefit cost ratios (BCR) estimated.

Fig. 31. Transplanting Boro rice on raised beds

Results and Discussion: With the climate smart conservation technology system (CSTCS), cropping intensity could be increased as it permitted growing three crops in a year compared with a single crop with conventional tillage (CT). Production costs were reduced by 45-80% in the CSTC system compared with CT as the machines could perform four operations in a single pass and relay cropping was possible. Irrigation water requirement was 35% less in CSTCS than in CT. Overall, CSTC increased system productivity by 10-15% over that with CT. Farmers were impressed by the higher total grain yield as well as total gross margin from CSTCS.

Conclusions: This project deals with climate smart conservation technologies (CSTC) for drought prone, less favorable ecosystems which are essential for increasing cropping intensity, system productivity and saving natural resources. Preliminary results indicated beneficial effects of CSTC which can be confirmed in future project work.

28. Project Code and Title: TF74-NRM/20. Field Based Applied Research on "Aquifer Storage and Recovery (ASR)" technology for increasing cropping intensity of Bangladesh

Implementing Organizations: Bangladesh University of Engineering and Technology (BUET) and Bangladesh Agricultural Development Corporation (BADC)

Principal Investigator: Dr. Sara Nowreen, Assistant Professor, Institute of Water and Flood Management (IWFM), BUET

Location: (i) Paba, Rajshahi; (ii) Naldanga, Natore; (iii) Mirzapur, Tangail; (iv) Dacope, Khulna.

Budget: TK: 87, 57,000

Introduction: Aquifer storage and recovery (ASR) is a concept of artificial recharge and has recently been promoted by the Bangladesh Delta Plan 2100. India has many success stories of implementing ASR for increasing cropping intensity. However, no field-based application has yet been attempted in Bangladesh for agricultural purposes. Bore well aquifer type ASR is expected to be a useful innovative water management solution for farmers facing drought, water logging and salinity situations to increase cropping intensity. ASR can free farmers' lands from water logging in the peak monsoon and during post-monsoon period allowing farmers to access good quality irrigation water. ASR is an added benefit in terms of salinity mitigation in the coastal region.

Objective: To explore the viability of using the Aquifer Storage and Recovery (ASR) tool to mitigate slow or late drainage and supply post-monsoon irrigation in drought prone and saline areas of Bangladesh.

Materials and Methods: Bore holes and observation wells have been set up. Lithology tests have been done. Hydro-chemical tests for color, EC, salinity, TDS, turbidity, alkalinity, hardness, pH and concentrations of Fe, Mn, P and Cl have been done for the pre-monsoon season to assess baseline conditions of the current aquifer. A pumping test has been done at Naldanga, Natore mainly to assess transmissivity of the aquifer.

Results and Discussion: During December 2020-June 2021, lithology tests of a total of 40 bore holes (10 at each site) have been conducted in the presence of a geologist (consultant) as a part of aquifer testing to delineate the aquifer conditions at the trial sites. One aquifer test, i.e., pumping test, has been conducted by BADC in the same union of Naldanga upazila to understand the overall aquifer geometry and aquifer characteristics that include vertical and horizontal hydraulic conductivity, transmissivity, storage coefficient, and specific yield. Pipes have been installed at 8 monitoring wells (at 0 m and 50 m distances from the existing 4 ASR structures) to automatically monitor groundwater levels on a regular basis. High-resolution observations of the groundwater level and rainfall will be made at Naldanga, Natore and Dacope, Khulna sites near the center of the recharge facility (i.e., at 0 m distance from the ASR trial sites) and at a sufficient distance from the recharge facility (i.e., at around 50m from the ASR). Both sites will be equipped with automated data loggers (i.e., groundwater level loggers installed with a tipping bucket rain gauge) which have been already procured. Pre-monsoon water quality tests have been completed at four locations. Water quality will be tested four times a year at three monthly intervals coinciding with the pre-monsoon, monsoon, post-monsoon and dry seasons.

Conclusions: Given concerns over undesirable water quality changes due to the implementation of ASR, the study will closely observe the contribution of the injectant, hydro-geochemical quality of the infiltration water, response to rainfall events and flooding, etc. at four ASR trial sites (i.e., Natore, Rajshahi, Tangail, and Khulna). The opportunity of using the ASR setup in the saline coastal areas, namely, Khulna, will also be explored. In this regard, so far, aquifer mapping, pumping tests, fortnightly water table observations and water quality tests have been conducted at the ASR trial sites.

29. Project Code and Title: TF79-So-E/20. Shifting of conventional agriculture towards high value enterprise for better livelihood of the rural people

Implementing Organizations: Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh Agricultural Research Council (BARC), Dhaka, Seba Sangstha (NGO)

Principal Investigator: Dr. M. Zulfikar Rahman, Professor, Department of Agricultural Extension Eucation, BAU, Mymensingh

Locations: Haor areas of Itna (Kisherganj), Trishal (Mymensingh), Kapasia (Gazipur), *char* lands of Gaibandha, Bandarban (Chattogram Hill Tracts), Satkhira Sadar

Budget: Tk. 198 lakh

Duration: December 2021 to November 2023

Introduction: Development of technologies and innovations has resulted in gradual shifts of the traditional rice monoculture system to diversified and modern technology oriented specialised farming systems greatly impacting livelihoods of the farming communities in rural Bangladesh. However, constraints like sub-optimal use of agricultural land, improper use of technologies, labor price fluctuations, rural migration, conversion of agricultural land to non-farm establishments like brick kilns, gas stations, industries and rural settlements, riverbank erosion, water logging, natural hazards and disasterse etc. have been restraining rural economic growth in the country. This project will assess the impacts of the shifts of conventional farming towards high value crops and enterprises focusing on shifts from traditional rice varieties to short-duration varieties, rice and other crop lands to pond aquaculture and shrimp/*gher* culture, homestead space to poultry rearing, char land to sandbar farming and natural vegetation in hill areas to fruit orchards.

Objective: To assess the extent and nature of livelihood changes among rural people due to shifts of conventional agriculture to modern technology oriented, high-value farming systems, identify the drivers of such shifts and evaluate the emerging opportunities and challenges in shifts towards high-value enterprises.

Materials and Methods: The project work comprised visits to the study areas for preliminary assessment of the locations and meetings and discussions with concerned officials of the Department of Agricultural Extension (DAE), Department of Fisheries (DoF) and Department of Livestock Services (DLS), focal group discussions (FGD) and Key Informant Interviews (KII) questionnaire preparation.

Results and Discussion: The study will be conducted at six locations of Bangladesh to study specific shifts in farm enterprise. The project began with the visit of the concerned research teams to selected study areas for preliminary assessment of the locations. Meetings and discussions took places with the concerned officials, mainly the upazila level officers of DAE, DoF and DLS. The specific study areas for data collection were selected based on the opinions of the concerned officers. KIIs were conducted with the concerned upazila level officers viz., Upazila Agriculture Officer (UAO), Upazila Livestock Officer (ULO) and Upazila Fisheries Officer (UFO). At the same time, FGDs were conducted with groups of farmers in the selected study areas. The FGD and KII results were used for finalizing the field survey questionnaire. The development of questionnaire for data collection is in progress.

Conclusions: The project is expected to yield important information on the present situation, trends and drivers of transformation of agriculture towards high values crops and enterprises in Bangladesh. The output may contribute to the development of appropriate strategies for further development of the agricultural sectors as farmers of the country head towards commercial farming from the traditional subsistence agriculture.

30. Project Code and Title: TF80-NRM/20). Development of biochar enriched fertilizer for enhancing nutrient use efficiency in agriculture

Implementing Organizations: Patuakhali Science and Technology University (PSTU), Patuakhali and Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Professor Dr. Shamim Mia, Department of Agronomy, PSTU

Locations: Department of Agronomy, PSTU and Soil Science Division, BARI, Gazipur

Budget: Tk. 50 lakh

Duration: December 2020-November 2023

Introduction: Nutrient use efficiency of agricultural crops in Bangladesh is low due to small reactive surfaces in soil. Application of organic matter including biochar could potentially increase the reactive surface areas in soil resulting in a better use efficiency of nutrients applied with fertilizers. The effect of biochar in enhancing

nutrient use efficiency, however, would depend on its surface properties. It is, thus, important to produce function-specific biochar. This project aims at producing biochar with different functional groups that would bind nutrients with positive or negative charges.

Objective: To produce both positively and negatively charged biochar.

Materials and Methods: For the production of positively charged biochar, biomass (sawdust) was collected from a local saw mill and dried at 105°C. The biomass was then loaded with different minerals (Fe, Al, Mg) and their combinations. The minerals were added as 0.5 M solutions while the biomass to solution ratio was maintained at 1:2. The mixture was then dried overnight at 60°C, wrapped with aluminum foil and placed in a slow pyrolysis kiln. The pyrolysis temperature was monitored at different residence times. The temperature was increased from ~300°C at the 2nd hr to 807°C at the 28th hr. The temperature was then decreased gradually in the next 20 hrs to 350°C at the 48th hr.

Results and Discussion: As can be seen in Table 15, the production of biochar was significantly higher for the mineral loaded treatments (~60%) while it was the lowest for the control treatment (~30%). A higher production rate was possibly due to a higher metal content in the biomass because metals are less prone to loss upon heating. However, it is not known yet whether mineral doping can reduce carbon loss through chemical interactions.

Conclusions: Preliminary results suggest that good quality biochar can be produced in slow pyrolysis kilns. Production of biochar was high with mineral loading of the organic biomass. The project is expected to fine tune the process of biochar production through future trials and tests.

Table 15. Biochar production rates with different treatments

Treatment	Biochar production rate (% of initial biomass)
Control	29.57±0.48 c
Al-doped biochar	61.53±0.54 a
Fe- doped biochar	64.23±2.83 a
Mg-doped biochar	60.17±1.34 ab
Fe, Al and Mg	53.65±1.93 b

31. Project Code and Title: TF81-NRM/20. Intervention in surface water utilization through integrated minor irrigation schemes for escalating water and land productivity in coastal region (ISIMISC)

Implementing Organization: Bangladesh Rice Research Institute (BRRI)

Principal Investigator: Dr. Mir Nurul Hasan Mahmud, SSO, Irrigation and Water Management (IWM) Division, BRRI

Locations: Sadar upazilla of Patuakhali district and Taltali upazila of Barguna District

Budget: Tk. 115 lakh

Duration: March 2021 to February 2024

Introduction: The fallow or single cropped agricultural lands in the coastal region of Barishal is a potential target for expansion of Boro rice cultivation to increase the cropping intensity. To grow Boro rice, low-salinity surface water, particularly water from the rivers Buriswar and Bishkhali, can be used through integrated minor irrigation schemes. This project is designed to study the possibilities of increasing water and land productivity through efficient water diversion, modern distribution systems and judicious water management practices. The project will also try to determine the most water-efficient cropping patterns in the target areas.

Objective: Increasing land and water productivity through water-saving technologies and water-efficient cropping patterns in the coastal districts.

Materials and Methods: The project work will comprise: 1) monitoring of river and canal water salinity--measurements of water EC at 15-day intervals during November to March each year, 2) survey of canal systems to assess the availability of suitable water resources in two selected polders-- canal dimension (width and length) measurements using GPS techniques and satellite image referencing and ground truthing,

3) determiming water-efficient cropping patterns-- six rice-based cropping patterns (Table 16) will be tested, crop water requirements and sytetem productivity will be evaluated.

Table 16. Six cropping patterns to be tested for water use efficiency and system productivity in the southern coastal districts

Cropping pattern		
Wet season	Dry season	Early wet season
T. Aman	Fallow	Fallow
T. Aman	Boro	Fallow
T. Aman	Fallow	T. Aus
T. Aman	Sunflower	T. Aus
T. Aman	Pumpkin	T. Aus
T. Aman	Watermelc	T. Aus

Results and Discussion: A comprehensive map with the canal and river systems of Polder No. 44 of Taltali upazila of Barguna has been prepared using QGIS computer tools (Fig. 32). The area in Polder 44 is about 20,035 ha. The length of canals is 175 km. The available water resources in the canal system amount to about 135,00,000 m^3 which can provide for irrigation for about 1200 ha of Boro rice.

Two FGD's were conducted in the Auliapur union of Patuakhali sadar upazila and Chotobogi union of Taltali upazila of Barguna. The farmers have been traditionally reluctant to cultivate Boro rice although abundant fresh water, suitable for irrigation, is available in many canals and rivers. Farmers' reluctance to grow Boro rice appeared to have emanated from unavailability of low lift pumps and power tillers, labor shortage, lack of seeds and knowledge of Boro rice cultivation and a conventional mindset against dry season rice.

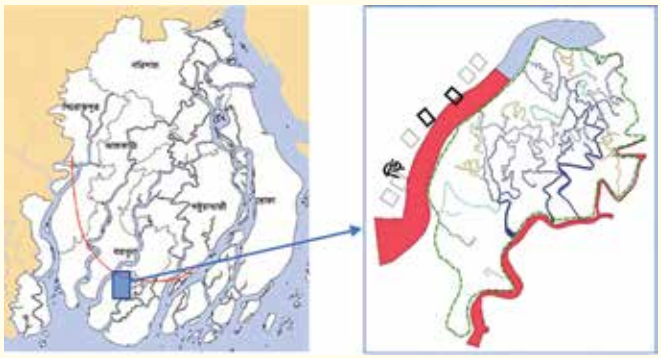


Fig. 32. Map showing river and canal system of Polder no. 44: Red and blue marks in the river indicate saline and nonsaline water, respectively

Plots for the cropping pattern experiment were established in Patuakhali Sadar and Taltali of Barguna. The first component crop, T. Aman rice 2021 was transplanted.

Conclusions: Preliminary findings revealed that hundreds of ha can be brought under Boro rice cultivation and increase cropping intensity in the southern coastal districts of Patuakhali and Barguna by irrigating lands with available but hitherto untapped non-brackish water reserves in canals and rivers. However, there are such constraints in cultivating Boro rice in this region as lack of agricultural machinery and farmers' mindset. Water use technology development and dissemination and farmers' training on the cultivating modern Boro rice varieties are expected to overcome the constraints.

32. Project Code and Title: TF 84-SoE/20. Adoption of climate resilient crop varieties in selected environmentally vulnerable areas of Bangladesh and its impact on farm productivity

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh

Principal Investigator: Dr. Hasneen Jahan, Professor, Department of Agricultural Economics, BAU, Mymensingh

Locations: Satkhira (salinity affected), Jamalpur (flood affected), Chapai Nawabganj (drought affected area), Sunamganj (haor), Thakurgaon (drought and high temperature), Meherpur (high temperature and blast affected)

Budget: Tk. 70 lakh

Duration: March 2021 to February 2024

Introduction: Bangladesh is one of the countries in the world worst affected by climate change. Adoption of agricultural technologies that can withstand climatic stress is crucial for maintaining food security in the

country. Development of nutrient-rich stress tolerant crop varieties is a good option to achieve and maintain food security in the face of threats from climate change. It is, therefore, essential to study factors influencing farmers' decisions to adopt climate resilient crop varieties, constraints and opportunities that exist in this adoption process, impact of adoption on farm profitability and productivity, etc.

Objective: To study climate resilient crop adoption trends among farmers and related economic performances.

Material and Methods: The project is designed to survey 1,200 farmers of whom 800 will be rice farmers and the 400 will be wheat farmers, and 600 will be adopters and 600 will be non-adopter farmers. In total 18 (6 locations x 3) focal group discussions (FGDs) and key informant interviews (KII) will be conducted. Socioeconomic characteristics of farmers, logit regression analysis, Problem Confrontation Index (PCI), gross margin, net return, benefit-cost ratio (BCR), Cobb-Douglas production function will be run to achieve the objectives. Statistical tools (t-test, Chow test) will be used to examine the differences between adopter and non-adopter farmers.

Results and Discussion: So far, consultations with the DAE officials and researchers of BRRI, BINA and BWMRI have been done to select crop varieties based on their climate resilience. On the basis of these consultations, 6 upazilas, Nachole (Chapai Nawabganj), Shyamnagar (Satkhira), Islampur (Jamalpur), Bishwambharpur (Sunamganj), Ranisankail (Thakurgaon) and Gangni (Meherpur) were selected as the study locations. A detailed questionnaire has been developed for the survey. The questionnaire includes household socio-demographic information, household asset information, land and cropping pattern information, cost and return information of crop, problem and prospect of specific variety, market and credit information, farming problem, and particular opinion about the climate resilient variety. A good number of enumerators (30) have been selected from among students of the Agricultural Economics and Rural Sociology Faculty of BAU to collect data from various locations. Though most of the enumerators have experience of data collection, an intensive training on the questionnaire is designed for the enumerators so that the quality of data is ensured. The questionnaire has been pre-tested in the field with farmers (Fig. 33), and a final questionnaire has been prepared with some modifications for the survey. The questionnaire will be transferred to the tab and data will be collected electronically. For cost and return analysis, data will be collected seasonally (Aus, T. Aman, Boro) after crop harvests so that farmers can provide proper information.

Fig. 33. Pre-testing of questionnaire on climate resilient crop variety adoption with a farmer

Conclusions: This research is expected to generate knowledge and information regarding adoption of climate resilient crop (rice and wheat) varieties. This information will be helpful for farmers, extension workers, researchers, and other stakeholders, and will also help the government in policy formulation.

4.1.2 Commissioned Research Program (CRP)

4.1.2A 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 areas where the soil and climate are most 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 land potential for higher agricultural output under different crops/cropping patterns in selected upazilas of Bangladesh. The GIS based approach for crop zoning will assist in identifying land capable of producing high agricultural output. It would facilitate location specific information on suitable crops ensuring sustainable use of scarce land and water resources. It may be mentioned here that the government, in the in the 8th Five Year Plan (FYP), has included and emphasized crop zoning policies and strategies for the crop sub-sector of Bangladesh agriculture.

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 the committees were 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 and soil surveys done by SRDI. The methodology for land suitability assessment and crop zoning has been finalized. Existing 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 issues toward the development of an effective crop zoning system of Bangladesh.

Results and Discussion: An online GIS based software, Crop Zoning Information System (CZIS), has been developed and uploaded to the government National Data Center (NDC) cloud. The different modules of the software are being tested with input data and the output checking is continuing to verify its appropriateness. The land type classification module, as developed, will segregate land type within the mapping unit of soil and landform map of the Upazila Nirdeshika. The land and soil properties map layers have been prepared based on land type and soil group. The edaphic suitability module enables assessment of physical suitability of crops whereas the agro-climatic module facilitates climatic suitability assessment of crops. Bio-physical suitability

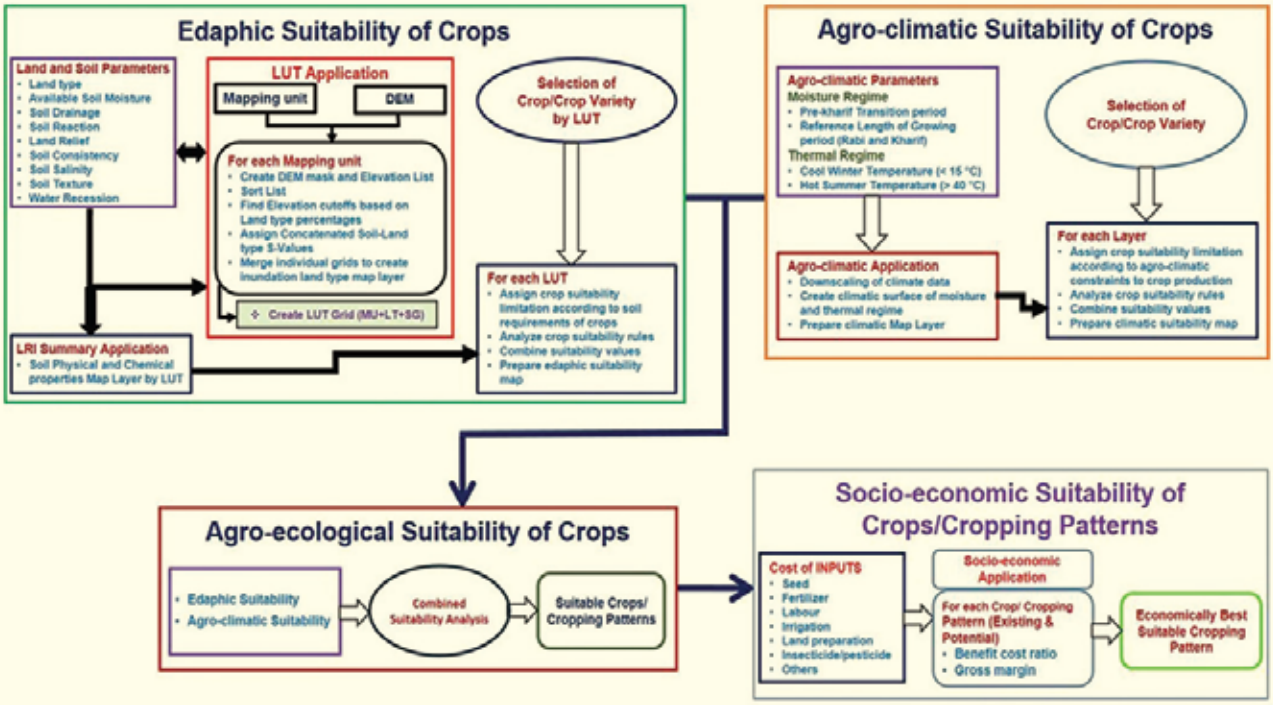


Fig. 34. Conceptual framework and processes of crop suitability assessment

of crops has been evaluated through combining agro-edaphic and agro-climatic suitability modules (Fig. 34). These have been determined based on the criteria stated in Land Resources Appraisal of Bangladesh [FAO/UNDP (1988)]. Besides, a mobile app named 'Khamari' ('খামারি') has been developed (Fig. 35) as a handy tool to empower farmers and other agriculture stakeholders with much needed information relevant to agricultural productivity. The app can be downloaded and installed from the Google Play Store or from www.cropzoning.gov.bd. Users of the CZIS/mobile app will get location based information on suitable crops, profitable cropping patterns, crop varieties with their yields and durations, crop specific fertilizer recommendations, upazila-wise crop zoning information and upazila-wise cropping pattern information with gross margins and BCR. Also, an agri-advisory portal has been developed for providing information relevant to agricultural development. A dashboard of the crop zoning system has been developed for quick and easy access of information. The website address of the above application system is www.cropzoning.gov.bd. The crop zoning outputs have been validated at the field level in 114 upazilas along with desk validation.

Fig. 35. Cell phone app 'Khamari' ('খামারি'): A handy tool to guide farmers

Conclusions: The Government of Bangladesh has included crop zoning in FYP 8 (2020-25) considering its importance in sustainable agricultural development. 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 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. Once the crop zoning system is fully operational it will fulfill the much awaited decision support tool needed for knowledge based, pragmatic agricultural production planning.

4.1.2B Recently Inititated Projects

34. Project Code and Title: CRP-II. Modeling climate change impact on agriculture and developing mitigation and adaptation strategies for sustaining agricultural production in Bangladesh (Phase-II)

Implementing Organizations: Bangladesh Rice Research Institute (RRRI), Bangladesh Agricultural Research Institute (BARI), Bangladesh Agricultural University (BAU), Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU)

Coordinator: Dr. Jatish C Biswas, KGF

Location: All Bangladesh

Budget: Tk. 1068.19 lakh

Duration: December 2020 - November 2023

Introduction: The global mean surface temperature during 2006-2015 was 0.87°C higher than that averaged over the period 1850-1900. Increases in temperature and atmospheric CO_2 level adversely affected natural resources. The yields of crops, fish and livestock are likely to decrease in the future, which need to be evaluated. In the first phase of the project, the effect of climate change on crops, mostly rice, wheat and maize, was evaluated. To assess the impact of climate change on agriculture as a whole, the project work needs to be expanded to include, in addition to crops, livestock and fisheries identifying the vulnerable regions. The second phase of the project is designed accordingly with a view to generating information that can be used to delineate greenhouse gas reduction strategies and develop and fine tune suitable climate smart crop, livestock, fisheries and resource management options for sustainable agricultural enterprises in the future.

Objective: Assessment of climate change impacts on Bangladesh agriculture and delineation of adaptation and mitigation strategies for sustained productivity.

Materials and Methods: Field and laboratory experiments were conducted. Socio-economic need based data were collected through field surveys and from secondary literature. Greenhouse gas (GHG) emissions were estimated based on measured data (static closed chamber technique) and data from secondary sources. Landsat 8 OLI and MODIS Terra/Aqua satellite imageries were utilized along with GIS and remote sensing techniques, use of CERES-Rice, APSIM and SimCLIM climate models. Analyses were done following standard protocols.

Fig. 36. Collection of sample from field to measure GHG emission

Table 17. Estimated grain yield reduction with elevated air temperature at different locations of the country

Location	Normal grain yield (kg/ha)	Yield reduction (%) with projected temp. (°C) rise			
		1	2	3	4
Dinajpur	5579	0	18	31	39
Rangpur	6150	0	16	33	42
Bogura	5330	10	25	35	51
Rajshahi	5837	8	26	35	44
Jashore	6011	16	27	40	51
Satkhira	6191	13	33	41	51
Mymensingh	5843	19	33	42	56
Cumilla	6251	19	35	49	57
Barishal	5886	16	34	41	51
Chattogram	5252	16	34	43	51
Moulvibazar	6346	5	24	39	51
Faridpur	6286	17	30	43	53
Patuakhali	5969	16	33	44	51
Chandpur	4893	16	31	48	61
Gazipur	6118	3	17	33	41

balance (NECB) was -487.6 to -976.0 kg C/ha depending on the crop investigated. Irrigation water management greatly contributed to indirect GHG emission (29.82%) followed by fertilizer application (6.46%). Detailed investigation is needed in this field.

In the project expereiments, NPK briquette and prilled urea gave the highest N_2O emission peak, higher than that from N fertilization with urea supergranule (USG) for maize, wheat and potato. In the Boro season, shoot length and dry matter, seedling strength and photosynthetic pigments of 5-10 day-old seedlings were reduced drastically at 5-10o C. Fish egg number and its diameter increased with augmented water temperature up to a certain limit.

Results and Discussion: Information based on 40 models and the modified Mann-Kendall test under RCP4.5 and RCP8.5 emission scenarios indicated that there could be a significant increase in precipitation in the months of March, May, June, July, August, September and October during 2011-2040 and 2041-2070 periods under RCP4.5. The study based on the CERES-Rice model in DSSAT indicated that the growth duration of BRRI dhan28 could be reduced by 30 days in Moulvibazar in a 4°C temperature rise scenario. Reduction in grain yield could be 0-17%, 16-35%, 31-49% and 39-61% (Table 17) from that under normal conditions in the event of seasonal mean temperature increases by 1°C, 2°C, 3°C and 4°C, respectively. The CH_4 emission/sequestration situations in rice-wheat-maize cultivation for top 20 rice-producing countries were estimated. In 2018, China produced the highest amounts of CH_4 and the lowest amount was produced by Democratic Republic of Congo (Fig. 37). Total GHG emission from paddy fields was the highest in China and the position of Bangladesh was 6th among 10 Asian rice-producing countries. The net ecosystem C

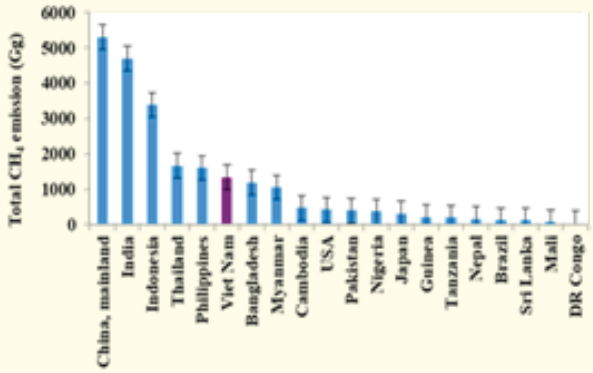


Fig. 37. Methane emission from paddy fields in top 20 rice producing countries during 2018; vertical lines on the bars indicate SE

Conclusions: As temperature rise is projected to severely affect agricultural production, development of climate smart varieties/breeds and their adaptation will be of prime importance in the future. Stronger efforts are needed to measure real life GHG emission from crop fields and other agricultural enterprises.

4.1.3 Capacity Enhancement Program (CEP)

4.1.3A 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 agricultural research result/information are crucial for researchers both for 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 information for evaluating strengths and weaknesses of earlier work and initiating 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 communication 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. The total number of entries into the database reached 34,928 by 2020-21, new entries numbering 8,428. This database is readily available and accessible at http://armis.barcapps.gov.bd for any interested user from anywhere in the world. The contributions by different organizations are shown in Fig. 38. During the reporting period 23 hands-on training sessions were held at institute levels where a total of 545 scientists/academicians (users and focal points) were trained.

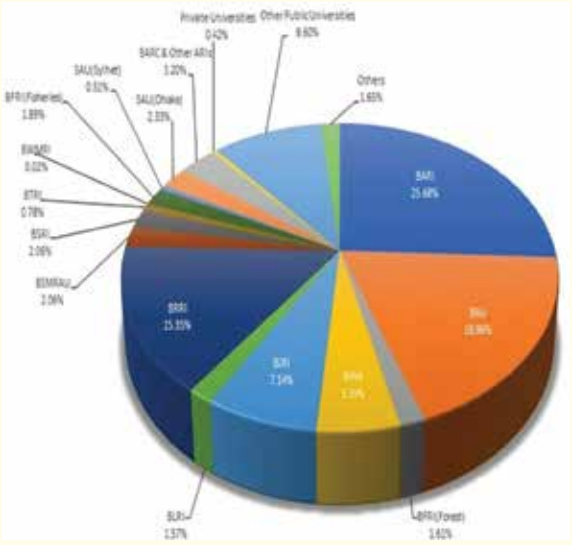


Fig. 38. Contributions (% of entries) by different organizations to the ARMIS database

Conclusion: 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 reviewing and evaluating earlier work, identifying gaps, avoiding unnecessary repetition and, based on need analysis, beginning new research work.

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 feed, soil conditioners and manure, bio-agents against pests and diseases of crops, and in industries as gums and chemicals. However, not much is known about seaweeds, their collection from the Bay of Bengal and their utility and value in Bangladesh. Some people of Saint Martin's Island (SMI) and Nuniachara, 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 collection of seaweeds and their round the year cultivation and demonstration of their multipurpose uses.

Materials and Methods: 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. Farming/cultivation of seaweeds in open sea is being carried out using the one-step seed production method at Nuniachara of Cox's Bazar Sadar upazila. Five other locations such as, Moheshkhali, Sonadia, Choufoldondi, Nazirartek, Rejukhal were selected later on and preliminary field trias are being conducted. In Saint Martin's Island (SMI), 215 different species of seaweeds from 102 groups have been recorded. Since the beginning of the project, each year about eight commercially impotant seaweeds have been collected with the help of professional scuba divers for adaptive trials. Moreover, some other seaweeds viz. *Gracilaria tenuistipitata*, *Ulva rigida* and *Ulva linza* were collected from Nuniachara and Fishery Ghat of Cox's Bazar and Noapara of Teknaf, respectively. One species, *Hypnea boergesenii*, was collected from Inani Beach of Ukhiya district. These seaweeds were used to produce "one-step" and "multi-step" seed production. The farming/cultivation of seaweeds in open sea was carried out using the one-step seed production method. Capacity building work for researchers, extension experts from the Department of Agricultural Extension (DAE) and local farmers was continued.

Results and Discussion:

• *Gracilaria tenuistipitata* can be grown in open sea using one step seed and semi floating method during October to March of the year. The highest yield was obtained in December when the water turbidity was the lowest (Table 18).

Table 18. Monthly variation in the yield of the seaweed Gracilaria tenuistipitata and water quality paratmeters in open sea culture, October 2020 to March 2021, Nuniachara, Cox's Bazar

Month	Seaweed fresh wt. (t/ha)	Seaweed dry wt. (t/ha)	Water temp. (ºC)	Water salinity (‰)	Water turbidity (NTU)[1]	Water pH
October'20	3.68±0.63	0.65±0.11	30.63±0.95	21.35±1.31	49.92±10.53	8.01±0.13
November'20	8.74±0.69	1.54±0.12	29.15±1.51	21.27±1.91	42.50±11.93	7.34±0.26
December'20	10.60±0.59	1.87±0.10	29.11±1.20	25.55±1.23	20.25± 9.71	7.73±0.34
January'21	7.07±0.60	1.25±0.11	22.58±1.82	27.77±1.65	22.76±3.25	7.14±0.57
February'21	8.28±0.56	1.46±0.09	25.33±2.87	30.00±1.61	26.89±4.38	7.46±0.23
March'21	5.20±0.50	0.92±0.08	29.22±1.69	31.65±1.31	30.07±3.25	7.41±0.20

[1]Nephelometirc Turbidity Unit

• For *Ulva lactuca*, the best time to grow in open sea was found to be January-April of the year. Multi-step seeds of this seaweed can be produced in the laboratory during July to September and seedlings can be produced and reared till December. Finally, from laboratory developed seedlings one-step seeds can be produced and grown in open sea for large scale production. The highest yield of Ulva lactuca at Nuniachara was obtained in the month of March, which was 4.92 t/ha fresh *Ulva lactuca*, the drying of which yielded 0.79 t/ha. In January, the fresh yield was 3.25 t/ha (0.52 t/ha when dried) which was the lowest among the three months. Yield gradually increased from January to March.

Fig. 39. Dr. Shaikh Bokhtiar, Executive Chairman, BARC and other dignitaries visiting the seaweed demonstration plot at Nuniachara, Cox's Bazar

• Agar was extracted from a locally available seaweed species, *Gracilaria tenuistipitata*, in the Seaweed Research Laboratory of OFRD, Cox's Bazar. A new protocol to produce agar was developed which yielded 8 g agar from 50 g dried *Gracilaria tenuistipitata*, amounted to 16% agar on dry weight basis.

• FT-IR spectra was used to study chemical bonding of the extracted agar. The peaks indicated the presence of 3,6-anhydrogalactose bridges confirming the composition of the extracted agar.

• Seaweeds grown under deep sea were collected by scuba divers from SMI and transferred to Cox's Bazar. To find out their adaptability and productivity in open sea, an experiment was set up at Nuniachara and Rejukhal. The environment and water quality of these two areas are very different from that in SMI. Due to high temperature and turbidity, seaweeds did not survive long. Among seven species, *Chrysymenia* was alive for 5 days at Nuniachara and 10 days at Rejhukhal. The green seaweed *Caulerpa maxicana* survived 4 days and 9 days at Nuniachara and Rejukhal, respectively. *Sargassum, Hypnea* and *Caulerpa fergusonii* decomposed after 5 days of seeding. On an average, the survival rate of seaweeds was higher at Rejhukhal than that at Nuniarchara.

• *Ulva lactuca* and *Gracilaria tenuistipitata* can be grown in indoor conditions using the Von Stosch Enriched (VSE) seawater medium, keeping light intensity lower than 100 µE m^{-2} s^{-1} and temperature between 20 to 30ºC, with a 10:14 L:D period for around six months from October to March. Germanium dioxide (GeO_2) is very much effective in controlling diatoms.

- Removal of epiphytes from tips of *Gracilaria tenuistipitata* using the agar drag technique during tip culture in laboratory was found effective. After dragging in agar media, tips were grown separately in VSE medium, seawater enriched with *Gracilaria* extract medium and in only seawater. Tips grew well in VSE seawater compared with the other two media.
- Two species (*Gracilaria tenuistipitata* and *Ulva lactuca*) were selected for releasing as BARI seaweed varieties. These two varieties have great potential as food items and medicinal herb.

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. Two seaweed species, *Gracilaria tenuistipitata* and *Ulva lactuca*, were successfully grown in open sea in Cox's Bazar. These two species (*Gracilaria tenuistipitata* and *Ulva lactuca*) were selected for releasing as BARI seaweed varieties. Post-harvest processing of seaweeds was carried out and some recipes were developed. Trials are in progress for optimizing the procedure of agar extraction from seaweeds like *Gracilaria tenuistipitata*. Measures were taken to explore seaweed markets and building up awareness among local farmers and entrepreneurs. These findings and initiatives hold promise for the commercial exploitation of a hitherto unutilized marine resource of the country.

4.1.4 International Collaborative Program (ICP)

4.1.4A Ongoing Projects

37. Project Code and Title: ICP-II. Nutrient management for diverse 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 and decreasing arable lands 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, prevent the use of unbalanced doses or overuse of fertilizers and check the development of nutrient deficiencies. Recent evidences suggest that the yield gaps arising from indiscrepancies between 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.

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. The five major activities of the project comprise: (1) socio-economic and gender aspects of fertilize use, (2) soil fertility and fertilizer management, (3) upscaling

of the technologies, (4) policy suggestions related for fertilizers and (5) human resources development,. The focal 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). In the coastal zone, the focal areas and research hubs are: Dacope upazila, Khulna (AEZ-13) and 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-to-face interviews were current fertilizer use according to farm type, cropping pattern, land type, gender, fertilizer application time for different crops, availability, types and prices 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 existing field problems identified through field visits, discussions with farmers and 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:

- Detailed soil surveys in Dacope, Khulna and Amtali, Barguna revealed moderate to high soil salinity in the dry season, late drainage, low soil fertility particularly in respect of N, P and Zn. Scarcity of fresh water for irrigation and unusual rains are the major environmental constraints to Rabi crop production in the coastal areas. Soil acidity was also found in the Amtali area. With proper management, including mulching, small scale supplemental irrigation with fresh water in the dry season, use of salt tolerant crops/varieties and recommended fertilizers may boost productivity of both wetland and dry season crops in the coastal zone.
- In wheat-mungbean-T. Aman cropping pattern experiments at Ishwardi, either 100% or 125% of recommended doses (RD) of fertilizers gave a superior system yield and economic benefits. However, soil K depletion appeared to continue.
- In the mustard-mungbean-T.Aman cropping pattern experiment at Ishwardi, 120-36-70-40-3-1 kg/ha NPKSZnB brought about the highest yields and economic benefits but soil K depletion still appeared to remain a problem.
- The second cycle (2020-21) results of the "Integrated nutrient management for the rice-based cropping system under minimal soil disturbance practice" trial at Bijoynagar, Godagari, Rajshahi, indicated no significant difference between tillage practices like strip tillage (ST) and conventional tillage (CT) in terms of crop yields Application of 100%/125% of soil test based (STB) fertilizer doses significantly increased crop yields over those obtained with fertilizer doses in farmers' practice (FP).
- RD fertilizers and FP doses gave similar yields of T. Aman rice in the potato-maize-T. Aman rice cropping pattern at Jagannathpur, Thakurgaon during 2020. The highest yield of potato (28.46 t/ha) in 2020-21 was obtained with seed dibbling within the strips and

Fig. 40. Visit to an experimental field at a coastal saline location by scientists from collaborating institutions of Bangladesh and Murdoch University, Australia

mulching with rice straw. The average potato yield in FP plots was 25.48 t/ha.

- Rice straw incorporation significantly increased the yields of T. Aman 2020 rice (BRRI dhan71) and Boro 2020-21 rice (BRRI dhan88) at Paba, Rajshahi. Application of 25% extra fertilizer significantly increased the grain yield of BRRI dhan88 irrespective of residue management and crop establishment method.
- The optimum N, P, K, Zn and B rates for T. Aman rice (BRRI dhan87) and Boro rice (BRRI dhan81) were identified for AEZ 11 (BRRI farm, Rajshahi).
- In a long-term conservation agriculture (CA) experiment on the wheat-mungbean-T. Aman and Boro-Aus-T. Aman cropping patterns, the short-duration T. Aman rice variety, BRRI dhan49, responded well to a high N nitrogen rate of up to 140% of RD, but there was no significant difference in yield between ST and CT or between crop residue management treatments. However, wheat and mungbean performed better with ST and crop residue retention.
- In an experiment on the effect of biochar and compost mixture on N loss through NH_3 volatilization, biochar alone or biochar plus compost mixture significantly reduced NH_3 volatilization.
- T. Aman rice gave a higher grain yield with 140% STB of Zn on a coastal saline soil at Dacope, Khulna.
- The system productivity and economic benefits of the cropping patterns T. Aus-T. Aman-sunflower and T. Aus-T. Aman-sweet gourd were higher with STB + 25% NK fertilizer doses at Amtali, Barguna in the coastal saline zone.
- Grain yields of T. Aman and Boro rice increased significantly with the application of vermicompost at the rates of 1 and 2 t/ha at Dumuria, Khulna. Yield of Boro rice 2020-21 increased significantly with application of vermicompost at the rate of 2 t/ha over 0 and 1 t/ha at Amtali, Borguna.
- Early sown (within November) sunflower gave the highest seed yield (3.5 t/ha) with 150 kg N/ha in the coastal areas of Dacope, Khulna while late sowing (end of December) needed more N. Nitrogen use efficiency of sunflower was found to decrease with delaying sowing time. Use of rice straw mulch increased the seed yield of the crop by ~7%.
- The optimum rate of P for growing sunflower in the coastal areas of Dacope, Khulna was found to be 30-40 kg P/ha. About 75% yield of the crop could be achieved without applying P in the study area.
- The optimum rate of K for growing sunflower in the coastal areas of Dacope, Khulna was found to be 40-60 kg K/ha. About 80% yield of the crop could be achieved without applying K in the study area.
- Wheat could be grown successfully by sowing seeds on wet soil under zero tillage in the coastal areas of Dacope, Khulna. Optimum rates of nutrients for the crop was found to be 120-140 kg N/ha, 20-30 kg P/ha and 40-60 kg K/ha.
- Broadcast Aus rice could be grown successfully in the coastal areas of Dacope, Khulna. The optimum N rate for the crop could be 70 kg N/ha, and P and K were found to have little effect on yield of the crop. About 80% yield of the crop could be achieved without application of P and K.
- The optimum rates of N and P for T. Aman rice in the coastal areas of Dacope, Khulna were found to be 75-95 kg N/ha and 8 kg P/ha.
- The present recommendation of N was found to be optimum for growing maize in the coastal region. Application of urea in three equal splits at 15, 30 and 45 days after sowing (DAS) gave significantly higher yield of sunflower than that with the current practice of application (1/2 basal+1/4 at 30DAS+1/4 at 45 DAS) at Amtali, Barguna. A dose of 36 kg P/ha, i.e., 60% of the present recommendation, was found to be sufficient for growing maize in Dacope, Khulna. Furrow application of P fertilizer gave higher yield of maize compared with the traditional broadcast application.

- For sunflower, 40% to 140% of recommended N, i.e., 42 to 147 kg N/ha produced statistically similar grain yield in Dacope, Khulna. Application of 20% to 140% of recommended P, i.e., 7.2 to 50.4 kg P/ha also produced statistically similar grain yield.

Conclusions: The project activities are ongoing providing useful scientific information so far. The nutrient use gaps between current farmers' practice and scientific recommendations are influenced mainly by category of farmer, crop residue retention, crop rotation, fertilizer use in previous crop, distance to 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 ongoing long-term cropping pattern experiments is in progress. Introduction of a new crop, sunflower, into the existing single crop 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 soil for transplanting of rice) and crop residue retention gave good results in terms crop yields and improvement of soil properties.

38. 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 Bangladesh 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 for work on wheat on saline land. In Bangladesh, BARI is the main agronomic research partner along 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 Barishal 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 conventional practice have not yet been identified. Demonstrations across the Barishal Division with some also in Khulna were a major feature of the Yr3 (2019-20) crop program. In 2020-21, demonstrations, seed production and research experiments on cowpea, field pea, grasspea, lentil and mungbean were conducted. Demonstrations of different pulse crops were performed in farmer's fields by scientists of the BARI On-Farm Research Division (OFRD). To identify salt tolerant pulses and wheat genotypes, popular varieties released by BARI, advanced lines and exotic germplasm were tested under saline conditions. Data on yield and yield contributing traits were collected and levels of soil salinity measured.

Results and Discussion: In experiments on pulse and wheat crops during four consecutive cropping seasons in 2017-18 to 2020-21, line sowing of mungbean (30- 40 cm apart) gave higher seed yield than broadcasting. In trials on weed management of mungbean, one hand weeding significantly reduced the weed population and increased yield. Within the management packages for mungbean, high inputs (line sowing at 30 cm apart, fertilizers @ 20-40-20-10 kg/ha of NPKS, one weeding at 20 days after emergence (DE), irrigation, insect and disease control if needed) gave a higher yield (1373 kg/ha) than that with farmers' practice (1107 kg/ha). In a trial on varietal adaptation of mungbean, BARI Mung-6, BARI Mung-7 and BINA Mung-8 were the highest yielders and their yield levels did not differ statistically significantly from one another. In an adaptation trial on exotic germplasm of cowpea, two high-yielding genotypes CPL-7-17 and CPL-8-17 were advanced to variety release trials. A few other cowpea genotypes, E-32, E- 59, E-97 and E-92, also showed tolerance to salinity up to a certain level. In the evaluation of grasspea germplasm, the genotype IGYT-216 gave the highest seed yield (1166 kg/ha), which was more than that delivered by any of the existing varieties tested. The grasspea genotypes varied in their tolerance of waterlogging stress (10-day waterlogging period). In the adaptive trials, BARI Mung-6, BARI Felon-1, BARI Khesari-3, BARI Motor-3 and BARI Masur-7 performed better than the local cultivars. The wheat genotypes BARI Gom 27, BARI Gom 29, KRL 1-4, KRL 19, BAW 1290, BARI Gom 33, BAW 1147 and BAW 1272 performed well in saline areas of southern Bangladesh. The wheat crosses BioW 6, BioW 12, BioW 31, BioW 50 and BioW 65 performed better than their parents, BARI Gom 25 and BARI Gom 26, in saline areas. Around 10 tons of quality seeds were produced and distributed to farmers, and a total of 2000 farmers including 15% female participants were trained at the demonstration sites.

Fig. 41. Demonstration of field pea in Barishal

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.

4.1.4B Recently Initiated Projects

39. Project Code and Title: (CN/FRPP). ICP IV/2020/1338: Development of short-duration cold-tolerant rice varieties for *hoar* areas of Bangladesh

Implementing Organizations: International Rice Research Institute (IRRI), Dhaka Office and Bangladesh Rice Research Institute (BRRI), Gazipur

Project Leader/Principal Investigator: Dr. Mohammad Rafiqul Islam, Rice Breeder, IRRI/ Dr. Partha Sarathi Biswas, PSO, Plant Breeding Division, BRRI

Locations: Haor areas in Nikli, Kishoreganj district, Ajmeriganj, Baniachong and Sadar, Habiganj district and Biswambharpur and Tahirpur, Sunamganj distric

Budget: Tk. 137,049 lakh

Duration: September 2020 - August 2025

Introduction: Boro rice cultivation is prevalent in the *haor* areas of Bangladesh. BRRI dhan28 and BRRI dhan29 are extensively grown accounting for more than 90% of arable land. BRRI dhan28 and BRRI dhan29 have average growth periods of 140 and 160 days, respectively, and are typically harvested in mid-April to mid-May. However, the *haor* region has lately been suffering severe flash floods often in the first week of April during which premature rice is totally submerged before harvest. This results in significant losses for farmers and jeopardizes their food security and livelihood. To minimize farmers' losses in rice production due to flash floods in the *haor* region, it is necessary to develop rice varieties that are cold-tolerant during the reproductive stage and have a shorter growth period (120-140 days) with a high yield (6-7 t/ha) level which can be harvested averting the flash floods.

Objective: To develop of cold-tolerant, high-yielding rice varieties with shorter growth duration for the Boro season.

Materials and Methods: Three breeding lines were evaluated in a regional yield trial (RYT) under cold stress and non-stress at 10 *haor* locations. Also, 218 lines were tested for cold tolerance at the reproductive stage, 68 lines tested in advanced yield trials (AYT) at three sites, 260 IRRI lines evaluated at Habiganj and 6,317 fixed lines in line stage testing (LST) against 20 trait single nucleotide polymorphism (SNP) markers to identify superior lines for cold tolerance, high amylose content and disease and insect resistance. Around 33,500 F2-F5 progenies were advanced in the rapid generation advance (RGA) nurseries and 1,521 plants of 21 parents and 232 plants of 13 F1s and their parents were genotyped using 10 QC (quality control) SNPs for parental purification. Seventeen lines and 250 gene bank entries were screened for cold tolerance at reproductive and seedling stages.

Results and Discussion: Two IRRI breeding lines, IR100722-B-B-B-B-11 and IR100723-B-B-B-B-61, showed a 2.0 t/ha yield advantage over the check variety BRRI dhan28 with similar growth duration under cold stress. These lines also showed superior performance in non-stress conditions, with an average yield of 7.6 t/ha while BRRI dhan28 yielded 6.6 t/ha with similar growth duration. Importantly, these two lines had acceptable levels of amylose (26%) and protein (8.5%) in grain. In an observational yield trial (OYT), 25 breeding lines with a growth duration of 150-156 days gave a substantially higher yield under both cold and non-stress

Fig. 42. BRRI and IRRI rice breeders on a field visit in a *haor* area

conditions with a minimal yield loss compared with the cold sensitive check variety BRRI dhan28 across the sites. Seven genotypes with a medium growth duration (151-154 days) yielded 7.19-7.98 t/ha and another seven with a long duration (155-157) yielded 7.53-7.84 t/ha in AYT. Eight lines with an average yield of 7.6 t/ha and growth duration of 142 days, 28 lines having an average yield of 8.9 t/ha and a 147- day growth duration and 9 lines with 9.28 t/ha yield and a 155-day growth duration were chosen from 260 IRRI lines. A set of 384 uniform lines with genes for resistance to the bacterial leaf blight (BLB) and blast diseases and to the brown plant hopper (BPH) insect pest, cold tolerance, acceptable grain quality and an acceptable phenotype were isolated from 6,317 entries tested in LST. In all, 33,500 progenies were advanced in RGA. Twenty high-value crosses were made using genetically pure parents and 11 crosses were confirmed as true F1s through hybridity test using SNP markers. Besides, 3 exotic and 37 BRRI Gene Bbank accessions showed moderate cold resistance at the seedling stage.

Conclusions: In preliminary trials, the IRRI breeding lines, IR100723-B-B-B-B-61 and IR100722-B-B-B-B-11, showed high yield potentials and acceptable grain quality under both cold stress and non-stress regimes and could be promoted to the variety release pipeline. Moreover, advanced breeding lines that were found promising and tolerant to cold stress at the reproductive stage could be evaluated further to identify suitable lines for the *haor* ecosystem.

4.1.5 Technology Piloting Program (TPP)

4.1.5A Completed Projects

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 Organizations: Bangladesh Agricultural Research Institute (BARI), Grameen Unnayon Prokolpo (GUP), a partner NGO of MCC, Bangladesh

Principal Investigator (PI): Dr. Mossammat Shamsunnahar

Location(s): Horticulture Research Center, BARI, Gazipur, Shahjahanpur upazila of Bogura district and Churamonkathi under Jashore sador upazila, Jashore

Total budget: Tk. 8144045.00 lakh

Duration: January 2018 to April 2021

Introduction: Soil-borne plant pathogens, e.g., fungi, bacteria, nematodes etc. 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 implemented to disseminate and popularize the eco-friendly technology among 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 herzanium*) 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 the yield of ginger. The technology was slected for dissemination through a TPP project. 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. 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. In 2020-21, as the pilot project involved research and extension work, one NGO, GUP (Grameen Unnayon Prokolpo), Shahjahanpur, Bogura and RARS, BARI Jashore were involved as implementing component organizations. The bio-control agent *Trichoderma harzanium* was multiplied in the laboratory using Yeast-Enriched Richards's (YER) solution and sent to all project sites. Training, adaptive and demonstration trials were arranged by the lead organization. Extension experts, local NGOs and researchers worked together for successful completion of the project.

Results and Discussion: About 135 L of mother spore suspension (3 x 1020 cfu/ml) was produced in the laboratory which was used in Tricho-compost and Tricho-leachate preparation. A 192.85 t lot of Tricho-compost and 4960 L of Tricho-leachate were produced. These were used in vegetable production in farmers' fields. One commercial Tricho-compost producer, Mr. Md. Husain Ali, alone produced 95 t of Tricho-compost. He sold about 80% of his product and used the rest in his vegetable fields.

Thirty-five demonstration trials with six winter vegetables crops such as, cabbage, cauliflower, bottle gourd, tomato, brinjal and country bean, and four summer vegetable crops such as, pointed gourd, brinjal, country bean and bottle gourd were completed in farmers' fields in Bogura and Jashore during the reporting period. The use of Tricho products substantially reduced pest damage and increased yields of vegetables (Table 19). This resulted in enhanced economic returns for farmers from vegetable production. The project ended with a message to vegetable farmers that Tricho-products would be helpful in sustainable and safe production of vegetables enhancing farmers'incomes and improving livelihood.

Table 19. Effect of Tricho-products on vegetable crops in farmers' field demonstrations in Bogura and Jashore, July 2020-June 2021

Crop	Results
Cabbage	Disease reduction: 55-65% Yield increase: 32-37%
Cauliflower	Disease reduction: 57-61% Yield increase: 27-29%
Bottle gourd	Fruit damage in treated plot: 1.5-2.7% Fruit damage in untreated plot: 3.6-4.4%
Tomato	Fruit damage reduction: 72-85% Yield increase: 29-34%
Brinjal	Disease reduction: 55-69% Yield increase: 32-38%
Country bean	Pod damage reduction: 55-68% Yield in treated plot: 21-26 t/ha Yield in control plot: 17-20 t/ha
Pointed gourd	Disease reduction: 50-72% Yield increase: 23-29%
Brinjal	Disease reduction: 55-65% Yield increase: 25-37%
Country bean	Disease reduction: 45-59% Yield increase: 30-45%
Bottle gourd	Pest and disease reduction: 45-48%. Yield increase: 31-47%

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 to effectively suppress diseases in vegetable crops.

4.1.5B Ongoing Projects

41. Project Code and Title: TP 20/2020. Productivity enhancement of goor and chewing type sugarcane through management of major diseases

Implementing Organizations: Bangladesh Sugarcrop Research Institute (BSRI), Krishibid Somobay Society Ltd (KSSL)

Principal Investigator: Dr. Md. Shamsur Rahman, CSO and Head, Pathology Division, BSRI

Locations:

Budget: Tk. 205.58473 lakh

Duration: January 2020 - December 2022

Introduction: A project entitled "Productivity enhancement of *goor* and chewing type sugarcane through management of major diseases in non-mill zones" funded by KGF was conducted during September 2015 to December, 2018 which yielded useful information regarding disease management in sugarcane production which needed to be disseminated to farmers in large areas in both non-mill and mill zones for the production of quality foundation and certified seed canes. This technology piloting project was initiated for technology dissemination in 12 districts in the coastal, *char* and flood plain ecosystems in Bangladesh. The moist hot air treatment (MHAT) technology of disease management is being demonstrated for eight sugarcane varieties.

Objective: Disease-free healthy seed cane production in order to increase productivity of sugarcane in both mill and non-mill zones and also to improve farmers' knowledge and skills through training.

Materials and Methods: Four sugar/goor varieties and three chewing varieties of sugarcane were included in the seed production and validation trials, respectively. For foundation seed cane production, 27 foundation seed plots (15 in the 1st year and 12 in the 2nd year) were set up. Seeds (one bud sett) of selected varieties were treated by MHAT at 54°C at relative humidity (RH) above 95% for 4 hours and chemotherapy (sett dipping in 0.2% solution of the fungicide Bavistin 50 WP for 10 minutes). Seedlings were raised in soil-filled poly bags which were transplanted in the field at the age of 30 to 40 days. The foundation seed canes aged 9 to 10 months were used for producing certified seeds. In the 2nd year, 250 certified seed plots were set up at different locations (Table 20). In addition, validation trials were conducted at 5 locations in mill zones. At each location one validation trial plot was set up with selected varieties and local varieties. Selected varieties and modern technologies were used in 50% of the plots while farmers grew their own varieties with farmers' practices. Data on germination, disease incidence, tiller production, millable cane, and yield of cane and recovery of sugar were recorded. Fourteen batches of farmers with 40 participants/batch were trained on modern practices of sugarcane cultivation with intercrops at 14 locations.

Table 20. District and upazila-wise project locations

District	Upazila
Narail	Kalia
Jhenaidah	Kaliganj (Mobarakganj Sugar Mill area)
Manikganj	Singair
Dhaka	Dohar
Sirajganj	Sadar, Kamarkhand
Natore	Lalpur (North Bengal Sugar Mill area)
Chapai Nawabganj	Shibganj
Rajshahi	Sadar (Rajshahi Sugar Mill area)
Joypurhat	Sadar (Joypurhat Sugar Mill area)
Thakurgaon	Sadar (Thakurgaon Sugar Mill area), Haripur
Pabna	Ishurdi
Satkhira	Tala

Results and Discussion:

Foundation seed production

This program was undertaken at 5 locations namely, Sadar upazila of Rajshahi, Kalia upazilla of Narail, Kaliganj upazilla of Jhenaidah, Singair upazilla of Manikganj and Sadar upazila of Thakurgaon. The varities grown were Isd 16, BSRI Akh 41, BSRI Akh 45 and BSRI Akh 46 were grown. BSRI Akh 41 was the highest yielder (136-147 t/ha) while the other varieties yielded 84-106 t/ha (Table 21). There was 0% disease incidence irrespective of

Table 21. Performance of foundation seed cane in farmers' fields at different locations of five districts

Location	Variety	Yield (t/ha)	Brix (%)
Thakurgaon Sadar	BSRI Akh 45	83.79	21.0
	BSRI Akh 46	90.90	20.6
Rajshahi Sadar	Isd 16	96.25	21.2
	BSRI Akh 46	105.35	19.7
Kalia, Narail	Isd 16	93.23	21.5
	BSRI Akh 41	136.45	20.4
Kaliganj (Mobarakganj sugar mill), Jhenaidah	BSRI Akh 45	98.20	20.8
	BSRI Akh 46	105.98	20.6
Singair, Manikganj	BSRI Akh 41	147.03	19.60

variety and location. Across locations, the harvested seeds were used for plantation of 30 certified seed plots (33 decimal each) in surrounding areas (Fig. 44).

Validation trial

The validation trial was conducted at 3 locations namely, Haripur (Thakurgaon), Kamarkand (Sirajganj) and Dohar (Dhaka). At Dohar, the plots were completely destroyed due to heavy rain and flood. At Kamarkhand also, the experimental plots were affected seriously due to heavy rain. However, no disease infection occurred in any plot at any location. The average yield with BSRI recommended technologies was 140 t/ha which was significantly higher than 84 t/ha in the farmers' practice plots. Some of the canes of the validation trial were used as seeds for plantation by the farmer and the remaining were sold in the market.

Fig. 43. Plot for production of certified seeds of sugarcane

Conclusions: The sugarcane production technology using MHAT treated setts, developed by BSRI, gave better control of major diseases and increased yield of sugarcane. Sustainable sugarcane production with high yield and disease-free seeds can be achieved by using certified seeds. Production of foundation and certified seeds is essential to increase sugarcane productivity and farmers' incomes.

4.1.6 Lump Sum Grants (LSG)

4.1.6A Completed Projects

42. Project Code and Title: LSG-1-C/20. Research to find out the reasons for price increases of rice, potato and onion

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

Principal Investiagtor: Dr. M. Mosharraf Uddin Molla, Member-Director, Agricultural Economics and Rural Sociology (AERS) Division, BARC, Dhaka

Locations: Naogaon, Sherpur, Cumilla, Bogura, Rangpur, Munshiganj and Dhaka City, Pabna, Faridpur, Natore, Rajshahi, Kustia

Budget: Tk. 19.885 lakh

Duration: 6 months

Introduction: Prices of rice, potato and onion became highly volatile in 2019-2020 in Bangladesh. Many factors contributed to market instability. Under a directive from the Ministry of Agriculture (MoA), BARC implemented a short-term, intensive research program to identify the causes of price hikes of rice, potato and onion in domestic markets of the country. This project attempted to analyze various factors related to the production, trade, consumption, market prices of the commodities and suggest suitable policy options to control market prices of essential commodities.

Objective: To identify the key reasons of price hikes of rice, potato and onion in 2020 and suggest policy measures to ensure price stability.

Materials and Methods: The study was mainly based on secondary data obtained from different sources. Additionally, some quality data were collected from different stakeholders such as, farmers, wholesalers,

beparis, other traders and consumers through FGD and KII. Demand and supply situations, domestic production and imports, profits, etc. were critically analyzed. The findings were reported out in a national workshop held on January 26, 2021 at BARC in presence of the Minister for Agriculture, Government of the People's Republic of Bangladesh.

Results and Discussion: The study revealed that price hikes of rice were related to, among other things, i) rising cost of production, ii) slowing down by farmers of the sale of rice from their household stocks instead of the usual practice of quickly selling out the surpluses, iii) rice dealers and mill owners anticipated food shortages and hoarded rice, iv) unhealthy business rivalry among big rice mill owners, v) delayed and insufficient domestic purchases, vi) imports of rice and vii) lack of market control by the government. Some of the policy measures suggested to stabilize rice prices were production cost minimization, modernization of the government's domestic stock maintenance policy for paddy/rice, fixing the government purchase price at a 20% profit margin against farmers' cost of production, government purchase-stockpiling of at least 10% of the produce to gain a leverage in market interventions and preventing manipulations by traders' syndicates.

Fig. 44. Honorable Minister for Agriculture, Dr. M. Abdur Razzaque, MP speaking at the national workshop on commodity price hikes, BARC, Dhaka, January 26, 2021

Hoarding of huge amounts of potato in anticipation of future price rises by growers and traders, exports to neighboring countries, lower production compared with the last year, spread of rumors about the production, supply and prices by yellow media and unscrupulous traders, market manipulation by business syndicates etc, were identified as the causes behind potato price hikes. Mitigation measures recommended were i) establishment of a price commission for agricultural produce and fixing maximum and minimum support prices (MSP), ii) greater government control over potato preservation and transactions by the cold storages, iii) creating government stocks of potato, iv) value addition to potato through manufacture of potato food items and v) development and production of potato varieties with high demands overseas, vi) strong punitive measures against price manipulations.

Price hikes of onion were traced to an export embargo by India, market manipulation by traders' syndicates, rumors resulting in an unnecessary purchase spree by consumers, poor government monitoring and market control measures, etc. Suggested policy measures included i) exploring alternative international markets for import of onion during emergency situations, ii) minimizing dependence on imports through an increase in domestic production of onion including summer onion, iii) year round control of prices through the establishment of a price commission, iv) strengthening of government control of the markets including stern measures against dishonest trade syndicates.

Conclusions: This short-term project provided valuable insights into the causes and patterns of the recent price hikes of rice, potato and onion in local markets. The mechanisms of price hikes and syndicates responsible for this were identified. Project scientists suggested policy measures to prevent and arrest such price hikes in the future.

4.1.6B Recently Initiated Projects

43. Project code and title: LSG-4-C/21. Method development for comb honey production

Implementing Organization: Sher-e-Bangla Agricultural University (SAU)), Dhaka

Principal Investigator: Prof. Dr. Mohammed Sakhawat Hossain

Location: Pabna (Apiary: Adarsha Moukhamar, Ishwardi)

Budget: Tk. 10 lakh

Duration: 06 months

Introduction: Honey is a popular drink in Bangladesh especially due to its medicinal value, but adulterated honey or fake honey is also sold in the markets. For this reason, to date, honey in Bangladesh is not a trustworthy product. Due to lack of trust, many honey consumers rely on foreign honey which cost nearly 8.6 crore taka in imports during the fiscal year 2019-2020. However, pure honey can be produced in the country without much difficulty. This project dealt with method development for comb honey (cassette, bottle, plate etc.) production at farm level by using beehive.

Objective: To develop comb honey production method at colony level.

Materials and Methods: An apiary was selected at Ishwardi, Pabna consisting of 40 honey beehives. Twenty strong bee colonies were used to develop comb honey inside a super chamber on each strong bee colony. A litchi orchard was used as the source of nectar. Four methods were used to harvest comb honey: T1= comb cassette, T2= bottle with wax foundation, T3= bottle without wax foundation and T4= only frame in super (control). Data were taken on honey harvest interval (days) and weights of honey in cassette, bottle, frame and super.

Results and Discussion: Honey collection from the super chamber of bee hive was the highest (1.703 kg/frame) in control and the second highest amount (0.495kg/cassette) of honey was harvested from comb cassette method followed by bottle without wax foundation method (0.381kg/unit) and bottle with wax foundation method (0.213kg/unit), respectively in terms of weight per unit. But, in terms of area per super chamber of beehive, the highest (53.546 kg/super) yield of honey was obtained from the comb cassette-beehives which was followed by control (30.638kg/super), bottle without wax foundation (11.433) and bottle with wax foundation (6.405kg/super), respectively. Overall, in terms of area per super maximum honey yield was obtained with the comb cassette method utilizing beehives. The comb cassette method increased honey yield by 74.77% over that obtained with the traditional method during the litchi blooming period.

Conclusions: Comb honey yield with different methods utilized in the beehives varied in comparison with traditional frame honey method. Cassette in the super can be utilized for increasing honey yield in the beehives.

44. Project Code and Title: LSG 5-C/21. Exploring the status and potentials of minor cereals in Bangladesh

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

Principal Investigator: Prof Dr. Md. Rafiqul Islam, Department of Agronomy, BSMRAU

Locations: Coastal areas, Chattogram Hill Tracts, Barind Tract, *Char* lands and Brahmaputra Floodplain

Budget: Tk. 10 lakh

Duration: 6 months

Introduction: Bangladesh faces great challenges in attaining food and nutritional security because of a high population density and little scope for expanding crop lands and cropping intensity. There is a rapidly growing local and global market for diverse and healthy foods, and most of the minor cereals (millets, barley, sorghum, and oats, etc.) are recognized as climate-smart crops and healthy food items. Although these cereals have a long history of cultivation in Bangladesh, research and upscaling have been inadequate so far. Thus, it is necessary to explore the status and prospects of minor cereals in the country.

Objective: Documentation and mapping of cultivation status and prospects of minor cereal crops in different Agroecological Zones (AEZ).

Materials and Methods: Project activities entailed field and questionnaire surveys, productivity and profitability analysis, focal group discussions (FGD), regional workshops, mapping and database creation, secondary data collection.

Results and Discussion: Information on area, yield, and the number of farmers involved in cultivating minor cereals was collected, documented and maps are being produced using GIS tools. During 2020-2021, minor cereal crops occupied 4,813 ha, where 28,420 farmers were involved (Table 22). Barley, millets viz., foxtail millet (*kaon*), proso millet (*cheena*) and pearl millet (*bajra*), and oats were the noticeable minor cereals. The majority of the minor cereal crops were foxtail millets (63.0%), grown in 38 upazilas of which Shariakandi (Bogura), Ulipur (Kurigram), Munshiganj Sadar, and Saghata and Fulchari of Gaibangha districts were the major ones. The highest average yield recorded was 1.93 t/ha for barley and pearl millet followed by other millets and oats. Among minor cereal farmers, the majority (89%) are involved in millets cultivation. The survey indicated that areas under foxtail and proso millets increased 4-7 times during the last five years compared with the BBS report. Barley production also increased to some extent, but sorghum production was not noticeable. Varieties of minor cereals are few, and farmers mostly use traditional varieties. However, cultivation of some improved varieties of foxtail and proso millets and barley was found where there were interventions by research and extension organizations. Varietal improvement, market chain development and value addition are essential for increasing production of these crops. Creating farmers' and consumers' awareness about the health and nutritional benefits of minor ceareals is also necessary.

Table 22. Area, yield and number of farmers cultivating minor cereals in Bangladesh during 2020-2021

Minor cereal	Area, yield and number of farmers	
Barley	Area (ha)	362
	Yield (t/ha)	1.93
	Barley farmers (no.)	2936
Foxtail millet	Area (ha)	3033
	Yield (t/ha)	1.17
	Foxtail millet farmers (no.)	16257
Proso millet	Area (ha)	1358
	Yield (t/ha)	1.30
	Proso millet farmers (no.)	8434
Pearl millet	Area (ha)	30
	Yield (t/ha)	1.93
	Pearl millet farmers (no.)	610
Oats	Area (ha)	30
	Yield (t/ha)	1.08
	Oat farmers (no.)	183
Total	Total minor cereal area (ha)	4813
	Minor cereals farmers (no.)	28420

Conclusions: The study revealed that foxtail millet and proso millet are dominant minor cereals commonly cultivated in *char* areas of Bangladesh. Barley is widespread in the central-west region of the country. Intervention with improved varieties of minor cereal crops and improved agronomic management practices with farmers' motivation is imperative for intensive and extensive cultivation of minor cereals. Varietal improvement, market chain development, and value addition are essential. Creating consumers' and farmers' awareness about the health and nutritional benefits of minor cereals is also necessary.

45. Project Code and Title: LSG 6-C/2021. Invasion of exotic Rugose spiraling whitefly in Bangladesh: A baseline survey study on its geographical distribution, host plants dynamics and infestation severity

Implementing Organization: Bangladesh Agricultural Universityn (BAU), Mymensingh

Principal Investigator: Professor Dr. Gopal Das, Department of Entomology, BAU

Locations: Department of Entomology, BAU, Mymensingh and 14 agricultural regions of Bangladesh

Budget: Tk. 10 Lakh

Duration: 6 months

Introduction: The Rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus*, is a fairly new insect species in the world. This invasive insect pest was first identified in Bangladesh in 2019 in coconut plants at RARS, BARI, Jashore. Later on, its aggressive outbreak has been observed in different districts of the country. It has a large host range worldwide (>118) although its main host is the coconut plant. It has a high reproductive potential with several generations per year. As RSW is a new invader in Bangladesh, its biology, current outbreak scenario in different regions of the country, host range and severity of infestation on different host plants are being studied.

Objective: To study the biology of RSW, identify RSW-infested geographical locations as well as host plants and assess the infestation severity.

Materials and Methods: Details of RSW biology (oviposition and egg-adult period) have been studied on coconut (native and dwarf) and guava saplings under normal temperature and humidity (30.0 ± 1.2°C, RH: 77.0 ± 4.5%) conditions. Moreover, the effect of different constant temperature regimes (e.g. 20, 25, 30, 35 and 40°C) on the developmental periods (days) of different stages of RSW is being studied using an incubator. In addition, a baseline survey is being carried out in 14 agricultural regions to identify the RSW-infested geographical locations, host plants and infestation severity (e.g. % plant, leaf and leaflet infestation, percent leaf area covered with sooty mold fungus etc.) on different host plants.

Results and Discussion:

Developmental period of RSW: Current laboratory study showed that RSW took 35.25 ± 1.20, 35.95 ± 1.25, 36.00 ± 1.35 and 37.50 ± 1.20 days to complete the life cycle on native coconut, Siam green, Siam blue and guava, respectively at 30.0±1.2°C temperature and 77.0 ± 4.5% relative humidity.

RSW-infested geographical locations: Out of 14 agricultural regions, surveys in 20 districts in 7 agricultural regions indicated severe RSW invasion in alsmost all districts.

Host plants: To date, 42 host plants of RSW including fruit, forest, crop, ornamental and flower plants have been identified in 20 surveyed districts. Among them coconut, banana, betel nut and guava were found to be common in all districts.

Fig. 45. Severely infested dwarf Siam green coconut plant (top) and banana leaf (bottom), reflected by the formation of a black thick layer of sooty mold fungus

Infestation severity: About 94% (range: 85-100%) native and 81% (range: 75-100%) dwarf hybrid (mainly Siam green and Siam blue) coconut varieties were found to be infested by RSW (Fig. 45). About 100% coconut plants were found to be infested in majority of the surveyed districts. Very severe infestation (on average 88.35% frond, 76.60% leaflet, 83.56% leaf area covered by sooty mould fungus) was observed on native coconut varieties and less severity was found on hybrid varieties and it might be associated with frequent application of insecticides on dwarf varieties. No appropriate control measures have been taken against this insect pest on native coconut plants in any of the 20 districts surveyed. This is probably the reason for the rapid outbreak of this insect pest across the country.

Next to coconut, banana plants (Fig. 45) were found to be infested severely (35.50-67.34% with the mean of 49.56%). About 45.45% (range: 29.30-65.60%) banana leaves were found to be infested where about 93% leaf area was found to be covered with sooty mold fungus. Moderate to low infestation was observed on betel nut, citrus, guava, mango, jackfruit etc.

Conclusions: This project studies the Rugose spiraling whitefly (RSW), a new insect pest in Bangladesh. To date, 42 host plants have been identified including fruit, forest, crop, ornamentals and flowering plants. Extreme outbreak of RSW was found on native coconut plants in 80% of the surveyed districts. Management measures against this pest need to be developed quickly.

Technical Progress

Livestock

Domestic animals comprise an essential component of farm economy being an important source of farmers' cash income. Today, livestock contributes 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 2020-21, of the total of 68 on-going projects, 15 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 Competitive Grants Program (CGP)

CGP 3rd Call

4.2.1A Completed Projects

46. 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

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 in 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 are essential. Preparatory to vaccine development molecular characterization of the causal agent of Brucellosis and an epidemiological risk factor analysis are 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 serum samples from the Military Dairy Farm (MDF), Savar, and the Central Cattle Breeding and Dairy Farm (CCBDF), Savar, and human serum samples 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), Complement Fixation Test (CFT), Standard Agglutination Test (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 (enzyme-linked immunosorbent assay), conventional PCR with sequencing and construction of phylogenetic tree. Real time PCR and MLVA, Bruce ladder PCR, CFT and SAT were also performed. Dairy cattle found *Brucella* positive with sero-molecular tests were selected for therapeutic trials. Treatment efficacies were evaluated on the basis of haemato-biochemical changes and antibodies levels at pre- and post-treatment values.

Results and Discussion: Out of 1003 serum samples, 43 (26 from CCBDF and 17 from MDF) reacted positive in RBT and out of 1003 milk samples, 14 (8 from CCBDF and 6 from MDF) reacted positive in MRT, 24 in

ELISA and SAT. Among 715 human serum samples 16 reacted positive in RBT in MDF, Savar and MMCH. Numerous pink colored *Brucella* like organisms with a blue background were observed under microscope. On the basis of 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), motility test, *Brucella* species and biovars were determined as *Brucella abortus* biovar 3. For a confirmatory diagnosis of brucellosis, isolation of *Brucella* bacteria is the best method which is also considered as a "gold standard" test. In this study, colonies grown on *Brucella* agar were examined by Modified Ziehl Neelsen staining which revealed that the organism was *Brucella* spp. since there were aggregates of red colored coccobacilli in the microscopic field. Brownian movement was observed under phase contrast microscope at 40×10 X object. Culture positive isolates tested positive in catalase and oxidase tests. The isolate of this study also showed agglutination with the *Brucella abortus* specific serum (Fig. 46). Moreover, the resultant colonies were tested by PCR for further confirmation.

Fig. 46. Agglutination in the *Brucella abortus* specific serum agglutination test

The univariable logistic regression analyses was used to evaluate the association between sero-prevalence of bovine brucellosis with breeds, age, parity, abortion, repeat breeding, retention of placenta and seasons in lactating dairy cows. The logistic regression revealed that breed, age, parity and abortion had significant association with seropositivity of Brucellosis in dairy lactating cows. However, there was no significant difference between sero-prevalence and repeat breeding, retained placenta and season of the year in lactating dairy cows. The epidemiology of Brucellosis is a complex matter due to wide-range hosts, variable status of infection (latent, carrier, sub-clinical and clinical) at both the individual and population levels and several risk factors.

Changes during necropsy in guineapig liver, spleen, heart, lungs and kidney were observed. The change was most prominently observed in spleen as splenomegaly but the color remained unchanged. The liver and heart (endocardium) were congested and histopathological changes in guineapig and fetuses of naturally infected cows occurred. Histopathologic lesion in guinea pig and biologically relevant models can improve understanding of pathogenesis in humans due to similarities in disease development. This histopathological study for the first time in Bangladesh using guinea pig enabled successful detection of pathological changes in major organs after inoculation with aborted fetal contents from cows.

The OD (optical density) value of the serum of guinea pig after inoculation of heat inactivated *Brucella abortus* vaccine was 0.0945 at 0th week and 0.1025 at 1st week which was near about the negative control OD 0.106. After that, the OD value started to rise significantly ($p<0.01$) from the 2nd week (OD 0.2287) and reached to a peak level at 4th week (OD 0.2842) and then started to decline significantly ($p<0.01$) from 6th week (OD 0.1832) to 9th week (OD 0.1015). The OD value of 9th week post vaccination was also near about the negative control OD 0.106. The humoral immune response (antibody titer) between heat inactivated *B. abortus* biovar 3 and the commercially available attenuated *B. abortus* strain RB51 vaccines were compared in guinea-pigs and indigenous cattle. The indigenous cattle (heifer) immunized with killed vaccine showed reciprocal antibodies titers with RBT were found 1: 50 at 7 days, 1: 120 at 14 days, 1: 400 at 21 days, 1: 800 at 28 days, 1: 35 at 40 days and 0 at 60 days. The mean ELISA antibody titer in case of RB51 vaccinated heifer start to increase at 7 days of post-vaccination (OD value 0.094 ± 0.01603) and then increased gradually and reached at

peak at day 60 (OD value 0.592 ± 0.398). After sixty days it started to decline and reached a lower level at day 150 (OD value 0.112 ± 0.0188) and at day 180 (OD value 0.0822 ± 0.00249) antibody titer was found similar to day 0 (0.082600 ± 0.0051). In this study there was a significant rise in the antibody level, so use of adjuvant with this heat inactivated vaccine may produce satisfactory rise of antibody level and may also give a protection against brucellosis for a longer duration.

Dairy cattle found *Brucella* positive with sero-molecular tests were selected for the therapeutic trials. Treatment efficacies were evaluated on the basis of haemato-biochemical changes and antibodies levels at pre- and post-treatment values. *Brucella*-infected cows (pre-treatment) showed significantly ($p < 0.05$) lower values of TEC (6.47 ± 0.45; 7.69 ± 0.68), Hb (8.75 ± 0.87; 10.93 ± 1.56), TLC (3.90 ± 0.21; 7.85 ± 0.76) and neutrophils count (26.80 ± 0.89; 28.96 ± 0.67) in comparison to non-infected control cows, whereas PCV (37.87 ± 1.0 ; 39.33 ± 1.83), ESR (00.6.0 ± 0.1; 00.75 ± 0.13), eosinophils (3.02 ± 0.21; 9.93 ± 0.21) and basophils (2.15 ± 0.42; 0.92 ± 0.11) values were higher in *Brucella*-infected than non-infected dairy cows. Comparison of haematological values between pre-and post-treatment revealed that the TEC (6.47± 0.45; 6.99 ± 0.52), Hb (8.75 ± 0.87; 10.38 ± 1.02), PCV (39.33 ± 1.83; 40.83 ± 1.17) and neutrophils (26.80±0.89 ; 27.20 ± 1.02) increased significantly ($p < 0.05$) at post-treatment, whereas eosinophils (4.93 ± 0.21; 3.93 ± 0.28) and basophils (2.15 ± 0.42; 1.50 ± 0.25) count decreased significantly ($p < 0.05$) at post treatment but the TLC (3.90 ± 0.21; 4.24 ± 0.28) and ESR (0.75±0.13; 0.70 ± 0.08) values did not differ significantly ($p > 0.05$) between pre-and post-treatment values.

The significantly ($p < 0.05$) higher values of serum glucose (77.8 ± 3.37; 72.35 ± 3.55), creatinine (1.82 ± 0.19; 0.96 ± 0.20), total serum protein (6.70 ± 0.37; 5.71 ± 0.37), ALT (23.01±1.27; 31.60 ± 0.71) and AST (95.84 ± 4.36; 75.98 ± 1.24) were recorded in Brucella-infected than non-infected control dairy cows. It appeared that the glucose (77.8 ± 3.37; 71.50 ± 5.73) and AST (95.84 ± 4.36; 91.33 ± 4.45) values decreased significantly ($p < 0.05$) in antibiotic post-treated animals than pre-treatment respective values. Comparison of haematological and biochemical changes between healthy and Brucellosis infected humans were also recorded in this study.

All the four *Brucella*-infected dairy cows treated with antibiotics (oxytetracycline and streptomycin) injections for 48 days tested negative to *Brucella* infection by using sero-molecular methods. These four treated animals receiving dual antibiotics therapy showed significantly ($p < 0.05$) increased level of Hb (10.38 ± 1.02) and PCV (40.83 ± 1.17) in comparison with pre-treatment Hb (8.75 ± 0.87) and PCV (39.33) values. The biochemical constituents especially glucose and AST values decreased in comparison to pre-treatment values. The ELISA results showed that the mean OD value (antibody titer) of the serum of cows infected with *Brucella* was 2.28 at 0 day of therapy and 1.39, 0.98, 1.17 at day 30 and 90 and 180 days, respectively. The OD value started to decline significantly at day 30 ($p < 0.004$) than from day 0 and decrease up to 90 days ($p < 0.0001$) then started to rise at day 180 insignificantly ($p < 0.210$). After completing the therapy (180 days) change of OD value (antibody titer) is statistically significant from the start of the therapy ($p < 0.003$).

Conclusions: *Brucella 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 guinea pigs which persisted for a period of 6 weeks. Mass vaccination of livestock against brucellosis would be cost effective and would bring about net economic benefits. Combined long acting oxytetracycline and streptomycin against clinical *Brucella* infection showed some encouraging results in crossbred dairy cows.

47. 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 Center 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 Guillain-Barre´ 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 was 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.

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 GBS-related *Campylobacter jejuni* in Bangladesh. Questionnaires were developed for assessing the economic loss from 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. Cross-sectional surveys were conducted in 300 dairy farms to confirm prevalence, potential risk factors of zoonotic tuberculosis and campylobacteriosis. The samples (swabs and tissue samples) were collected, and tested via basic (culture, microscopy, biochemical tests and histopathology) and advance techniques (PCR and sequencing) for the both organisms. Knowledge and practices of cattle handlers were assessed through cross-sectional participatory study. Data on financial parameters were collected and assessed in economic loss assessment models for estimating the impact of these diseases.

Fig. 47. Collection of data from a cattle handler for the assessment of zoonotic tuberculosis and campylobacteriosis in the outskirts of Dhaka

Results and Discussion: The study confirmed the occurrence of bovine campylobacteriosis in Mymensingh and Dhaka districts. A total of 194 samples were found to be positive with *Campylobacter* spp., and thus, an overall prevalence of 18% (194/1080) was confirmed in the samples. Of different samples (N=1080), the prevalences of *C. jejuni*, *C. coli* and *C. fetus* were 12.6%, 5.1% and 0.3%, respectively. Animal-level occurrence of *C. fetus* was estimated to be 8.7% by a survey conducted in breeding bull farms. In case of bTB, 11 isolates were confirmed, through molecular-based assays (LPA) using culture positive tissue samples and

observation of histopathological changes, as *Mycobacterium orygis* as the causal agent.

In multivariable analysis, important risk factors were identified as age of farm (more than 5 years), no/minimum cleaning and disinfection practices and animal roaming outside which were linked with the *Campylobacter* occurrence status at the farm level.

The total financial loss from bovine campylobacteriosis was assessed to be Tk 1282.3 million (US$ 14.1 million) in farmed crossbred cattle in the two study districts. On the contrary, the annual economic loss due to bTB was estimated at Tk 1,347.72 million (US$ 16.04 million) in farmed cattle of the two districts.

In the survey, almost all respondents (99%) recognized the public health burden of tuberculosis in Bangladesh. However, most (58%) had inadequate knowledge of bTB transmission to humans. Those who had reared animals for 1–5 years, 6–10 years and 11–15 years were, respectively, 2.72, 2.49 and 2.86 times more likely to apply appropriate practices compared to those who reared animals for >15 years. The study confirmed that both pathogens are circulating in farmed cattle of Dhaka and Mymensingh districts of Bangladesh directly impacting animal productivity and carrying the risk of transmission from animals directly or even through the food chain to humans.

Conclusions: The study points to the need for farmer participatory training and good farm practices for cattle farmers and attendants including the environmental, animal, and human "One Health" approach to mitigate the prevalence of pathogens in animals and the farm environment and prevent further transmission to animals and humans.

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

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

Principal Investigator: Dr. Jahangir Alam, CSO, Animal Biotechnology Division (ABD), 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: The study was conducted in veterinary hospitals and pet clinics in Dhaka and Chattogram metropolitan areas. Initial screening of samples (when possible) was done at sample collection sites and confirmatory diagnosis was made at NIB. Samples collected in Chattogram were cultured at CVASU and then transported to NIB for molecular analysis. Initial screening with a quick diagnostic kit was done at the sample collection site and after that different biochemical and molecular tests for strain detection were done at NIB, Savar, Dhaka and CVASU pet clinic, Chattogram. Some strains were also identified by MALDI-TOF

(Matrix-Assisted Laser Desorption/Ionization Time-of-Flight) Mass Spectrometry and SST (Sanger sequencing techniques) and later on the data were analysed by different bioinformatical tools.

Results and Discussion: During the 2020-21 period, 250 samples (oral=71, rectal swab=168, skin scrap=11) with 358 questionnaires from dog, cat, rabbit, pigeon and bird in Central Veterinary Hospital (CVH), Dhaka, Teaching and Training Pet Hospital and Research Center, CVASU, Purbachal, Dhaka and CVASU pet hospital, Chattogram were collected. On the basis of signs and symptoms 155 samples were tested by a quick diagnostic kit of which 27 were positive for canine parvovirus in dogs and 29 positive for feline panleukopenia in cats, 10 for parasitic infestation and 10 for dermatitis. Among the samples, 44 cases were categorized as "others" (wounds, fowl cholera, pigeon pox, poisoning, common cold, gastritis etc.). The collected swab (oral and rectal) samples (Fig. 48) were later cultured in ABD of NIB. The pathogens *E. coli* (59), *Salmonella* spp. (10),

Fig. 48. Sample collection from dog at CVASU pet hospital

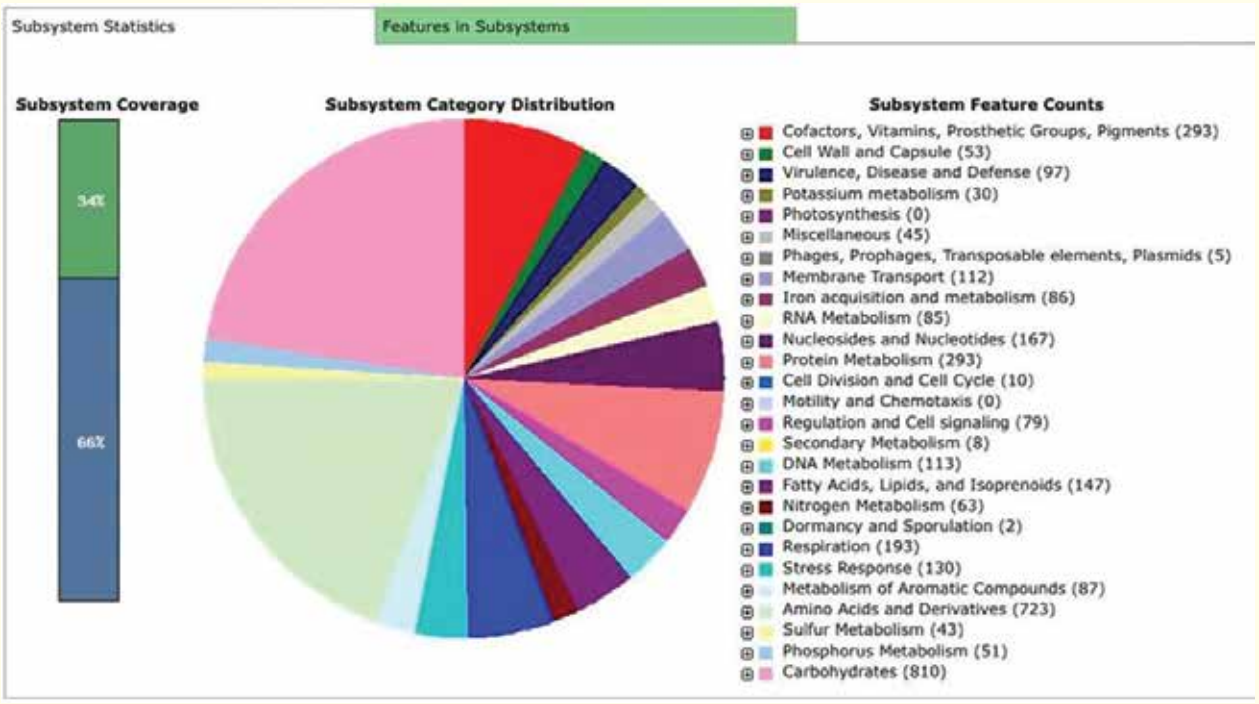


Fig. 49. Predicted genetic composition of *Raoultella planticola*

Streptococcus spp. (23), *Staphylococcus* spp. (33) and *Campylobacter* spp. (73) were collected from 198 samples. *E. coli* (n=35), *Staphylococcus* spp. (n=30), *Campylobacter jejuni* (n=33) *Salmonella* spp. (n=07) and *Streptococcus* spp. (n=22) were confirmed by five types of species-specific primers. Previously one bacterium named *Raoultella ornithinolytica* was found using the MALDI-TOF technique which, for further details, was sent for whole genome sequencing. After analyzing the full data using the Type (Strain) Genome Server (TYGS) system finally *Raoultella planticola* instead of *Raoultella ornithinolytica* was confirmed (Fig. 49). The microbiological identification of *R. planticola* remains a challenge even after 30 years of its identification. These two species, *Raoultella planticola* and *Raoultella ornithinolytica*, are clinically important because they

cause pneumonia, urinary tract infection and biliary tract infections. The recent emergence of ESBL (extended spectrum beta-lactamase)-producing and carbapenem-resistant nosocomial *R. planticola* infections is a matter of concern.

Along with the above, 16 SrRNA metagenome sequencing of 34 e-DNA samples, isolated from feces samples of fancy birds (finch, cockatiel, love bird and budgerigar), pigeons, dogs and cats, was done which revealed the presence of several microorganisms in their gut systems.

Conclusions: Zoonotic diseases in pets and causative pathogens have been detected in Bangladesh. Analysis of samples from cats, dogs and birds revealed that many pets carry pathogens like *E. coli*, *Salmonella* spp., *Staphylococcus* spp., *Streptococcus* spp., *Campylobacter* spp. which are zoonotically virulent. Virologic analysis irrespective of zoonoses by quick screening test reveal circulation of canine parvovirus (CPV) and feline panleukopenia virus (FPLV). The pathogen, *Raoultella planticola*, isolated from a cat oral swab sample, was detected for the first time in Bangladesh. Diseases can be transmitted to humans which calls for good hygiene and care in handling pets.

49. 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, seven herbs (pineapple, garlic, *neem*, moringa, spearmint, lemon grass, and ivy gourd) were selected. Initially the herb samples were collected from the Forage Herbs Bank established by this project. The phenolic and flavonoid levels of the seven medicinal forage plants were determined under freezing, shade-drying and sun-drying conditions. Furthermore, two specific bioactive components of each of the selected herbs, were measured by uHPLC and GC-MS. Based on bioactive components, sustainability, and convenience, the shade drying method was found to be more effective. Four herbs were selected finally and a mixture was developed with the selected herbs and fed to dairy animals at doses of 0, 100, 200, and 300 g/animal/d. Milk was tested for antioxidants, minerals (Ca, P, and Zn), and fatty acid composition.

Results and Discussion: Incorporation of the herbs powder mixture with the total mixed ration (TMR) diet increased milk yield by 20% compared to the control diet (TMR). The herbs mixture improved the level of secondary metabolites in poor quality ration which enhanced the blood antioxidants status and milk antioxidants level especially fatty acid profile (Fig. 50). It significantly improved the milk yield and decreased the cost of feed through reducing the feed conversion ratio (FCR) resulting in enhanced farmers' income. The antioxidant status of dairy cows was improved due to incorporation of herbs mixture. As a result, milk antioxidants especially the zinc level increased which would help boost immunity in human consumers.

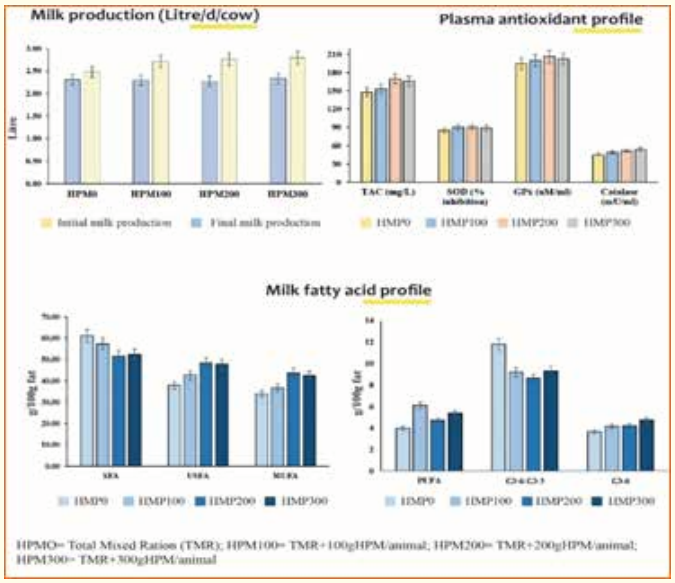


Fig. 50. Influence of herbs powder mixture (HPM) on milk yield, plasma antioxidant level and milk fatty acid profile of dairy cow

Conclusions: Detailed chemical and biochemical analysis of indigenous herbs offers a good opportunity to develop feed mixes for safe and nutritious feeding of cattle. This project developed a herb mixture to add to cattle feed that boosted milk supply and improved milk quality. This points to an opportunity of increased national milk yield and growth of the antioxidant fortified milk chain market. The findings of the project need to be validated and scaled-up in collaboration with officials of the Department of Livestock Services (DLS) and feed entrepreneurs.

50. 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 addressed the issue of improving the lamb production potentiality of native sheep through a holistic breeding plan including 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.

Materials and Methods: Identification and characterization of different sheep populations have been performed. Accordingly, a baseline flock in Bhuanpur under a society, an elite sheep flock at BLRI and a nucleus center at BAU have been formed where animal tagging, performances recording and selection/culling were performed. Interventions, support and training were provided. Quality rams were distributed yearly,

rotated half yearly and replaced yearly for the the three ram parks constructed at the farmer's level for genetic improvement. Genome-wide genotyping and association through 50K SNP beadchip analysis has been performed to elucidate the genetic architecture of native sheep to be exploited in breeding and improvement programs. Recording of productive and reproductive performance of sheep is being continued. Isolation 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: For characterization, 97 rams and 517 ewes from different locations were categorized based on visually distinct features in the Barind, coastal, garole, Muzzafarnagari and Tangail sheep. In order of importance, coat color, different body conformations as most discriminating variables, they were recorded as morphometric or phenotypic features. Whitish color was found to be the more frequent coat color of sheep than either blackish and or brownish color. For performance characteristics such as birth weight, weight at 6 months, mature live weight, litter size and age at first lambing were studied (Table 23). This study indicated morphometric, productive and reproductive variations among the sheep populations of Bangladesh. Selection of ewes and breeding with supplied rams with systematic ram rotation activities during the last three years enhanced the production potential of the selected sheep population. A significant reduction in lamb mortality and improvement of flock health status has also been achieved through capacity building and providing continuous support to the sheep farmers.

Table 23. Morphometric features and performance of ewes of sheep from different genetic sources in Bangladesh

Characteristics	Genetic source				
	Barind	Coastal	Garole	Muzzafarnagari	Tangail
Body length (cm)	$49.74^{a}\pm0.273$	$54.85^{b}\pm0.214$	$44.2^{c}\pm0.152$	$73.3^{d}\pm0.162$	$51.45^{e}\pm0.199$
Weither height (cm)	$50.47^{a}\pm0.164$	$52.07^{b}\pm0.178$	$45.81^{c}\pm0.209$	$69.15^{d}\pm0.189$	$50.69^{a}\pm0.309$
Chest girth engh (cm)	$58.48^{a}\pm0.13$	$63.82^{b}\pm0.083$	$56.74^{c}\pm0.104$	$75.81^{d}\pm0.205$	$59.58^{e}\pm0.153$
Tail length (cm)	$11.81^{a}\pm0.136$	$11.23^{b}\pm0.135$	$7.854^{c}\pm0.151$	$34.02^{d}\pm0.345$	$11.04^{b}\pm0.129$
Ear length (cm)	$6.098^{a}\pm0.117$	$11.6^{b}\pm0.115$	$4.799^{c}\pm0.282$	$14.19^{d}\pm0.09$	$9.63^{e}\pm0.185$
Head length (cm)	$14.99^{a}\pm0.062$	$15.34^{b}\pm0.057$	$14.8^{a}\pm0.062$	$17.43^{c}\pm0.111$	$14.99^{a}\pm0.056$
Rump height (cm)	$47.73^{a}\pm0.109$	$50.11^{b}\pm0.163$	$47.87^{a}\pm0.083$	$62.76^{c}\pm0.25$	$48.94^{d}\pm0.135$
Eye to eye distance (cm)	$11.12^{ab}\pm0.081$	$12.03^{c}\pm0.052$	$11.03^{a}\pm0.073$	$12.71^{d}\pm0.116$	$11.4^{b}\pm0.095$
Birth weight (kg)	$0.882^{a}\pm0.016$	$1.224^{b}\pm0.008$	$0.874^{a}\pm0.02$	$2.703^{c}\pm0.042$	$1.029^{d}\pm0.014$
Body weight at 6-month age (kg)	$7.003^{a}\pm0.085$	$9.473^{b}\pm0.039$	$6.415^{c}\pm0.133$	$20.63^{d}\pm0.127$	$8.014^{e}\pm0.057$
Mature live weight (kg)	$14.97^{a}\pm0.199$	$22.26^{b}\pm0.188$	$13.8^{c}\pm0.246$	$33.29^{d}\pm0.400$	$15.79^{a}\pm0.164$
Age at first lambing (days)	$384.9^{a}\pm0.587$	$425.6^{b}\pm0.475$	$412.7^{c}\pm0.890$	$489.3^{d}\pm0.825$	$415.5^{e}\pm0.713$
Litter size (number)	$2.265^{a}\pm0.036$	$1.287^{b}\pm0.017$	$2.328^{a}\pm0.046$	$1.034^{c}\pm0.014$	$2.203^{a}\pm0.047$

DNAs isolated from the blood of 96 different sheep of Bangladesh were genotyped using 50k (50,000 SNPs) ovine SNP bead chip. Population structure, genetic relationships, variability among different sheep of Bangladesh, genetic admixture at regional and global levels have been identified. Genome-wide Association Analysis (GWAS) for different economically important traits (Fig. 51) identified several candidate causative SNPs, which can be used to select breeding ewes for further breeding and improvement programs for the sheep population of Bangladesh.

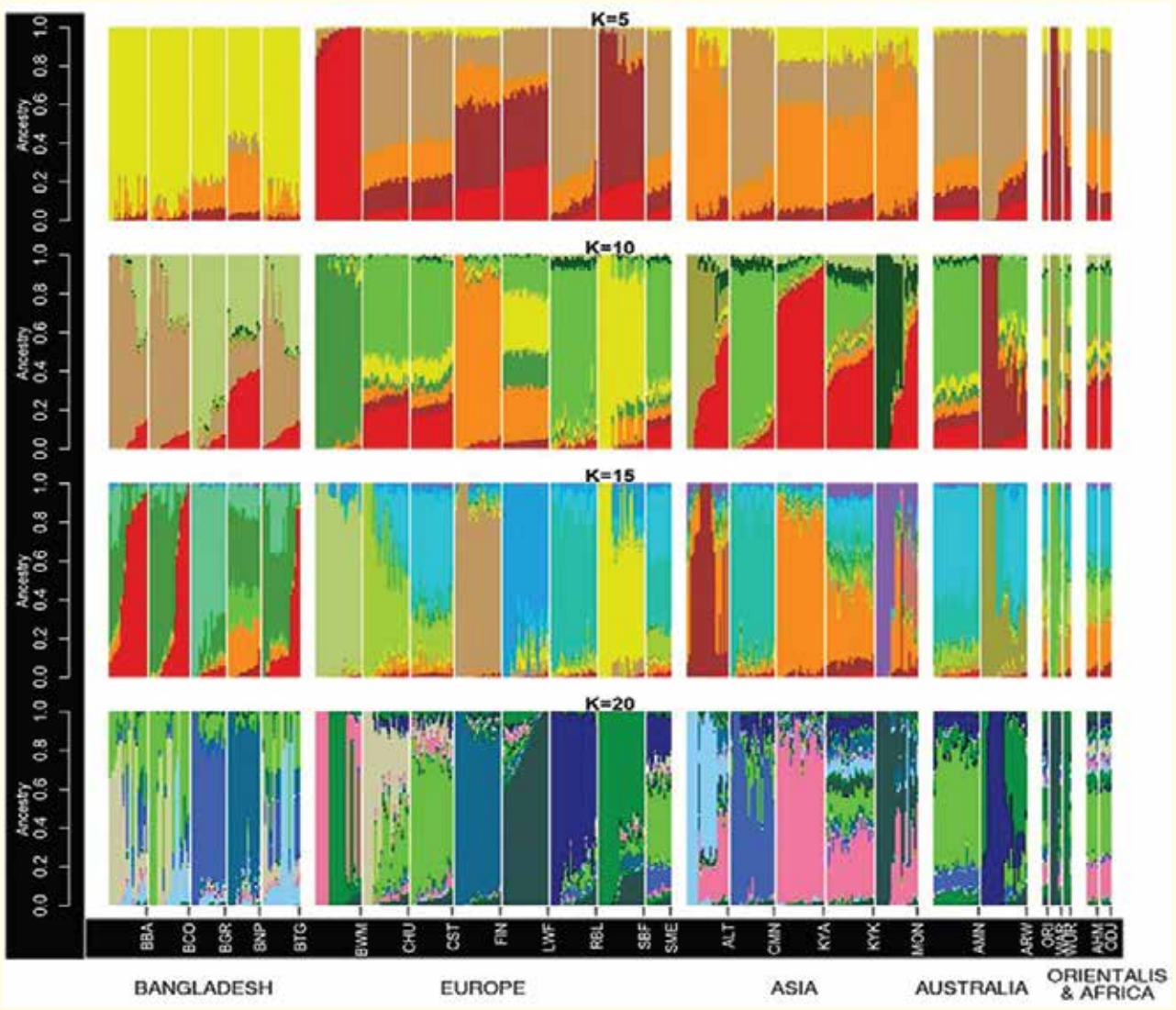


Fig. 51. Admixture analysis of the studied native sheep populations of Bangladesh in a global context: Clustering of 5 different types of sheep populations of Bangladesh with 20 sheep breeds from Europe, Asia, Australia and Africa based on an analysis of 50K SNP beadchip (BBA: Barendra, BCO: Coastal, BGR: Garole, BNP: Muzzafarnagari/Nagpuri, BTG: Tangail)

Conclusions: The project provided extensive descriptions of phenotypic characteristics of different types of sheep in Bangladesh. This study has laid the foundation in the country to exploit sheep genetic resources for livestock keepers and animal breeders. Systematic selection and breeding have been found to enhance the productivity of selected populations of sheep. Additionally, molecular genetic diversity of the sheep populations helped scientists understand the origin of different sheep of Bangladesh and differences in their genetic architecture. Causative SNPs for production traits have been identified to support a sustainable breed improvement strategy.

51. 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 poor digestibility. This study was designed to develop alternative feeding management which would be technologically and economically feasible and safe and nutritious for cattle 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 involved 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 and economic performance of the dairy cattle, and 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) by AOAC 2004 methods. The neutral detergent fiber (NDF) and acid detergent fiber (ADF) of feed stuff 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 considered the IPAO (I = input, P = process, A = assumptions, O = output) system.

Results and Discussion: The study showed that straw chop length plays a crucial role in feed intake, digestion and milk production. Straw chops of 4-inch length is preferable to that of 8-inch or 2-inch length. The use of loose straw results in lower intake and less milk production. In respect of chemical value addition to straw, use of urea at the level of 3% was found to be appropriate as this level gave the highest increase in CP and also there was no negative impact on the blood nitrogen of cattle. The densification of the straw using hydraulic pressure was found to bring about the following significant changes:

Fig. 52. Storage of baled rice straw

i) Volume of the straw was reduced by 7

times, so that densified 40 kg occupied a space of only 9 sq ft instead of 60 sq ft of the same amount of loose straw, substantially reducing the straw storage cost.

ii) Transport of baled straw is possible with a rickshaw which was not possible with loose straw; capacities of the traditional van (manual) and truck to haul cattle roughage were increased by 4 times and 2 times, respectively.

iii) From the economic point of view, with the densified straw (bales) the storage loss was reduced by 30% cutting down costs by 25% and ultimately the cost of milk production was decreased by 12%.

The project extended its technology to the farm level by conducting feeding trials, farmers' demonstrations and also by developing an etrepreneurship business model. The business model revealed that medium scale entrepreneurs could establish straw business with a return on investment (ROI) of 16% while the bank interest rate is only 5%.

Conclusions: The nutritional quality of rice straw, the dominant cattle feed in the country is rather poor in quality. Physical and chemical value addition to rice straw may improve the nutritional quality of feed and increase milk yield. A business model for young entrepreneurs for marketing value added rice straw was developed by the project with a potential ROI of 16%.

52. 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 three ecological zones like Barind, Jamuna Basin and coastal areas in Bangladesh. Under traditional feeding systems, the sheep are left to graze on harvested or fallow lands, roadsides 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 sought to

Fig. 53. Lamb grazing in a lowland natural field

develop lamb production farming communities in selected areas, popularize lamb production and optimize the lamb 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 distributed 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 continued.

Results and Discussion: The total numbers of lamb born were 2357, 1859 and 1368 in the Jamuna, Barind and Coastal belt, respectively. Lamb weights at birth of male and female of Jamuna basin were 1.44, 1.47, 1.46 and 1.42, 1.45 and 1.44 kg in 5, 10 and 15 flock size whereas in Rajshahi they were 1.71, 1.45, 1.43, and 1.50, 1.37, 1.44 kg and in coastal area 1.78, 1.70, 1.65, and 1.76, 1.65 and 1.62 kg, respectively. Lamb weights of 12 month of age of male and female of Jamuna basin were 19.19, 18.21, 17.11 and 16.74, 16.68 and 15.49 kg in 5, 10 and 15 flock size whereas Rajshahi were 14.45, 13.73, 13.25, and 13.98, 12.97, 12.44 and coastal were 20.12, 20.85, 20.10 and 19.25, 19.58, and 19.80 kg, respectively.

Fig. 54. Stall feeding of lamb

Feed concentrate (1.5%) supplementation performed better. For rural poor beginners 5 flock size performed better than that of 10 and 15 flock size. Grazing showed better productive performance than stall feeding. Up to one year uncastrated group showed better productive performance but castrated sheep were better in meat quality attributes. Lamb age of 9 or 12 months was found better in terms of productive and meat quality traits. All components successfully achieved three specific objectives of the project. Vaccination, deworming, shearing, castration, bathing were practiced as good management. In the three regions, (1) cultivable, rented in and fodder land, (2) sheep population, (3) incomes from cattle, sheep and homestead gardens, (4) consumption of fish, meat and vegetables significantly increased. The average protein intakes of hard core poor, absolute poor and non-poor during the baseline survey were 62, 91 and 160 g/day whereas at endline survey after project implementation protein intakes increased to 80, 118 and 192 g/day, respectively. Market access and bargaining capacity, savings and livelihood assets and self employment opportunities were created in the project areas.

Conclusions: Demonstration, promotion and extension of good rearing practices, management and health services 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. The project ended with the expectation that, sheep rearing would be spread throughout the country as a relatively easy and cheap way of increasing protein intake and incomes of small rural households.

CGP 4th Call

4.2.1B Recently Initiated Projects

55. Project Code and Title: TF 77-L/20. Molecular characterization of Newcastle disease virus (NDV) in search for an avirulent virus for the development of a thermotolerant vaccine.

Implementing Organization: Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram and Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur

Principal Investigators: Professor Dr. Pankaj Chakraborty (CVASU), Dr. Md. Robiul Karim (BSMRAU)

Locations: (a) Department of Medicine and Surgery, Department of Microbiology and Veterinary Public Health, Faculty of Veterinary Medicine (FVM) and Poultry Research and Training Center (PRTC), Chattogram Veterinary and Animal Sciences University (CVASU), Khulshi, Chattogram-4225, (b) Department of Medicine, Faculty of Veterinary Medicine and Animal Science (FVMAS), Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur-1706.

Budget: Tk. 120 lakh

Duration: December 2020 to Novemebr 2023

Introduction: The Newcastle disease (ND), popularly known as ranikhet disease, is one of the most prevalent lethal viral diseases of chickens in Bangladesh. To protect rural chickens against ND, vaccination is usually practiced with Baby Chick Ranikhet Disease Vaccine (BCRDV) and Ranikhet Disease Vaccine (RDV) produced by BLRI. However, as both the vaccines are thermolabile, it causes lyophilized vaccine viruses to be inactivated because proper cold chain is not maintained prior to and/or during the vaccination in rural areas. This project was initiated to detect and characterize avirulent ND strains in backyard chickens of Bangladesh in order to develop an effective thermotolerant vaccine to overcome losses incurred by ND.

Objective: Characterization of avirulent ND virus strain(s) from backyard chickens of Bangladesh in order to develop a thermotolerant ND vaccine.

Materials and Methods: Fifty stored cloacal swab samples were used for the diagnostic test. The samples were collected from backyard chickens from an ongoing KGF project (CRP-IV) in the Chattogram Hill Tracts (CHT). The samples were inoculated in the allantoic cavities of 9 days old embryonated chicken eggs (Fig. 55). Allantoic fluids from the eggs were harvested after 3-4 days of inoculation. The hemagglutination assay (HA) was used to detect the presence of hemagglutinating virus in the inoculated allantoic fluid. Positive samples in the HA test were further tested for hemagglutination inhibition (HI) to detect the presence of ND.

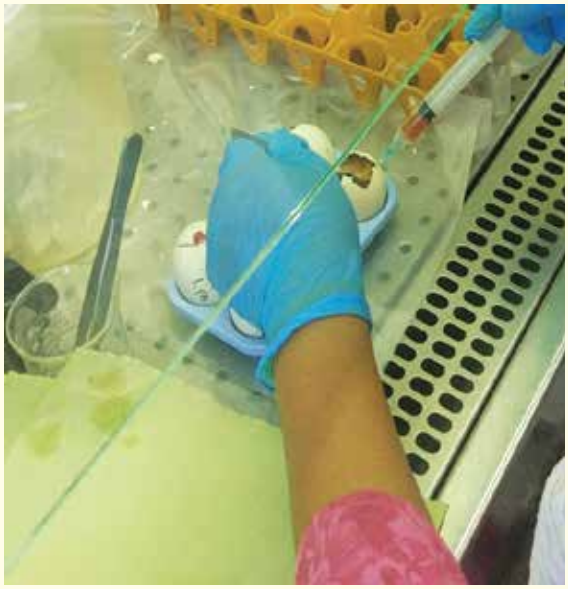


Fig. 55. Eggs being incoulated with swab samples

Results and Discussion: Out of 50 samples, 17 were found to have titers from the HA test. The HA positive samples could be positive for any hemagglutinating virus such as ND, AI (Avian Influenza) etc. These 17 samples were then screened by the HI test for the presence of ND virus (NDV) using ND specific serum and 13 samples were tested positive for HI. Next, RNAs will be extracted from these 13 samples and real time RT-PCR will be performed to differentiate between virulent and avirulent NDV.

Conclusions: Detection of NDV in tested samples is a significant progress of this project which will be helpful in carrying out future research work to meet the objectives.

56. Project Code and Title: (TF 78-L/20. Selection of crossbred dairy cattle using phenotypic and genomic information for efficient productivity and resilience in tropical environment of Bangladesh

Implementing Organizations: Bangladesh Agricultural University (BAU), Mymensingh, Department of Livestock Services (Central Artificial Insemination Laboratory, Savar, Dhaka), BRAC AI Enterprise (BRAC Bull Stations, Shambhuganj, Mymensingh and Bogura)

Principal Investigator: Professor Dr. Mohammad Shamsul Alam Bhuiyan, Dept. of Animal Breeding and Genetics, BAU

Locations: Selected crossbred dairy animals owned by farmers belonging to Bangladesh Dairy Farmers Association (BDFA) or others in Dhaka, Mymensingh, Rangpur, and Chottogram Divisions, Central Artificial Insemination Laboratory, Savar, Dhaka, BRAC Bull and Buck Station, Mymensingh and Bogura.

Budget: Tk. 99.95 lakh

Duration: December 2020 to November 2023

Introduction: Genomic selection is being increasingly used in dairy cattle breeding with high precision due to availability of pedigree, performance records and genotypic data. The aim of this project is to establish a system of recording and to utilize genomic tools to select high-productivity dairy animals in Bangladesh. SNP genotyping of selected animals will be performed to implement genomic prediction for economically important productive and reproductive traits, breed composition and admixture analysis. This will eventually lead to the development of a systemic approach to select potential cows, candidate bulls and bull mothers from community herds with appropriate genetic proportions leading to the development of productive and resilient crossbred dairy populations in the country.

Objective: Establishment of simplified performance database and genomic evaluation system in order to select potential crossbred dairy cattle in Bangladesh.

Materials and Methods: The project will be implemented in two distinct phases: (i) establishment of a performance database for two predominant and preferred crossbred cattle populations (H x L and SL x L) and (ii) genomic research utilizing indigenous and crossbred cattle populations of Bangladesh with the aim of undertaking genomic prediction to identify animals of superior genetic merit, determine genetic composition of crossbreds and genome-wide association studies (GWAS) to examine association between phenotypes and genome. Phenotypic performance records and blood samples will be collected from a total of 1000-1100 crossbreds in the genetic evaluation and selection process.

Results and Discussion: During year 1, the main objective is to quantify and evaluate the productive, reproductive and resilience of Holstein-Local and Sahiwal-Local crossbred cattle. In this regard, 62 farmers were selected so far from Chattogram, Mymensingh and Dhaka divisions. The herd sizes of the selected farmers ranged between 18 and 234 individuals. Only potential dairy cows having a maximum of 3rd to 4th lactation records and having possibility to continue their production for at least a couple of years in the enlisted farms were considered. Accordingly, farmers' training, herdbook (Fig. 56) preparation and distribution, purchase of ear tag and tagger, and animal selection from the selected farmers have been performed. Besides, 118 Holstein x Local and Sahiwal x Local

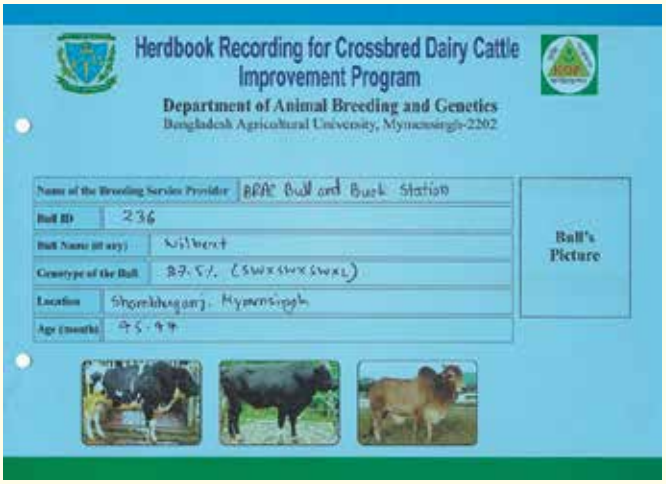


Fig. 56. Herdbook for animal performance recording

breeding bulls have been selected from the Central Artificial Insemination Laboratory (CAIL), Savar, Dhaka and BRAC AI Enterprise (Bull and Buck Station, Shambhuganj, Mymensingh). Herdbook based record keeping is ongoing through interactions with the farm owners or discussion with assigned personnel of breeding bull stations. The accumulated information will help screen potential crossbred dairy cows and candidate crossbred bulls as well as establish a database on animals' productive and reproductive performances in order to fulfil the project objectives.

Conclusions: Selection of farmers and animals as well as herdbook based performance recording are in progress. However, data generation through farmers' participatory approach is a bit challenging that needs continuous monitoring for collection of objective data.

57. Project Code and Title: TF 82-L/20. Value addition in composting poultry manure for better compost quality and reduction of environmental pollution

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh

Principal Investigator: Professor Dr. Md. Mukhlesur Rahman, Department of Animal Science, BAU

Location(s): Department of Animal Science, BAU, Mymensingh

Budget: Tk. 66.372 lakh

Duration: December 2020 - November 2023

Introduction: Huge amounts of manure are produced everyday from 1,50,000 commercial poultry farms, 500 parent stock farms and non-farm poultry species as well as poultry industries. This manure creates an unhygienic environment and is a source of greenhouse gas (CO_2, N_2O, CH_4) emission. This project is designed to develop composting techniques for livestock manure to improve the quality of compost, reduce environmental pollution and at the same time provide nutrients for crop production and sustain soil fertility.

Objective: Production of MAP containing compost from poultry manure for enhancing agricultural production.

Materials and Methods: The total composting operation will be carried out in the Department of Animal Science, BAU by optimizing the composting materials, bulking materials and composting methods with 1.2 M Mg on the basis of the OP of the manure. Continuous air flow will be provided by an aerator at a fixed aeration rate for optimum microbial growth. Size and shape of the struvite (hydrated Mg) crystals will be measured by scanning electron microscopy (SEM). After choosing the bulking materials, composting with different composting methods such as passive composting pile, wind row and aerated static pile will be done to develop a suitable method. Heavy metals will also be identified in the struvite containing compost. Field trials of the value added compost will be conducted to optimize the application rates for crop growth in comparison with chemical fertilizers.

Results and Discussion: Preparation of the composting shed has been done. Composting operation with $MgCl_2$ addition will start shortly.

Conclusions: This project is expected to develop scientific techniques of preparing compost from poultry wastes which can be a valuable source of organic matter and nutrients for soils and crops.

58. Project Code and Title: TF 83-L/20. Designing a sustainable feeding strategy for dairy cow production in Bangladesh

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh

Principal Investigator: Professor Dr. Mohammad Ashiqul Islam, Department of Dairy Science, BAU

Locations: Dairy Farm, Dairy Chemistry and Technology Laboratory and Dairy Cattle Production Laboratory,

Department of Dairy Science, BAU

Budget: Tk. 59.49 lakh

Duration: March 2021 to February 2024

Introduction: Smallholder dairy farming system is important in the livelihood of rural farmers. In Bangladesh, there is a considerable gap (30% deficiency) between milk production and demand. Most of the native cattle of our country are being crossed with exotic breeds with a view to increasing milk production and productivity of the animals. This requires adequate nutrition of the animals. This project addresses animal nutrient requirements through feed improvement.

Objective: To select roughage and concentrate ingredients for cost effective ration formulation for dairy cows focusing on nutritional status and milk production.

Materials and Methods:

Results and Discussion: Project inception workshop has been completed. Laboratory is getting ready.

Conclusions: The project will address the issue of quality feed for dairy cows to improve cattle health and enhance milk production.

4.2.2 Commissioned Research Program (CRP)

4.2.2A Ongoing Projects

59. 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 Veterinary 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 (Chattogram Hill Tracts)

Budget: Tk. 549.50 lakh

Duration: April 2017 to March 2022

Introduction: Chattogram 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 chickens, a potential meat producing poultry genotype are still available 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 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 is being implemented in four upazillas of 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 livestock, 4) growing fodder crops and assessing their nutritional values, 5) regular vaccination drives and 6) studying opportunities of livestock entrepreneurs and value chain development. The breeder and grower sheep and chicken houses have been built and animals distributed to the beneficiaries. A feeding trial, including tree leaves (rain tree, shameplant, *neem* tree leaves and *kumarilata*) was done on sheep. Napier, Pakchong and maize were cultivated on dry and partially irrigated lands. Routine vaccination against foot-and-mouth disease (FMD), Peste des Petits Ruminants (PPR), blackquarter (BQ), Newcastle and fowl pox diseases and deworming are ongoing. Chicken meat and egg quality characteristics were studied. The profitability of different segments (mini-hatchery, breeder, grower and integrated farmers) of the hilly chickens model was determined.

Results and Discussion: Production performance and survival of sheep in the hilly environment 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 reduced feed costs and enhanced productivity of animals. Napier, Pakchong and maize can be cultivated on dry and partially irrigated lands as feed for sheep. However, after planting Napier and Pakchong in the dry and partially irrigated lands it was observed that their growth was stunted due to lack of irrigation and green fodder yield at the first cut was 89 to 122 kg/decimal. For maize fodder, irrigation was needed every week, fodder yield was 130 to 136 kg/decimal. The reproductive traits (conception rate, lambing interval, gestation period) of ewes fed by different tree leaves differed significantly among locations and treatments. The differences of these traits were due to management, nutrition and physical conditions of ewes. Routine vaccination against FMD, PPR, BQ, Newcastle, fowl pox diseases and deworming kept the animals immune.

Fig. 57. Hilly chicken feeding outside in the poultry shed

The mature live weight of male and female chickens differed between types (spotted vs reddish-brown, 2900 vs 2650g) and also the annual egg production (85 vs 92) differed significantly. The quality assessment of meat and eggs of hilly chickens showed insignificant difference between genotypes. The nutritive value, meat and egg quality of hilly chickens were similar as those for non-descriptive *deshi* (ND) chickens and the hilly chicken meat is softer and more pliable than either broiler or ND chicken meat. The profitability study among the segments of the hilly chicken model showed that a unique segment is channeling whereas the integrated approach is profitable.

Conclusions: This project demonstrated that survival of sheep and 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 an egg and meat producer since the former is well adapted to the hilly environment.

4.2.3 Technology Piloting Program (TPP)

4.2.3A Completed Projects

60. 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 February 2021

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 veterinary services at farmers' door steps provided by mobile veterinary teams termed "Mobile Veterinary Service" (MVS) could reduce calf mortality from 13.2% to 2% and improve the fertility of cows. This technology piloting project was implemented to disseminate the MVS package with a view to improving animal health and productivity in two more upazilas of Mymensingh and Sherpur districts. MVS included three service packages: a) package 1: i) surveillance of livestock diseases, ii) training on animal health management, iii) formation of community groups, and iv) linking with markets; b) package 2: i) delivery of preventive veterinary services; c) package 3: i) 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. All livestock as well as backyard poultry were included as animals for intervention. During the past three-year period, the project area and beneficiaries were served regularly with veterinary services such as treatment of animal diseases, de-worming, vaccination, fodder cultivation, artificial insemination (AI) and other services as and when required. Continuous surveillance of diseases was done. Moreover, all the 500 farmers were thoroughly trained on livestock rearing, hygienic management of farms, deworming and vaccination, signs and symptoms of sickness of animals and first aid. They were also provided thermometers, spray machines and health cards to maintain biosecurity in their farms.

Results and Discussion: In the study area a total of 2339 cattle, 669 goats and 3230 poultry were diagnosed with different diseases and treated accordingly. A total of 3610 cattle and 1739 goats were dewormed with different anthelmintics, moreover 4302 cattle, 685 goats and 4394 birds were vaccinated against different diseases. Two hundred sixteen (216) farmers newly cultivated different types of fodder (mainly Napier grass) at their homesteads and/or on fallow lands for their cattle. Five hundred farmers were trained on biosecurity and general animal health management practices.

A total of 567 (including 78 Brahma) AI were performed. Two hundred sixty-five calves in Fulbaria (including 36 Brahma calves) and 201 calves in Nakla were born during the period. The mortality was reduced to only 1.8%. Fertility of cows was improved due to timely diagnosis and veterinary care of the infertile cows. Due to timely preventive veterinary services, the morbidity of livestock declined gradually (Fig. 61), only 9 cattle and one goat died during a period of four years (Fig. 58). No outbreak of PPR or FMD was reported during the last year of the project.

An average 12.44% growth of cattle was observed in the research area at the end of the project which was much

greater than the national average growth rate of livestock (3.25%). The amount of milk production increased gradually. Significant increase of milk production was observed at Nakla due to transformation of indigenous cow to crossbred cow. In Nakla at inception only 16% cows were crossbred which turned to 69% at completion of the study. Per head annual income of farmers was increased by 112% in 4 years which indicated an average 28% per year.

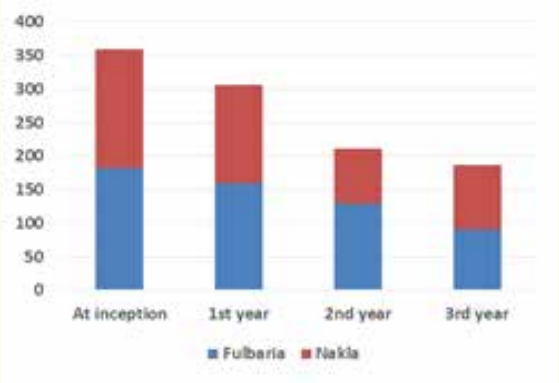


Fig. 58. Gradual reduction of morbidity of cattle in Fulbaria and Nakla upazilas

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

4.2.4 Technology Commercialization Program (TCP)

4.2.4A Recently Initiated Projects

61. Project Code and Title: TCP-1. BAU-Bro chicken conservation and piloting their producer-group farming

Implementing Organizations: (a) Bangladesh Agricultural University (BAU), Mymensingh, (b) Palli Karma-Sahayak Foundation (PKSF), Dhaka and (c) Protein Mart (BD) Ltd., Dhaka

Principal Investigator: Dr. Md. Bazlur Rahman Mollah, Department of Poultry Science, BAU

Locations: Department of Poultry Science, BAU, Mymensingh, Kishoregoanj, Gazipur, Jamalpur, Joypurhat, Bogura, Naogaon, Natore, Rajshahi and Chapai Nawabganj districts

Budget: Tk. 5552.24 lakh

Duration: January 2021 to December 2024

Introduction: Poultry farming plays a major role in providing cheap animal protein to the human diet in Bangladesh. However, it is heavily dependent on imported strains, feeds, vaccines and medicines. To reduce dependence on imported strains, BAU developed broiler sire and dam lines from locally available genetic resources and released two broiler strains, BAU-Bro White and BAU-Bro Color. Furthermore, a validation and refinement study was conducted in different areas of Bangladesh with KGF funds (KGF Project: TF-17-ARI/15). Farmer level studies indicated that the developed strains could be reared at the farm level profitably and a significant demand for BAU-Bro chickens prevails. In addition, strain development is a continuous process and proper maintenance of developed strains is pivotal for sustainable production. Therefore, continued selection for growth and feed conversion ratio (FCR) of the developed chicken lines and commercialization of BAU-Bro chicken are necessary to meet the current demands, increase of its market share to reduce the import of parents and sustainability of developed BAU-Bro strains.

Objective: Conservation, improvement, popularization and dissemination of BAU-Bro chickens to increase its market share.

Materials and Methods: A "BAU Poultry Conservation and Research Center (BPCRC)" will be established by utilizing earlier infrastructure (feed mill, hatchery, renovated sheds, laboratory etc.), developed previously through an earlier KGF project (TF-17-ARI/15, NATP Phase-I) and other required infrastructure. Phenotypic data for growth and reproductive traits of sire and dam lines, parents and the resulting BAU chicken will be

collected for refinement. The sire and dam lines will be selected from every generation for body weight, growth, egg size and egg production. Molecular characterization of each sire and dam line and best linear unbiased prediction (BLUP) of breeding value for each individual will be performed. The BAU-Bro parents and BAU-Bro chicks will be disseminated and popularized to hatcherymen. PKSF will facilitate distribution of BAU-Bro Color chicks through its partner organizations and beneficiaries. For an uninterrupted supply of BAU-Bro chicks conveniently at reasonable prices at farmers' doorsteps, a forward linkage (BPCRC → local hatchery → farmers) will be developed with local hatcheries and farmers by providing BAU-Bro parents to the local hatcheries. Traceability and branding of BAU-Bro live and dressed chickens will be carried out in association with Protein Mart BD Ltd., a commercial company, engaged in meat and fish processing and marketing in Bangladesh.

Results and Discussion: Engineering drawing and designing for the construction of BPCRC have been completed. Site selection, land aquisition and approval process is ongoing. Selection from male and female chicks from generation 16 (G16) has been completed. Phenotypic data collection from G16 samples is going on. Blood samples from all the G16 individuals have been collected. DNA isolation of all samples has been completed. The selected birds are at the growing stage. Three-way crossbred chickens (950 females, 130 males) are at the production stage. Currently, 2000 commercial day old chicks (DOCs) are produced every week from this population. Distribution of DOC has been started. A dedicated Facebook page has been created for product promotion and marketing. Construction of a website is ongoing.

Conclusions: This project has opened a new era of collaboration among scientists, farmers and commercial enterpreneurs to commercialize a product developed by scientists and at the same continue R&D for technology fine tuning. The commercialization of improved chicken breeds developed by scientists will contribute to the intake of good quality meat by consumers and enhance their nutrition security.

4.2.5 Lump Sum Grants (LSG)

4.2.5A Recently Initiated Projects

62. Project Code and Title: LSG 2-L/21. Environmental disaster due to lead exposure in Magura Sadar: Exposure evaluation and rapid disaster mitigation

Implementing Organization: Bangladesh Agricultural Universityn (BAU), Mymensingh

Principal Investigator: Professor Dr. Kazi Rafiqul Islam, Department of Pharmacology, BAU

Location(s): Village Barasia and its surrounding area in Magura Sadar upazilla, Magura district

Budget: Tk. 19.97 lakh

Duration: March to October 2021

Introduction: In December 2020, print and news media became rife with the news of sudden accidental lead (Pb) exposure/toxicity causing the death of a number cattle and signs of respiratory illness among the inhabitants of Barasia village and surrounding areas in the Sadar upazila of Magura district in western Bangladesh. This triggered panic among people of Barasia and worried the local administration. Initial investigation revealed that a newly installed factory was extracting Pb from discarded automobile batteries releasing toxic wastes into the surrounding environment. As Pb is a potent environmental pollutant, very persistent with bioaccumulation characteristics and is highly toxic to living beings, this project was designed to study the pollution situation there and recommend mitigation measures.

Objective: To evaluate the extent of Pb contamination in humans, livestock, plants and environment in the study area and formulate short- and long-term mitigation strategies.

Materials and Methods: A questionnaire survey in Barasia village and surrounding areas was conducted. Blood samples of local inhabitants and domestic animals were collected on the basis of age and sex. The Pb

contents of surrounding soils, vegetation (grass, small plants, rice plants, wheat plants), harvested crops (grains and straw) and water from different sources were determined. GIS based spatial and temporal heat maps showing the distribution of Pb contamination will be prepared. Some short-term mitigation measures have been suggested and long-term measures focusing on reducing the human and environmental exposure levels and safeguarding people from further exposure will be advocated.

Results and Discussion: The Pb poisoning in this area occurred from discarded automobile batteries from which a newly installed factory was extracting Pb that spilled over into the surrounding environment. During survey among the villagers, telltale signs of chronic Pb poisoning in several individuals were noticed. Survey data revealed a positive correlation between Pb poisoning with educational and economic status of the villagers. Thirty-five blood samples from humans and 15 from animals were collected from the study area. According to the geographical locations and GIS tracing, 153 environmental, 97 vegetation, 4 fish and 10 poultry samples were collected. In addition, within one month of an incidence of exposure, postmortem samples from one dead cattle and other environmental and vegetation samples were also collected. Analysis of postmortem samples from dead animals, vegetation and agricultural crops showed Pb concentrations over 1,000 to 100,000 times that of the Maximum Permissible Limit (MPL). Immediately after exposure several animals died and villagers became sick. During that period one dead heifer's postmortem samples as well as environmental and vegetation samples were also collected and lead concentrations analyzed. After measurement of the lead concentration in soil samples, a spatial and temporal GIS based heat map of the affected area will be prepared to ascertain the possible sources and predict the short/long term outcome of lead contamination in soil and environment. A holistic but rapid protocol to evaluate the extent of Pb exposure in humans, livestock, crops and environment in the affected area was designed. Community based awareness building programs among the villagers were organized and environmental and agricultural measures for safety against Pb poisoning were suggested. The following instructions were given as a short-term mitigation approach:

- Isolate the entire factory area with tight fencing and restrict the area for both humans and animals to reduce the exposure.
- Stop using/consumption of contaminated rice by humans and grass and straw by animals.
- Stop consuming meat of affected animals and poultry.
- Dispose of/destroy harvested crops, straw, grass grown in fields adjacent to the factory.
- Deep ploughing of the contaminated fields.
- Cultivate maize, corn, zoysia grass in the contaminated lands/fields and treat soil with EDTA.

Conclusions: The findings about lead poisoning of the environment and its adverse effects on humans and animals from a lead extracting factory should serve as a warning. Similar poisoning may have occurred at other places. More detailed studies are needed to delineate the polluted areas of the country and to develop effective mitigation measures.

Technical Progress

FISHERIES

Fish and the Bangladeshis are inseparable. Bangladeshis have traditionally been reputed as regular and avid 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 fish. About 17 million people of the country, including 1.4 million women, depend on fisheries for their livelihoods comprising fishing, fish 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 Competitive Grants Program (CGP)

CGP 3rd Call

4.3.1A Completed Projects

63. Project Code and Title: TF 37-F/17. Development of health management strategy against bacterial diseases in 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 June 2021

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, Heteropneustes fossilis* 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. Previous studies suggest that certain bacteria like *Aeromonas* spp., *Pseudomonas* spp., *Edwardsiella tarda*, fungi like *Aphanomyces invadans, Saprolegnia* spp., some parasites and other factors such as environmental stress, nutritional deficiency etc. are mainly responsible for the disease outbreak among different fish. 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. Probiotics could play an important role in fish health management through improvement of body physiology and creation of a disease- and stress-free environment. This project studied the effect of probiotics supplements for fish in pond culture in terms of growth and health conditions, and the research work included identification of disease-causing bacteria and understanding the infected environment to manage bacterial fish diseases for sustainable finfish aquaculture.

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 (during July 2018 to June 2019, the study was carried out in 36 fish ponds from 3 divisions of Bangladesh where improved aquaculture was being practiced. To understand the baseline situation in fish health management, detailed data were collected through pond surveys using a pre-tested questionnaire. The effect of probiotics on the growth of *koi* fish (*Anabas testudineus*), histological changes of gut and liver of tilapia and *koi* were studied and hematological and bacteriological studies of *koi* under different probiotic supplements in culture ponds were done. Fifteen experimental ponds located beside the Faculty of Fisheries, BAU, Mymensingh were used for a period of 90 days from August to November 2020 to culture *koi*. The ponds represented five treatments each with three replications. Healthy *koi* fingerlings with an average size of 1.57 ± 0.02 g collected locally and stocked @ 450 fingerlings/pond (0.75 decimal) at a density of 600 fingerlings/decimal. Three commercial probiotics, Zymetin, pH FIXER and Super PS, were used in *the koi* culture. The treatments were: T1 prepared with soil probiotic (Super PS), T2 with gut probiotic (ZYMETIN, at a dose of 10g/kg feed), T3 set with combined soil, gut and water probiotics, T4 with water probiotic (pH FIXER, 1 kg /hectare) and T5 (control) with the basal diet only without any probiotic. Histological,

hematological, microbiological and water quality parameters were studied at the Fish Disease Laboratory, BAU, Mymensingh (Fig. 59). Samples of fish gut and liver of tilapia and *koi* were collected fortnightly for histological observations following standard protocols and procedures.

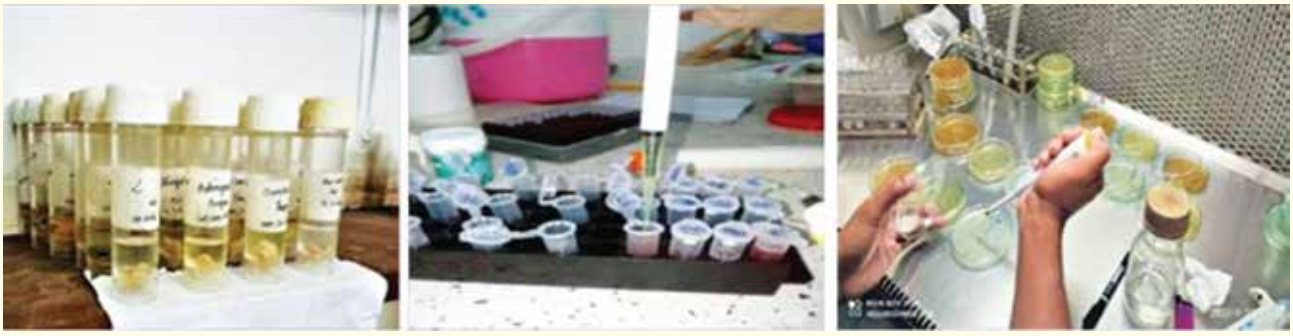


Fig. 59. Histological (extreme left), hematological (center) and bacteriological studies of fish samples

Results and Discussion: Water quality parameters of all the treatments were favorable for *koi* culture. Morphometric measurements showed the net weight gain, % weight gain, protein efficiency ratio to be the highest and feed conversion ratio (FCR) the lowest in the combined probiotics treated fish (T3) followed by gut (T2), water (T4) and soil probiotic (T4) treated fish and the lowest in control (T5). In histological studies, both tilapia and *koi* liver samples of control fish (T5) had pathologies like vacuums, hemorrhage and necrosis, but liver had almost normal structure in fish treated with probiotics (Fig. 60). In respect of gut histology, villi length (VL), enterocyte height (EH) and fold length (FL) were smaller at the beginning of the experiment which increased with the culture period. In mid-season and at the end of the culture period, the control fish (T5) showed hypertrophied and partly lost villi whereas VL, EH and FL had the greatest increases in T3 followed by T2, T4 and T1. Blood hematological parameters like WBC, RBC and hemoglobin increased in T3 samples followed by those for T2, T4 and T1 which indicated higher immune response than that with T5 (control, no probiotic). The gut bacterial load in *koi* was the highest for T3 which indicated beneficial effect of combined (gut, water and soil) probiotics. The gut bacterial load in fish from T2 or T4 ponds also increased compared with that from the control ponds (T5). Twenty-three bacterial species were isolated in diseased fish samples collected from the study areas; these bacterial species were found to be virulent and resistant to most of the antibiotics that farmers had applied.

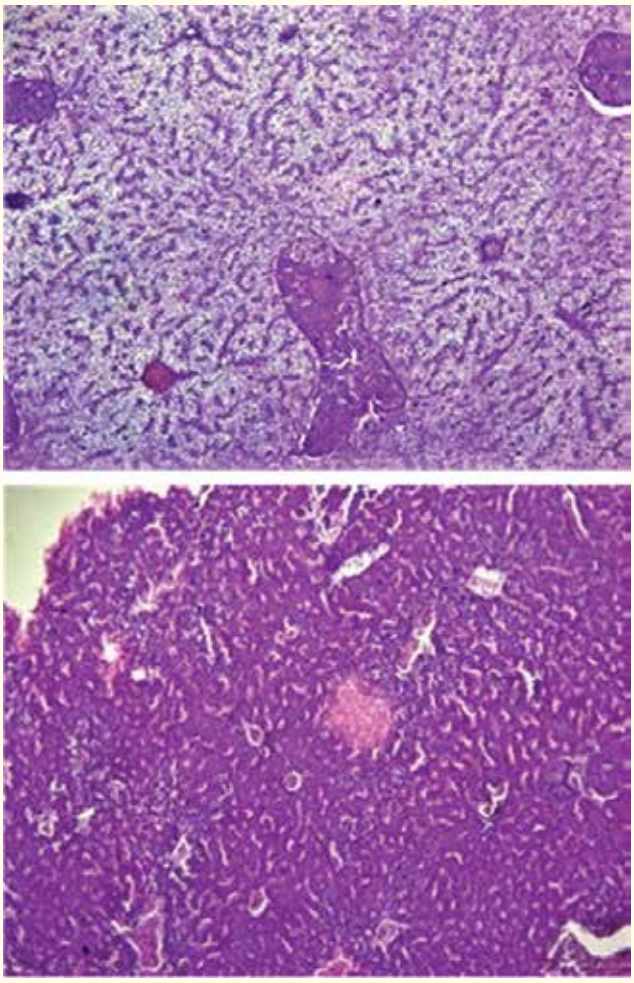


Fig. 60. Sections of almost normal liver (top) and necrotic liver (bottom) of tilapia

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 practices, use of probiotics rather than use of chemical drugs and antibiotics in fish culture and fish health management. A combined (gut, soil and water) probiotics regimen was developed for fish culture and the project research indicated that regular probiotics feeding in aquafarms may increase fish production and significantly minimize the risk of diseases in fish, especially bacterial diseases.

64. 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 Shyamnagar upazila of Satkhira district

Budget: Tk. 69.84 lakh

Duration: December 2017 to March 2021

Introduction: Shrimp farming has emerged as a very profitable fisheries enterprise in Bangladesh. However, due to intensification and other reasons related to climate 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: Six experimental ponds, each 30 decimals in size, were reconstructed and prepared for the Aquamimicry culture system in Shyamnagar, Satkhira. Grass was planted on the embankment of the ponds to prevent soil erosion which ultimately lowered the pond sludge volume. Small-mesh nets were set up along the embankment of each experimental pond to maintain biosecurity. The feeds used were commercial feed (CF) alone and combinations of CF, liquid fermented rice bran (LFRB) and liquid fermented soyben meal (LFSM). The experimental treatments are shown in Table 24. For the preparation and application of LFRB and LFSM as supplemental feeds for Aquamimicry culture, 10 liter of water was mixed with 1 kg of ground rice bran or soybean meal and kept for 24 hours with continuous aeration. A commercial probiotic (Red Cap) was used for fermentation. The pH of LFRB or LFSM was maintained at 6.0-7.0. Calcium carbonate was used to

Table 24. Experimental design for the Aquamimicry system

Treatment	Culture system	Feed application
T0	Existing semi-intensive	100% CF
T1	Aquamimicry	10% LFRB/LFSM + 90% CF
T2	Aquamimicry	30% LFRB/LFSM + 70% CF

CF= commercial feed, LFRB)= liquid fermented rice bran, LFSM= liquid fermented soybean meal

buffer the pH. Before stocking of shrimp seeds (PL), the ponds were filled with available saline water through filtration. LFRB, LFSM, molasses and probiotics were applied to the experimental ponds to allow growing natural fish feed. Stocking of specific pathogen-free (SPF) post-larvae (PL) was done at stock densities of 9-10 PL/m^2. Commercial feed was used as the feed supplement on top of LFRB and LFSM. Water quality parameters (temperature, salinity, ammonia, alkalinity, transparency and pH) and plankton growth were monitored at regular intervals and analyzed on the spot and in the BSMRAU laboratory. Fish growth, plankton analysis (determining plankton concentration using the Sedgewick Rafter (SR) cell counter fortnightly), and microbiological analysis were performed and histology and blood hemocytes of shrimp were studied to assess the functioning of the new system.

Results and Discussion: In this experiment, survival of stocked shrimp PL had been a serious challenge. Stocked PL suffered severe mortality in the 1st year and 3rd year, but not in the 2nd year stocking seasons. The first year stock crashed within 30 days while in the 3rd year, massive mortality occurred in the control ponds (T0) after 45 days followed by gradual mortality in the remaining Aquamimicry experimental ponds. The initial growth performance of stocked PL was better in the Aquamimicry ponds than that in the control ponds. The highest specific growth rate (SGR), 3.24%, was found in the Aquamimicry ponds in the third year where 30% LFSM was used and the lowest SGR (1.98%) was found in the control ponds. To ascertain the reason of PL mortality, different water quality and microbiological parameters were studied which indicated that the possible cause of PL mortality could be a sudden deterioration of water salinity after heavy rains. A quick decline in water salinity to 2-3 ppt due to heavy rainfall created an imbalance in the osmoregulation process in shrimp bodies and increased the frequency of urination; the urinary pores in shrimp opened frequently facilitating the entry of pathogens. In shrimp, the antennal gland that functions as an excretory organ is a perfect portal for pathogen entry.

Plankton concentrations in the ponds were affected by the treatments. LFRB/LFSM increased phytoplankton and zooplankton production by 38-40% over that in control ponds. Growth of beneficial microbes not only supplements the feed but also balances the natural ecosystem and eliminates pathogenic microorganisms. To confirm this, microbial samples were analyzed in the laboratory. No *Vibrio parahaemolyticus*, the key pathogenic microorganism responsible for EMS (early mortality syndrome) diseases in shrimp, was found in the Aquamimicry ponds.

Regarding the immunity parameters, total haemocytes collected from the haemolymph of shrimp grown in Aquamimicry ponds were studied. The highest haemocyte (3.8X103) count was found in the Aquamimicry ponds which indicated greater immunity in the shrimp. The histology of hepatopancreas also showed well developed shapes of hepatopancreatic tubules in the treatment ponds compared to control ponds. In terms of shrimp production, 53kg (436kg/ha) and 58kg (488kg/ha) of shrimp were harvested having an average shrimp size of 42±1.43g and 44±2.63g, respectively, from T2R1 and T2R2 ponds during the 2nd year of the experiment. The study observed seasonal and year-wise fluctuations of weather parameters (temperature, rainfall, drought, water salinity) which might have affected survival and growth of shrimp and invited different pathogens in the shrimp farms especially during the early stage of culture (within 45 days).

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.

65. 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: December 2017 to March 2021

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 polyunsaturated fatty acids (PUFA) and beta glucan (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 boost fish production securing steady supplies of quality fry to the farmers. This project aimed 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 PUFA and BG from squid and mushroom, respectively.

Materials and Methods: The experiment was conducted in both earthen ponds and concrete cisterns at BAU. Experimental ponds and cisterns were stocked with naturally collected brood fish of three species from rivers and open water sources. *M. cavasius, O. pabda* were reared in cisterns while for rearing *L. rohita*, earthen ponds were used. Selected mature broods from the reared stock were used for the dietary supplement trials and induced breeding. Each cistern was stocked with 45 broods of all three species of fish which were fed with the experimental diets for 4 months (April-July) prior to the breeding season. Gonadal development, breeding and fry rearing experiments were conducted for two successive breeding seasons except in the first year. The earthen ponds were also stocked with these three fish species for comparison. Chopped squid as a source of PUFAs and mushroom powder as a source of BG was provided in the fish diet. PUFA and BG mixed with other ingredients were supplied to the experimental fish. For the control treatment, all three species of fish were fed a diet without PUFAs and BG enriched feed. To evaluate the effects of dietary supplement, in addition to data on physicochemical conditions of water and growth of fish, some histological and serological parameters related to gonadal maturation, reproductive performance, hatching and embryonic development were studied using sophisticated lab equipment and through induced breeding of all the three fish species. The histomorphology of liver, serum calcium ion concentration, sperm viability and vitellogenin were used to assess gonadal maturation and a spawning trial was conducted to study reproductive performance. Acetylcholinesterase activity, blood cell count, antioxidant enzyme, lysozyme enzyme, alternative complement, respiratory burst, reactive oxygen species and IgM were measured using standard methods to explain the immunomodulatory effects of BG in association with PUFAs enriched diet on *O. pabda, M. cavasius* and *L. rohita*.

Fig. 61. Injecting hormone for induced breeding of *L. rohita, O. pabda* and *M. cavasius* fish species

Results and Discussion: Treated groups of *Ompok pabda, M. cavasius* and *Labeo rohita* attained significantly higher ($P<0.01$) weight increment compared with the control group and significantly higher ($P<0.05$) length increment after the dietary supplement. In comparison with the control group, the treated group exhibited an advanced gonadal maturation and higher reproductive performance in the spawning trial. The induced spawning results showed significantly better fertilization rate, hatching rate and survival rate of offspring of *O. pabda, M. cavasius* and *L. rohita* in treated group compared to control group. Abundantly deposited lipid granules in the livers of treated fish were found in histological studies during the spawning season whereas less lipid granules in the livers of the control group fish were deposited. Lipid deposition in liver is an indication of better gonadal development that leads to higher fecundity in female and good quality sperm in male brood fish. Viable sperms in treated group of *O. pabda, M. cavasius* and *L. rohita* were significantly higher ($P<0.01$) compared with that in the control fish.

The serum Ca^{2+} level and vitellogenin in the treated females were significantly higher ($P<0.05$) than those in the control females of *L rohita, M. cavasius* and *O. pabda*. The WBCs count in blood of *O. pabda, M. cavasius* and *L. rohita* fed with BG was found to be significantly increased ($P<0.05$) over that in fish not fed with BG. The lysozyme activity in the presence of BG in the serum of *L. rohita, O. pabda* and *M. cavasius* was higher than that in fish in the absence of BG. The complement activity in the serum of BG fed *L. rohita, O. pabda* and *M. cavasius* was significantly higher.

Biochemical analyses revealed that BG significantly increased anti-oxidant enzymes, respiratory burst and IgM in the test fish species. The AChE activity was significantly higher ($P<0.01$) in the BG and BG + *A. hydrophila* group of fish than that in the control and control+*A. hydrophila* groups.

Conclusions: The project demonstrated that supplementing brood stock diets with polyunsaturated fatty acids and beta glucan may produce fish broods with a high immunity profile and increased spawning success, fecundity, total egg volume, individual egg weight, hatching success, healthy fry and ultimately boost fish production securing a steady supply of quality fry to fish farmers.

4.3.1B Ongoing Projects

66. 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: Bangladesh is ranked 4th in the world in inland fish production, accounting for a total fish production of 4.38 million metric tons in 2018-19, of which, about 85% came from freshwater fisheries and aquaculture and the rest from marine sources. Small-scale fisheries and aquaculture produce about 97.30 % of the fish and only 2.70% is produced by medium to large-scale commercial fisheries. Unfortunately, due to improper handling during fish transport and marketing, small-scale fisheries and aquaculture enterprises suffer huge post-harvest losses (PHL) to the tunes of 28-30% in respect of quantity of wet fish and 15.5% in terms of quality, the penalty being a staggering Tk. 18,000 crore annually (@Tk. 300/kg). Such fish PHL does not bode well for the Bangladeshi people many of whom already suffer from malnutrition. On the other hand, a big PHL cuts down incomes of small-scale fishers, fish traders and processors of the country. It is, therefore, imperative to reduce fish PHL though improved fish handling, transportation, preservation and distribution methods and devices. Also, 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

etc. 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, fish powder, fish soup, 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. For the project work, ten fish landing centers (FLC), i.e., Chamraghat, Morichkhali, Mach Mohal, Chowganga, Tarail Mach Bazar, Roder Podda, Notun Bazar, Dhuldia, Korgaon and Kotiadi Bazar, were selected in five haor upazilas of Kishoregonj, namely, Karimganj, Tarail, Itna, Nikli and Kotiadi. Similarly, FLCs were chosen from the Daudkandi Flood Plain Fisheries (DFPF) in Daudkandi upazila of Cumilla district. Several tools for fish handling and transport were developed and tested. Some processed food items were developed for value addition to fish catches.

Results and Discussion:

Development of fish handling tools

Several useful, easy to handle, cheap fish handling and preservation tools were developed such as, (i) manually operated ice crusher machine, (ii) self-powered aerator-cum-oxygen accumulator (Fig. 62), (iii) portable folding SS-table, (iv) insulated tank ice box (TIB), (v) solid stackable plastic crates and (vi) improved ice crushing petty with pestle. These tools were field tested and fine tuned for field use and handed over to fish trader groups (FTGs), and they are using these tools to preserve fish quality during transport from landing centers to markets. In addition, the design of the country fishing boat built earlier (reported in KGF Annual Report 2019-20) was improved installing cold chain facilities on the boat decks equippedwith TIB ice box in deck-hold, ice crushing petty, plastic crates, etc. for capture fishing and demonstrated to capture fishermen. Capture fishermen were well motivated, most of them installed TIB on their boats to keep harvested fish fresh on board. Five country boats are being revitalized for the fishermen FTGs by the project on a cost-sharing basis.

Fig. 62. Self-powered aerator-cum-water agitator used during fish transport

Value added products

The molecular process of lipid stabilization mechanism in muscle food system by novel antioxidants was studied and techniques were developed to stabilize fish lipid by novel safe antioxidants extracted from plant sources. To identify antioxidants from natural sources, various herbal elements like carrot, cucumber, gourd, lentil, etc. were searched for micro-molecular level anti-oxidative properties. Carrot was found to be effective having good anti-oxidative properties. Stabilized *pangas* fish powder was developed for the first time in the country by stabilizing lipid and removing the fish smell by natural means for multipurpose use to add value to fish.

Value added ready-to-cook or ready-to-eat products from different freshwater fish, predominantly from tilapia and *pangas*, were developed for the first time in the country with appropriate levels of ingredients, additives, spices and stabilizers considering local taste preferences. The value-added products are, (i) stabilized mince from *pangas*/tilapia to produce mince-based products, (ii) powder products from tilapia and *pangas*, (iii)

cooked pickles or condiment type products, and (iv) bone-free wet fish products. A very good quality *pangas* powder and crispy *pangas* pickles, branded as 'BAU *Pangas* Powder' and 'BAU Crispy *Pangas* Pickles' have been developed for commercial level up-scaling.

Pangas powder is unique in the sense that the whole fish, instead of fillet or mince is used in powder formulation. From 1 kg fish, priced at Tk.100, about 250 g powder was produced, that could be sold at Tk. 500, @ Tk.200/100g. Because of its powder form, it can be preserved for more than a year at room temperature. From *pangas* powder, fish *achar, bhorta*, soup, noodles, curry, *khichuri*, etc. can be prepared or it can be incorporated into bakery products, biscuits, chips, crackers or other similar snack items to fortify protein nutrition cheaply. Experiments are underway to study methods of inducing long time shelf-life in *pangas* powder at ambient temperature and as a food item to fortify/supplement protein nutrition in protocols for feeding school children/the elderly/diseased persons.

Fig. 63. Fish balls prepared from fresh water fish

Awareness and skill development

Awareness and skill development training programs continue. So far, in the three years of the project, 30 awareness development training sessions were conducted at two research sites. Entrepreneurship development training (EDT) is also in progress, the objectives being to increase family income by utilizing low priced freshwater fish in the preparation of different types of value-added products which have prospective markets in cities and rural areas. At the end of three years, 26 EDTs have been conducted.

Post-harvest Loss Reduction Laboratory

Two new laboratories, "Post-harvest Fish Loss Reduction Laboratory" and "Cold Room Laboratory" have been established and equipped with machinery in the Department of Fisheries Technology (BAU-FT), first ever in the history of BAU. Equipment include rotary evaporator, gel electrophoresis, rheometer, thermo-regulated water-bath, vacuum packaging machine, magnetic stirrer, electric shaker, precision electric balance, electric mincer machine, electric kneader machine, sausage filler machine, electric grinder, pH meter, auto-programmed hot air oven, deep freezer, laboratory freezer, computer, printer, scanner, etc. The laboratories have been connected with LAN, internet and other on-line support facilities.

Fisheries Resource Center

A Fisheries Resource Center (FRC) is where all stakeholders of the fishery value-chain gather to receive services to mitigate post-harvest fishery losses in the supply chain and improve skills and capacity for the development of their fishery trade. It is a common facility of training-cum-community center owned by the Fish Traders Group (FTG) of the project from where all capacity building and skill development services in terms of training and logistics will be provided. In addition, all project related activities will be launched catering to the FRCs. An FRC has been established, first ever in the history of the post-harvest fish loss reduction arena in the country. The center has been developed in Balikhola near Chamra Ghat, the biggest fish landing center and *arot* in the Kishoreganj *haor* area, where about 70% of the exclusive *haor* fishes are landed and huge numbers of tourists, businessmen and passengers gather and pass this port for various reasons every year.

Revitalization of traditional fishing boat

A new concept has been introduced among the capture fishermen on revitalization of the country fishing boats equipping them with on-the-deck cold chain facilities for capture fishing. This includes a partitioned engine room to prevent oil spills into the fish hold, insulated tank ice box in the deck-hold, provisions of ice crushing petty and pestle, plastic crates, etc. on board. The concept has received tremendous popularity among the DoF field officers and fishermen FTGs as they have found it convenient to keep fish safe and preserve fish quality on board the fishing vessel. Many of the capture fishermen have already revitalized/renovated their fishing boats quickly. Awareness development training and campaigns are ongoing to up-scale the technology throughout the entire traditional capture fisheries in Bangladesh.

Dissemination materials

Forty-five ICT materials (brochure, leaflet, flyers, posters, PPW plans in *penaflex*, factsheets) related to post-harvest fish loss reduction for awareness development and capacity building were printed and distributed. Two manuals in Bengali are in the process of printing.

Conclusions: This project demonstrated the benefits of improved fish handling measures and value addition methods (preparing fish fillets, frozen mince blocks, surimi, fish chatny, fish powder, fish soup, noodles, cookies, etc. from fresh fish) to fishing communites, fish handlers and traders. The project developed entrepreneurship to process and market value added products (VAP) from fish. MoUs are under process between BAU and several commercial entrepreneurs (Shawpna, BRAC, etc.) for commercial processing and marketing of VAP. The concept of "Post-harvest Fish Loss" emanating from the KGF sponsored project generated a great deal of interest nationally. The Department of Fisheries (DoF) has incoroporated this in its core program and initiated several projects on reduction of post-harvest fish loss country-wide in collaboration with several international development partner agencies (FAO, WFC, etc.).

CGP 4th Call

4.3.1C Recently Initiated Projects

67. Project Code and Title: TF 75-F/20; Study the effects of probiotics on growth and reproduction of selected farmed fishes in Bangladesh

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh

Principal Investigator: Prof. Dr. Md. Shahjahan, Department of Fisheries Management, BAU

Location: Department of Fisheries Management, BAU

Budget: Tk. 70 lakh

Duration: December 2020 to November 2023

Introduction: The interest in probiotics as an environmentally friendly alternative is increasing and its application is both empirical and scientific. The main objective of using probiotics for fish culture is to re-establish a favorable association between beneficial and harmful microorganisms that make up the micro-biota of the intestine of fish. Bacteria present in the aquatic environment influence the composition of the gut micro-biota in fish and vice versa. Probiotics are used for increasing growth, improvement of water quality and enhancement of reproduction of fish. This project is designed to study in details the effect of probiotics on fish in aquaculture.

Objective: To investigate the effects of selected probiotics on growth performances of rohu, Nile tilapia, *gulsha* and shing in aquarium, ponds and biofloc system.

Materials and Methods: Surveys were conducted in aquaculture farms regarding the use of probiotics.

Results and Discussion: Eighty-eight different probiotic products from 36 companies are being used in aquaculture farms of Bangladesh supposedly to promote growth, control disease and for water treatment. The use of commercial probiotics varies from region to region, but "Pond Care and Safegut", a product of the SK+F company, is mostly used. Two probiotics were selected and their characterization at the microbiology laboratory of BAU is in progress.

Conclusions: Work on the efficacy of probiotics in aquaculture is ongoing, useful information is expected to be available from the laboratory and field studies.

68. Project code and title: TF 76-F/20. Development of locally engineered low-cost recirculating aquaculture system (RAS) in Bangladesh

Implementing Organizations: Sher-e-Bangla Agricultural University (SAU), Dhaka and Bangladesh Agricultural Research Institute (BARI), Gazipur

Principal Investigator: Prof. Dr. A. M. Shahabuddin, Department of Aquaculture, Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka 1207

Location: Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka 1207

Budget: Tk. 159.60 lakh

Introduction: The recirculating aquaculture system (RAS) is a healthy fish production system that ensures healthy environmental conditions for proper growth of fish. Mechanization and intensification in aquaculture through RAS is important for fisheries developement in Bangladesh. Due to lack of expertise, appropriate design and high price tag, it is difficult to manage the system. RAS system needs to be efficient, low-cost, and simple to operate. This project attempts at establishing a low-cost RAS using local resources and testing it as a novel approach of intensifying fish production in the country.

Objective: To design, develop and validate low-cost RAS for commercial fish species.

Materials and Methods: An RAS facility will be built at the SAU campus. A piece of land with an area of around 5,000 square feet has been allocated for this purpose. A baseline survey was conducted and different RAS projects were visited to observe their present status and understand problems of the RAS system in Bangladesh.

Results and Discussion: Construction of the RAS shed has been completed and indoor work is going on. A low-cost tank has been designed (Fig. 64) and tested for construction. To reduce energy cost and maintain the

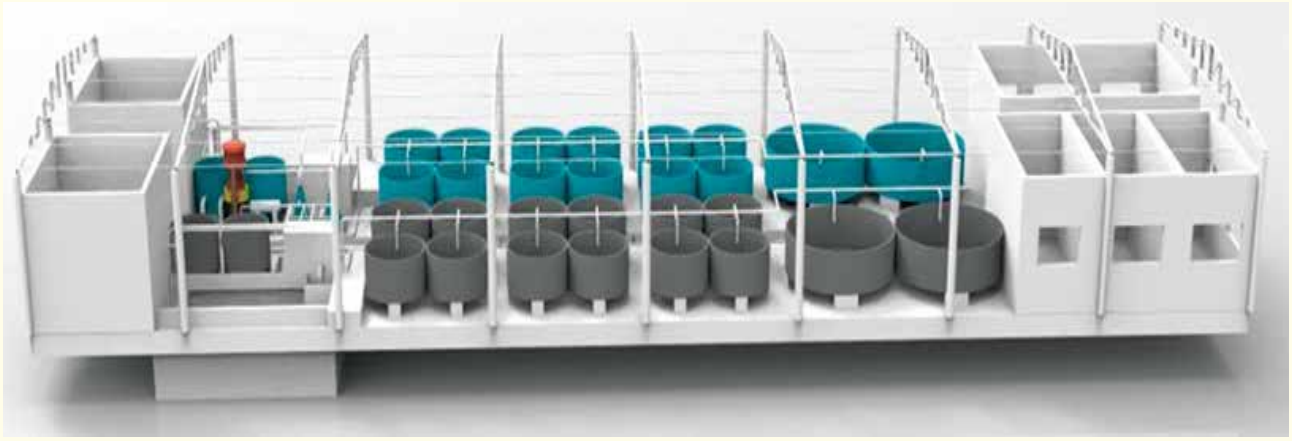


Fig. 64. Design of the recirculating aquaculture system (RAS) being built at SAU campus, Dhaka

gravity flow system, underground biofilter tanks have been designed and built. In pre-trials, locally produced bio-media showed standard performance to control ammonia. A low-energy mechanical filter (drum filter) has been designed and built using locally available materials that will reduce the cost of the RAS operation. The construction of low-cost tanks, machine room, feed room, water inlet, water outlet to the system is in progress.

Conclusions: Work on building a recirculating aquaculture system (RAS) facility is in progress. Pre-trials indicated that locally produced bio-media would perform well in controlling ammonia.

69. Project Code and Title: TF 85 F-20. Development of sustainable mass seed production technology for *golda* shrimp (*Macrobrachium rosenbergii*) and production of quality broodstock in captivity

Implementing Organization: Bangladesh Agricultural University (BAU), Mymensingh

Principal Investigator: Dr. Md. Shamsul Alam, Professor, Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh

Location: BAU, Mymensingh

Budget: Tk. 100.16 lakh

Duration: April 2021 to March 2025

Introduction: The agro-climatic conditions of Bangladesh are suitable for *golda* shrimp farming throughout the country, but it has so far remained limited mainly to the southwestern coastal districts of Bangladesh. Unpredictability in post-larvae (PL) production in the hatcheries is the major problem in expanding *golda* farming. Prawn hatcheries have been encountering difficulties in PL production for long due to high mortality, and many hatcheries have been closed. Dependency on unpredictable and diminishing wild sources for mother prawn is another constraint to *golda* hatchery. This project seeks to identify the *golda* hatchery operation problems and determine mitigation measures for a reliable supply of broodstock.

Objective: To develop a sustainable mass seed production technology and broodstock of *golda* shrimp (*Macrobrachium rosenbergii*) by nutrition, genetic and health management.

Materials and Methods: A nursery pond was prepared by drying, removing bottom clay, repairing the banks and installing net fence. Lime was applied at a dose of 1 kg/decimal. Rotenone (ACI) powder was applied to eradicate unwanted animals. *Golda* PL was stocked at a density of 500/decimal. *Golda/Bagda* nursery feed containing 40% protein was provided twice a day. Water quality parameters such as pH, total hardness and alkalinity of the nursery pond water and its dissolved oxygen, nitrite-nitrogen and nitrate-nitrogen concentrations were measured. After 45 days of stocking, 20 individuals were randomly collected using a push net and their lengths and weights recorded.

Results and Discussion: The pond water quality parameters such as pH, total hardness and dissolved oxygen, nitrite-nitrogen and nitrate-nitrogen concentrations were within the optimal range for freshwater prawn nursery operation (Table 25) except alkalinity which was found to be higher than normal. The mean length and weight of 20 randomly collected stocked larvae sampled after 45 days of rearing were 5.00±0.61 cm and 1.03±0.38 g, respectively. The growth of the sampled individuals was normal and good.

Table 25. Water quality parameters of the nursery pond

Parameter	Value	Normal values
Dissolved oxygen	5 ppm	>4 ppm
pH	7.8	7.0-8.5
Nitrate-nitrogen	15 ppm	0-40 ppm
Nitrite nitrogen	0.5 ppm	<2.0 ppm
Total hardness ($CaCO_3$)	100 ppm	30-150 ppm
Alkalinity ($CaCO_3$)	110 ppm	20-60 ppm

Conclusions: The project work began very recently, the findings are yet to be conclusive.

4.3.2 Lump Sum Grants (LSG)

4.3.2A Recently Initiated Projects

70. Project Code and Title: LSG-3-F/21: Challenges of biofloc technology in Bangladesh Aquaculture: An ambiguous media hype?

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

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

Location(s): Different districts

Budget: Tk. 9.50 lakh

Duration: March 2021 to December 2021

Introduction: The use of social media for commercial purposes in Bangladesh is rapidly increasing. Success stories of many new agricultural technologies including Biofloc has created enthusiasm among many neo-aquaculturists to exploit the "technology". Many YouTubers are motivating people by showing "success stories" of new technologies but hiding information about many flop cases. A single search in any search engine like Google with the key words "Biofloc Bangladesh" will show thousands of contents and links on the Biofloc technology. Most of them provide a one-sided story of "success" missing the other side, i.e., "failure". Such one-sided propaganda in many cases lure neo-aquaculturists to engage in fish farming without a proper understanding of the technology. New investors are losing their capital and accusing the technology out of frustration. This short-term study was designed to study the scenario of the Biofloc fish culture system in Bangladesh.

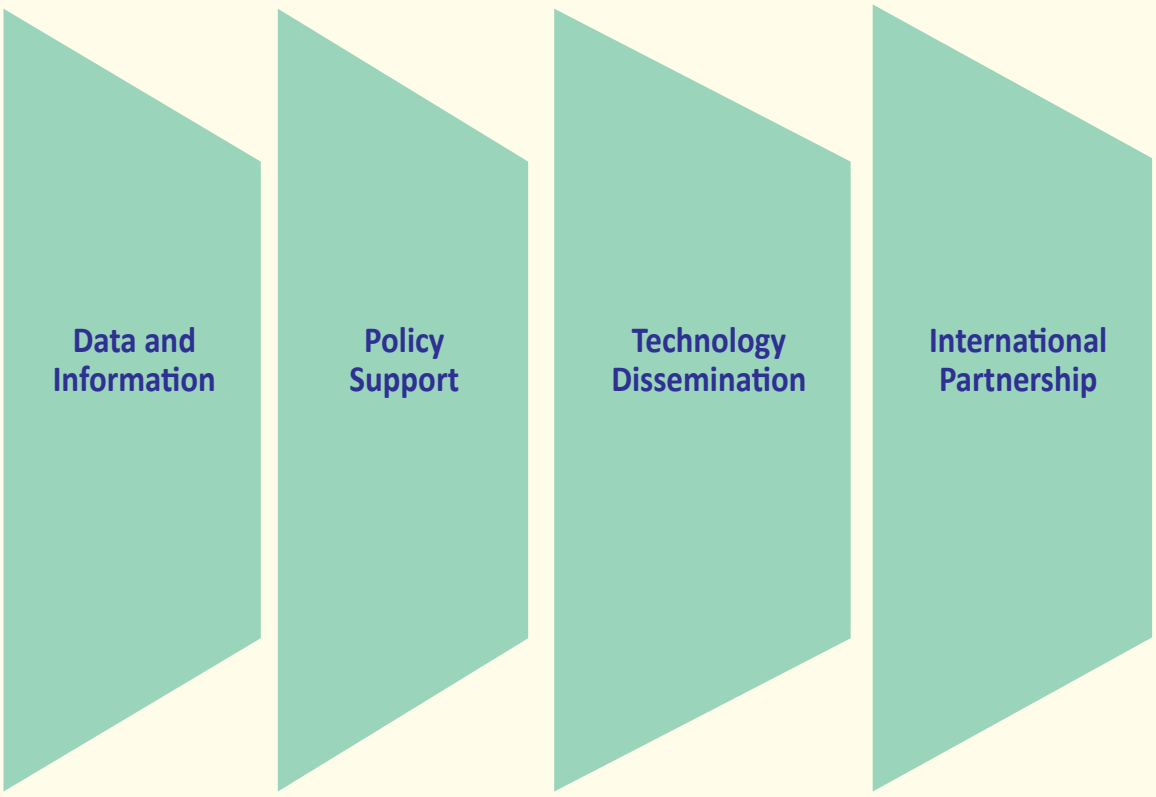
Objective: To assess the state of commercial Biofloc fish production at farmers' level and the role of social media advertisements in disseminating the technology.

Materials and Methods: In this brief study data were collected both from web sites (Google, Facebook and YouTube) and on-field interviews. A semi-structured questionnaire was used to interview different Biofloc entrepreneurs across the country. Farmers of both groups, influenced and not influenced by the media, were selected. For the media influenced farmers, information was collected from the film/video contents and for the other group a snow-ball approach was adopted where the first identified farmer helped to find his/her peer for an interview. The study planned interviewing 80 non-media motivated and 20 media motivated farmers selected randomly from across the country.

Results and Discussion: The project work was seriously affected by the second wave of the Covid-19 pandemic. In the field survey, data have been collected from 156 farmers in 21 districts of Dhaka, Khulna, Mymensingh, Chattogram, Rangpur, Rajshahi and Barishal divisions. The data showed the highest Biofloc farm concentration in Dhaka followed by Mymensingh and Khulna. In case of social media impact, around 20 hits per day in 2019 were found which increased to 100 hits per day in 2020 and fell down to only 6 in 2021. The comparative scenario of 'Aquaculture vs. Biofloc' from 30/9/2018 to 30/9/2021 showed that 'Biofloc' reached three to four times more hits compared to 'Aquaculture' in 2019 and 2020. It clearly indicated that for a certain period of time people were going crazy about Biofloc. An analysis of Facebook pages showed that a total of 279 unique Facebook pages were using selected keywords. The time range of the creation of the Facebook pages was between 2014 and 2021. Despite the Covid19 situation in 2020, the highest number of Facebook pages were created which decreased dramatically during 2021. Similarly, the investigation found a total of 573 videos from 302 unique channels and most of the channels were created since 2015 and are now on the decline. More information will be available after processing of the field data obtained from the interviews.

Conclusions: The initial observation indicated that media created a hype on Biofloc and people took it as a means of quick earning easily without knowing the basic science and related literature or having any hands-on experience previously. Many people invested lots of money depending solely on social media news or blogs and incurred financial losses. The study would develop a 'cautionary message' for the neo-entrepreneurs advocating wise investment to avoid loss of money and time.

Other Initiatives and Services



5. Other 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 the 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 assist 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. Video clips of relevant project activities in farmers' fields and interviews of farmers/scientists/extension workers are recorded and telecast. In 2020-21, KGF arranged with the TV channel "Channel 24" for broadcasts of dissemination material/talk shows with the title "KGF Rupantorer Krishi". Episodes of KGF Rupantorer Krishi were scheduled to be telecast every Friday at 4:30 pm and re-telecast the next day at 6:30 am. However, in 2020-21, due to the Covid-19 pandemic, preparation of the tele episodes was restricted, so only three episodes could be aired on the 11th, 18th and 25th of June 2021 on seaweeds (Fig. 65), hilly chickens and BAU chickens, respectively. Videos of the Channel 24 episodes of "KGF Rupantorer Krishi" are available at links on Facebook as shown in Table 26.

Fig. 65. Interview of Dr. Shaikh M Bokhtiar, Executive Chairman, BARC and Chairman, KGF Board of Directors (L) and a field day at Cox's Bazar on cultivation of seaweeds (R) telecast by Channel 24 TV in episodes of the "KGF Rupantorer Krishi" series

Table 26. Links on Facebook for videos of episodes of "KGF Rupantorer Krishi" telecast in 2021 by Channel 24

Episode	Telecast date (2021)	Facebook link
Seaweed	June 11	https://www.facebook.com/KGFRUPANTORERKRISHI/videos/993250237900685
Hilly chicken	June 18	https://www.facebook.com/KGFRUPANTORERKRISHI/videos/554422955951731
BAU chicken	June 25	https://www.facebook.com/KGFRUPANTORERKRISHI/videos/4686528058045369

5.4 International partnership: Information, knowledge and technology exchange

Having been authorized by Clause 15 of the Memorandum of Article of Association (MAA) that reads "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 Center for Integrated Mountain Development (ICIMOD), Nepal
- Indian Society of Coastal Agricultural Research (ISCAR)
- International Center for Climate Change and Development (ICCCAD), Bangladesh

5.5 International visits/delegations

There was no visit abroad in 2020-21 by any KGF official due to the raging Covid-19 pandemic. However, the Executive Director and other professionals of KGF participated in various international events of interest virtually through the Zoom platform.

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 2020-21, KGF arranged four Board meetings (74th to 77th), two meetings (34th and 35th) of the Technical Advisory Committee (TAC), two (13th and 14th) Annual General Meetings (AGM) and one (7th) Emergency Gerneral Meeting (EGM) as shown in Table 27.

6.1 Training programs/workshops/seminars/consultation meetings

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. Also, internal workshops mostly in relation to monitoring of on-going projects and national workshops are regularly organized by KGF to strengthen coordination and support for work on agricultural R&D issues. The Foundation also assists in organizing international workshops to establish linkages and collaboration between national and international agricultural research organizations and universities. Office work was seriously interrupted by the Covid-19 pandemic for which meetings, workshops etc. could not be held as regularly and as frequently in 2020-21 as in the previous years. However, several training sessions, national and international workshops/seminars/meetings were held in 2020-21, important among them are listed in Table 27.

Fig. 66. A KGF TAC meeting in progress

Table 27. List of important workshops/seminars/consultation meetings/Board meetings organized by KGF during 2020-2021

Subject	Date	Venue
KGF and BKGET AGM, EGM, Board and TAC meetings in 2020-2021		
KGF AGM/EGM		
13th AGM	26/09/2020	Radisson Hotel
14th AGM	06/04/2021	BARC Conf Rm-1
7th EGM	14/02/2021	BARC Conf Rm-1
KGF/BKGET Board Meetings		
74th KGF Board Meeting	14/08/2020	BARC Conf Rm-1
75th KGF Board Meeting	12/11/2020	BARC Conf Rm-1
76th KGF Board Meeting	30/01/2021	BARC Conf Rm-1
77th KGF Board Meeting	21/03/2021	BARC Conf Rm-1
69th BKGET Board meeting	19/09/2020	Virtual
70th BKGET Board meeting	24/09/2020	Virtual

Subject	Date	Venue
KGF and BKGET AGM, EGM, Board and TAC meetings in 2020-2021		
76th KGF Board Meeting	30/01/2021	BARC Conf Rm-1
77th KGF Board Meeting	21/03/2021	BARC Conf Rm-1
69th BKGET Board meeting	19/09/2020	
70th BKGET Board meeting	24/09/2020	Virtual
Other meetings/workshops in 2020-21		
Progress brief meeting, ICP-II (NUMAN) project	07/12/2020	Virtual
MoU signing for MoU CGP 4th Call projects	13/12/2020	KGF Annex
Coordinator and PIs' meeting: TF-65 project	08/11/2020	KGF Office
PCR workshop of TF- 23-AM/15 project	16/11/2020	Virtual
PCR workshop of CEP-III project -	16/11/2020	Virtual
Workshop on research planning through ARMIS	17/11/2020	BARC Auditorium
PCR workshop of TF- 31-VC/15 project	19/11/2020	Virtual
PCR workshop of on CRP-III project	19/11/2020	Virtual
PCR workshop of on t BR 2-C/17 project	24/11/2020	Virtual
PCR workshop of on TF-29AM/15 project	26/11/2020	Virtual
Meeting of ACIAR and KGF teams	01/10/2020	Virtual
PCR workshop of TF 23 project	28/10/2020	Quazi Bodruddoza Auditorium, BARI
KGF-IRRI MoU signing: ICP-IV	01/09/2020	KGF Board Rm
Meeting with CRP-II project team	10/9/2020	KGF ED's Office
Workshop on identifying KGF's future activities to combat adverse situations like the Covid-19 pandemic	12/09/2020	BARC Auditorium
PCR workshop of CEP-III project	17/08/2020	Virtual
Meeting with Representative of Solidaridad Network Asia	26/08/2020	KGF ED's Office
PCR workshop of BR-3-CI/17 project	29/09/2020	Virtual

6.2 Celebration of *Mujib Shoto Barsho* and Golden Jubilee of Indepennce

KGF, along with the nation celebrated *Mujib Shoto Barsho* (the Birth Centenary Year) in honor of the 100th birth anniversary of Bangabandhu Sheikh Mujibur Rahman, Father of the Nation and the Golden Jubilee of the independence and victory of Bangladesh. The professionals, officers and staff of KGF, led by Dr. Jiban Krishna Biswas, Executive Director, celebrated the auspicious events with due respect and solemnity throughout the year.

Fig. 67. Celebrating *Mujib Shato Barsha* and Golden Jubilee of Independence

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 ongoing projects in two ways, i.e., (i) desk monitoring and (ii) field monitoring. KGF also evaluates these ongoing projects through hiring external teams.

Fig. 68. Dr. Jiban Krishna Biswas, Executive Director, KGF on a visit to an experimental field of a KGF sponsored project

Fig. 69. A KGF specialist with project scientists and participating farmers on an internal monitoring visit to a KGF project field trial

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 through ocsasional visits for physical verification of trials at the planned sites. 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 teams comprising competent and experienced agricultural scientists and academicians 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, if necessary, revises the project funding and work strategies. In 2020-21, one external monitoring team, comprising 15 members chosen from among experienced and knowledgeable scientists from crop, livestock and fisheries disciplines, headed by Dr. Matiur Rahman (Plant Breeding), former Director General, BARI monitored CGP, CEP and TPP projects at various locations in different regions of the country. The external monitoring team, following field visits and rigorous evaluation of the technical and financial performances of the projects reported that the projects were being implemented satisfactorily. However, the team members provided some feedbacks on the project activities for better implementation of the projects.

Fig. 70. Members of an Independent Monitoring Team on an external monitoring visit to a KGF project site

6.4 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 presented in this report. However, it is available at the KGF office.

6.5 Publications

6.5.1 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 2020-21 is the 12th of the series of annual reports of KGF.

6.5.2 Jonobol Nitimala 2020

In the year under report, KGF published an important document, a booklet containing official gudelines for the human resources management at KGF. This document outlines the academic qualifications, skills and

experiences needed for appointment to various positions of KGF, terms of reference (TOR), duties and responsibilities of various categories of staff, their rights and privileges, etc. which would be very useful in human reources management at the Foundation.

6.5.3 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.

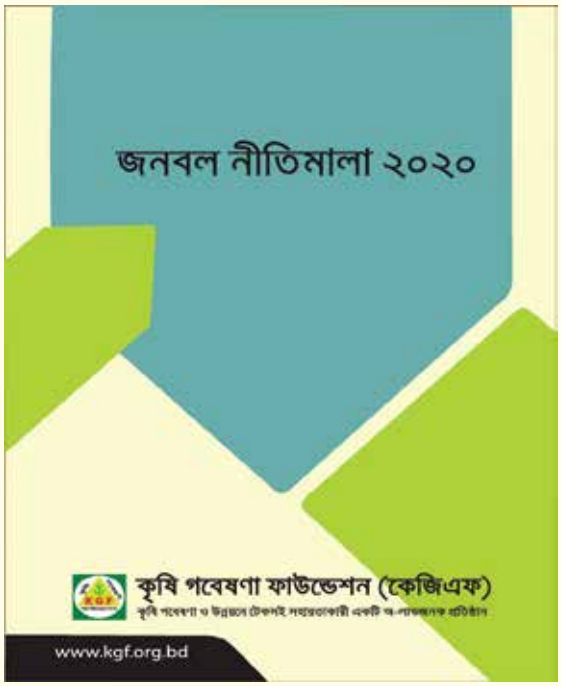


Fig. 71. KGF Booklet: Jonobol Nitimala 2020

7. Governance

7.1 The Board of Directors (BoDs)

The Board of Directors (BoDs) of KGF comprise seven elected members from the General Body (GnB) who are reputed personalities in diverse fields of agricultural research and development. A list of members of the KGF BoD and BoD is furnished in Annex-1. BoD has the authority to take any decision needed for the smooth functioning of KGF.

Fig. 72. A few members of the KGF Board of Directors with Dr. Shaikh M Bokhtiar (third from left), Executive Chairman, BARC and Chairman, Board of Directors and General Body, KGF

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).

7.2 Annual General Meeting (AGM)

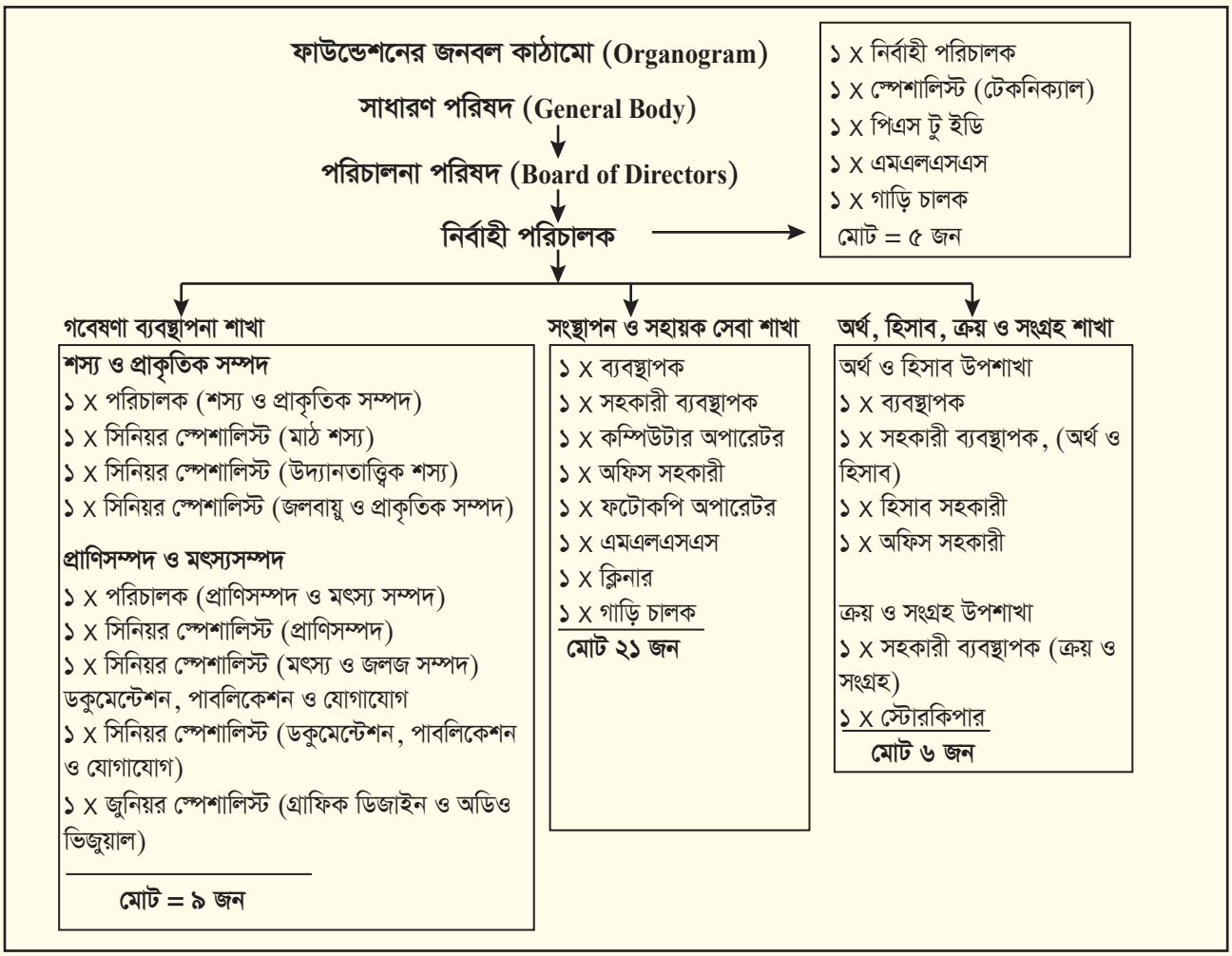
The 13th and 14th Annual General Meetings (AGM) of KGF were held on 20 Septemeber, 2020 and 6 April, 2021 at Hotel Radisson, Dhaka and BARC Conference Room-1, respectively. In addition, the 7th Emergency General Meeting (EGM) was held on February 14, 2021 at BARC Conference Room-1. Executive Chairman of BARC and Chairman, General Body and Board of Directors, KGF presided over the meetings.

7.3 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, review BARC prioritized researchable areas, select issues appropriate for inviting proposals for KGF funding, identify areas where new initiatives

may be required and recommend resource allocations for CGP and other projects. To accomplish this, several TAC meetings were arranged by KGF. A list of KGF projects so far approved by TAC since the inception of KGF is provide in Annex-2.

8. The KGF Organogram



9. The KGF Team

Dr. Jiban Krishna Biswas, Executive Director (August 18, 2020 to date)
Dr. Tapan Kumar Dey, Senior Program Specialist (Crops)
Dr. Md. Hazrat Ali, Program Specialist (Field Crops) (Left August 2020)
Dr. Shahabuddin Ahmad, Senior Specialist (Horticultural Crops)
Mr. Mohammad Nuruzzaman, Program Specialist (Fisheries)
Ms. Nasrin Akter, Senior Specialist (Documentation, Publication & Communication)
Dr. Shahrina Akhtar, Specialist (Technical)
Mr. Mehedi Hasan, Manager (Establistment & SS)
Ms. Fatema Parvin, PS to Executive Director, KGF
Ms. Tahsina Naznin, Joniour Specialist (Graphic Design & Audio Visual)
Md. Delowar Hossain, Assistant Manager (Finance and Accounts)

Mr. Md. Rafiqul Islam Akanda, Assistant Manager (Support Service)

Mr. Mohammed Abul Khair, Assistant Manager (Procurement)

Ms. Mahmuda Begum, Audit and Accounts Supervisor

Ms. Noormahal Begum, Logistics and Common Services Supervisor

Ms. Jarin Tasmim, Accounts Assistant

Mr. Aminul Islam Khan, Store Keeper

Mr. Bidyuth Chokkraborti, Office Assistant

Mr. Md. Rashidul Hasan, Office Assistant (Accounts)

10. Financial Management

10.1 Statement of expenditure (SOE)

In the reporting period, 2020-21, KGF received Tk. 4578.76 lakh from BKGET and the expenditure was Tk. 4492.34 lakh up to 30 June, 2021, which was 98% of the released fund. Progress was satisfactory in implementing different programs. The details of expenditure during fiscal 2020-21 are shown in the Annex-3.

10.2 Budget for Fiscal Year 2021-22

Annual work plan 2021-22

The Foundation has prepared the annual work plan for 2021-22. The detailed plan (gang chart) by items is given in the Annex-4.

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-5.

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 2021 and fiscal year 2020-21. KGF finance and accounts were audited by Zoha Zaman Kabir & Co. (Chartered Accountants). The detailed audit report is presented in Annex-6.

Annex-1

List of Members of the General Body (GnB) and Board of Directors (BoD)

Sl	Name	Position	Photo
01	Dr. Md. Kabir Ikramul Haque Chairman, General Body, KGF, and Executive Chairman, BARC Farmgate, Dhaka-1215	GnB and BoD	
02	Dr. Shaikh Mohammad Bokhtiar Executive Chairman Bangladesh Agricultural Research Council Farmgate, Dhaka	GnB and BoD	
03	Dr. Md. Abdus Sattar Mandal Emeritus Professor and Former Vice-Chancellor Bangladesh Agricultural University, Mymensingh	GnB and BoD	
04	Dr. Abul Kalam Azad Director General Bangladesh Agricultural Research Institute, Gazipur	GnB and BoD	
05	Dr. Md Abdul Wohab Director General Bangladesh Agricultural Research Institute, Gazipur	GnB and BoD	
06	Dr. Md Nazirul Islam Director General Bangladesh Agricultural Research Institute, Gazipur	GnB and BoD	
07	Dr. Md Shahjahan Kabir Director General, BRRI	GnB and BoD	
08	Dr. Shaikh Abdul Quader Managing Director Agriconcern Ltd.	GnB and BoD	

Sl	Name	Position	Photo
09	Mr. Md. Manjurul Hannan Managing Director, Hortex Foundation	GnB and BoD	
10	Dr. F H Ansarey Managing Director and CEO ACI Agribusinesses	GnB and BoD	
11	Dr. Md. Shah-E-Alam Vice Chancellor City University, Dhaka	GnB	
12	Dr. Md Shahidur Rashid Bhuiyan Vice Chancellor Sher-e-Bangla Agricultural University Sher-e-Bangla Nagar, Dhaka	GnB	
13	Dr. Md Abdul Muyeed Director General, DAE Khamarbari, Farmgate, Dhaka-1215	GnB	
14	Dr. Shaikh Azizur Rahman Director, Animal Health and Administration Department of Livestock Services	GnB	
15	Dr. Humnath Bhandari IRRI Representative in Bangladesh	GnB	
16	Dr. Kashfia Ahmed Chairman, Win Miaki Ltd.	GnB	

List of BKGET Funded Projects

Annex-2

A. Competitive Grants Programs (CGP)

CGP 1st Call

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, Mohanpur 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 Bheramara, Daulatpur of Kushtia
8	TF 08-NR: Evaluation and Up scaling of Resource Conservation Technologies (RCTs) for Improving Productivity in the Drought Prone Areas. Date of commencement: May 13, 2013	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
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	Jashore 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 Barishal 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 Nawabganj; Rajshahi; Natore; Naogaon; Rangpur; Dinajpur; Thakurgaon; Jashore; Kushtia; Meherpur; Satkhira; Chuadanga; Mymensingh; 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 and 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, Barishal, Rangpur, Dinajpur, Nilphamari, Bandarban, Rangamati and Khagrachari
3	TF 17-ARI: ARI Refining and Validation of BAU-Bro chickens. Duration: Mar 2015 to Feb 2018	Prof Ashraf Ali, BAU: 01675145096	BAU, Mymensingh

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
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, Shibganj, Sirajganj Sadar, Manikganj, 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, Patiya, Chattogram
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, Shirajganj 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, Jashore, Cumilla
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

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
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 Bogura
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	Bogura, Rajshahi, Jhenaidah and Jashore
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, Joypurhat, 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	Chattogram, Khulna, Mymensingh
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, Cumilla
3	TF-39-F/17: Adaptation of Disease Management Strategy in the Existing Culture practices of Shrimp through Aquamimicry System.	Dr. SM Rafiquzzaman, Dept of Fisheries Biology and aquatic environment, BSMRAU, Gazipur, Cell # 01754041311	BSMRAU and Satkhira

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
	Duration : 13th Dec 2017 to Nov 2020 (12th Dec 2020)		
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, Munshiganj, Debiganj
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 of Gopalganj, 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, Mymensingh
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 and Mymensingh; Lab: Dept Microbiology/Hygine and Phermacology, BAU; Dept of 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 Chattogram
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

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
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, Nowgaon, Bogura, Natore, Sirajganj, 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
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, Jaashore
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, Barishal, 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

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
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	*Char* lands of Ramgati, Raipur, Kamalnagar upazilas of Lakshmipur district
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. Duration : Jan 2018 to Dec 2019	Prof. Dr. Md. Abdur Rahim, Department of Hoticulture, Mymensingh Agriculture University (BAU).	BAU,Khulna,Barishal,Patuakhali
Interim-1			
28	TF-65-C/19: Post-harvest Management, Processing and Marketing of Jackfruits loss reduction and value addition of fresh water fish. 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. 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 Division, 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 Division, BARI, Mymensingh.	Two upazilas at Mymensingh district (Sadar and Nandail), two upazilas at Netrakona district (Durgapur and Kalmakanda) and two upazilas of Sherpur district (Nalitabari and Nokla)
30	TF-67-C/19: Survey of Water melon diseases and Integrated Management of wilt and stem blight disease. Duration : Nov. 2019-Oct. 2022	Dr.Md.Mahfuz Alam, SSO & PI, Plant Pathology Divisiton	Gazipur, Noakhali and Patuakhali

CGP 4th Call

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
1	TF 68-C/20: Molecular Characterization of biovars *of Ralstonia solanacearum*, the causal agent of bacterial wilt of solanaceous crops and its Integrated management Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Dr. Mafruha Afroz, SSO, Plant Pathology Section, HRC,BARI, Cell: 1716011482 Email:mafruha_afroz@yahoo.com	Horticulture Research Center, Joydebpur, Gazipur ; Tuber Crop Research Sub Center, BARI, Bogura and Agriculture Research Station, BARI
2	TF 69-C/20: Adaption,Validation,Multiplication and Maintenance of Lilium Genotype in Bangladesh Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Dr.Farjana Nasrin Khan, PSO, Floriculture Division, HRC, BARI, Cell: 1910047191 Email:khan_farjana@yahoo.com	Dhaka(Savar), Gazipur(Gazipur Sadar), Rangpur(Rangpur Sadar), Jashore (Jhikargacha)
3	TF 70-C/20 Technology Development for Lisianthus (*Eustoma grandiflorm*) Production and its varietal Improvement for Flower Industry Development in Bangladesh Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Dr.Abul Faiz Md. Jamal Uddin, Dept.of Horticulture, SAU,Sher-e-Bangla Nagar,Cell: 1731840979 Email: jamal4@yahoo.com	Department of Horticulture, Faculty of Agriculture, SAU
4	TF 71-CC/20 Sustainable management of blast, sheath blight and bacterial blight diseases of rice through Nano-particles (NPs) Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Dr . Md. Abdul Latif, CSO & Head Plant Pathology Division, BRRI,Cell: 01715034094 Email: alatif1965@yahoo.com	BRRI
5	TF 72-NRM/20 Management of soil fertility with profitable and agro-ecologically suitable crop varieties for increasing cropping intensity in northern region of Bangladesh Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Prof. Dr. A. K. M. Zakir Hossain, Dept. of Crop Botany,BAU, Memensingh-2202, Cell: 1713113559,Email: zakir@bau.edu.bd	Mithapukur upazila of Rangpur and Shahjahanpur upazila of Bogura district
6	TF 73-NRM/20 Increasing Crops and Soil Productivity through Climate Smart Conservation Technologies (CSCTs) in Drought & Non Traditional Areas of Bangladesh Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Dr. Md. Illias Hossain, PSO (Agronomy),Wheat and Maize Research Institute, Shyampur, Rajshahi,Cell: 1712632167 Email: iliasrwrc@gmail.com	Narail and Rajshahi districts
7	TF 74-NRM/20 Field based applied research on Aquifer storage and recovery (ASR) technology for increasing cropping intensity of Bangladesh Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Dr. Sara Nowreen, Assistant. Prof, Institute of water and flood management (IWFM),BUET, Cell: 1553636657, Email: snowreen@iwfm.buet.ac.bd /,sara.sohel@gmail.com	Rajshahi (Paba), Natore (Naldanga) and Tangail (Mirzapur)

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
8	TF 75-F/20 Molecular approaches to study the effects of probiotics on growth and reproduction of cultivable fish species in Bangladesh Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Prof. Dr. Md. Shahjahan, Department of Fisheries Management,BAU, Mymensingh-2202 Cell: 01718590903 Email: mdshahjahan@bau.edu.bd	BAU, Mymensingh
9	TF 76-F/20 Development of low cost recirculating aquaculture system (RAS) for the sustainable intensification and mechanization of aquaculture in Bangladesh Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Dr. M. A Shahabuddin, Associate Professor, Dept. of Aquaculture, SAU, Sher- e- Bangla Nagar, Dhaka Cell: 1835950573 Email :amsu.aqua@sau.edu.bd	Sher-e-Bangla Agricultural University (SAU), Dhaka
10	TF77-L/20 Molecular characterization of virulent Newcastle disease virus (NDV) strains circulating in Bangladesh: In-search for a thermos table NDV vaccine for backyard chickens Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Dr. Pankaj Chakraborty, Associate Professor & Coordinator, CASR, CVASU, Khulshi, Chattogram-4225 Cell: 1712976747 Email: pcb23m@yahoo.com	CVASU
11	TF 78-L/20 Development of Crossbred Dairy Cattle Using Genomic Information for Efficient Productivity and Resilience in Tropical Environment of Bangladesh Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Prof. Dr. Mohammad Shamsul Alam Bhuiyan, Dept. of Animal Breeding and Genetics, BAU,Mymensingh-2202 Cell: 01745748849 Email: msabhuiyan@gmail.com	BAU
12	TF 79-SoE/20 Shifting in Conventional Agriculture towards High Value Enterprise for Better Livelihood of the Rural People Duration: Dec 13, 2020 – Nov 12, 2023 (36 mo)	Prof. Dr. M Zulfikar Rahman, Dept. of Agricultural Extension Education, BAU Cell: 01714074313 Email : zulfikarbau64@gmail.com	BAU
13	TF 80-NRM/20 Development of biochar enriched fertilizer for enhancing nutrient use efficiency in agriculture Duration: Mar 02, 2021 – Feb 01, 2024 (36 mo)	Dr. Shamim Mia, Associate Professor, Dept. of Agronomy, Dumki, Patuakhali-8202 PSTU, Cell No: 01786308562 Email:smia_agr@pstu.ac.bd Component Org.: BARI, Gazipur	Patuakhali Science and Technology University (PSTU), BARI and the University of Sydney, Australia

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
14	TF 81-NRM/20 Intervention in surface water utilization through integrated minor irrigation schemes for escalating water and land productivity in coastal region (ISIMISC) Duration: Mar 02, 2021 – Feb 01, 2024 (36 mo)	Mir Nurul Hasan Mahmud Senior Scientific Officer, Irrigation& Water Management Division, BRRI, Joydebpur, Gazipur-1701Cell: Email: nurul.iwm@brri.gov.bd Dr. Md. Towfiqul Islam, CSO& Head, Irrigation& Water Management Division, BRRI, Joydebpur, Gazipur-1701 head.iwm@brri.gov.bd; islam.towfiq@yahoo.com Mobile No. 01715090879	Patuakhali and Barguna
15	TF 82-L/20 Value addition in composting poultry manures for better compost quality and reduction of environmental pollution Duration: Mar 02, 2021 – Feb 01, 2024 (36 mo)	Prof. Dr. Md. Mukhlesur Rahman, Dept. of Animal Science, BAU, Mymensingh-2202, Mobile: 01933-548922, E-mail: mmrahman.as@bau.edu.bd	BAU, Mymensingh
16	TF 83-L/20 Designing a sustainable feeding strategy for dairy cow production in Bangladesh Duration: Mar 02, 2021 – Feb 01, 2024 (36 mo)	Prof. Dr. Mohammad Ashiqul Islam, Dept. of Dairy Science, BAU, Mymensingh-2202, Cell no: 01712-428472 Email:	BAU Dairy Farm (BAU), Mymensingh
17	TF 84- SoE Adoption of Climate resilient crop varieties in selected environmentally vulnerable areas of Bangladesh and its impact on farm productivity. Duration: Mar 02, 2021 – Feb 01, 2024 (36 mo)	Prof. Dr. Hasneen Jahan, Dept. of Agril. Economics BAU	Rajshahi, Tangail, Jashore, Satkhira and Sunamganj
18	TF 85-F/20: Development of sustainable mass seed production technology for (Macrobrachium rosenbergii) and production of quality broodstock in captivity. Duration: March 2021 – Feb 2015 (48 mo)	Professor Dr. Md. Samsul AlamDept. of Fisheries Biology and GeneticsBAU, Mymensingh	

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, Cell: 01716839404	BRRI Joydebpur

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
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 Jashore; RARS Barisaal; 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. Commissioned 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 Duration : Jul 2013 to Sep 2018	Dr. Munshi Rashed Ahmed, Chief Scientific Officer, RHARS, Khagrachari, BARI, Cell phone: 01748717603, Email: munshirashid@gmail.com	Selected watersheds in Bandarban (1), Khagrachari (3) and Rangamati districts
	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 in Bandarban, Khagrachari and Rangamati districts
	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 in 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 in 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 in 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

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
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, CVASU (Chattogram), Bandarban (Sadar and Naikhangchari), 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 upazilas 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
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, Chattogram

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, BARC, Dhaka. Cell: 01716420890	Takurgaon, Rajshahi, Ishurdi, Barguna, Khulna, Mymensingh
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, Jhalokhati, Pirojpur, Barishal, 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. Lump Sum Grants (LSG)

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
1	LSG-1-C/20. Research to find out the reasons for the prices increase of rice, potato and onion Duration: 6 months	Dr. Md. Mosharraf Uddin Molla, Member Director (cc), AERS Division & Chief Scientific Officer, AERS Division, BARC, Email: md-aers@barc.gov.bd,	Dacope, Khulna and Amtali, Barguna
2	LSG-2-L/21. Environmental disaster due to lead exposure in magura sadar: exposure evaluation and rapid disaster mitigation Duration: 8 months	Professor Dr. Kazi Rafiqul Islam, Department of Pharmacology, Faculty of Veterinary Science, Cell No: 01711285766, Email: krafiq73@yahoo.com, kazirafiq@bau.edu.bd	Takurgaon, Rajshahi, Iswardi, Barguna, Khulna, Mymensingh
3	LSG-3-F/21. Challenges of biofloc technology in bangladesh aquaculture: an ambigous media hype Duration: 6 months	Professor Dr. S.M. Rafiquzzaman, Dept. of Fisheries Biology and Aquatic Environment, BSMRAU, Gazipur, Email: rafiarib@yahoo.com	Takurgaon, Rajshahi, Iswardi, Barguna, Khulna, Mymensingh
4	LSG-4-C/21. Method Development for Comb Honey Production Duration: 6 months	Professor Dr. Mohammed Sakhawat Hossain, Department of Entomology, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207	Khulna, Satkhira, Jalokhati, Pirojpur, Barisal, Patuakhali, Barguna
5	LSG-5-C/21. Exploring the status and potentials of minor cereals in Bangladesh Duration: 6 months	Professor Dr. Md. Rafiqul Islam, Department of Agronomy, Bangabandhu Sheikh Mujibur, Rahman, Agricultural Uni, mversity, Gazipur-1406	Khulna, Satkhira, Jalokhati, Pirojpur, Barisal, Patuakhali, Barguna
6	LSG-6-C/21. Invasion of exotic rugose spiraling whitefly in Bangladesh: A baseline survey study on its geographical distribution, host plants dynamics and infestation severity Duration: 6 months	Dr. Gopal Das, Professor, Address: Department of Entomology, Bangladesh Agricultural University, Mymensingh-2202, Cell: 8801749285388, +8801306406215, Email: gopal_entom@yahoo.com,gopal_entom@bau.edu.bd	Khulna, Satkhira, Jalokhati, Pirojpur, Barisal, Patuakhali, Barguna

F. 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 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

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
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, Bogura, 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 Jhalokati
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	Chatttogram 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, Mymensingh, 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. Duration : Jan 2018 to Dec 2020	Dr. Mrs. Shamsunnahar, PSO, HRC, BARI	Gazipur, Jashore, Comilla and Bogura
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, Barishal, Bhola, Madaripur, Gopalgong, Faridpur, Jhenaidah , Hessor, Kushtia, Khulna, Satkhira, Cox's Bazar, Chattogram, Noakhali, Cumilla, Brahmanbaria, Narsingdi, Gazipur, Tangail, Manikganj, Mymensingh, Jamalpur, Sherpur, Kishoreganj, Bogura, Rajshahi, Rangpur, Joypurhat, Gaibandha, Dinajpur, Nilphamari, Panchagar, and Thakurgoan.

Sl	Project title, code no. and duration	Coordinator/PI/CI	Location
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 Narail, Kaliganj of Jhenaidah, Singair of Manikganj, Dohar of Dhaka, Sadar and Kamarkhand of Sirajganj, Lalpur of Natore, Shibganj of Chapai Nawabganj, Sadar of Rajshahi, Sadar of Joypurhat, Sadar and Haripur of Thakurgaon

G. 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

KRISHI GOBESHONA FOUNDATION

Statement of Expenditure (SOE) for the Period from July, 2020 to 30 June, 2021

Fig. in Crore Tk.

Sources of Fund / Head of Income:		Budget for 2020-21 is under Approval by 13 th AGM for 2020-21	Fund Received from BKGET, 2020-21	Quarterly expenditure (1st April,2021 to 30 June ,2021)	Cummulative Expenditure Fiscal Year 2020-21	Un-spent Balance	Progress
Opening Balance 01/07/2020 (Cash at Bank Tk. 1.4413469 (Crore) + Petty Cash in hand Tk. 0.0025 (Crore)		0.0000	1.4438				
Fund refund from field office (CRP-1- Hill Agricultue).		0.0000	1.1462				
Fund Received from BKGET 2020-21		56.0000	43.1976				
Total Fund for the period of July 2020 to 31 May, 2021		56.0000	45.7876				
Sl. No.	**Line Items / Head of Expenditures**	**Budget for 2020-21 is under Approval by 13 th AGM for 2020-21**	**Fund Received and with last year Balance , 2020-21**	**Expenditure for 1st April-2021 to 30 June. .2021**	**Cummulative Expenditure July'2020 to 30 June, 2021**	**Un-spent Balance (Tk.)**	**Achivement %**
1	Program Cost:						
1.1	Research Grants Program (on-going):						
	(a) Competitive Grants Program (CGP)						
	(i) CGP (2nd Call)	0.0000	0.3400	0.0000	0.3316	0.0084	98%
	(ii) CGP (3rd Call)	8.1192	8.7486	1.3653	8.7287	0.0199	100%
	(iii) CGP (4th Call)	10.0000	3.2776	0.5939	3.2752	0.0024	100%
	(iv) LSG Program	0.0000	0.3000	0.2998	0.2998	0.0002	100%
	(iii) Basic Research	0.9935	0.7300	0.1001	0.7233	0.0067	99%
	Sub- total (CGP)	19.1127	13.3962	2.3591	13.3586	0.0376	100%
	(b) Commissioned Research Program (CRP) :						
	(i) CRP-1: Hill Agriculture (i,ii,iii,iv,v)	0.0000	0.0000	0.0000	0.0000	0.0000	0%
	(ii) CRP-2: Modeling Climate Change on Bangladesh Agriculture	3.0000	2.8200	1.6748	2.7914	0.0286	93%
	(iii) CRP- 3: Sugarcane R&D in CHT	0.0000	0.0800	0.0000	0.0791	0.0009	0%
	(iv) CRP- 4: R&D on Hill Livestock	1.1660	1.3872	0.0000	1.3817	0.0055	0%
	(v) CRP-5 Assessment of land suitability & Crop Zoning	4.0000	4.2500	0.0000	4.2500	0.0000	100%
	Sub- Total- CRP	8.1660	8.5372	1.6748	8.5022	0.0350	100%
	(C) (i) Technology Piloting Program (TPP)	2.7418	1.2188	0.1349	1.1996	0.0192	98%

Sources of Fund / Head of Income:		Budget for 2020-21 is under Approval by 13 th AGM for 2020-21	Fund Received from BKGET, 2020-21	Quarterly expenditure (1st April,2021 to 30 June ,2021)	Cummulative Expenditure Fiscal Year 2020-21	Un-spent Balance	Progress
	(ii) TCP (BAU-Bro chicken Conservation and piloting their producer group farming).	0.0000	2.1500	1.7494	2.1494	0.0006	100%
	Sub-Total (TPP)	2.7418	3.3688	1.8843	3.3490	0.0198	99%
	(d) International Collaborative Program (ICP)	0.0000	0.0000			0.0000	0%
	(i) ICP- I : Cropping System Intensification in the Salt Affected Coastal Zone of Bangladesh & West Bangal, India. (ACIAR), Soil nutrition , Pulse and Wheat.	0.0000	0.0000	0.0000	0.0000	0.0000	0%
	(ii) ICP-II : NUMAN	1.2500	1.7100	0.7012	1.7012	0.0088	99%
	(iii) ICP- III- Incorporating Salt Tolernt Wheat and Pules into Small Holder farming system in Southern Bangladesh	0.6000	0.4900	0.0000	0.4530	0.0370	0%
	(iv) ICP-IV Development of short duration Cold Tolerant Rice Varieties for Haor Areas of Bangladesh Implementation By IRRI .	0.0000	2.3124	1.1352	2.2705	0.0419	98%
	Sub- Total-(ICP)	1.8500	4.5124	1.8364	4.4247	0.0877	98%
	(e) Other Program:						
	(i) Mitigation of Greenhouse Gas (GHG)	0.0170	0.0000	0.0000	0.0000	0.0000	0%
	(ii) R&D of Seaweed cultivation.	1.3693	2.4654	0.6130	2.0702	0.3952	84%
	(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..	1.2000	2.6772	0.8558	2.6742	0.0030	100%
	Sub-Total (other Program)	2.5863	5.1426	1.4688	4.7444	0.3982	92%
	Total Research Grants Program	34.4568	34.9572	9.2235	34.3788	0.5784	98%
1.2	Capacity Enhancement Program (CEP):						

Sources of Fund / Head of Income:		Budget for 2020-21 is under Approval by 13 th AGM for 2020-21	Fund Received from BKGET, 2020-21	Quarterly expenditure (1st April,2021 to 30 June ,2021)	Cummulative Expenditure Fiscal Year 2020-21	Un-spent Balance	Progress
	(a) Human Resource Development (HRD) Program: Higher studies, Skill enhancement of scientists and R&D 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 R&D partners, Independant Monitoring Team.	1.2000	1.6800	0.2425	1.6527	0.0273	98%
	(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.	0.2964	0.4900	0.1028	0.3839	0.1061	78%
	(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.	0.9000	0.2300	0.0000	0.2242	0.0058	97%
	(d) Mujib Year : Observation of International /National events/ Mujib Year.	1.5000	1.0000	0.0000	1.0000	0.0000	100%
	(e) ARMIS Program	1.0000	1.2262	0.3321	1.2183	0.0079	99%
	(f) Global Institute for Food Security (GIFS), University of Saskatchewan Canada & Bangladesh Agricultural Research Council (BARC)	5.0000	0.0000	0.0000	0.0000	0.0000	0%
	Sub- total	9.8964	4.6262	0.6774	4.4791	0.1471	97%
	Total Program Cost	44.3532	39.5834	9.9009	38.8579	0.7255	98%
2	Operational Support Cost:						

Sources of Fund / Head of Income:		Budget for 2020-21 is under Approval by 13 th AGM for 2020-21	Fund Received from BKGET, 2020-21	Quarterly expenditure (1st April,2021 to 30 June ,2021)	Cummulative Expenditure Fiscal Year 2020-21	Un-spent Balance	Progress
2.1	Research Grants Program (Up -Coming): CRP, ICP, CEP, Technology Piloting Program, etc.	6.0000	0.0600	0.0000	0.0570	0.0030	95%
2.2	(a) Salaries: i) Salaries of KGF Technical /Admin & Finance/Office and General Support Service Management Staff and support service (ii) Remuneration of contractual services & other staff, etc	3.5000	3.8723	1.0020	3.7668	0.1055	97%
	(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	0.7500	1.0400	0.6306	1.0098	0.0302	97%
2.3	(c) General Operating Cost: Utilities, hiring of vehicles, repair & maintenance/ renovation, supply & services, TA/DA , Audit fees/ financial/ technical services, AGM/EGM/Board Meeting.	1.1629	1.0319	0.2840	1.0319	0.0000	100%
	(d) Contingency/ Any other misc. cost (as per need)	0.2339	0.2000	0.0072	0.1877	0.0123	94%
	Sub-total of Operational Support Cost	11.6468	6.2042	1.9238	6.0532	0.1510	98%
		56.0000	45.7876	11.8247	44.9111	0.8765	98%
Progress: Tk. 44.9134 (Crore) 30 June, 2021 against Total fund of Tk. 45.7876 (Crore)							

(As per need, line-item costs may be adjusted by the ED, KGF within the Total budget)

Trust fund grants Tk. 5600.00 (Crore) will be utilized as per objective of the BKGET Clause iv no.7 (page -10) and the provisions of the Memorandum of KGF.

Fiscal Year 2020-21:
Annual approved budget: Tk. 56.00 crore
Fund expenditure Tk. 43.8156 crore

Progress on annual budget 78.24 %

Fund received from BKGET 2020-21: Tk. 43.1979 crore

Total fund = Tk. 45.7876 crore (fund received from BKGET, Tk. 43.1976 crore + last year's un-spent balance Tk. 1.4438 crore + un-spent balance from CRP-1 after project completion, Tk. 1.1462 crore)

KGF Work Plan and Implementation
FY: 2021-22 (Tentative)

Sl. No.	List of Activities/Programs	Performance Schedule (Tentative)											
		J	A	S	O	N	D	J	F	M	A	M	J
	A. Competitive Grants Program (CGP)												
1.	TAC evaluation and budget rationalization of the CGP projects												
2.	Board approval, MoU signing and awarding grants to the CGP projects												
3.	Coordination, implementation and management of on-going CGP and Basic Research projects												
	B. Commissioned Research Program (CRP)												
1.	Coordination, implementation and management of on-going projects												
	C. Capacity Enhancement Program(CEP)												
1.	Coordination, Implementation and management of on-going projects												
2.	Development and implementation of training on statistics/advanced breeding/ disease forecasting/crop modeling/IPM/crop management/molecular biology/IPR, etc.												
3.	Need based consultative meetings, seminars, workshops, etc.												
4.	Need based assistance to develop/improve physical facilities to the NARS institutes												
5.	National and international linkages & collaboration with reputed universities and R&D organizations												
	D. International Collaborative Program(ICP)												
1.	Coordination, implementation and management of on-going and upcoming projects												
2.	TAC evaluation and budget rationalization of ICP projects												
3.	Board approval, MoU signing and awarding grants to ICP projects												
	E. Technology Piloting/ Upscaling Program (TPP)												
	Continue implementation of the on-going and upcoming projects.												
	F. Ongoing and Upcoming Projects												
1.	CGP 5th Call												
2.	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.	Board/AGM/EGM/other meetings												
2.	Preparation and printing of annual report (BKGET & KGF)/project brief/data management /technology bulletin/need based fact sheet/ data management/ other reports/ occasional publications /compilation of technical and scientific booklets etc.												
3.	Building Floor for KGF in the 6th Floor of AIC building, BARC Campus												
4.	Preparation of action plan/implementation plan/ activity plan, etc,												
	Misc. other activities												

Annex-5

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
	(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) **Mujib Year :** 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 of the BKGET Clause iv no.7 (page-10) and the provisions of the Memorandum of KGF.

Jiban Krishna Biswas *PhD*
Executive Director, KGF

KRISHI GOBESHONA FOUNDATION (FGF)
FUND OF BANGLADESH KRISHI GOBESHONA ENDOWMENT TRUST (BKGET)
INDEPENDENT AUDITORS' REPORT
&
FINANCIAL STATEMENTS
FOR THE YEAR ENDED 30 JUNE 2021

Independent Auditors' Report
Of Krishi Gobeshona Foundation (KGF)
Fund of Bangladesh Krishi Gobeshaona Endowment Trust (BKGET)

Qualified Opinion

We have audited the financial statements of Krishi Gobeshona Foundation (KGF) , which comprise the statement of financial position as at 30 June 2021, and the statement of comprehensive income and expenditure, statement of receipts and payment for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, except for effect of the matter described in the Basis for Qualified Opinion section of our report, the accompanying financial statements present fairly in all material respects of the statement of financial position of Krishi Gobeshona Foundation as at 30 June 2021, and of its financial performance and its cash flows for the year then ended in accordance with International Financial Reporting Standards (IFRSs).

Basis for Qualified Opinion

We conducted our audit in accordance with International Standards on Auditing (ISAs). Our responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the Company in accordance with the International Ethics Standard Board for Accountants' Code of Ethics for Professional Accountants (IESBA Code), together with the 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 these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our qualified opinion.

- The foundation has not charged any depreciation on its fixed assets.
- The foundation has shown the total allocated amount of any project as expense whether it has been incurred or not. Nevertheless, the unused amount of that respective project is refunded to KGF.
- Some projects closed in the preceding years. The unused money of those projects has been returned amounting Tk. 11,692,472 during the year. But the actual unused amount of those projects cannot be verified by us for the lacking of respective documents.

Other Information

Management is responsible for the other information. The other information comprises all of the information other than the financial statements and our auditor's report thereon.

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.

Zoha Zaman Kabir Rashid & Co., a partnership firm registered in Bangladesh and a member firm of MSI Global Alliance, a leading international association of independent legal and accounting firms
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sponsibilities of Management and Those Charged with Governance for the Financial Statements

nagement is responsible for the preparation of financial statements that give a true and fair view in cordance with IFRSs, Companies Act 1994 and for such internal control as management determines is cessary to enable the preparation of financial statements that are free from material misstatement, whether e to fraud or error.

preparing the financial statements, management is responsible for assessing the Company's ability to continue a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis accounting unless management either intends to liquidate the Company or to cease operations, or has no listic alternative but to do so.
ose charged with governance are responsible for overseeing the Company's financial reporting process.

uditor's Responsibilities for the Audit of the Financial Statements

ur objectives are to obtain reasonable assurance about whether the financial statements as a whole are free m material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our inion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in cordance with ISAs will always detect a material misstatement when it exists.

isstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they uld reasonably be expected to influence the economic decisions of users taken on the basis of these financial tements

part of an audit in accordance with ISAs, we exercise professional judgment and maintain professional cpticism 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.

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- Obtained sufficient appropriate audit evidence regarding the financial information of the entities or business activities within the company to express opinion on the financial statements. We are responsible for the direction, supervision and performance of the company audit. We remain solely responsible for our audit opinion.

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 the 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 auditors' 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 explanation which to the best of our knowledge and belief were necessary for the purpose of our audit and made due verification thereof;

b) in our opinion, proper books of account as required by law have been kept by the Company so far as it appeared from our examination of those books;

c) the statement of financial position and statement of Income & Expenditure dealt with by the report are in agreement with the books of account;

Dated, Dhaka
15 December, 2021

Md. Iqbal Hossain FCA
Partner, Enrolment No.:596 (ICAB)
Zoha Zaman Kabir Rashid & Co.
Chartered Accountants
DVC: 2112210596AS689472

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Krishi Gobeshona Foundation (KGF)
Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund
Statement of Financial Position
As at 30 June 2021

Particulars	Notes	Amount in Taka	
		30 June 2021	30 June 2020
Assets:			
Non-current assets:			
Property, Plant and Equipment's	4.00	**38,019,846**	**37,256,601**
Current assets:			
Loans & advances	5.00	1,322,000	1,440,000
Security Deposits	6.00	1,110,000	1,110,000
Cash & Cash Equivalents	7.00	8,790,113	14,438,469
Total current assets		**11,222,113**	**16,988,469**
Total Assets		**49,241,959**	**54,245,070**
Fund and Liabilities:			
Fund Account (BKGET Fund)	8.00	49,241,959	54,245,070
Other Liabilities			
Total Fund and Liabilities		**49,241,959**	**54,245,070**

The annexed notes 1 to 18 and Annexure -A & B form an integral part of these financial statements.

Manager (Finance & Acounts) **Director** **Executive Director**

Signed in terms of our separate report of even date.

Md. Iqbal Hossain FCA
Partner, Enrolment No. 596 (ICAB)
Zoha Zaman Kabir Rashid & Co.
Chartered Accountants

Dated, Dhaka
December 15, 2021

Zaman Kabir Rashid & Co. Chartered Accountants

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Krishi Gobeshona Foundation (KGF)
Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund
Statement of Income & Expenditure
For the Year ended 30 June 2021

Particulars	Notes	Amount in Taka	
		30 June 2021	30 June 2020
Income:			
Grant	8.02	448,695,129	330,054,971
Interest Received	18.00	1,085,191	1,738,651
Other Received	18.00	57,346	48,320
Total Income:		**449,837,666**	**331,841,942**
Less : Expenditure			
Salaries and Allowances	09.00	54,222,589	53,286,214
Training, Workshop & CGP Related Expenses	10.00	29,459,711	16,129,200
Operational Cost	11.00	15,941,697	17,219,779
Competitive Grant Program CGP	12.00	175,669,935	114,568,185
LSG Project	13.00	3,568,200	-
Commissioned Research Project CRP-1	14.00	85,022,450	92,772,825
Pilot Project	15.00	33,486,867	9,767,796
Basic Research & CEP ii & iii	16.00	42,466,217	19,420,418
Other Projects	17.00	10,000,000	8,452,526
Total Expenditure:		**449,837,666**	**331,616,943**
Excess of Income over Expenditure (Transferred to Fund Account)		-	-

The annexed notes 1 to 18 and Annexure -A & B form an integral part of these financial statements.

Manager (Finance & Acounts) **Director** **Executive Director**

Signed in terms of our separate report of even date.

Md. Iqbal Hossain FCA
Partner, Enrolment No. 596 (ICAB)
Zoha Zaman Kabir Rashid & Co.
Chartered Accountants

Dated, Dhaka
December 15, 2021

Krishi Gobeshona Foundation (KGF)
Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund
Statement of Receipts and Payments
For the Year ended 30 June 2021

Particulars	Notes	Amount in Taka	
		30 June 2021	30 June 2020
A. Receipts:			
Opening balance:			
Cash at Bank		14,413,469	45,413,882
Cash in Hand		25,000	25,000
Fund Received	8.01	431,975,876	299,588,929
Refund of Unspent Balance against advance		879,652	551,012
Missc.Received		11,716,142	1,187,116
Other Received	18.00	1,142,537	1,786,971
Total		460,152,676	348,552,910
B. Payments:			
Salaries and Allowances	SCH-3	53,043,389	53,286,214
Acquisition of property plant and equipment's	ANX-A	763,245	965,887
Training, Workshop & CGP related expenses	SCH-1	27,857,176	14,400,354
Operational Cost	SCH-2	14,324,729	16,067,215
Loans & advances	AX-B	5,160,355	4,413,022
Competitive Grant Program CGP	12.00	175,669,935	114,568,185
LSG Program	13.00	3,568,200	-
Commissioned Research Project CRP-1	14.00	85,022,450	92,772,825
Pilot Project	15.00	33,486,867	9,767,796
Basic Research & CEP ii & iii	16.00	42,466,217	19,420,418
Other Projects	17.00	10,000,000	8,452,526
Total Payments		451,362,563	334,114,441
Closing balance:			
Cash at Bank	7.00	8,765,113	14,413,469
Cash in Hand	7.00	25,000	25,000
Total		460,152,676	348,552,910

The annexed notes form an integral part of these financial statements.

Manager (Finance & Acounts) **Director** **Executive Director**

Signed in terms of our annual Report of even date.

Md. Iqbal Hossain FCA
Partner, Enrolment No. 596 (ICAB)
Zoha Zaman Kabir Rashid & Co.
Chartered Accountants

Dated, Dhaka
December 15, 2021

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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 2021

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- I 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 va

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.

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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 2020 to 30 June 2021.

iv) General:

Figures appearing in the Financial Statements have been rounded off to the nearest Taka.

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		Amount in Taka	
		30 June 2021	30 June 2020
4.0	**Property, Plant and Equipment's**		
	A. Cost:		
	As on 01.07.2020	37,256,601	36,290,714
	Add: Addition during the year	763,245	965,887
	Less: Adjustment during the year	-	-
	As on 30.06.2021	**38,019,846**	**37,256,601**
	Less:		
	B. Accumulated Depreciation:		
	As on 01.07.2020	-	-
	Add: Depreciation charged during the year	-	-
	Less: Adjustment during the year	-	-
	As on 30.06.2021	-	-
	Written Down Value (WDV) (A-B) as on 30.06.2021	**38,019,846**	**37,256,601**
	(Details have been shown in Annexure-A)		
5.00	**Loans & advances**		
	Mojibor Rahman	-	40,000
	Sahjahan	-	35,000
	Abul Khair	190,000	300,000
	Alam Mia	-	82,500
	Iqbal Hossain	7,500	97,500
	Faruque Hossain	25,000	100,000
	Zerin Tasnin	190,000	300,000
	Aminul Alam Khan	45,000	100,000
	Motaleb Hossain	45,000	100,000
	Pervin Begum	25,000	85,000
	Rehana Begum	45,000	100,000
	Salauddin Liton	45,000	100,000
	Nurmohol Begum	92,400	-
	Fatema Pervin	190,000	-
	Rafiqul Islam Akanda	190,000	-
	Ranu Akter	110,000	-
	Normohammad Mustafa Sockder	50,000	-
	Rafiqul Islam Akanda	40,100	-
	Abul khaiyer	32,000	-
	Total	**1,322,000**	**1,440,000**
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	25,000	25,000
	Pubali Bank Ltd. Farmgate Br. A/C# 0522	8,765,113	14,413,469
	Total	**8,790,113**	**14,438,469**

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		Amount in Taka	
		30 June 2021	30 June 2020
8.00	**Fund Account (BKGET Fund)**		
	Opening Balance	54,245,070	83,523,996
	Add: Fund Received during the year (**Note - 8.01**)	431,975,876	299,588,929
	Misse.Received	11,716,142	1,187,116
		497,937,088	384,300,041
			-
	Less: Transferred to grant income **(Note-8.02)**	448,695,129	330,054,971
	Add : Excess of Income over Expenditure	-	-
	Total	49,241,959	54,245,070
8.01	**Fund Received during the year:**		
	Fund received from BKGET Fund	431,975,876	299,588,929
8.02	**Transferred to grant income**	448,695,129	330,054,971
9.00	**Salaries and Allowances**		
	Expert salary (Including CPF)	26,142,048	30,922,903
	Allowance/ Bonus	4,760,850	3,354,250
	Officer & Staff salary	-	282,581
	Recreation Allowance	1,363,750	-
	Contractual Service salary (Including Security Service Bill)	12,408,782	14,686,993
	Gratuity	5,752,431	-
	Employees Contribution(CPF Fund)	3,225,384	3,625,438
	Security Service Salary	569,344	639,049
	Total	54,222,589	53,511,214
10.00	**Training, Workshop & CGP Related Expenses**		
	Hiring of vehicle CGP monitoring	72,193	601,890
	CGP TA/DA (review and M & E cost)	832,997	896,525
	Honarioum	23,876,986	9,917,822
	PhD Scholarship	3,075,000	2,984,117
	Advance Adjustment	1,602,535	1,728,846
	Total	29,459,711	16,129,200
11.00	**Operational Cost**		
	Entertainment	11,468	29,957
	Car Repair & Maintenance	1,902,738	593,621
	Other Repair & Maintenance	163,144	223,387
	Overtime Bill	863,141	806,785
	Bank Charge	49,760	61,627

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		Amount in Taka	
		30 June 2021	30 June 2020
	Electricity Bill	1,423,435	1,645,388
	Audit fee	330,750	185,438
	Printing and Publication/documents, video	2,452,033	4,445,921
	Miscellaneous Expenses	787,722	461,378
	Office Rent	2,718,646	2,820,208
	Gas, Fuel & Oil etc.	1,361,946	1,230,332
	Car Insurance Premium	553,578	528,717
	Telephone/ Mobile Bill, Courier, Internet & Website	505,865	750,892
	Office Supplies & Stationary	524,042	48,448
	Training workshop (National/International)	120,711	1,644,549
	Retention Fee	330,750	417,000
	Postage bill	-	8,567
	Internet bill	225,000	165,000
	Adjustment with advance	1,616,968	1,152,564
	Total	**15,941,697**	**17,219,779**
12.00	**Competitive Grant Program CGP**		
12.01	**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	**-**	**-**
12.02	**2nd Call:**		
	TF 16-WF	-	455,972
	TF 17-ARI	-	600,000
	TF 19-EM	-	295,633
	TF23-AM	533,350	1,047,150
	TF 24-EM	-	681,612
	TF 26-ARI	-	2,750,040
	TF 27-SF	-	321,635
	TF 29-AM	1,780,000	1,768,500
	TF 31-VC	-	3,573,700
	TF 32-SF	-	155,072
	TF 33-ARI	-	2,562,900
	TF 36-FP	174,240	-
	Total 2nd Call	**2,487,590**	**14,212,214**

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		Amount in Taka	
		30 June 2021	30 June 2020
12.03	**3rd Call**		
	TF-37-F/17	1,467,000	1,185,000
	TF-38-F/17	4,533,300	7,259,000
	TF-39-F/17	583,600	1,534,000
	TF-40-F/17	655,200	1,923,000
	TF-41-SBR/17	5,238,900	1,939,500
	TF-42-AE/17	229,323	1,915,677
	TF-43-C/17	6,858,265	4,209,000
	TF-44-L/17	766,400	2,171,000
	TF-45-F/L/17	4,485,515	7,399,101
	TF-46-F/L/17	874,500	2,921,000
	TF-47L/17	764,775	1,406,250
	TF-48-L/17	1,122,660	1,267,200
	TF-49-L/17	3,087,106	1,663,175
	TF-50-C/17	12,627,335	15,596,395
	TF-52-C/17	2,158,732	1,040,350
	TF-53-C/17	1,924,045	1,001,950
	TF-54-SBR/17	619,600	1,536,000
	TF-55-AE//17	323,480	683,700
	TF-56-C/17	2,096,236	3,720,590
	TF-57-C/17	1,000,000	1,532,799
	TF-58-C/17	2,951,222	3,001,550
	TF-60-SBR//17	1,245,600	1,483,000
	TF-61-C/17	1,001,700	1,604,000
	TF-62-L/17	6,913,809	8,606,910
	TF-63-Char/17	2,436,975	1,947,433
	TF-64-Fruits/17	1,321,000	1,011,000
	TF-65-C/19	9,272,500	2,904,000
	TF-66-C/19	5,036,100	3,077,900
	TF-67-C/19	1,442,000	846,900
	Total 3rd Call	**83,036,878**	**86,387,380**
12.04	**4th Call**		
	TF 68-C/20	1,695,000	-
	TF 69-C/20	4,082,300	-
	TF 70-C/20	2,115,000	-
	TF 71-C/20	15,958,000	-
	TF 72-NRM/20	644,800	-
	TF73-NRM/20	1,528,900	-
	TF74-NRM/20	2,529,000	-
	TF75-F/20	1,317,500	-
	TF76-F/20	3,932,330	-
	TF77-L/20	3,077,500	-
	TF78-L/20	1,367,000	-
	TF79-SOE/20	4,070,000	-
	TF-80-NRM/20	394,800	-
	TF-82-L/20	813,800	-

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		Amount in Taka	
		30 June 2021	30 June 2020
	TF-83-L/20	633,650	-
	TF-84-SOE/20	620,400	-
	TF-85-F/20	1,118,820	-
	Total 4th Call	**45,898,800**	-
	ICP-II (NUMAN)	17,012,050	8,306,322
	ICP- III (Soit tolerent wheat pules)	4,529,817	5,662,269
	ICP-IV (Shot duration hoar project)	22,704,800	-
	Total	**175,669,935**	**114,568,185**
13.00	**LSG Program**		
	LSG-02-L/21	1,198,200	-
	LSD-3-F/21	570,000	-
	LSG-04-L/21	600,000	-
	LSG-05-C/21	600,000	-
	LSG-06-C/21	600,000	-
	LSG Total	**3,568,200**	-
14.00	**Commissioned Research Project CRP-1**		
	CRP-1 Hill Agriculture	-	32,882,225
	CRP-2:Modeling Climate Change	27,914,000	-
	CRP-5 (Crop Zoning)	42,500,000	30,170,250
	CRP-4 (Hill Live Stock)	13,817,000	13,357,500
	CRP-3 (Sugarcane)	791,450	8,203,850
	ARMIS (ICT)	-	8,159,000
	Total	**85,022,450**	**92,772,825**
15.00	**Pilot Project**		
	Pilot Project-16	5,376,605	1,430,550
	Pilot Project -17	2,192,713	2,023,250
	Pilot Project-18	-	4,669,660
	Pilot Project -19	-	1,644,336
	Pilot Project -20	4,426,249	-
	TCP 1 (BAU-BRO-Chicken)	21,491,300	-
	Total	**33,486,867**	**9,767,796**
16.00	**Basic Research : With CEP i ii & iii**		
	BR1-C/17	2,244,182	742,148
	BR2-C/17	-	1,316,087
	BR3-C/17	-	1,640,000
	BR4-C/17	500,000	591,995

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		Amount in Taka	
		30 June 2021	30 June 2020
	BR5-C/18	2,418,900	1,557,500
	BR6-C/17	2,069,700	-
	BR7-C/17	-	1,891,295
	BR8-C/17	-	2,626,000
	Total	**7,232,782**	**10,365,025**
	Capacity Enhancement Program (CEP)		
	CEP-I (Armis project)	12,183,000	-
	CEP-II (Seaweed cultivation project)	20,701,935	-
	CEP-III (Mitigation green house gas)	2,348,500	9,055,393
	Sub Total	**35,233,435**	9,055,393
	Total	**42,466,217**	**19,420,418**
17.00	**Other Projects**		
	Seaweed project	-	5,500,000
	Mujib Borsho	10,000,000	-
	KGF ACAIR Grants (ICP- 1)	-	2,952,526
	Total	**10,000,000**	**8,452,526**
18.00	**Other Received**		
	Interest Received	1,085,191	1,738,651
	Other Received	57,346	48,320
	Total	**1,142,537**	**1,786,971**

Krishi Gobeshona Foundation (KGF)
Bangladesh Krishi Gobeshona Endowment Trust (BKGET) Fund
Schedule of Fixed Assets
As at 30 June 2021

Annexure-A
Figures in Taka

Particulars	Cost				Rate %	Depreciation				Written down value as on 30.06.2021
	As on 01.07.2020	Addition during the	Adjustment during the	As on 30.06.2021		As on 01.07.2020	Charged during the	Adjustment during the	As on 30.06.2021	
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	1,342,122	141,454	-	1,483,576	0%	-	-	-	-	1,483,576
Multimedia Projector	95,680		-	95,680	0%	-	-	-	-	95,680
Office Equipment	5,015,888	507,039	-	5,522,927	0%	-	-	-	-	5,522,927
Furniture & Fixtures	1,987,224	114,752	-	2,101,976	0%	-	-	-	-	2,101,976
Electric Equipments	883,979		-	883,979	0%	-	-	-	-	883,979
Total	**37,256,601**	**763,245**	**-**	**38,019,846**		**-**	**-**	**-**	**-**	**38,019,846**

Note: Depreciation has never been charged on fixed assets during the year and previous years.

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KRISHI GOBESHANA FOUNDATION (KGF)
Schedule of Advance
For the year ended 30 June 2021

Annexure-B
(Amount in Taka)

SL	Name	Opening (01-07-2020)	During the year	Refund	Adjusted	Closing (30-06-21)
1	Mojibor Rahman	40,000	-	-	40,000	-
2	Sahjahan	35,000	-	-	35,000	-
3	Abul Khayir	300,000	-	-	110,000	190,000
4	Alam Mia	82,500	-	-	82,500	-
5	Iqbal Hossain	97,500	-	-	90,000	7,500
6	Faruque Hossain	100,000	-	-	75,000	25,000
7	Zerin Tasnin	300,000	-	-	110,000	190,000
8	Aminul Alam Khan	100,000	-	-	55,000	45,000
9	Motaleb Hossain	100,000	-	-	55,000	45,000
10	Pervin Begum	85,000	-	-	60,000	25,000
11	Rehana Begum	100,000	-	-	55,000	45,000
12	Salauddin Liton	100,000	-	-	55,000	45,000
13	Nurmohol Begum	-	200,000	-	107,600	92,400
14	Md. Sazzadur Rahman Sarker	-	8,000	-	8,000	-
15	Md. Nurruzzaman	-	40,000	19,200	20,800	-
16	Habibur Rahman Kondokar	-	5,000	-	5,000	-
17	Fatema Pervin	-	328,000	-	138,000	190,000
18	Rafiqul Islam Akanda	-	300,000	-	110,000	190,000
19	Ranu Akter	-	150,000	-	40,000	110,000
20	Dr.Jibon Krishna Biswas	-	6,000	-	6,000	-
21	Dr.Md. Ainul Haqe	-	75,000	-	75,000	-
22	Dr. Md. Nurul Hapue	-	75,000	-	75,000	-
23	Dr. Md.Muklesur Rahman	-	75,000	-	75,000	-
24	Dr. Mohammad Badrul Hasan Badal	-	75,000	-	75,000	-
25	Anowarul Haque	-	12,000	-	12,000	-
26	Normohammad Mustafa Sockder	-	100,000	-	50,000	50,000
27	Rafiqul Islam Akanda	-	3,412,928	843,560	2,529,268	40,100
28	Abul khaiyer	-	298,427	16,892	249,535	32,000
	Total	**1,440,000**	**5,160,355**	**879,652**	**4,398,703**	**1,322,000**

Annexure-C

Misscelenous Received

Fund received (Refund) :

CRP-1, Component-i (Hill)	3,328,442
CRP-1, Component-ii (Hill)	359,536
CRP-1, Component-iv (Hill)	2,910,422
CRP-1, Component-v (Hill)	4,121,988
TF-35-SF/15	548,072
TF-31-VC/15	148,571
CRP-3 (Sugarcane)	275,441
Total Fund Refund	**11,692,472**
Add: Cheque Cancel	23,670
Total Refund	**11,716,142**

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Krishi Gobeshona Foundation (KGF)
Schedule of Cash use for Adjustment and Expenditure
For the year ended 30 June 2021

Training, Workshop & CGP Related Expenses	**Schedule-1** **Amount in Taka**
Training, Workshop & CGP Related Expenses (Notes 11.00)	29,459,711
Less: Adjustment with advance	1,602,535
Cash use for Training, Workshop & CGP Related Expenses	**27,857,176**

Operational Cost	**Schedule-2** **Amount in Taka**
Operational Cost (Notes 12.00)	15,941,697
Less: Adjustment with advance	1,616,968
Cash use for Operational Cost	**14,324,729**

Salaries & Allowances	**Schedule-3** **Amount in Taka**
Salaries & Allowances(Notes 10)	54,222,589
Less: Adjustment with related expenses	1,179,200
Cash use for Salaries & Allowances	**53,043,389**

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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, NGOs and private enterprises, 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 adaptation for enhancing productivity and quality of crops, fisheries and livestock through effective management of R&D in 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 the 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 (BARC). 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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