Sub-Project ID-051

Program Based Research Grant (PBRG)

Sub-project Completion Report

on

Validation of Crop Intensification Technologies for Improving System Productivity, Soil Health and Farm Income in South Central Coastal Region

Sub-project Duration
January 2019 to December 2022

Coordinating Organization
Bangladesh Agricultural Research Institute, Gazipur

Project Implementation Unit
National Agricultural Technology Program-Phase II Project
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

December 2022

Program Based Research Grant (PBRG)

Sub-project Completion Report

on

Validation of Crop Intensification Technologies for Improving System Productivity, Soil Health and Farm Income in South Central Coastal Region

Sub-project Duration
January 2019 to December 2022

Implementing Organization

Soil Science Division, BARI, Gazipur

Oilseed Research Centre, BARI, Gazipur

Agarian Research Foundation, Dhaka

Project Implementation Unit
National Agricultural Technology Program-Phase II Project
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

December 2022

Citation:
Hossain M.S., Akhter S., Saha C.K., Barman A., Neogi M.G., Akter N. and Islam, T. 2022. Validation of crop intensification technologies for improving system productivity, soil health and farm income in south central coastal region. Project Completion Report, 1-123p

Edited by:
Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

Acknowledgement

The execution of PBRG sub-project has successfully been completed by Bangladesh Agricultural Research Institute using the research fund of WB, IFAD and GoB through Ministry of Agriculture. We would like to acknowledge to the World Bank for arranging the research fund and supervising the PBRGs by BARC. It is worthwhile to mention the cooperation and quick responses of PIU-BARC, NATP-2 in respect of field implementation of the sub-project in multiple sites. Preparing the sub-project completion report required to contact a number of persons for collection of information and processing of research data. Without the help of those persons, the preparation of this document could not be made possible. All of them, who have made it possible, deserve appreciation. Our thanks are due to the Director PIU-BARC, NATP-2 and his team who given their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for designing their future research projects in order to technology generation as well as increasing production and productivity for sustainable food and nutrition security in Bangladesh. It would also assist the policy makers of the agricultural sub-sectors for setting their future research directions.

Published in: Deccember 2022

Printed by: [Name of press with full address]

Abbreviation and Acronyms

ACP	Alternate Cropping Pattern
AEZ	Agro-Ecological Zone
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCR	Benefit Cost Ratio
BRRI	Bangladesh Rice Research Institute
CP	Cropping Pattern
DAE	Department of Agricultural Extension
FRG	Fertilizer Recommendation Guide
FSRD	Farming System Research Development
GM	Gross Margin
GR	Gross Return
ha	Hectare
INMS	Integrated Nutrient Management System
IDA	International Development Agency
IFAD	International Fund For Agricultural Development
LSP	Local Service Provider
MBCR	Marginal Benefit Cost Ratio
NATP	National Agricultural Technology Program
OFRD	On-Farm Research Division
PCR	Project Compilation Report
PIU	Project Implementation Unit
REY	Rice Equivalent Yield
SP	System Productivity
TVC	Total Variable Cost

Table of Contents

Executive Summary

Agricultural production in south central coastal region is lower than other parts of the country. Poverty incidence in the region is highest. Most people depend on agriculture for their livelihood; but cropping intensity and crop productivity is low largely because of unfavorable ecological conditions of Low Ganges River and coastal Tidal floodplain with uncontrolled water and as well as lack of potentials improved varieties and technologies. The low soil organic matter is another causes of low productivity and is considered as a serious threat to the sustainability of agriculture in Bangladesh. In view of high poverty associated with low cropping intensity and poor yields in the south central coastal regions, the project was engaged in implementing the NATP-BARC sub-project of "Validation of Crop Intensification Technologies for Improving System Productivity, Soil Health and Farm Income in South Central Coastal Region" in order to validation, adoption, demonstrations of high yielding varieties with improved production practices for increasing yield and production or productivity through improving cropping system. Thus, this project was developed in order for increasing cropping intensity in the south central coastal region incorporating dry season crops. The project activities were uninterruptly continued from January 2019 to June 2022 under pandemic situation. The project is being jointly implemented by Oilseed Research Center and Soil Science Division, Bangladesh Agricultural Research Institute (BARI) in collaboration with Agrarian Research Foundation (ARF) and is implemented under the leadership of Director (Research), BARI. Activities in the first year of project implementation concentrated on selection of area and farmers, and conducting baseline survey. The baseline survey was completed for existing crops practiced by the local farmers. After baseline survey, the Institute introduced three crop based cropping patterns two (Mustard-Mungbean-T. *aman* and Grasspea-Gimakolmi-T. *aman)* were tried in Madaripur and Gopalgonj, while the rest one (Sweet potato-Sesame-T. *aman*) in Bagerhat and Barishal regions. Afterwards three crop based cropping patterns were tried in farmer's field and were being sown in Rabi, Kharif-1, and Kharif-2 season 2019-2021. The farmer's trials were conducted with three crop varieties and three fertilizer levels (Recommended Fertilizer Dose, RFD from inorganic sources as per soil test bases, STB; RFD on STB with 5 tha^{-1} cow dung integrated plant nutrient system, IPNS approach; and Farmers practices). In Madaripur sadar and Kalkini upazilla field trials, it was observed that IPNS based fertilized plots yielded higher than farmers practices and BARI Sarisha-14 (1.72 tha^{-1}), BARI Mung-6 (1.79 tha^{-1}), BARI Khesari-3 (1.82 tha^{-1}), BARI Gimakolmi-1 (62.01 tha^{-1}) and BRRI dhan71 (5.61 tha^{-1} and 5.84 tha^{-1}) yielded higher than BARI Sarisha-17 (1.60 tha^{-1}) and BARI Sarisha-11 (1.71 tha^{-1}), BINA Mung-8 (1.61 tha^{-1}), local Khesari (1.52 tha^{-1}) and gimakolmi (50.67 tha^{-1}), BRRI dhan57 (4.77 tha^{-1}) and BRRI dhan75 (5.41 tha^{-1}) in the cropping pattern of Mustard-Mungbean-T. *aman* and Grasspea-Gimakolmi-T. *aman.* In case of Bagerhat sadar and Mollarhat upazilla locations, the cropping pattern Sweet gourd-Sesame-T. *aman* with IPNS based fertilizer plots yielded better perform than farmers practice and BARI Hybrid Mustikumra-2 (42.13 tha^{-1}), BARI Til-3 (1.41 tha^{-1}) and BRRI dhan71 (5.59 tha^{-1}) yielded higher than BARI Hybrid Mustikumra-3 (40.11 tha^{-1}), BARI Mustikumra-2 (30.66 tha^{-1}), BINA Til-4 (1.45 tha^{-1}) and BARI Til-4 (1.38 tha^{-1}), BRRI dhan57 (4.82 tha^{-1}) and BRRI dhan75 (4.83 tha^{-1}). In field crops, farmers' achieved higher yields and economic returns from their alternative or improved cropping pattern, which included improved high yielding varieties, IPNS approach and also better management practices. The improved cropping pattern increased rice equivalent yield by 50-75%, and gross return, gross margin as well as benefit cost ratio were also higher than existing pattern at Madaripur and Bagerhat district. For Low Ganges River Floodplain areas, Mustard (BARI Sarisha-14/BARI Sarisha-17)-Mungbean (BARI Mung-6/BINA Mung-8)-T. *aman* (BRRI dhan71/BRRI dhan75) pattern is recommended and Grasspea (BARI Khesari-3/BARI Khesari-5)-Gimakolmi (BARI Gimakolmi-1)-T. *aman* (BRRI dhan71/BRRI dhan75) can be a potential planting pattern for the south central coastal areas. Similarly, Sweet

gourd (BARI Hybrid Mustikumra-2/BARI Mustikumra-2)-Sesame (BARI Til-3/BARI Til-4)-T. *aman* (BRRI dhan71/BRRI dhan75) pattern is recommended for Tidal floodplain (Bagerhat) areas. Soil Science Division, BARI component conducted experiments starting with the Mustard and Khesari crops in Rabi season and harvested with good yields. From 2nd year trial, it was observed that IPNS based fertilizer application performed better than farmers practice with 3 cropping pattern of Gopalganj and Barishal. Among the varieties, BARI Sorisha-17, BARI Mung-6, BRRI dhan71, BARI Hybrid Mistikumra-3, BARI Till-3, BARI Khesari-3 and BARI GImakolmi-1 yielded better than the others varieties. Highest total rice (system) yield was obtained from IPNS based fertilizer management. Also highest gross margin and BCR were obtained from IPNS based fertilizer management. In case of ARF component, the project area is characterized by tidal floodplain (Jhalokathi and Pirojpur districts) and mostly fallow-transplanted aman-fallow cropping system is followed. Farmers grow long statured, long duration indigenous local varieties of aman rice under tidal flooded condition that mature in December to January. Dry season cropping is seldom practiced. The project attempted reintroduction of incorporating dry season crops (grasspea, mungbean and sesame) or grasspea relay inter-planted with aman rice and growing of mungbean after rice harvest depending on toposequence. Farmers' preferred crops were grasspea and mungbean; but productivity of dry season crops was very low. Cyclone Bulbul (November 2019) coupled with high tides submerged rice fields. On-farm experiment with grasspea was established by relay planting of seeds at three times at one week interval in standing aman rice in one location (Uttampur, Rajapur, Jhalokati) where 11 farmers participated. Yield performance of grasspea planted in first two planting dates was poor and farmers could not harvest yield from last planted grasspea. Mungbean (BARI Mung-6 and BU mung 5) was planted in four upazilas and three locations (Bhitabaria, Sialkati of Pirojpur district, and Nalchity, Challish Kahnia of Jhalokati district), and the yield was very low. Mungbean yield varied between 289 and 691 kg ha^{-1} across locations. In the second year of the project implementation, an exploratory trial on three aman rice variety including an aromatic, fine grain premier rice variety Kataribhog was conducted during wet season to examine the possibility of growing a relatively of early maturing fine grain rice that lends support to timely fitting of grasspea following transplanted aman in tidal floodplain. However, the performance of grasspea planted at two locations (Uttampur, Rajapaur) and Bheronbaria, Nalchity was fairly good. Moreover, 30 farmers in Palot (Rajapur, Jhalokati) and 15 farmers in Bheronbaria (Nalchity, Jhalokati) planted mungbean and an appreciably good yield was harvested in both the locations and the average yield ranged from 1,466 kg ha^{-1} to 1,683 kg ha^{-1}, and between 1,593 kg and 1,770 kg ha^{-1} across locations. Compared with first year's trial, second year trial gave higher yields of both grasspea and mungbean in both the locations regardless of treatment differences which might be attributed to prevailing weather conditions. Introduction of Kataribhog in aman season and its early harvest allowed timely planting of grasspea but did not bring any yield benefit to grasspea. Early planting and prevailing weather enhanced mungbean yield. Relay cropping of grasspea with transplanted aman and growing of high yielding varieties of mungbean could be an important option for increasing cropping intensity and thereby increasing production and farm income. According to the findings, it can be concluded that identification and expansion of high yielding varieties, high value crops and improved technologies in crop cycle or pattern in south central coastal region. Satisfactory improvement regarding production, consumption, family nutrition, employment opportunity reflected due to development of crop system productivity, cropping intensity under this project. The results of all the activities through cropping pattern implied at four locations of the country have presented here and would continue to create the opportunity for the resource-poor farmers to improve their livelihood in southern region of unfavorable ecosystem.

Keywords: Cropping pattern, cropping intensity, system productivity, integrated plant nutrient system, recommended fertilizer dose

PBRG Sub-project Completion Report (PCR)

A. Sub-project Description

1. Title of the sub-project

Validation of Crop Intensification Technologies for Improving System Productivity, Soil Health and Farm Income in South Central Coastal Region

2. Implementing organization

Bangladesh Agricultural Research Institute, Gazipur

3. Name and full address with phone, cell and E-mail of Coordinator, Associate Coordinator and PI/Co-PI(s)

Coordinator:

Dr. Md. Tariqul Islam
Director (Research), Research Wing, Bangladesh Agricultural Research Institute, Gazipur-1701. Tel: 02-49270001 Mobile: 01779519121
Email: *dir.res@bari.gov.bd*

Principal Investigator:

Component-1: Soil Science Division, BARI

Dr. Sohela Akhter
Director (current charge)
Tuber Crops Research Centre,
Bangladesh Agricultural Research Institute, Gazipur-1701.
Tel: 02-49270178 Mobile: 01922242737
Email: *sohela_akhter@yahoo.com*

Component-2: Oilseed Research Center, BARI

Dr. Md. Shakhawat Hossain
Senior Scientific Officer, Central Laboratory, Research Wing, BARI
Mobile: 01781539300,
Email: *shakhawatbari@yahoo.com*

Component-3: Agarian Research Foundation (ARF)

Md. Mahirul Islam Biswas
Research Associate, Agarian Research Foundation
315, West View, Kalampur, Saver, Dhaka.
Cell phone: 01715-333154
Email: *mahirul71@gmail.com*

Co-Principal Investigator:

Soil Science Division, BARI

Alak Barman
Scientific Officer, Soil Science Division
Bangladesh Agricultural Research Institute, Gazipur-1701.
Mobile: 01914561677
E-mail: *alakbarman.sau@gmail.com*

Component-2: Oilseed Research Center, BARI

Krisna Chandra Saha
Scientific Officer, Oilseed Research Centre, BARI,
Mobile: 01726740483
Email: *krisna.sau@gmail.com*

Component-3: ARF

Ms. Nurunnahar Akter
House: 315 West View, Kamalapur, Savar, Dhaka.
Cell phone: 01737-226137
Email: *lata.agr@gmail.com*

4. Sub-project budget (Tk)

4.1 Total (in Tk. as approved) : 1,56,25,000/-

4.2 Latest Revised (if any) : 1,67,72,000/-

5. Duration of the sub-project: January 2019 to November 2022

5.1 Start date (based on LoA signed) : January 2019

5.2 End date : December 2022

6. Background of the sub-project

Bangladesh is one of the most densely populated countries and vulnerable to climate change. Climate change accelerated the intensity and frequency of occurrences of salinity, irregular rainfall, flash flood, storms, high temperature etc. eventually pose serious threat on crop production and food security. Impact of climate change is increasingly visible through frequent cyclones and tidal surge that damage crops, properties, and lives imposing additional stresses to already delicately balanced agro-ecosystems. Climatic and hydrological conditions constrain intensive agricultural production in the south-central coastal regions. Agricultural production in south central coastal region is lower than other parts of the country. Poverty incidence in the region is highest. Most people depend on agriculture for their livelihood; but cropping intensity and crop productivity is low largely because of unfavorable ecological conditions. On the other hand, tidal floodplain ecosystem dominates in the central coastal region. Excepting a few months in dry season, rivers, tributaries and canals overflow inundating lowland and medium high lands. Diurnal high tide around full moon and new moon usually inundates the crop field. During low tide water normally recedes. High tides and low tides alternate two times daily. Tides remain active July through November inundating fields almost daily. Under such tidal submergence nothing can be grown except lowland rice. Crop varieties, particularly rice and production technologies developed and extensively adapted under irrigated condition elsewhere in the country are found not much suitable for tidal floodplains. Farmers thus grow mostly traditional rice varieties in aman season. Productivity of indigenous rice varieties is less, much lesser than that of HYVs grown under irrigated conditions elsewhere. The dominant crop in the

coastal area is the local T. *aman* rice (about 60-70%). However, the major cropping patterns in southern region are: Fallow-T. aus-T. *aman* (30%), and Fallow-Fallow-T. *aman* rice (15%), and Boro-Fallow-T. *aman* (12%). It was observed that an average of 40-45%, 30-35%, and 5-10% lands remain fallow in *Rabi*, *Kharif*-1 and *Kharif*-2 seasons, respectively and that is why the average cropping intensity in southern region is low only 175% (BBS, 2010). Late harvest of T. *aman* rice (up to mid January), delay receding of tidal flood water, soil salinity and lack of good quality irrigation water are the main causes of fallow lands. BARI developed modern varieties along with their production technologies of upland crops like oilseeds (e.g. BARI Sarisha-14, BARI Sarisha-17 for mustard, BARI Til-3, BARI Til-4 for sesame, and BARI Soybean-5, BARI Soybean-6 for soybean) and pulses (e.g. BARI Mungbean-5, BARI Mungbean-6 for mungbean, BARI Chola-8, BARI Chola-9 for chickpea, BARI Khesari-3, BARI Khesari-5 for grasspea) for improving the existing rice-based cropping systems (BARI, 2015). The yield potentialities of these varieties are higher (about 20 to 30%) as compared to local ones. BARI has developed several improved cropping systems for the tidal flood and salinity ecosystems of southern region such as: T. *aus* (BRRI dhan27)-T. *aman* (BRRI dhan57, BRRI dhan71, BRRI dhan75)-Mungbean, and Potato/Grasspea (zero tillage)-T. *aus* (BRRI dhan27)-T. *aman* (local/BR23). The existing rice-based cropping systems can also be improved further through incorporating saline and/or submergence tolerant varieties of upland crops. Therefore, evaluation and development of saline and/or submergence tolerant modern varieties of different upland crops including pulses and oilseed crops as well as their improved management practices are crucial for increasing the cropping intensity and crop diversification. BARI has also developed several crop component technologies for the tidal flooded coastal saline area: tomato and brinjal cultivation through fertigation method, fertilizer mixed drip irrigation method, cultivation of mustard, wheat, garlic, maize and potato (with mulch), tomato cultivation by using mulch. The local farmers have also adopted a few indigenous technologies like 'floating agriculture' and 'pit culture', which should be improved for mitigating the crop vulnerability. Improvement of agronomic management practices could increase yield to a certain extent (Hamid *et al*., 2015; Hamid *et al*., 2016) but breaking the yield ceiling can only be possible through breeding varieties capable of producing longer seedlings (>50 cm) in 30 days, high tillering, long stature plant tolerant to tidal flooding (Ullah *et al*., 2015). Moreover, 'Green Revolution' technology bypassed millions of rural people in less-favored environment of coastal areas of Bangladesh. High yielding varieties and appropriate technologies for crop production and intensification in tidal floodplain area are recognized as best instrument of increasing rural income and livelihood improvement of farming communities. In addition, crops

and varieties tolerant to drought and salinity can be grown in dry season. Adopting improved technologies for local and modern varieties of aman rice and growing upland crops with irrigation after rice will increase production and cropping intensity. However, prior to large-scale adoption, those technologies require validation.

This project was developed in order for increasing cropping intensity, system productivity, soil health as well as farmers' income in the south central coastal region incorporating dry season crops (mungbean, grasspea, mustard, sweet gourd and sesame) in fallow-transplanted aman and boro-T. *aman* rice system. Howover, This research project seeks to gain better understanding of the bio-physical and socio-economic factors constraining and promoting crop production, developing and adopting better crop production technologies in order for increasing agricultural production and improving rural economy in selected southern central districts. Beginning January 2019, the project is being jointly implemented by three components- Soil Science Division and Oilseed Research Center component, Bangladesh Agricultural Research Institute (BARI) and Agrarian Research Foundation (ARF). The project is implemented under the leadership of Director (Research), BARI. In these circumstances, a project was undertaken entitled "Validation of Crop Intensification for Improving System Productivity, Soil Health and Farm income in south central coastal region." funded by NATP Phase-2, BARC during January 2019 to June 2022. In this regard, out of three test cropping pattern two (Mustard-Mungbean-T. *aman* and Grasspea-Gimakolmi-T. *aman)* were tried in Madaripur (Madaripur sadar and Kalkini upazilla) and Gopalgonj (Gopalgonj sadar and Kashiani upazilla), while the rest one (Sweet gourd-Sesame-T. *aman*) in Bagerhat (Bagerhat sadar and Mollarhat upazilla) and Barishal (Gouronodi and Babugang). In case of ARF component, the project was implemented Rajapur and Nalcity upazila of Jhalokathi district and Bhandaria and Kaukhali upazila of Pirojpur district. The major focus of the sub-project was to improve cropping intensity by incorporating grasspea and mungbean in the predominantly fallow-fallow-T. *aman* rice system. Afterwards three crop based cropping patterns were tried three crop varieties and three fertilizer levels (Recommended Fertilizer Dose; RFD from inorganic sources as per soil test bases, STB; RFD on STB + 5 t ha^{-1} cow dung Integrated plant nutrient system, IPNS approach; and Farmers practices) in farmer's field and were being sown in Rabi, Kharif-1, and Kharif-2 season 2019-2022. This was an exploratory experiment in order for gaining an understanding whether the varieties (mungbean, grasspea, mustard, sweet gourd and sesame) could withstand repeated cycles of land, produce comparable yield and matures earlier than the traditional varieties in the locality. Developed technologies from this project and disseminate the technologies among the stakeholder that could help to overcome the potential or positive impact of south central coastal areas.

7. Sub-project general objectives:

I. Evaluation of bio-physical and socio-economic factors constraining intensification of crop production in southern six districts of Bangladesh,

II. Testing, validation and adoption of improved production practices for growing oilseed, pulse and vegetable crops during dry season after transplanted *aman* rice in six selected districts of central coastal districts and

III. Increasing farm income through intensive crop production and improving farmers' knowledge and skill through training, conducting on-farm trials and demonstrations on improved agricultural production technologies in south central coastal region.

8. Sub-project specific objectives:

Component-1 (Soil Science Division, BARI)

i. To develop integrated nutrient management packages for high yielding oilseed, pulses vegetables varieties under climate vulnerable area of south central coastal region.

ii. To monitor the changes in physico-chemical properties of soils under climate vulnerable area of south central coastal region.

iii. To asses soil microbial populations and their seasonal variation from the crop intensification under the changing climate.

iv. To improve farmers' knowledge and skill through training, on-farm trials and demonstrations on improved agricultural production technologies in south central coastal districts.

Component-2 (Oilseed Research Center, BARI)

i. To introduce high yielding oilseed, pulses, vegetables varieties after T. *aman* rice in south central coastal region.

ii. To evaluate best management practices for high yielding oilseed, pulses, vegetables production of south central coastal region.

iii. To improve farmers' knowledge and skill through training, on-farm trials and demonstrations on improved agricultural production technologies in south central coastal districts.

Component-3 (Agarian Research Foundation, Dhaka)

i. To evaluate socio-economic factors constraining intensification of crop production in southern districts of Bangladesh;

ii. To validate and adopt improve production practices for growing oilseeds, pulses, vegetables during dry season after transplanted aman rice.

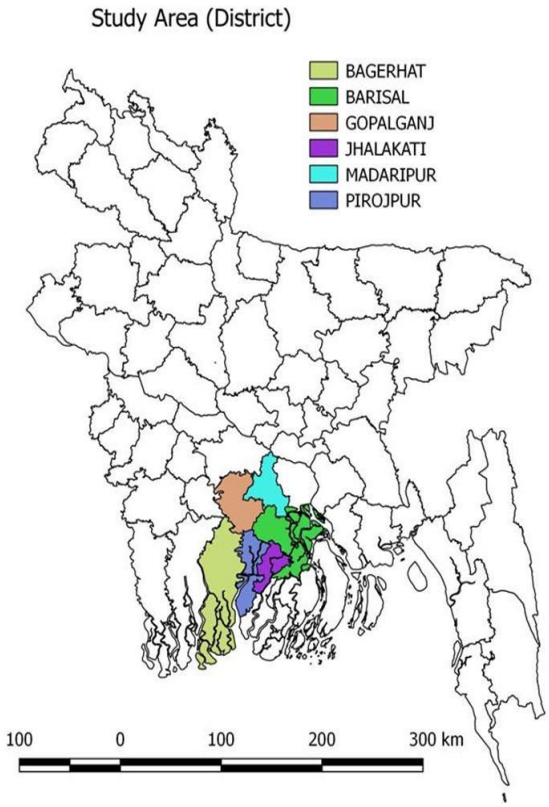
iii. To enhance farm income through intensive crop production and improving farmers' knowledge and skill through training, conducting on-farm trials and demonstrations on improved agricultural production technologies in central coastal region.

9. Implementing location (s):

Project Loctions:

Sub-project implementing locations for Oilseed Research Centre, Soil Science Division, BARI and ARF components were-

1. **Madaripur**
   i) Madaripur sadar, ii) Kalkini upazila
2. **Bagerhat**
   i) Bagerhat sadar, ii) Mollarhat upazila
3. **Goplalganj**
   i) Jalalabad sadar, ii) Kashiani upazila
4. **Barishal**
   i) Gouronodi, ii) Babugang upazila
5. **Jhalokathi**
   i) Rajapur ii) Nalcity upazila
6. **Pirojpur**
   i) Bhandaria ii) Kaukhali upazila



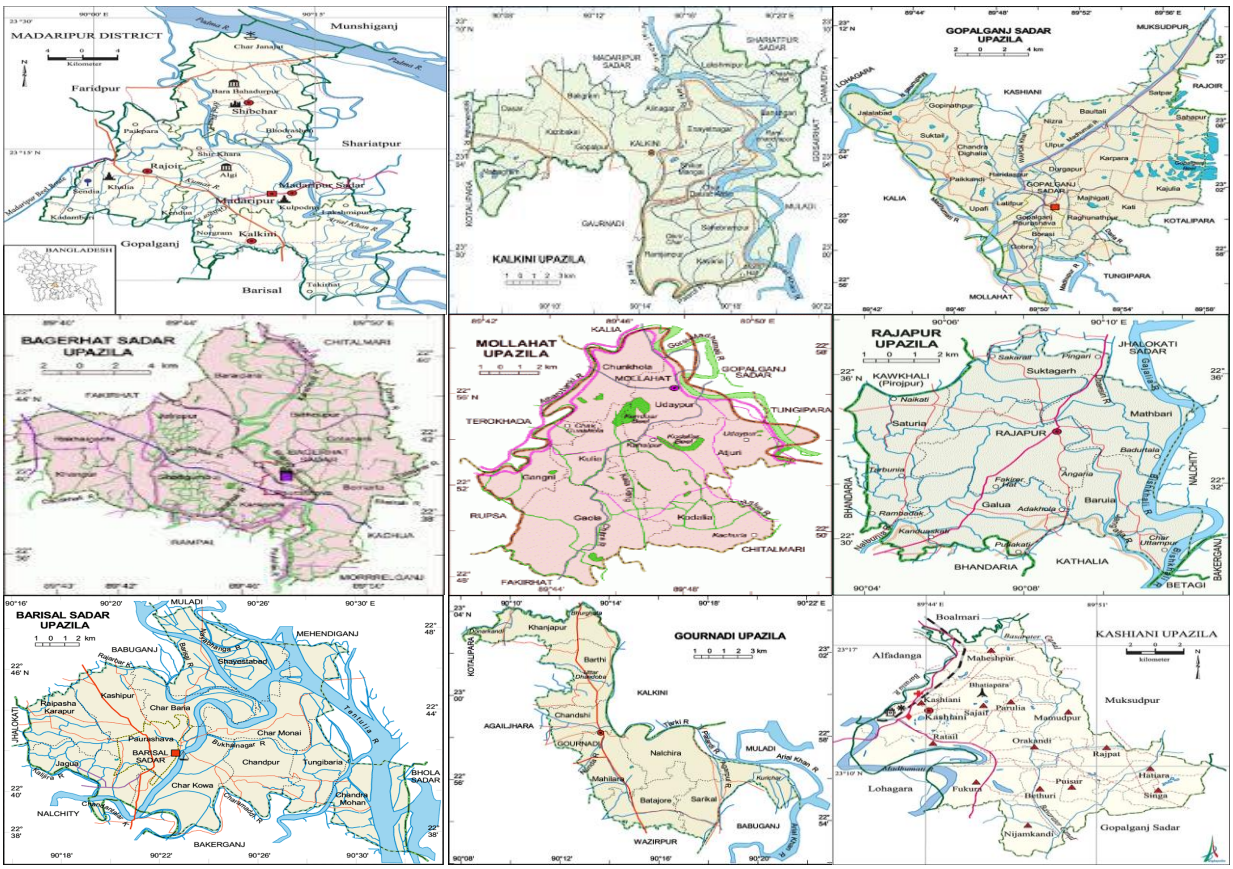


Fig 1. Project location at Madaripur sadar, Kalkini, Bagerhat sadar, Mollarhat, Jalalabad sadar, Kashiani, Bhandaria, Rajapur, Nalcity, Kaukhali, Gouronodi, Babugang upazila

10. Methodology in brief (with appropriate pictures):

Component-1 and Component-2

For the successful implementation of the proposed project validation of integrated nutrient management system, crop intensification for improving system productivity, soil health and farm income in south central coastal region, the following methods were considered-

Soil sample collection and analysis in Soil Science Division and Central Laboratory, BARI

This co-ordinated project was implemented at Madaripur (Madaripur sadar and Kalkini upazila), Bagerhat (Bagerhat sadar and Mollarhat upazila), Goplalganj (Jalalabad sadar and Kashiani upazila), Barishal (Gouronodi and Babugang upazila), Jhalokathi (Rajapur and Nalcity upazila) and Pirojpur (Bhandaria and Kaukhali upazila) district by Oilseed Research Centre, Soil Science Division, BARI, and ARF, Dhaka. Determine the benchmark status of initial and post harvest soil of physico-chemical properties and microbial population of farmers' field soils from tweelve upazilla's of Madaripur, Bagerhat, Gopalganj, and Barishal district.

The soil samples were collected and analyzed in Soil Science Laboratory and Central Laboratory of BARI to know initial and post harvest soil status of physio-chemical and microbial population from the following standard methods. Soil pH was measured by a combined glass calomel electrode (Jackson, 1958). Organic carbon was determined by wet oxidation method (Walkley and Black). Total N was determined by Kjeldahl method. Calcium, K and Mg were determined by NH_4OAc extraction method. Copper, Fe, Mn and Zn were determined by DTPA extraction followed by AAS reading. Boron was determined by $CaCl_2$ extraction method. Phosphorus was determined by Bray and Kurtz method (Acid soils) and Modified Olsen method (Neutral + Calcareous soils). Sulphur was determined by $CaH_4(PO_4)_2.H_2O$ extraction followed by turbidimetric method with $BaCl_2$. To know the soil health microbial population studies were done. Initial and post harvested soil samples were collected from different fields of Madaripur, Gopalganj, Barishal and Bagerhat district locations using global positioning system (GPS) record. Soil samples were collected by icebox aseptically and store in laboratory at 4^0C. Soil microbial population was determined by serial dilution techniques. Final diluted soil samples were streaked onto yeast extract mannitol agar (YEMA) plate and incubated at 30^0C for 2-3 days. Bacterial population was counted comparing morphological (colony) characteristics and data properly recorded. All data were statistically analyzed using R software.

Fig 2. Soil sample collection, sample preparation and data collection of tested plots.

Location: Madaripur and Goplalganj district
Cropping pattern: Mustard-Mungbean-T. *aman*

This field trial has been conducted in Low Ganges Floodplain Soils (AEZ-12) and Goplalganj-Khulna Bil (AEZ-14) of Madaripur sadar, Kalkini, Goplalganj sadar and Kashiani upazilla during 2019-2021. The cropping cycle of Mustard-Mungbean-T. *aman* were conducted with mungbean as the first crop in the pattern. After harvest, T. *aman* was sown in both the locations and then followed by mustard. The experiment was laid out in a randomized complete block design with three replications. The experimental plot size was 5m x 4m in both the locations. The cropping cycle was three crops (Mustard, Mungbean, T. *aman*) and nine varieties (Mustard: BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-11; Mungbean: BARI Mung-6, BARI Mung-8, BINA Mung 8; T. *aman*: BRRI dhan57, BRRI dhan71 and BRRI dhan75) and three fertilizer levels (F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per soil test bases (STB); F_2 = RFD on STB + 5 t ha^{-1} cowdung, integrated plant nutrient system (IPNS) approach; F_3 = Farmers practices) consisting of nine treatments and three replications. Urea, TSP, MoP, gypsum, Zinc sulphate, boric acid were used as a source of N, P, K, S, Zn and B, respectively. In case of mustard, mungbean, T. *aman* all P, K, S, Zn and B were applied as basal during final land preparation. Cowdung @ 5 tha^{-1} was applied before ploughing and laddering

as treatment only. All the intercultural operations such as irrigation, weeding, insect control etc were done as and when necessary. The total biomass was incorporated in the soil after harvest of mungbean. The same sequence was maintained in T. *aman* rice for fertilizer treatments.

Table 1. Agronomic management practices of different crop production under Mustard-Mungbean-T. *aman* cropping pattern at Madaripur and Goplalganj district during 2019-2021.

Sl. no.	Factors	Mustard			Mungbean			T. *aman*		
		2019	2020	2021	2019	2020	2021	2019	2020	2021
1.	Sowing/ planting time	28-10-2019	5-11-2020	10-11-2021	15-03-2019	21-03-2020	25-03-2021	11-07-2019	13.07. 2020	07.07. 2021
2.	Variety	BARI Sarisha-14 BARI Sarisha-17 BARI Sarisha-11			BARI Mung-6 BARI Mung-8 BINA Mung-8			BRRI dhan57 BRRI dhan71 BRRI dhan75		
3.	Seed rate (Kg/ha)	6-7			15-18			Seedling age = 20-25d Spacing = 20cm x15 cm		
4.	Plot size	5m x 4m			5m x 4m			6m x 5m		
5.	Fertilizer dose	<u>Fertilizer : 3 level</u> F_1 = Recommended Fertilizer Dose (RFD) from inorganic source on STB F_2 = RFD on STB + 5 t ha^{-1} cowdung (IPNS approach) F_3 = Farmers practices <u>Recommended dose</u> Mustard: N_{120} P_{46} K_{122} S_{26} Zn_3 B_2 kg ha^{-1}; Mungbean: N_{24} P_{22} K_{24} S_{14} Zn_2 B_2 kg ha^{-1}; T. aman: N_{120} P_{26} K_{100} S_{15} $Zn2_2$ kg ha^{-1}								
6.	Ploughing (no)			3-4			2-3			3
7.	Irrigation (no)			3			1			3
8.	Weeding (no)			2			3			2
9.	Pesticide application (no)			1			1			2
10.	Harvesting time	15.2. 2020	26.2. 2021	29.2. 2022	10.5. 2019	28.5. 2020	22.5. 2021	20.10. 2019	28.11. 2020	26.11. 2021

Fig

Fig 3. Agronomic management practices of different crop production under Mustard-Mungbean-T. *aman* cropping pattern.

Fig 3. Agronomic management practices of different crop production under Mustard-Mungbean-T. *aman* cropping pattern.

The entire quantity of P, K, S, Zn (as per STB), was applied during the final land preparation. Nitrogen was applied in three equal splits at seedling establishment stage 5-7 day after transplanting (DAT), active tillering stage (25-30 DAT) and 5-7 days before panicle initiation stage (45-50 DAT). The seedlings of three varieties of T. *aman* rice were transplanted in row to row 25 cm and hill to hill 15 cm spacing. Yield parameters data were recorded at certain growth stages of all the crops of the pattern. Data were analyzed by R software.

Cropping pattern: Grasspea-Gimakolmi-T. *aman*
Location: Madaripur and Goplalganj district

In Madaripur and Goplalganj district the cropping cycle of Grasspea-Gimakolmi-T. *aman* were conducted with the sowing of gimakolmi as the first crop during 18-25 April, 2019. After harvest, the second crop T. *aman* was sown in all locations from 10-17 July, 2019. Following T. *aman*, the next crop grasspea was sown on 15-27 Nobember 2019 and harvested from 15-29 March 2020. The experiment was laid out in a randomized complete block design with three replications. The experimental plot size was 6m x 5m in both the locations. The cropping cycle was three crops (Grasspea, Gimakolmi, T. *aman*) and nine varieties (Grasspea: BARI Khesari-5, BARI Khesar-3, Khesari (Local); Gimakolmi: BARI Gimakolmi-1, Subij pata (Local), Golden Line (Local); T. *aman*: BRRI dhan57, BRRI dhan71 and BRRI dhan75) and three fertilizer levels were same as before. The total biomass was incorporated in the soil after harvest of grasspea. The same sequence was maintained in T. *aman* rice for fertilizer treatments. Yield parameters data were recorded at certain growth stages of all the crops of the pattern. Data were analyzed by R software.

Table 2. Agronomic management practices of different crop production under Grasspea-Gimakolmi-T. *aman* cropping pattern at Madaripur and Goplalganj district during 2019-2021.

Sl. no	Factors	Grasspea			Gimakolmi			T. *aman*		
		2019	2020	2021	2019	2020	2021	2019	2020	2021
1.	Sowing/ planting time	18.11. 2019	15.11. 2020	27.11. 2021	25.3. 2019	18.3. 2020	23.3. 2021	17.07 2019	13.7. 2020	10.07. 2021
2.	Variety	BARI Khesari -5 BARI Khesari -3 Khesari (Local)			BARI Gimakolmi-1 Subij pata (Local) Golden Line (Local)			BRRI dhan57 BRRI dhan71 BRRI dhan75		
3.	Seed rate (Kg/ha)	35-40			-			Seedling age=20-25d Spacing= 20cm x15 cm		
4.	Plot size	5m x 4m			5m x 5m			6m x 5m		
5.	Fertilizer dose	<u>Fertilizer : 3 level</u> F_1 = Recommended Fertilizer Dose (RFD) from inorganic source on STB F_2 = RFD on STB + 5 t ha^{-1} cowdung (IPNS approach) F_3 = Farmers practices <u>Recommended dose</u> Grasspea: N_{20} P_{20} K_{24} S_{12} kg ha^{-1}; Gimakolmi: N_{115} P_{40} K_{55} S_{19} kg ha^{-1}; T. aman: N_{120} P_{26} K_{100} S_{15} $Zn2_2$ kg ha^{-1}								
6.	Ploughing (no)			3-4			2-3			3
7.	Irrigation (no)			-			1			3
8.	Weeding (no)			2			3			2
9.	Pesticide application (no)			1			1			2
10.	Harvesting time	15.3. 2019	26.3. 2020	29.3. 2021	10.5. 2019	28.5. 2020	22.5. 2021	20.10. 2019	28.11. 2020	26.11. 2021

Fig 4. Agronomic management practices of different crop production under Grasspea-Gimakolmi-T. *aman* cropping pattern

Fig 4. Agronomic management practices of different crop production under Grasspea-Gimakolmi-T. *aman* cropping pattern

Cropping pattern: Sweet gourd-Sesame-T. *aman*
Location: Bagerhat and Barishal

The cropping cycle of Sweet gourd-Sesame -T. *aman* was conducted with sesame as first crop in the pattern. After harvest, T. *aman* rice, sweet gourd were sown in Bagerhat sadar, Mollarhat, Gournadi, and Babugonj upazilla in selected farmers' fields. The experimental plot size was 5m x 4m in both the locations. There were three crop varieties (Sweet gourd: BARI Mistikumra-2,

Table 3. Agronomic management practices of different crop production under Sweet gourd-Sesame -T. *aman* cropping pattern at Bagerhat and Barishal district during 2019-2021.

Sl no	Factors	Sweet gourd			Sesame			T. *aman*		
		2019	2020	2021	2019	2020	2021	2019	2020	2021
1.	Sowing/ planting time	18.11. 2019	15.11. 2020	27.11. 2021	15.3. 2019	11.3. 2020	13.3. 2021	17.07. 2019	13.07. 2020	10.07. 2021
2.	Variety	BARI Mistikumra-2 BARI Hybrid Mistikumra-2 BARI Hybrid Mistikumra-3			BARI Til-3 BARI Til-4 BINA Til-4			BRRI dhan57 BRRI dhan71 BRRI dhan75		
3.	Seed rate (Kg/ha)	5-6			7-8			Seedling age=20-25d Spacing= 20cm x15 cm		
4.	Plot size	5m x 5m			5m x 4m			6m x 5m		
5.	Fertilizer dose	<u>Fertilizer : 3 level</u> F_1 = Recommended Fertilizer Dose (RFD) from inorganic source on STB F_2 = RFD on STB + 5 t ha^{-1} cowdung (IPNS approach) F_3 = Farmers practices <u>Recommended dose</u> Sweet gourd: N_{95} P_{45} K_{75} S_{26} Zn_3 B_2 kg ha^{-1}; Sesame: N_{95} P_{40} K_{75} S_{25} Zn_2 B_2 kg ha^{-1}; T. aman: N_{120} P_{26} K_{100} S_{15} $Zn2_2$ kg ha^{-1}								
6.	Ploughing (no)	3-4			2-3			3		
7.	Irrigation (no)	3-4			1			3		
8.	Weeding (no)	2			3			2		
9.	Pesticide application (no)	1			1			2		
10.	Harvesting time	15.3. 2019	26.3. 2020	29.3. 2021	10.05. 2019	28.5. 2020	22.05. 2021	20.10. 2019	28.11. 2020	26.11. 2021

BARI Hybrid Mistikumra-2, BARI Hybrid Mistikumra-3; Sesame: BARI Til-3, BARI Til-4, BINA Til-4; T. *aman*: BRRI dhan57, BRRI dhan71 and BRRI dhan75) and three fertilizer levels same as before. All the intercultural operations such as irrigation, weeding, insect and diseases control etc were done as and when necessary. The sweet gourd seeds were sown in pit on 15-27 November, 2019-2021 in selected farmers' fields. Yield parameters data were recorded at certain growth stages of all the crops of the pattern. Data were analyzed by R software.

Fig 5. Agronomic management practices of different crop production under Sweet gourd-Sesame -T. *aman* cropping pattern

Post harvest soil collection and analyzed

The cropping cycles in all patterns were completed and then the post harvest soil samples were collected all locations in same farmers' field. The collected samples were analyzed in Soil Science Laboratory and Central Laboratory of BARI to know post harvest soil status of physio-chemical and microbial population from the following standard methods.

Fig 6. Post harvest soil sample were collected for analysis of data in the test plots.

Component-3: Agrian Research Foundation

In case of ARF component, Baseline survey was conducted using a structured questionnaire (survey instrument). Major focus of the study being collection of information on the problems associated with dry season crop production, the questionnaire covered farmer's socio-economic profile, household assets, crops and cropping, and the problems associated with growing dry season crops farmers encountered. Prior to conducting survey the questionnaire was pre-tested and subsequently questionnaire improved incorporating the feedback from the pre-testing**.** The project area was conducted in four villages Rajapur, Nalcity, Kaukhali and Vandaria represents Jhalokathi and Pirojpur Districts. A total of 31 farmers were interviewed; none of them were female. This indicates that in Rajapur (Jhalakati) and Kawkhali (Pirojpur) female farmers are rare or absent.

On Farm trial of mungbean and T. Aman

Conducting on-farm trials on feasibility of growing mungbean at different toposequence in Rajapur and Nalcity under Jhalokathi district and Vandaria and Kaukhali under Pirojpur district in collaboration with DAE at project implementation level. Evaluating production economics of growing additional crops as mungbean and grasspea recording and analyzing data on yield, production cost and return of individual crops. In the second year, the exploratory trial with 3 transplanted rice varieties was conducted in one location (Uttampur, Rajapur) only. Number of farmers included in the trial differed. The three varieties of transplanted aman rice used (Kataribhog, Moulata, and Sadamota) formed treatment variables. Variety Kataribhog is an aromatic, fine grain rice while Moulata and Sadamota are coarse grain rice. Eighteen farmers planted Moulata, fifteen farmers planted Sadamota, and twelve farmers used Kataribhog. Seedlings of three aman rice varieties were raised and transplanted in late July when the age of seedlings was 60 days (Hamid et al., 2016). Farmers applied no fertilizers. Nor there was improved agronomic management (fertilizer application) administered for growing rice crop. The experimental crop encountered no unusual climatic hazards during the growing season. The crop received no rainfall since mid-November; field water receded early November 2020. The farmers were purposely selected and no statistical design was followed primarily because of unequal sample size and variation in land topography. Transplanted aman rice was harvested between 27 November through 5 January 2021 and data on grain yield recorded. Yield data were subjected to descriptive analysis giving mean yield, range and SE (±).

On Farm trial of Grasspea and T. Aman

The on-farm trials on grasspea conducted in two locations (Uttampur, Rajapur; Bheronbaria, Nalchity) aimed at exploring the appropriate planting time for achieving higher yield. Grasspea (BARI Khesari-3) seeds were relay inter-planted in transplanted aman rice on three planting dates at 10-day intervals on variable toposequence). Variation in grasspea planting date was due to variation in land topography. Uniform seed rate (75 kg per ha) was used at all planting dates.

Twenty farmers (10 from Uttar Uttampur of Rajapur under Jhalokathi district and remaining 10 from Bheronbaria of Nalcity of Jhalokathi district) participated in running the trials. In Uttampur, the grasspea trials was mostly superimposed over the previous aman rice trial, but all the farmers those who participated in rice trial could not be included in grasspea trial. Out of 12 farmers growing Kataribhog rice only farmers planted grasspea trial. Each participating farmers planted grasspea on a 0.135 ha (1 bigha of land). Absence of rainfall beginning mid-November when variety Kataribhog was at ripening stage while other two varieties (Moultat and Sadamota) were at dough stage. Depending on land topography and variety rice was harvested between 17 December 2020 and 5 January 2021. The lone farmer growing Kataribhog harvested rice on 17 December. Ten farmers, each planting grasspea on a 0.135 ha (1 bigha of land), participating in conducting the trial in each location.

On Farm trial of mungbean during 2020-2021

Thirty farmers in Palot (Nalchity) and 15 farmers in Bheronbaria (Nalchity) participated in mungbean trials during 2021 dry season. Two varieties (BARI Mung-6, and BU mug 5) were planted in one location- Palot (Rajapur) while in another location (Bheronbaria) single variety (BARI Mung-6) was tested. Mungbean trial was planted at three planting dates, but the location varied in start date. Planting time and varieties formed experimental variables at one location (Palot), and a single factor trial was set in another location (Bheronbaria). Planting mungbean seeds in Palot began on 16 January 2021 while Bheronbaria it was delayed by 10 days. BARI Mung-6 was planted in two locations while BU mug was in a single location (Palot). For BARI Mung-6 also the number of participatory farmers in two locations also differed. Therefore, instead of pooled data analysis trial data were separately analyzed using single factor (planting date) trial for individual location. Yield data of BU mug 5 was however compared with BARI Mung-6 using data from one location.

11. Results and discussion:

Component-1: Soil Science Division, BARI

Activity-1:

Benchmark status of the physio-chemical properties and microbial population of soils in South Central Coastal Region.

Baseline survey on the physio-chemical properties and microbial population of soils in Goplalganj (Kashiani and Sadar upazila) and Barishal (Gouronodi and Babugang upazila) were conducted. Soil samples each from Kashiani and Sadar upazila Goplalganj and Barishal (Gouronodi and Babugang upazila) were collected from cultivable land (0-15 cm layer) and analyzed. Summary of soil nutrient status of Goplalganj and Barishal has been mentioned in Tables 4 to 7.

Table 4a. Benchmark survey of soil physical properties and microbial population of sadar upazilla of Gopalganj

Property	Minimum	Maximum	Mean
% Sand	2	8	4
% Silt	23	31	27
% Clay	65	73	69
Moisture (%)	14.12	27.23	19.95
Rhizobium Population g^{-1} soil	5.0×10^{2}	$1.0x10^{5}$	5.0×10^{3}
PSB Population g^{-1} soil	$5.0x10^{2}$	1.0×10^{5}	2.5×10^{3}
Azotobactor Population g^{-1} soil	$1.0x10^{4}$	3.0×10^{5}	2.0×10^{4}

Table 4b. Benchmark survey of soil chemical properties of sadar upazilla of Gopalganj

Property	Minimum	Maximum	Mean
pH	7.3	8.4	7.9
OM (%)	0.7	2.8	1.48
Total N (%)	0.04	0.10	0.07
Ca (meq $100g^{-1}$)	10.1	27.2	18.7
Mg (meq $100g^{-1}$)	2.0	8.2	2.4
K (meq $100g^{-1}$)	0.2	0.7	0.4
P ($\mu g\ g^{-1}$)	2.00	28.00	12.2
S ($\mu g\ g^{-1}$)	19.00	35.00	26.4
B ($\mu g\ g^{-1}$)	0.04	0.42	0.19
Zn ($\mu g\ g^{-1}$)	0.01	5.48	1.76

All soils of Gopalganj sadar was alkaline and moisture content was ranged from 14.12%-27.23%. Soils were low in nitrogen content (Table 4a & 4b).

Table 5a. Benchmark survey of soil physical properties and microbial population of Kashiani upazilla of Gopalganj

Property	Minimum	Maximum	Mean
% Sand	3	5	3.8
% Silt	27	35	28
% Clay	60	71	67
Moisture (%)	13.83	25.97	18.45
Rhizobium Population g^{-1} soil	5.0×10^{2}	$5.0x10^{4}$	2.0×10^{3}
PSB Population g^{-1} soil	$1.1x10^{4}$	1.0×10^{5}	3.0×10^{4}
Azotobactor Population g^{-1} soil	$5.0x10^{3}$	2.0×10^{5}	3.5×10^{4}

Table 5b. Benchmark survey of soil chemical properties of Kashiani upazilla of Gopalganj

Property	Minimum	Maximum	Mean
pH	7.3	8.4	7.9
OM (%)	0.7	2.8	1.48
Total N (%)	0.04	0.10	0.07
Ca (meq $100g^{-1}$)	10.1	27.2	18.7
Mg (meq $100g^{-1}$)	2.0	8.2	2.4
K (meq $100g^{-1}$)	0.2	0.7	0.4
P ($\mu g\ g^{-1}$)	2.00	28.00	12.2
S ($\mu g\ g^{-1}$)	19.00	35.00	26.4
B ($\mu g\ g^{-1}$)	0.04	0.42	0.19
Zn ($\mu g\ g^{-1}$)	0.01	5.48	1.76

All soils of Kashiani upazilla Gopalganj was alkaline. Moisture content was ranged from 13.83%-25.97%. Soils were low in nitrogen content (Table 5a & 5b).

Table 6a. Benchmark survey of soil physical properties and microbial population of Babuganj upazilla Barisal

Property	Minimum	Maximum	Mean
%Sand	7	12	9.4
%Silt	45	53	48
%Clay	34	41	37
Moisture (%)	12.23	27.15	17.25
Rhizobium Population g^{-1} soil	1.0×10^{2}	$1.0x10^{5}$	5.0×10^{3}
PSB Population g^{-1} soil	$2.0x10^{4}$	5.5×10^{5}	5.5×10^{4}
Azotobactor Population g^{-1} soil	$1.0x10^{4}$	7.5×10^{5}	6.5×10^{4}

Table 6b. Benchmark survey of soil chemical properties of Babuganj upazilla Barisal

Property	Minimum	Maximum	Mean
pH	6.4	8.4	7.4
OM (%)	1.6	2.1	1.8
Total N (%)	0.07	0.12	0.09
Ca (meq $100g^{-1}$)	4.4	16.6	12.9
Mg (meq $100g^{-1}$)	1.5	4.4	3.1
K (meq $100g^{-1}$)	0.1	0.3	0.2
P ($\mu g\ g^{-1}$)	4.00	17.00	10
S ($\mu g\ g^{-1}$)	22.00	52.00	33
B ($\mu g\ g^{-1}$)	0.1	1.0	0.5
Zn ($\mu g\ g^{-1}$)	0.4	0.9	0.6

Table 7a. Benchmark survey of soil physical properties and microbial population of Gouranodi upazilla Barisal

Property	Minimum	Maximum	Mean
% Sand	8	14	11
% Silt	48	56	50
% Clay	35	42	38
Moisture (%)	11.36	28.02	16.82
Rhizobium Population g^{-1} soil	1.5×10^{2}	$1.5x10^{4}$	5.0×10^{2}
PSB Population g^{-1} soil	$1.5x10^{4}$	1.0×10^{5}	5.0×10^{4}
Azotobactor Population g^{-1} soil	$2.5x10^{4}$	2.0×10^{5}	2.5×10^{4}

Table 7b. Benchmark survey of soil chemical properties of Gouranadi upazilla Barisal

Property	Minimum	Maximum	Mean
pH	6.2	8.6	7.5
OM (%)	0.6	2.8	1.9
Total N (%)	0.04	0.15	0.07
Ca (meq $100g^{-1}$)	6.7	25.8	15.2
Mg (meq $100g^{-1}$)	1.4	7.1	3.7
K (meq $100g^{-1}$)	0.1	0.4	0.2
P ($\mu g\ g^{-1}$)	4.00	60.00	13
S ($\mu g\ g^{-1}$)	13.00	54.00	37
B ($\mu g\ g^{-1}$)	0.02	0.70	0.35
Zn ($\mu g\ g^{-1}$)	0.2	2.1	0.8

All soils of Gouranodi upazilla Barisal was alkaline. Moisture content was ranged from 11.36%-28.02%. Soils were low in nitrogen content (Table 7a & 7b).

Activity-2:

Varietal intensification and integrated plant nutrition systems on Mustard-Mungbean-T. *aman* cropping pattern in South Central Coastal Region of Bangladesh.

This field trial has been conducted in Goplalganj-Khulna Bil (AEZ-14) of Gopalgonj sadar and Kasheani upazila during 2019-21. A description of nutrient status of initial soils prior to fertilization has been presented in Table 8. This cropping cycle was started from the second crop mungbean. After harvest, T. *aman* rice was transplanted in both the locations.

Table 8. Initial soil chemical properties of experimental plots of Kasheani and Gopalgonj sadar upazila

Soil parameters	Kasheani	Gopalgonj Sadar	Critical level
pH	7.28	8.47	-
Organic matter (%)	2.00	1.79	-
Total N (%)	0.105	0.094	-
Exchangeable Ca (meq 100^{-1} g)	6.10	6.00	2.00
Exchangeable Mg (meq 100^{-1} g)	2.10	2.10	0.50
Exchangeable K (meq 100^{-1} g)	0.19	0.20	0.12
Available P (µg g^{-1})	37.0	44.0	10.0
Available Zn (µg g^{-1})	0.65	0.70	0.60
Available B (µg g^{-1})	0.18	0.19	0.20
Available Cu (µg g^{-1})	2.80	3.00	0.20
Available Fe (µg g^{-1})	79.0	101.0	4.00
Available S (µg g^{-1})	22.5	14.4	10.0

Mustard-Mungbean-T. *aman* cropping pattern

Mungbean:

Yield of different mungbean varieties under trial plots (RFD and IPNS) and farmers' practice were presented in Table 9 and 10. Yield of mungbean varieties (BARI Mung-6, BARI Mung-8 and BINA Mung 8) under trial plots were 1.64, 1.67, 1.49, 1.57, 1.58 and 1.59 tha^{-1}, and yield of farmers' practice were 1.47, 1.19 and 1.26 tha^{-1}, respectively in Gopalgonj sadar upazilla during 2019-21. On the other hand, yield of mungbean varieties of kasheani upazilla of Gopalgonj under trial plots were 1.57, 1.60, 1.45, 1.49, 1.52 and 1.45 tha^{-1}, and yield of farmers' practice were 1.43, 1.15 and 1.13 tha^{-1}, respectively. In the trial plots, different variety of mungbean yield were increased (RFD and IPNS) in Kasheani upazilla of Gopalgonj as compared to the farmers' practice probably might be use of STB fertilizer dose with RFD and IPNS approaches. Farmers' are interested to cultivate mungbean varieties under RFD and IPNS approaches.

Table 9. Effect of variety and integrated nutrient management on mungbean at Gopalgonj Sadar, Gopalgonj during 2019-21.

Treatment combination		Pod plant^{-1}	Seed pod^{-1}	100 seed wt. (g)	Seed yield (kg ha^{-1})	Stover (t ha^{-1})
Variety	Fertilizer dose					
BARI Mung-6	RFD on STB	33.7a	10.1	4.93ab	1640a	4.67
	RFD + 5t ha^{-1} CD IPNS)	34.6a	10.2	5.02a	1673a	4.80
	Farmers practices	28.6b	9.8	4.76abc	1477c	4.12
BARI Mung-8	RFD on STB	30.9	10.8	3.74cf	1494c	4.58
	RFD + 5t ha^{-1} CD IPNS)	31.2ab	10.9	3.88de	1570b	4.95
	Farmers practices	27.3b	9.9	3.44f	1191d	4.05
BINA Mung 8	RFD on STB	30.5ab	10.4	4.46bc	1583b	4.60
	RFD + 5t ha^{-1} CD(IPNS)	30.9ab	10.5	4.62abc	1590b	4.90
	Farmers practices	27.5b	10.0	4.33cd	1257bc	4.59
CV (%)		6.33	9.92	3.87	3.09	4.62

Table 10. Effect of variety and integrated nutrient management on mungbean at Kasheani, Gopalgonj during 2019-21.

Treatment combination		Pod plant^{-1}	Seed pod^{-1}	100 seed wt. (g)	Seed yield (kg ha^{-1})	Stover yield (t ha^{-1})
Variety	Fertilizer dose					
BARI Mung-6	RFD on STB	30.4a	9.68b	4.78a	1570a	4.39
	RFD + 5t ha^{-1} CD (IPNS)	30.9a	9.83b	4.82a	1603a	4.65
	Farmers practices	25.8c	9.40b	4.49ab	1433a-c	4.05
BARI Mung-8	RFD on STB	28.1b	10.4a	3.54c	1453a-c	4.34
	RFD + 5t ha^{-1} CD (IPNS)	29.1b	10.7a	3.64c	1490a-c	4.53
	Farmers practices	25.5c	9.47b	3.27c	1148bc	3.80
BINA mung 8	RFD on STB	28.7b	9.70b	4.38ab	1525	4.47
	RFD + 5t ha^{-1} CD (IPNS)	29.0ab	9.90b	4.45ab	1450a-c	4.65
	Farmers practices	25.3c	9.37b	4.27b	1133c	4.16
CV (%)		8.80	7.57	6.81	3.12	7.32

T. *aman*

Transplanted *aman* (*Oryza sativa* L.) is an important cereal crop and is generally grown in Kharif-2 season in Bangladesh. Yield performance of different T. *aman* rice varieties under trial plots (RFD and IPNS) and farmers' practice were presented in Table 11. In the trial plots, different variety of T. *aman* yield were increased (RFD and IPNS) in Jalabad, Sadar upazilla, Gopalganj and Fukra, Kasheani upazilla of Gopalganjas compared to the farmers' practice probably might be use of STB fertilizer dose with RFD and IPNS approaches. Farmers' are interested to cultivate T. *aman* varieties under RFD and IPNS approaches.

Table 11. Effect of variety and integrated nutrient management on T. *aman* in Mustard-Mungbean-T. *aman* cropping pattern at Gopalgonj sadar, and Kasheani, Gopalgonj during 2019-21 (mean data)

Treatment combination		Grain yield (t ha)	
Variety	Fertilizer dose	Gopalgonj Sadar	Kasheani
BRRI dhan57	RFD on STB	5.13c	5.01b
	RFD + 5t ha^{-1} CD (IPNS)	5.45c	5.02b
	Farmers practices	4.68d	4.44c
BRRI dhan71	RFD on STB	8.07a	6.97a
	RFD + 5t ha^{-1} CD (IPNS)	7.80a	6.81a
	Farmers practices	6.82b	5.47c
BRRI dhan75	RFD on STB	6.52b	6.18b
	RFD + 5t ha^{-1} CD (IPNS)	6.51b	6.55b
	Farmers practices	5.63c	4.80c
CV (%)		8.81	9.32

Mustard

Yield performance of different Mustard varieties under trial plots (RFD and IPNS) and farmers' practice were presented in Table 12. In the trial plots, different variety of Mustard yield were increased (RFD and IPNS) in Jalabad, Sadar upazilla, Gopalganj and Fukra, Kasheani upazilla of Gopalganj as compared to the farmers' practice probably might be use of STB fertilizer dose with RFD and IPNS approaches. Farmers' are interested to cultivate Mustard varieties under RFD and IPNS approaches.

Table 12. Effect of variety and integrated nutrient management on Mustard in Mustard-Mungbean-T.*aman* cropping pattern at Gopalgonj Sadar and Kasheani, Gopalgonj, 2019-2021 (mean data)

Treatment combination		Seed yield (t/ha)	
Variety	Fertilizer dose	Jalabad, Sadar	Fukra, Kasheani
BARI Sarisha-14	RFD on STB	1.51c	1.42c
	RFD + 5t ha^{-1} CD (IPNS)	1.62b	1.53b
	Farmers practices	1.43d	1.33d
BARI Sarisha-17	RFD on STB	1.54b	1.45c
	RFD + 5t ha^{-1} CD (IPNS)	1.73a	1.70 a
	Farmers practices	1.45 c	1.38cd
BARI Sarisha-11	RFD on STB	1.52b	1.51b
	RFD + 5t ha^{-1} CD (IPNS)	1.68a	1.64a
	Farmers practices	1.51b	1.40c
CV (%)		6.98	9.19

Total rice (system) yield:

Average yield, rice equivalent yield and total rice (system) yield as influenced by different treatments has been presented in Table 13. The highest total rice (system) yield of 16.18 $tha^{-1}yr^{-1}$ was obtained from treatment combination (BARI Sarisha-14, BARI Mung-6, BRRI dhan 71) with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach) and lowest total rice (system) yield of 11.74 $tha^{-1}yr^{-1}$ was obtained from treatment combination of BARI Sarisha-11, BINA Mung 8, BRRI dhan75 with farmer' practices.

Table 13. Average yield, rice equivalent yield, and total rice (system) yield of Mustard-Mungbean-T. *aman* cropping pattern at Gopalgonj sadar and Kasheani, Gopalgonj (mean data)

Treatment	Average yield of crops in the pattern (tha^{-1})			Rice equivalent yield of the pattern (tha^{-1})		Total rice (system) yield (tha^{-1})
	Mustard	Mungbean	T. *aman*	Mustard	Mungbean	
V1F1	1.56	1.57	5.05	3.90	5.57	14.53
V1F2	1.63	1.64	5.32	3.40	5.81	14.55
V1F3	1.45	1.46	4.60	3.03	5.17	12.80
V2F1	1.48	1.49	6.82	3.09	5.28	15.20
V2F2	1.54	1.55	7.46	3.21	5.50	16.18
V2F3	1.19	1.20	5.79	2.49	4.25	12.54
V3F1	1.52	1.52	6.18	3.18	5.40	14.76
V3F2	1.56	1.58	6.57	3.26	5.60	15.44
V3F3	1.19	1.20	5.00	2.48	4.26	11.74

- V1= BARI Sarisha-17, BARI Mung-8, BRRI dhan 57
- V2= BARI Sarisha-14, BARI Mung-6, BRRI dhan 71
- V3= BARI Sarisha-11, BINA Mung-8, BRRI dhan 75
- F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB
- F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach) F_3 = Farmers practices

Total variable cost, gross return, gross margin and BCR analysis

The benefit cost analysis of Mustard-Mungbean-T. *aman* cropping pattern, highest gross return and gross margin of 3,88,519 and 2,10,496 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination (BARI Sarisha-14, BARI Mung-6, BRRI dhan 71 with RFD on STB + 5 t ha^{-1} cowdung; IPNS approach) and the lowest gross return and gross margin of 2,81,807 and 1,06,018 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination of BARI Sarisha-11, BINA Mung-8, BRRI dhan75 with farmer' practices. The highest marginal benefit cost ratio of 2.10 was found from treatment combination RFD on STB + 5 t ha^{-1} cowdung; IPNS approach with varieties BARI Sarisha-14, BARI Mung-6, BRRI dhan71 at sadar upazila of Gopalganj.

Table 14. Gross return, total cost, gross margin and BCR of Mustard -Mungbean-T. *aman* cropping pattern at Gopalgonj sadar and Kasheani, Gopalgonj

Treatment	Gross return (TK)	Total variable cost (TK)	Gross margin (TK)	BCR
V1F1	348955	181107	167848	1.9
V1F2	349248	180105	169143	1.9
V1F3	307396	171101	136295	1.7
V2F1	364816	179503	185313	2.0
V2F2	388519	178023	210496	2.1
V2F3	300973	171349	129624	1.7
V3F1	354379	185567	168812	1.9
V3F2	370646	183098	187548	2.0
V3F3	281807	175789	106018	1.6
❖ V1= BARI Sarisha-17, BARI Mung-8, BRRI dhan 57 ❖ V2= BARI Sarisha-14, BARI Mung-6, BRRI dhan 71 ❖ V3= BARI Sarisha-11, BINA Mung-8, BRRI dhan 75			Mustard= 60 Tk/kg, Mungbean =85Tk/kg, Rice= 24 Tk/kg	

.

Fig 7: Effect of test mungbean, mustard, T. *aman* varieties with integrated nutrient management system in Mustard-Mungbean-T. *aman* cropping cycle at Gopalgonj sadar and Kasheani, Gopalgonj

Activity-3:

Varietal intensification and integrated plant nutrition systems on Sweet gourd – Sesame - T. *aman* cropping pattern in South Central Coastal Region of Bangladesh.

The second cycle of the pattern was conducted in Young Meghna Estuarine Floodplain (AEZ 18) soils of Barishal (Babugonj and Gouronodi) during 2019-2021. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 6m × 3m in Babugonj Sadar and 3m X 1.5m in Gouronodi. There were three crop varieties and three fertilizer levels which consisted of nine treatments. The treatments were shown in Table 15.

Sweet Gourd

Sweet Gourd (*Cucurbita maxima)* has a thick, orange or yellow shell, creased from the stem to the bottom, containing the seeds and pulp. It has a very versatile use for cooking. Among varied vegetables, sweet gourd is appreciated by consumers because of its fruits, tender stems, leaves and even flowers used as vegetables both at green and ripen stages. It is relatively a richer source of energy, carbohydrates and vitamins, especially that of high carotinoid contents and minerals. This crop is therefore thought to have potentiality to solve malnutrition problem of mass people of Bangladesh to certain extent particularly vulnerable groups in respect of vitamin-A requirement. Production of sweet gourd in Bangladesh is increasing day by day. Commercial farming of sweet gourd is popularizing throughout the country. Both the production area and production is increasing frequently throughout the recent years. Yield of sweet gourd varieties were tried with RFD, IPNS and farmers' practice, being presented in Table 15. Farmers' are interested to cultivate mustard varieties under RFD and IPNS approaches in both location of Barishal.

Table 15. Effect of variety and integrated nutrient management on Sweet gourd in Sweet gourd-Sesame -T. aman cropping pattern at Babugonj and Gouronodi, Barishal 2019-2021

Treatment combination		Yield (t /ha)	
Variety	Fertilizer dose	Babugonj	Gouronodi
BARI Misti Kumra-1	RFD on STB	27.5cd	25.2d
	RFD + 5t ha^{-1} CD (IPNS)	29.5c	28.9d
	Farmers practices	22.5d	23.1e
BARI Hybrid Misti Kumra-2	RFD on STB	35.8bc	36.3bc
	RFD + 5t ha^{-1} CD (IPNS)	40.3a	39.5b
	Farmers practices	35.8bc	34.7c
BARI Hybrid Misti Kumra-3	RFD on STB	38.4b	39.6b
	RFD + 5t ha^{-1} CD (IPNS)	40.5a	41.9a
	Farmers practices	36.7bc	35.3c
CV (%)		8.23	7.28

Sesame:

Sesame (*Sesamum indicum* L.) is one of the important oil crops with drought tolerant crops in Bangladesh. It contains 5.3% water, 5.2% minerals, 2.9% fibre, 18.3% protein, 43.3% fat and 25% carbohydrate per 100 g edible portion. Sesame is extremely susceptible to water logging. It is mainly grown in Kharif-1 season which is the dry-wet transition period due to start of monsoon rain. Sometimes create water logged due to heavy monsoon rainfall. Sesame crops damaged due to heavy rainfall. Seed yield of sesame varieties under trial plots (RFD and IPNS) and farmers' practice were presented in Table 16. Farmers' are interested to cultivate sesame varieties under RFD and IPNS approaches.

Table 16. Effect of variety and integrated nutrient management on Sesame in Sweet gourd-Sesame-T. *aman* cropping pattern at Babugonj and Gouronodi, Barishal 2019-2021

Treatment combination		Yield (t ha^{-1})	
Variety	Fertilizer dose	Babugonj	Gouronodi
BARI Till-2	RFD on STB	1.53c	1.49c
	RFD + 5t ha^{-1} CD (IPNS)	1.58b	1.55b
	Farmers practices	1.45d	1.41d
BARI Till-3	RFD on STB	1.69a	1.67a
	RFD + 5t ha^{-1} CD (IPNS)	1.72a	1.70a
	Farmers practices	1.61b	1.60b
BARI Till-4	RFD on STB	1.58b	1.59b
	RFD + 5t ha^{-1} CD (IPNS)	1.65ab	1.69a
	Farmers practices	1.49cd	1.51c
CV (%)		8.95	9.45

T. *aman*

Transplanted *aman* (*Oryza sativa* L.) is an important cereal crop and is generally grown in Kharif-2 season in Bangladesh. Yield performance of different T. *aman* rice varieties under trial plots (RFD and IPNS) and farmers' practice were presented in Table 17. In the trial plots, different variety of T. *aman* yield were increased (RFD and IPNS) in Babugonj upazilla, Gopalganj and Gouronodi upazilla of Barishal as compared to the farmers' practice probably might be use of STB fertilizer dose with RFD and IPNS approaches. Farmers' are interested to cultivate T. *aman* varieties under RFD and IPNS approaches.

Table 17. Effect of variety and integrated nutrient management on T. *aman* in Sweet gourd-Sesame-T. *aman* cropping pattern at Babugonj and Gournadi, Barishal 2019-2021

Treatment combination		Yield (t ha^{-1})	
Variety	Fertilizer dose	Babugonj	Gouronodi
BRRI dhan57	RFD on STB	4.13b	4.22b
	RFD + 5t ha^{-1} CD (IPNS)	4.46b	4.65b
	Farmers practices	3.58c	3.56c
BRRI dhan71	RFD on STB	5.21a	5.12ab
	RFD + 5t ha^{-1} CD (IPNS)	5.75a	5.89a
	Farmers practices	4.67b	4.56b
BRRI dhan75	RFD on STB	4.45b	4.33b
	RFD + 5t ha^{-1} CD (IPNS)	4.62b	4.59b
	Farmers practices	3.95c	3.84c
CV (%)		9.23	8.45

Total rice (system) yield:

Average yield, rice equivalent yield and total rice (system) yield as influenced by different treatments has been presented in Table 18. The highest total rice (system) yield of 26.17 tha^{-1} yr^{-1} was obtained from treatment combination (BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach) and lowest total rice (system) yield of 16.40 t ha^{-1} yr^{-1} was obtained from treatment combination of BMK = BARI Mistikumra-2, BARI Til-4, BRRI dhan57 with farmer' practices.

Table 18. Average yield, rice equivalent yield, total rice (system) yield, gross margin and BCR of Sweet gourd-Seasum-T. *aman* cropping pattern at Babugonj and Gournadi, Barishal 2019-2021

Treatment combination	Average yield of crops in the pattern (tha^{-1})			Rice equivalent yield of the pattern (tha^{-1})		Total rice (system) yield (t ha^{-1} yr^{-1})
	Sweet gourd	Sesame	T. *aman*	Sweet gourd	Sesame	
V1F1	26.87	1.50	4.24	11.19	3.44	18.88
V1F2	29.07	1.56	4.53	12.11	3.58	20.23
V1F3	22.82	1.42	3.62	9.51	3.27	16.40
V2F1	35.22	1.67	5.17	14.67	3.82	23.68
V2F2	39.55	1.71	5.76	16.47	3.93	26.17
V2F3	34.65	1.61	4.50	14.43	3.68	22.62
V3F1	37.72	1.56	4.42	15.71	3.57	23.72
V3F2	40.32	1.66	4.76	16.80	3.81	25.38
V3F3	34.75	1.48	3.85	14.47	3.40	21.74

- V1= BMK = BARI Mistikumra-2, BARI Til-4, BRRI dhan57
- V2= BHMK = BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71
- V3= BHMK = BARI Hybrid Mistikumra-3, BINA Til-4, BRRI dhan75
- F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB
- F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach) F_3 = Farmers practices

Total variable cost, gross return, gross margin and BCR analysis

The benefit cost analysis of Sweet gourd-Sesame-T. *aman* cropping pattern, highest gross return and gross margin of 6,28,263 and 3,55,758 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination (BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 with RFD on STB + 5 t ha^{-1} cowdung; IPNS approach) and the lowest gross return and gross margin of 3,93,703 and 1,42,602 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination of BARI Mistikumra-2, BARI Til-4, BRRI dhan57 with farmer' practices. The highest benefit cost ratio of 2.30 was found from treatment combination RFD on STB + 5 t ha^{-1} cowdung; IPNS apprach with varieties BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 at Gournadi upazilla of Barishal.

Table 19. Gross return, total variable cost, gross margin and BCR of Sweet gourd-Sesame-T. *aman* pattern at Babugonj and Gournadi, Barishal 2019-2021

Treatment combination	Gross return (Tk ha^{-1} yr^{-1})	Total variable cost (Tk ha^{-1} yr^{-1})	Gross margin (Tk ha^{-1} yr^{-1})	BCR
V1F1	453208	259999	193209	1.74
V1F2	485528	240233	245299	2.02
V1F3	393703	251101	142602	1.56
V2F1	568360	292908	275452	1.94
V2F2	628263	272505	355758	2.30
V2F3	543050	281975	261075	1.92
V3F1	569310	286890	282420	1.98
V3F2	609245	282705	326540	2.15
V3F3	521893	283997	237896	1.83

- V1= BMK = BARI Mistikumra-2, BARI Til-4, BRRI dhan57
- V2= BHMK = BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71
- V3= BHMK = BARI Hybrid Mistikumra-3, BINA Til-4, BRRI dhan75

Sweet gourd=10 Tk/kg,
Sesame = 50Tk/kg,
Rice= 24 Tk/kg

Fig 8: Effect of test sweetgourd, sesame, T. *aman* varieties with integrated nutrient management system in cropping cycle at at Babugonj and Gournadi, Barishal

Fig 8: Effect of test sweetgourd, sesame, T. *aman* varieties with integrated nutrient management system in cropping cycle at at Babugonj and Gournadi, Barishal

Activity-4:

Varietal intensification and integrated plant nutrition systems on Grasspea-Gimakolmi-T. *aman* cropping pattern in South Central Coastal Region of Bangladesh.

The initial farmer's field soil results in Gopalgonj sadar upazila showed that organic matter ranged from 1.85%, pH 7.99, Total N (0.2%), calcium (6.20 meq 100 g^{-1}), magnesium (2.20 meq 100 g^{-1}), potassium (0.18 meq 100 g^{-1}), phosphorus (35 µg g^{-1}), iron (85 µg g^{-1}), zinc (0.56µgg^{-1}), boron (0.18 µg g^{-1}) and copper (2.70 µg g^{-1}).

Table 20. Initial soil chemical properties of experimental plots of Gopalgonj Sadar upazila, 2019-21.

Soil parameters	Gopalgonj Sadar	Critical level
pH	7.99	-
Organic matter (%)	1.85	-
Total N (%)	0.20	-
Exchangeable Ca (meq 100^{-1} g)	6.20	2.00
Exchangeable Mg (meq 100^{-1} g)	2.20	0.50
Exchangeable K (meq 100^{-1} g)	0.18	0.12
Available P (µg g^{-1})	35.0	10.0
Available Zn (µg g^{-1})	0.56	0.60
Available B (µg g^{-1})	0.18	0.20
Available Cu (µg g^{-1})	2.70	0.20
Available Fe (µg g^{-1})	85.0	4.00
Available S (µg g^{-1})	20.7	10.0

Grasspea - Gimakolmi -T. *aman* cropping pattern

Gimakolmi:

Yield of different gimakolmi varieties under trial plots (RFD and IPNS) and farmers' practice were presented in Table 21 and 22. Leaf yield of gimakolmi varieties (BARI gimakolmi 1, Sabuj

pata and Goldern seed) under trial plots were 105, 121, 97.4, 106, 99.1 and 105 t ha^{-1}, and leaf yield of farmers' practice were 89.6, 83.5 and 83.8 tha^{-1},respectively in Gopalgonj sadar upazilla, Gopalgonj during 2019-21. On the other hand, in, leaf yield of gimakolmi varieties under trial plots were 87.7, 92.9, 79.7, 82.7, 99.1and 105tha^{-1}, and yield of farmers' practice were 89.6, 83.5and 83.8tha^{-1}, respectively. In the trial plots, different variety of gimakolmi yield were increased (RFD and IPNS) in Gopalgonj sadar and Kasheani upazilla of Gopalgonj as compared to the farmers' practice probably might be use of STB fertilizer dose with RFD and IPNS approaches.

Table 21. Effect of variety and integrated nutrient management on Gimakolmi at sadar upzila Gopalgonj during 2019-2021

Treatment combination		Plant height (cm)	Leaf $stem^{-1}$	Biomass (t ha^{-1})
Variety	Fertilizer dose			
BARI Gimakolmi-1	RFD on STB	23.4a	12.4a	105bc
	RFD + 5t ha^{-1} CD (IPNS)	25.6a	12.6a	121a
	Farmers practices	20.4b	10.1bc	89.6def
Sabuj pata (Local-1)	RFD on STB	20.7b	11.1ab	97.4cde
	RFD + 5t ha^{-1} CD (IPNS)	23.0a	11.6ab	106ab
	Farmers practices	19.9b	9.77cd	83.5ef
Golden seed(Local-2)	RFD on STB	19.4b	10.7bc	99.1bcd
	RFD + 5t ha^{-1} CD (IPNS)	20.5b	11.5ab	105bc
	Farmers practices	18.3c	9.13d	83.8f
CV (%)		2.41	3.48	8.62

Values in a column followed by a common letter are not significantly different at $P< 0.05$

Table 22. Effect of variety and integrated nutrient management on Gimakolmi at Kasheani, Gopalgonj during 2019-2021

Treatment combination		Plant height (cm)	Leaf $stem^{-1}$	Biomass (t ha^{-1})
Variety	Fertilizer dose			
BARI Gimakolmi-1	RFD on STB	21.8b	10.6b	87.7ab
	RFD + 5t ha^{-1} CD (IPNS)	25.3a	11.5a	92.9a
	Farmers practices	20.5bc	9.33b	80.6c
Sabuj pata (Local-1)	RFD on STB	20.3bc	9.60b	79.7c
	RFD + 5t ha^{-1} CD (IPNS)	21.0b	10.3b	84.7c
	Farmers practices	19.0bc	9.27b	71.4d
Golden seed(Local-2)	RFD on STB	18.9bc	9.67b	72.8d
	RFD + 5t ha^{-1} CD (IPNS)	20.2bc	10.1b	79.2c
	Farmers practices	17.1c	8.2c	64.3e
CV (%)		5.12	10.8	7.20

Values in a column followed by a common letter are not significantly different at $P< 0.05$

Grasspea - Gimakolmi -T. *aman* cropping pattern

T. *aman*

Yield performance of different T. *aman* rice varieties under trial plots (RFD and IPNS) and farmers' practice were presented in Table 23. Yield of T. *aman* varieties (BRRI dhan 57, BRRI dhan 71 and BRRI dhan 75) under trial plots were 5.57, 5.47, 8.37, 7.81, 6.96 and 6.98 tha^{-1}, and yield of farmers' practice were 4.61, 6.82 and 6.07 tha^{-1}, respectively in Gopalgonj sadar upazilla, Gopalgonj during 2019. On the other hand, in Kasheani upazilla of Gopalgonj, yield of T. *aman* varieties under trial plots were 5.15, 5.06, 7.78, 8.07, 6.59 and 6.89 tha^{-1}, and yield of farmers' practice were 4.22, 6.88 and 5.99 tha^{-1}, respectively. In the trial plots, different variety of T. *aman* yield were increased (RFD and IPNS) in Gopalgonj sadar and Kasheani upazilla of Gopalgonj as compared to the farmers' practice probably might be use of STB fertilizer dose with RFD and IPNS approaches. Farmers' are interested to cultivate T. *aman* varieties under RFD and IPNS approaches.

Table 23. Effect of variety and integrated nutrient management on T. *aman* in Grasspea - Gimakolmi-T. *aman* cropping pattern at Gopalgonj Sadar, and Kasheani, Gopalgonj during 2019-2021

Treatment combination		Grain yield (t ha)	
Variety	Fertilizer dose	Gopalgonj Sadar	Kasheani
BRRIdhan 57	RFD on STB	5.57c	5.15c
	RFD + 5t ha^{-1} CD (IPNS)	5.47c	5.06cd
	Farmers practices	4.61d	4.22d
BRRIdhan 71	RFD on STB	8.37a	7.78ab
	RFD + 5t ha^{-1} CD (IPNS)	7.81ab	8.07a
	Farmers practices	6.82b	6.88b
BRRIdhan 75	RFD on STB	6.96b	6.59b
	RFD + 5t ha^{-1} CD (IPNS)	6.98b	6.89b
	Farmers practices	6.07b	5.99c
CV (%)		7.92	9.76

Khesari

Grasspea (*Lathyrus sativus* L.) is a major pulse crop and known as "Khesari" in Bangladesh. It requires no major costs as a robi crop and is easy to cultivate under relay cropping system with rice as a cheap source of high protein and fodder. Moreover, it has an important role for improving soil fertility by adding around 67 kg ha^{-1} nitrogen through biological nitrogen fixation in a single season. Seed yield of Khesari varieties were tried with RFD, IPNS and farmers' practice, being presented in Table 24. Yield of Khesari varieties (BARI Khesari 2, BARI

Khesari 3 and Khesari (Local) undertrial RFD plots were 1.37, 1.55, 1.31tha^{-1}, and trial IPNS plots were 1.49, 1.63 and 1.36 tha^{-1}, and yield of farmers' practice were 1.32, 1.62 and 1.28tha^{-1}, respectively in Gopalganj sadar upazilla during 2020-2021. On the other hand, in Kasheani, Gopalganj, yield of Khesari varieties under trial RFD plots were 1.41, 1.75 and 1.33 tha^{-1} and trial IPNS plots were 1.52, 1.68 and 1.38 tha^{-1}, and yield of farmers' practice were 1.38, 1.55 and 1.26 tha^{-1}, respectively. In the trial plots, different variety of Khesari yield were increased (RFD and IPNS) compared to the farmers' practice probably might be used of STB fertilizer dose with RFD and IPNS approaches.

Table 24. Effect of variety and integrated nutrient management on Khesari-Gimakolmi-T. *aman* cropping pattern at Gopalgonj sadar and Kasheani, Gopalgonj 2019-2021

Treatment combination		Seed yield (tha^{-1})	
Variety	Fertilizer dose	Gopalgonj Sadar	Kasheani
BARI Khesari-2	RFD on STB	1.37c	1.41c
	RFD + 5t ha^{-1} CD (IPNS)	1.49bc	1.52b
	Farmers practices	1.32c	1.38c
BARI Khesari-3	RFD on STB	1.55ab	1.62a
	RFD + 5t ha^{-1} CD (IPNS)	1.63a	1.68a
	Farmers practices	1.52ab	1.55ab
Local	RFD on STB	1.31c	1.33d
	RFD + 5t ha^{-1} CD (IPNS)	1.36c	1.38c
	Farmers practices	1.28d	1.26e
CV (%)		6.98	9.22

Average yield, rice equivalent yield and total rice (system) yield

Average yield, rice equivalent yield and total rice (system) yield as influenced by different treatments has been presented in Table 25. The highest total rice (system) yield of 31.50 tha^{-1} yr^{-1} was obtained from treatment combination (BARI Khesari-3, Gimakolmi-1, BRRI dhan71 with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach) and lowest total rice (system) yield of 24.06 t ha^{-1} yr^{-1} was obtained from treatment combination of Khesari (Local), Golden seed (Local-2), BRRI dhan 75 with farmer' practices.

Table 25. Average yield, rice equivalent yield, and total rice (system) yield of Gimakolmi-Khesari-T. *aman* cropping pattern at Gopalgonj sadar and Kasheani, Gopalgonj 2019-2021

Treatment	Average yield of crops in the pattern (tha^{-1})			Rice equivalent yield of the pattern (tha^{-1})		Total rice (system) yield (tha^{-1})
	Gimakolmi	Khesari	T. *aman*	Gimakolmi	Khesari	
V1F1	96.06	1.36	5.16	20.01	3.11	28.29
V1F2	106.46	1.47	5.32	22.18	3.38	30.88
V1F3	84.40	1.30	4.30	17.58	2.99	24.88
V2F1	88.78	1.55	7.40	18.49	3.55	29.45
V2F2	95.80	1.63	7.79	19.95	3.75	31.50
V2F3	77.41	1.49	6.38	16.12	3.41	25.92
V3F1	85.90	1.28	6.49	17.89	2.93	27.32
V3F2	92.15	1.33	6.89	19.19	3.05	29.14
V3F3	73.90	1.21	5.88	15.39	2.79	24.06

V1= BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan 57; V2= BARI Khesari-3, Sabujpata (Local-1), BRRI dhan 71; V3= Khesari (Local), Golden seed (Local-2), BRRI dhan 75; F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach) F_3 = Farmers practices

Total variable cost, gross return, gross margin and BCR analysis

The benefit cost analysis of Sweet gourd-Sesame-T. *aman* cropping pattern, highest gross return and gross margin of 7,56,223 and 4,67,219 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination (BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 with RFD on STB + 5 t ha^{-1} cowdung; IPNS approach) and the lowest gross return and gross margin of 5,77,623 and 2,96,526 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination of BARI Mistikumra-2, BARI Til-4, BRRI dhan57 with farmer' practices. The highest benefit cost ratio of 2.61was found from treatment combination RFD on STB + 5 t ha^{-1} cowdung; IPNS apprach with varieties BARI Khesari-3, Sabujpata (Local-1), BRRI dhan 71 at Gournadi upazilla of Barishal.

Table 26. Gross return, gross margin and BCR of Gimakolmi-Khesari -T. *aman* cropping pattern at Kasheani and sadar upazila Gopalgonj 2019-2021

Treatment	Gross return (TK)	Total variable cost (TK)	Gross margin (TK)	BCR
V1F1	679053	290305	388748	2.33
V1F2	741178	285308	455870	2.59
V1F3	597233	280905	316328	2.12
V2F1	706984	298997	407987	2.36
V2F2	756223	289003	467219	2.61
V2F3	622313	287978	334335	2.16
V3F1	655740	291678	364062	2.24
V3F2	699478	285765	413713	2.44
V3F3	577623	281097	296526	2.05

❖ V1= BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan 57
❖ V2= BARI Khesari-3, Sabujpata (Local-1), BRRI dhan 71
❖ V3= Khesari (Local), Golden seed (Local-2), BRRI dhan 75

Khesari = 55 Tk/kg,
Gimakolmi-1 = 5Tk/kg,
Rice= 24 Tk/kg

Fig 9: Effect of test gimakolmi, grasspea, T. *aman* varieties with integrated nutrient management system in Grasspea-Gimakolmi-T. *aman* cropping cycle at Gopalgonj sadar and Kasheani, Gopalgonj

Component-2: Oilseed Research Center, BARI

Activity-1.

Initial status of the physio-chemical properties and microbial population of soil at Madaripur sadar, Kalkini, Bagerhat sadar and Mollarhat upazilla during 2019.

Agriculture in Bangladesh depicts excessive tillage, crop residue removal, imbalance fertilization, etc. that degraded soil health with accelerated decomposition of soil organic matter (SOM). Cropping intensity has increased over time by increasing puddled rice production (BBS, 2012). Consequently, most of the soils contain less than 1.5% SOM, and some soils have even less than 1% SOM (BARC, 2018). The sub-tropical humid climate causes rapid breakdown of SOM by heterotrophic microbes; consequently, nutrients loss occurs through different processes, viz. leaching, volatilization, runoff etc. The low SOM is a cause of low productivity and is considered as a serious threat to the sustainability of agriculture in Bangladesh (Jahiruddin and Satter, 2010). Intensification of agricultural land use with high expansion of modern crop varieties has increased remarkably which has exhausted nutrients from soil. Thus, with advancement of time, soil fertility has declined and chronologically the deficiency of nitrogen, phosphorus, potassium, sulphur, zinc and boron has arisen in the soils (Jahiruddin and Satter, 2010). With a view, to find out the suitable combination of fertilizer/nutrient management for maximizing the crop yield in the cropping system and to evaluate the system productivity and economic profitability in this system.

The initial farmer's field soil results in Madaripur sadar, Kalkini, Mollarhat and Bagerhat sadar upazila showed that organic matter ranged from 1.49-1.89%, pH 7.91-8.26, Total N (0.85-0.109%), calcium (11.12-22.32 meq 100 g^{-1}), magnesium (1.94-4.06 meq 100 g^{-1}), potassium (0.099-0.366 meq 100 g^{-1}), phosphorus (12-52 μg g^{-1}), iron (92.11-108.42 μg g^{-1}), zinc (0.85-0.93 μg g^{-1}), boron (0.37-0.61 μg g^{-1}) and copper (2.05-2.76 μg g^{-1}). Besides, initial soil microbial properties of experimental plots results showed that *Rhizobium* ranged from ($2.8x10^4$-$5.0x10^4$ $cfug^{-1}soil$), PSB from ($2.5x10^3$-$4.0x10^5$ $cfug^{-1}soil$) and *Azotobacter* from ($2.3x10^4$–$4.6x10^5$ $cfug^{-1}soil$) in Madaripur sadar, Kalkini, Mollarhat and Bagerhat sadar upazila, respectively. The soil samples were collected from four farmers fields from Madaripur (Madaripur sadar and Kalkini upazila, Madaripur), and two from Bagerhat (Bagerhat sadar and Mollarhat upazila, Bagerhat). The soil chemical and microbiological properties were analyzed by Soil Science Division and Central Laboratory, BARI. A description of initial nutrient status

of experimental plots of Madaripur and Bagerhat district soils prior to fertilization has been presented in Table 27 and Table 28.

Table 27. Initial soil chemical status of experimental plots of Madaripur sadar, Kalkini, Bagerhat sadar and Mollarhat upazila.

Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Madaripur sadar	8.26	1.71	21.16	3.85	0.161	0.095	52	28	0.43	97.54	0.91
Kalkini	8.21	1.65	21.77	3.96	0.23	0.085	12	15	0.37	99.43	0.89
Madaripur sadar	8.02	1.89	22.32	4.06	0.166	0.109	78	21	0.41	95.21	0.93
Kalkini	8.19	1.74	21.06	3.83	0.346	0.093	12	27	0.61	88.27	0.92
Bagerhat sadar	7.91	1.58	21.06	2.02	0.099	0.085	33	13	0.45	93.35	0.87
Mollarhat	8.21	1.49	11.12	1.94	0.156	0.082	14	14	0.48	97.21	0.85
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Table 28. Initial microbial population of soil in experimental plots (Madaripur sadar, Kalkini, Bagerhat sadar and Mollarhat upazila).

Sl no	Location	*Rhizobium*	PSB	*Azotobacter*
		cfug^{-1}soil		
01	Madaripur sadar upazilla	$5.0x10^4$	$2.5x10^3$	$4.3x10^5$
02	Mostafapur, Madaripur sadar upazilla	$3.5x10^5$	$4.2x10^4$	$2.5x10^3$
03	Kalkini upazilla (Anayet nagar), Madaripur	$4.1x10^3$	$2.5x10^5$	$3.6x10^5$
04	Kalkini upazilla (Payerpur), Madaripur	$2.3x10^4$	$2.7x10^3$	$2.3x10^5$
05	Bagerhat sadar upazilla	$3.1x10^5$	$4.6x10^5$	$3.9x10^4$
06	Mollarhat upazilla, Bagerhat	$2.8x10^4$	$3.2x10^4$	$4.6x10^5$

.

Fig 10. Sample preparation and data collection

Fig 11. Determination of soil nitrogen by Kjeldal method and data analyzed

Activity-2:

Varietal intensification and integrated plant nutrition systems on Mustard-Mungbean - T. *aman* cropping pattern at Madaripur sadar upazila, Madaripur.

❖ **Location: Madaripur sadar upazila, Madaripur**

Sadar upazila Madaripur, preliminary stage the project was conducted four farmers' field for three years. The initial soil was analyzed and presented in Table 29. After three years the post soil samples were collected and analyzed. The initial farmer's field soil results in Madaripur sadar, Kalkini, Mollarhat and Bagerhat sadar upazila showed that organic matter ranged from 1.71%, pH 8.06, Total N (0.109%), calcium (21.16 meq 100 g^{-1}), magnesium (3.85 meq 100 g^{-1}), potassium (0.16 meq 100 g^{-1}), phosphorus (52 µg g^{-1}), iron (97.54 µg g^{-1}), zinc (0.91 µg g^{-1}), and boron (0.43 µg g^{-1}). Besides, initial soil microbial properties of experimental plots results showed that physical status of moisture 15%, clay soil 66%, and *Rhizobium* from ($4.1x10^3$ $cfug^{-1}$soil), PSB ($2.5x10^5$ $cfug^{-1}$soil), *Azotobacter* from ($3.6x10^5$ $cfug^{-1}$soil) in Madaripur sadar upazila, respectively.

Table 29. Initial soil physical, chemical and microbial population of sadar upazila Madaripur.

Initial chemical status of the experimental plots in sadar upazilla Madaripur											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Madaripur sadar	8.06	1.71	21.16	3.85	0.16	0.095	52	28	0.43	97.54	0.91
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial population status of experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				$cfug^{-1}$soil		
Madaripur sadar	7	27	66	15	$4.1x10^3$	$2.5x10^5$	$3.6x10^5$

1st Crop Mustard

Mustard (*Brassica campestris* L.) is an important oilseed crop being grown in Robi season in Bangladesh. Yield performance of different mustard varieties were tried with recommended fertilizer dose (RFD) from inorganic source as per soil test basis (STB), RFD on STB + 5 tha^{-1} cowdung (IPNS approach), and farmers' practice, being presented in Table 30. Plant height, siliqua/plant, seeds/siliqua, 1000-seed weight, seed yield, straw yield and field duration of mustard at Madaripur district have been differed significantly among the varieties (BARI Sarisha-14, BARI Sarisha-17 and BARI Sarisha-11). Yield of mustard varieties under trial RFD plots were 1.53, 1.59, 1.73 tha^{-1}, and trial IPNS plots were 1. 62, 1.72 and 1.77 tha^{-1}, and yield of farmers' practice were 1.46, 1.51 and 1.59 tha^{-1}, respectively at Madaripur sadar upazila during 2019-2021.

Table 30. Performance of mustard varieties under integrated nutrient management system at Madaripur sadar upazila 2019-21.

Treatment combination		Crop characteristics and yield					
Variety	Fertilizer dose	Days to maturity	Plant height (cm)	Siliqua plant^{-1} (no)	Seed Siliqua^{-1} (no)	1000 seed wt. (g)	Seed yield (t ha^{-1})
BARI Sarisha-17	F1	85b	86.67c-e	83.67a	22.67a-c	3.64ab	1.53cd
	F2	87b	84.67de	84.33a	25.02a	3.67a	1.62b
	F3	85b	80.00e	75.67b	21.03cd	3.24cd	1.46d
BARI Sarisha-14	F1	87b	95.01bc	84.67a	25.01a	3.43a-c	1.59bc
	F2	87b	94.02b-d	84.02a	24.67ab	3.56a-c	1.72a
	F3	86b	89.67cd	73.33b	24.33ab	3.25cd	1.51d
BARI Sarisha-11	F1	105a	107.00a	64.33c	21.67bc	3.32b-d	1.73a
	F2	106a	108.01a	66.67c	22.33a-c	3.46a-c	1.77a
	F3	105a	102.03ab	59.67d	18.33d	3.01d	1.59bc
CV(%)		5.96	7.74	4.08	7.64	5.71	2.89

* F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices.

2nd Crop Mungbean

Mungbean (*Vigna radiate* L.) is the second most important pulse crop in terms of area and production in Bangladesh (BBS, 2015). It is generally grown in Kharif-1 season and the critical reason of the poor crop productivity of pre-monsoon season mungbean is the higher crop-weed competition (Kumar et al., 2017). Yield of different mungbean varieties under trial plots (RFD, IPNS, and farmers' practice) were presented in Table 31. Yield of mungbean varieties (BARI

Mung-6, BARI Mung-8 and BINA Mung-8) under trial RFD plots were 1. 63, 1.77, 1.59 tha^{-1}, and trial IPNS plots were 1. 69, 1.79 and 1.61 tha^{-1}, and yield of farmers' practice were 1.39, 1.31 and 1.19 tha^{-1}, respectively at Madaripur sadar upazilla during 2019-2021.

Table 31. Performance of mungbean varieties under integrated nutrient management system at Madaripur sadar upazila 2019-21.

Treatment combination		Crop characteristics and yield				
Variety	Fertilizer dose	Pod plant^{-1}	Seed pod^{-1}	100 seed wt. (g)	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})
BARI Mung- 8	F1	27.01cd	12.02ab	3.36b	3.64bc	1.63c
	F2	29.33b	13.33abc	3.78ab	4.09a	1.69bc
	F3	23.67e	10abc	3.07b	2.89e	1.39d
BARI Mung- 6	F1	29. 67b	9.67bc	3.66ab	3.66bc	1.77ab
	F2	32.01a	10.67abc	3.94ab	3.89ab	1.79a
	F3	26.33cd	9.01bc	3.08b	3.13de	1.31d
BINA Mung -8	F1	26.01d	11.67ab	4.18ab	3.40cd	1.59c
	F2	28.01bc	12.01ab	3.91ab	4.08a	1.61c
	F3	21.00f	8.01c	5.78a	3.07de	1.19e
CV(%)		3.83	19.41	12.37	6.41	3.79

3rd Crop T. *aman*

Transplanted *aman* (*Oryza sativa* L.) is another important cereal crop and is generally grown in Kharif-2 season in Bangladesh. Yield performance of different T. *aman* rice varieties under trial plots (RFD, IPNS and farmers' practice) were presented in Table 32. Yield of tested T. *aman* varieties (BRRI dhan57, BRRI dhan71 and BRRI dhan75) under RFD plots were 4.63, 5.51, 4.94 tha^{-1}, and trial IPNS plots were 4.77, 5.61 and 5.41 tha^{-1}, and yield of farmers' practice were 3.96, 4.61 and 4.50 tha^{-1}, respectively at Madaripur sadar upazilla during 2019-2021.

Table 32. Performance of T. *aman* varieties under integrated nutrient management system at Madaripur sadar upazila 2019-2021.

Treatment combination		Crop characteristics and yield					
Variety	Fertilizer dose	Plant height (cm)	Panicle m^{-2}	Grain panicle^{-1} (no)	1000 grain wt. (g)	Straw yield (t ha^{-1})	Grain yield (tha^{-1})
BRRI dhan 57	F1	121.67bc	452.70de	162.33d	23.01c	5.47f	4.63 a-c
	F2	124.33ab	490.71d	183.67b	28.02a	6.05c	4.77 a-c
	F3	114.01e	514.01c	148.01e	21.01de	5.29g	3.96c
BRRI dhan 71	F1	122.33ab	499.30d	172.67c	22.67c	5.78d	5.51ab
	F2	125.67a	561.31a	188.33a	28.67a	6.27a	5.61a
	F3	118.33cd	486.30d	146.67e	20.01e	5.63e	4.61a-c
BRRI dhan 75	F1	125.67a	4732d	163.67d	21.33d	6.17b	4.94a-c
	F2	124.67ab	534.66b	173.67c	25.33b	6.26a	5.41ab
	F3	115.67de	459.3de	143.67f	18.33f	5.83d	4.50bc
CV(%)		1.88	4.21	0.98	2.96	2.21	11.91

Total rice (system) yield:

Average yield, rice equivalent yield and total rice (system) yield as influenced by different treatments has been presented in Table 33. The highest total rice (system) yield of 15.90 t ha^{-1} yr^{-1} was obtained from treatment combination combination (BARI Sarisha-14, BARI Mung-6, BRRI dhan71 with RFD on STB + 5 t ha^{-1} cowdung; IPNS approach and lowest total rice (system) yield of 12.25 tha^{-1} yr^{-1} was obtained from treatment combination of BARI Sarisha-17, BARI Mung-8, BRRI dhan57 with farmer' practices.

Table 33. Average yield, rice equivalent yield and total rice (system) yield of Mustard-Mungbean -T. *aman* pattern at sadar upazila Madaripur.

Treatment combination	Average yield of crops in the pattern (tha^{-1})			Rice equivalent yield of crops in the pattern (tha^{-1})		Total rice (system) yield (t ha^{-1} yr^{-1})
	Mustard	Mung bean	T. *aman*	Mustard	Mung bean	
V1F1	1.53cd	1.77ab	4.63a-c	3.83	5.91	14.36
V1F2	1.62b	1.79a	4.77a-c	4.05	6.34	15.16
V1F3	1.46d	1.31d	3.96c	3.65	4.64	12.25
V2F1	1.59bc	1.63c	5.51ab	3.98	5.78	15.26
V2F2	1.72a	1.69bc	5.61a	4.31	5.99	15.90
V2F3	1.51d	1.39d	4.61a-c	3.78	4.93	13.31
V3F1	1.73a	1.59c	4.94a-c	4.33	5.64	14.91
V3F2	1.77a	1.61c	5.41ab	4.43	5.71	15.54
V3F3	1.59bc	1.19e	4.50bc	3.98	4.22	12.69

❖ V1= BARI Sarisha-17, BARI Mung-8, BRRI dhan57; V2= BARI Sarisha-14, BARI Mung-6, BRRI dhan71; V3= BARI Sarisha-11, BINA Mung-8, BRRI dhan75 ; F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices

Total variable cost, gross return, gross margin and MBCR analysis

The benefit cost analysis of Mustard-Mungbean-T. *aman* cropping pattern, highest gross return and gross margin of 3,81,490 and 2,16,869 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination (BARI Sarisha-14, BARI Mung-6, BRRI dhan71 with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach) and the lowest gross return and gross margin of 2,93,990 and 1,17,682 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination of BARI Sarisha-17, BARI Mung-8, BRRI dhan57 with farmer' practices. The highest marginal benefit cost ratio of 2.32 was found from treatment combination RFD on STB + 5 t ha^{-1} cowdung; IPNS approach with varieties BARI Sarisha-14 followed by BARI Mung-6, BRRI dhan71 and BRRI dhan75.

Table 34. Gross return, total variable cost, gross margin and MBCR of Mustard-Mungbean -T. *aman* pattern at Madaripur sadar upazilla, Madaripur.

Treatment combination	Gross return (Tk ha^{-1} yr^{-1})	Total variable cost (Tk ha^{-1} yr^{-1})	Gross margin (Tk ha^{-1} yr^{-1})	MBCR
V1F1	344544	186308	158236	1.85
V1F2	363830	185308	178522	1.96
V1F3	293990	176308	117682	1.67
V2F1	366190	174560	191630	2.11
V2F2	381490	164621	216869	2.32
V2F3	319390	161360	158030	1.98
V3F1	357510	203364	154146	1.76
V3F2	372960	177862	195098	2.10
V3F3	304548	183324	121224	1.66

Note: Price: Mustard = 70 Tk kg^{-1}, Mungbean = 90 Tk kg^{-1}, Rice = 30 Tk kg^{-1}, Urea = 16 Tk kg^{-1}, TSP = 25 Tk kg^{-1} , MoP = 15 Tk kg^{-1} , Gypsum = 12 Tk kg^{-1}, Zinc sulphate = 200 Tk kg^{-1}, Boric acid: 220 Tk kg^{-1}, Labour = Tk. 500 day^{-1}, Land preparation for all crops 3 times ploughing and laddering = Tk 1000 $bigha^{-1}$, Irrigation for T. *aman* = Tk. 800 ha^{-1}; V1: BARI Sarisha-17, BARI Mung-8, BRRI dhan57; V2: BARI Sarisha-14, BARI Mung-6, BRRI dhan71; V3: BARI Sarisha-11, BINA Mung-8, BRRI dhan75

Soil fertility status

Nutrient uptake by grain and straw of all crops of the cropping pattern were influenced by different fertilizer treatments. The initial soil as well as in soil after completion of Mustard-Mungbean-T. *aman* cropping cycle, the average soil fertility status were no appreciable change or mostly unchanged. The organic matter content of the soil increased due to biomass addition of the leguminous crops. Somewhere it was changed positively. As potassium showed negative balance, more potassium is to be added to improve soil fertility status and may be sustained in the study area of AEZ-12 and AEZ-14.

Table 35. Physical, chemical and microbial status of post soil in experimental plots of sadar upazilla Madaripur

Chemical data of the experimental plots (post soil in Madaripur sadar upazilla)											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Madaripur sadar	8.08	1.89	22.32	4.06	0.11	0.11	78	21	0.41	98.69	0.93
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfu g^{-1} soil		
Madaripur sadar	7	28	65	16	$5.1x10^3$	$3.5x10^5$	$4.6x10^5$

Fig 12. Effect of test mustard, mungbean, and T. *aman* varieties with integrated nutrient management system in Mustard-Mungbean-T. *aman* pattern at Madaripur sadar upazila.

Activity-3:

Varietal intensification and integrated plant nutrition systems on Mustard-Mungbean - T. *aman* cropping pattern at Kalkini upazilla, Madaripur.

❖ **Location: Kalkini upazila, Madaripur**

The initial farmer's field soil results in Kalkini upazila showed that organic matter from 1.65%, pH 8.21, Total N (0.085%), calcium (21.77 meq 100 g^{-1}), magnesium (3.96 meq 100 g^{-1}), potassium (0.23 meq 100 g^{-1}), phosphorus (12 µg g^{-1}), iron (99.43 µg g^{-1}), zinc (0.89 µg g^{-1}), and boron (0.37 µg g^{-1}). Besides, initial soil microbial properties of experimental plots results showed that *Rhizobium* from ($4.1x10^3$ $cfug^{-1}$soil), PSB from ($2.5x10^5$ $cfug^{-1}$soil) and *Azotobacter* from ($3.6x10^5$ $cfug^{-1}$soil) in Kalkini upazilla, Madaripur.

Table 36. Initial soil physical, chemical and microbial population of Kalkini upazilla, Madaripur.

Initial chemical status of the experimental plots soil at Kalkini upazila, Madaripur											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Kalkini upazilla	8.21	1.65	21.77	3.96	0.23	0.085	12	15	0.37	99.43	0.89
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfug^{-1}soil		
Kalkini upazilla	12	29	59	15	4.1x10^3	2.5x10^5	3.6x10^5

1st Crop Mustard

In Kalkini upazila, yield of mustard varieties were tried recommended fertilizer dose (RFD) from inorganic source as per soil test basis (STB), RFD on STB + 5 t ha^{-1} cowdung (IPNS approach), and farmers' practice, being presented in Table 37. Plant height, siliqua/plant, seeds/siliqua, 1000-seed weight, seed yield, straw yield and field duration of mustard at Kalkini upazila have been differed significantly among the varieties (BARI Sarisha-14, BARI Sarisha-17 and BARI Sarisha-11).

Table 37. Performance of mustard varieties under integrated nutrient management system at Kalkini upazila, Madaripur 2019-2021.

Treatment combination		Crop characteristics and yield					
Variety	Fertilizer dose	Days to maturity	Plant height cm)	Siliqua plant^{-1} (no)	Seed Siliqua^{-1} (no)	1000 seed wt. (g)	Seed yield (t ha^{-1})
BARI Sarisha-17	F1	86b	83.33ef	72.01ef	27.33a	3.95ab	1.59c-e
	F2	87b	86.33de	77.67cd	29.33a	4.18a	1.67cd
	F3	84b	81.01f	68.33f	20.01bc	3.76ab	1.46f
BARI Sarisha-14	F1	87b	87.67cd	78.67b-d	29.67a	3.70ab	1.57de
	F2	88b	91.02c	85.33a	28.02a	3.94ab	1.71c
	F3	84b	85.67de	70.67f	21.67b	3.49ab	1.46f
BARI Sarisha-11	F1	106a	110.02a	81.01a-c	20.33bc	3.87ab	1.83b
	F2	105a	111.67a	83.33ab	19.03c	3.20b	1.98a
	F3	105a	99.67b	76.02de	18.02c	3.37b	1.53ef
CV(%)		5.41	8.62	5.71	5.79	12.23	3.96

* F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices.

2nd Crop Mungbean

Yield of different mungbean varieties under trial plots (RFD, IPNS, and farmers' practice) were presented in Table 38. Yield of mungbean varieties (BARI Mung-6, BARI Mung-8 and BINA Mung-8) under trial RFD plots were 1. 71, 1.67, 1.59 tha^{-1}, and trial IPNS plots were 1. 72, 1.76 and 1.60 tha^{-1}, and yield of farmers' practice were 1.51, 1.56 and 1.40 tha^{-1}, respectively at Kalkini upazilla during 2019-2021.

Table 38. Performance of mungbean varieties under integrated nutrient management system at Kalkini upazila 2019-2021.

Treatment combination		Crop characteristics and yield				
Variety	Fertilizer dose	Pod plant^{-1}	Seed pod^{-1}	100 seed wt. (g)	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})
BARI Mung- 8	F1	33abc	10.67b-d	3.13cd	3.78c	1.71a-c
	F2	37a	11.33abc	3.50ab	4.57b	1.72ab
	F3	27bcd	8.33e	2.31f	3.26d	1.51de
BARI Mung- 6	F1	33a-c	11.33a-c	3.21b-d	3.40d	1.67a-c
	F2	35ab	12.67a	3.58a	4.91a	1.76a
	F3	25cd	10.01c-e	2.99de	3.06d	1.56cd
BINA Mung -8	F1	26cd	10.67b-d	3.17cd	3.74c	1.59b-d
	F2	28b-d	12.01ab	3.41a-c	4.94a	1.60b-d
	F3	22d	9.33de	2.77e	3.27d	1.40e
CV(%)		16.54	10.54	5.79	3.98	5.49

3rd Crop T. *aman*

Yield performance of different T. *aman* rice varieties under trial plots (RFD, IPNS and farmers' practice) were presented in Table 39. Yield of tested T. *aman* varieties (BRRI dhan57, BRRI dhan71 and BRRI dhan75) under RFD plots were 4.38, 5.41, 5.33 t ha^{-1}, and trial IPNS plots were 4.64, 5.48 and 5.44 tha^{-1}, and yield of farmers' practice were 3.09, 4.26 and 4.87 tha^{-1}, respectively at Kalkini upazila during 2019-2021.

Table 39. Performance of T. *aman* varieties under integrated nutrient management system at Kalkini upazila 2019-2021.

Treatment combination		Crop characteristics and yield					
Variety	Fertilizer dose	Plant height (cm)	Panicle m^{-2}	Grain panicle^{-1} (no)	1000 grain wt. (g)	Straw yield (t ha^{-1})	Grain yield (tha^{-1})
BRRI dhan 57	F1	120.67cd	410.3e	23.23b	23.23b	6.25ab	4.38cd
	F2	126.33ab	409.3e	29.6a	29.6a	6.71a	4.64cd
	F3	115.33ef	473a	21.5c	21.5c	5.73b	3.09d
BRRI dhan 71	F1	118.67de	410.9e	19.67d	19.67d	6.06ab	5.41ab
	F2	128.67a	425.3c	20.7cd	20.7cd	6.35ab	5.48a
	F3	111.33f	444.9b	17.33e	17.33e	6.04ab	4.26ab
BRRI dhan 75	F1	123.33bc	389.57f	21.7bc	21.7bc	5.85b	5.33ab
	F2	124.67a-c	383.9g	29.07a	29.07a	5.98ab	5.44ab
	F3	114.01f	422.1d	20.7cd	20.7cd	4.67c	4.87bc
CV(%)		1.99	0.26	3.80	3.80	7.97	7.01

Total rice (system) yield:

Average yield, rice equivalent yield and total rice (system) yield as influenced by different treatments has been presented in Table 40. The highest total rice (system) yield of 16.34 $tha^{-1}yr^{-1}$ was obtained from treatment combination (BARI Sarisha-14, BARI Mung-6, BRRI dhan71 with RFD on STB + 5 tha^{-1} cowdung; IPNS approach and lowest total rice (system) yield of 12.39 t ha^{-1} yr^{-1} was obtained from treatment combination of BARI Sarisha-17, BARI Mung-8, BRRI dhan57 with farmer' practices.

Table 40. Average yield, rice equivalent yield and total rice (system) yield ($tha^{-1}yr^{-1}$) of Mustard -Mungbean -T. *aman* pattern at Kalkini upazila, Madaripur.

Treatment combination	Average yield of crops in the pattern (tha^{-1})			Rice equivalent yield of the pattern (tha^{-1})		Total rice (system) yield (t ha^{-1} yr^{-1})
	Mustard	Mung bean	T. *aman*	Mustard	Mung bean	
V1F1	1.59c-e	1.71a-c	4.38cd	4.31	6.06	14.74
V1F2	1.67cd	1.72ab	4.64cd	4.52	6.09	15.25
V1F3	1.46f	1.51de	3.09d	3.95	5.35	12.39
V2F1	1.57de	1.67a-c	5.41ab	4.25	5.91	15.58
V2F2	1.71c	1.76a	5.48a	4.63	6.23	16.34
V2F3	1.46f	1.56cd	4.26ab	3.95	5.53	13.74
V3F1	1.83b	1.59b-d	5.33ab	4.96	5.63	15.92
V3F2	1.98a	1.60b-d	5.44ab	5.36	5.67	16.47
V3F3	1.53ef	1.40e	4.87bc	4.14	4.96	13.97

V1: BARI Sarisha-17, BARI Mung-8, BRRI dhan57; V2: BARI Sarisha-14, BARI Mung-6, BRRI dhan71; V3: BARI Sarisha-11, BINA Mung-8, BRRI dhan75; F_1: Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2: RFD on STB + 5 t ha^{-1} cowdung (IPNS approach); F_3: Farmers practices

Total variable cost, gross return, gross margin and MBCR analysis

The benefit cost analysis of Mustard-Mungbean-T. *aman* cropping pattern, highest gross return and gross margin of 3,92,270 and 2,17,088 (Tk ha^{-1} yr^{-1}) were obtained from treatment combination (BARI Sarisha-14, BARI Mung-6, BRRI dhan 71 with RFD on STB + 5 t ha^{-1} cowdung; IPNS approach) and the lowest gross return and gross margin of 2,97,410 and 1,08,548 (Tk ha^{-1} yr^{-1}) were obtained from treatment combination of BARI Sarisha-17, BARI Mung-8, BRRI dhan57 with farmer' practices. The highest marginal benefit cost ratio of 2.24 was found from treatment combination RFD on STB + 5 t ha^{-1}cowdung; IPNS approach with varieties BARI Sarisha-14, BARI Mung-6, BRRI dhan71.

Table 41. Gross return, total variable cost, gross margin and MBCR of Mustard-Mungbean -T. *aman* pattern at Kalkini upazila, Madaripur.

Treatment combination	Gross return (Tk ha^{-1} yr^{-1})	Total variable cost (Tk ha^{-1} yr^{-1})	Gross margin (Tk ha^{-1} yr^{-1})	MBCR
V1F1	353820	179808	174012	1.97
V1F2	366110	172864	193246	2.12
V1F3	297410	188862	108548	1.57
V2F1	373840	199860	173980	1.87
V2F2	392270	175182	217088	2.24
V2F3	329740	194084	135656	1.7
V3F1	382020	209956	172064	1.82
V3F2	395260	185182	210078	2.13
V3F3	335330	183184	152146	1.83

Note: Price: Mustard = 70 Tk kg^{-1}, Mungbean = 90 Tk kg^{-1}, Rice = 30 Tk kg^{-1}, Urea = 16 Tk kg^{-1}, TSP = 25 Tk kg^{-1} , MoP = 15 Tk kg^{-1} , Gypsum = 12 Tk kg^{-1}, Zinc sulphate = 200 Tk kg^{-1}, Boric acid: 220 Tk kg^{-1}, Labour = Tk. 500 day^{-1}, Land preparation for all crops 3 times ploughing and laddering = Tk 1000 $bigha^{-1}$, Irrigation for T. *aman* = Tk. 800 $bigha^{-1}$; V1: BARI Sarisha-17, BARI Mung-8, BRRI dhan57; V2: BARI Sarisha-14, BARI Mung-6, BRRI dhan71; V3: BARI Sarisha-11, BINA Mung-8, BRRI dhan75; F_1: Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2: RFD on STB + 5 t ha^{-1} cowdung (IPNS approach); F_3: Farmers practices

Soil fertility status

In Kalkini upazilla, the initial soil as well as in soil after completion of Mustard-Mungbean-T. *aman* cropping cycle, the average soil fertility status were no appreciable change. The organic matter content of the soil increased due to biomass addition of the leguminous crops. Somewhere it was changed positively. As phosphorus and sulphur showed negative balance, more phosphorus and sulphur are to be added to improve soil fertility status and may be sustained in the study area of AEZ-12 and AEZ-14.

Table 42. Post soil physical, chemical and microbial population of Kalkini upazila, Madaripur.

Post chemical data of the experimental plots soil											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Kalkini upazilla	8.11	1.71	23.77	3.89	0.21	0.088	10	11	0.37	98.55	0.88
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfug^{-1}soil		
Kalkini upazilla	11	31	60	16	$5x10^3$	$3.5x10^5$	$4.6x10^5$

Fig 13. Effect of test mustard, mungbean, and T. *aman* varieties with integrated nutrient management system in Mustard-Mungbean-T. *aman* pattern at Kalkini, upazila, Madaripur.

Activity-4:

Varietal intensification and integrated plant nutrition systems on Grasspea–Gimakolmi -T. *aman* cropping pattern at Madaripur sadar upazila, Madaripur.

❖ **Location: Madaripur sadar upazila, Madaripur**

The initial farmer's field soil results in Madaripur sadar upazila showed that organic matter from 1.89%, pH 8.02, Total N (0.11%), calcium (22.32 meq 100 g^{-1}), magnesium (4.06 meq 100 g^{-1}), potassium (0.17 meq 100 g^{-1}), phosphorus (78 µg g^{-1}), iron (95.21 µg g^{-1}), zinc (0.93 µg g^{-1}), and boron (0.41 µg g^{-1}). Besides, initial soil microbial properties of experimental plots results showed that *Rhizobium* from ($3.5x10^5$ $cfug^{-1}$soil), PSB from ($4.2x10^4$ $cfug^{-1}$soil) and *Azotobacter* from ($2.5x10^3$ $cfug^{-1}$ soil) in Madaripur sadar upazilla, Madaripur.

Table 43. Initial soil physical, chemical and microbial population of Madaripur sadar upazila, Madaripur.

Initial chemical status of the experimental plots soil											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Madaripur sadar	8.02	1.89	22.32	4.06	0.17	0.11	78	21	0.41	95.21	0.93
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of experimental plots soil							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfug^{-1}soil		
Kalkini upazilla	7	28	65	14	$3.5x10^5$	$4.2x10^4$	$2.5x10^3$

❖ 1st Crop Grasspea

Grasspea (*Lathyrus sativus* L.) is a major pulse crop and known as " Khesari" in Bangladesh. It requires no major costs as a robi crop and is easy to cultivate under relay cropping system with rice as a cheap source of high protein and fodder. Moreover, it has an important role for improving soil fertility by adding around 67 kg ha^{-1} nitrogen through biological nitrogen fixation in a single season (Wang et al., 2000). Pod plant^{-1}, seed pod^{-1}, 100 seed wt, stover yield and seed yield of Khesari varieties were tried with recommended fertilizer dose (RFD) from inorganic source as per soil test basis (STB), RFD on STB + 5 t ha^{-1} cowdung (IPNS approach) and farmers' practice, being presented in Table 44. Yield of grasspea varieties (BARI Khesari-3, BARI Khesari-5 and Khesari (Local) under trial RFD plots were 1.45, 1.74, 1.36 t ha^{-1}, and trial IPNS plots were 1.65, 1.82 and 1.52 t ha^{-1}, and yield of farmers' practice were 1.31, 1.48 and 1.25 tha^{-1}, respectively at Madaripur sadar upazila during 2019-2021.

Table 44. Performance of grasspea varieties under integrated nutrient management system at Madaripur sadar upazila 2019-21.

Treatment combination		Crop characteristics and yield				
Variety	Fertilizer dose	Pod plant^{-1}	Seed pod^{-1}	100 seed wt. (g)	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})
BARI Khesari-5	F1	25.33bc	8.33c	5.99a	3.53bc	1.45b-d
	F2	28.67a	9.33b	6.24a	3.60ab	1.65a-c
	F3	22.67d	7.00d	5.36b	3.01d	1.31d
BARI Khesari-3	F1	24.70c	11.00a	3.60c	3.39c	1.74ab
	F2	26.67b	11.33a	3.78c	3.80a	1.82a
	F3	26.0bc	9. 48b	3.09d	2.17f	1.48b-d
Khesari (Local)	F1	19.90e	8.40c	3.57cd	2.68e	1.36cd
	F2	18.33f	9.00b	3.72c	2.88de	1.52a-d
	F3	17.78f	8.00c	3.44cd	2.17f	1.25d
CV(%)		3.43	3.62	6.51	3.99	12.15

* F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices.

2nd Crop Gimakolmi

Yield of different gimakolmi varieties under trial plots (RFD, IPNS, and farmers' practice) were presented in Table 45. Leaf yield of gimakolmi varieties (BARI Gimakolmi-1, Sabuj pata (Local) and Goldern seed (Local) under trial RFD plots were 59.33, 48.33, 49.01 tha^{-1}, and trial IPNS plots were 62, 50.67, 56.66 tha^{-1}, and leaf yield of farmers' practice were 57, 43.67 and 53 tha^{-1}, respectively at Madaripur sadar upazila during 2019-2021.

Table 45. Performance of gimakolmi varieties under integrated nutrient management system at Madaripur sadar upazila 2019-2021.

Treatment combination		Crop characteristics and yield		
Variety	Fertilizer dose	plant height (cm)	Leaf stem^{-1}	Biomass (t ha^{-1})
BARI Gimakolmi-1	F1	21.00c	10.00b	59.33ab
	F2	26.67a	11.00a	62.00a
	F3	19.00d	9.00cd	57.00a-c
Sabujpata (Local-1)	F1	17.67e	8.67d	48.33de
	F2	19.00d	9.67bc	50.67cd
	F3	16.67f	7.67e	43.67e
Golden seed (Local-2)	F1	19.00d	9.83b	49.00de
	F2	22.33b	9.40bc	56.67a-c
	F3	15.67g	8.50d	53b-d
CV (%)		2.08	4.48	7.58

3rd Crop T. *aman*

Yield performance of different T. *aman* rice varieties under trial plots (RFD, IPNS and farmers' practice) were presented in Table 46. Yield of tested T. *aman* varieties (BRRI dhan57, BRRI

Table 46. Performance of T. *aman* varieties under integrated nutrient management system at Madaripur sadar upazila 2019-21.

Treatment combination		Crop characteristics and yield					
Variety	Fertilizer dose	Plant height (cm)	Panicle m^{-2}	Grain panicle^{-1} (no)	1000 grain wt. (g)	Straw yield (t ha^{-1})	Grain yield (tha^{-1})
BRRI dhan 57	F1	123.3b	453.30f	162.33d	21.76de	6.66e	4.50d
	F2	126.7a	462.03d	183.67b	29.06a	7.03c	4.56d
	F3	115.7c	515.10a	148.01e	21.80de	6.26f	4.11e
BRRI dhan 71	F1	123.7b	460.11e	172.67c	23.23c	6.76d	5.85a
	F2	127.1a	482.10c	188.33a	29.61a	7.27a	5.84a
	F3	116.7c	489.03b	146.67e	21.50e	6.63e	4.82c
BRRI dhan 75	F1	127.7a	434.01g	163.67d	22.50cd	7.16b	5.37b
	F2	127.0a	435.10g	173.67c	26.21b	7.25a	5.45b
	F3	116.3c	460.70de	143.67f	19.13f	6.82d	4.75cd
CV(%)		0.58	0.24	0.98	1.83	0.56	2.96

dhan71 and BRRI dhan75) under RFD plots were 4.50, 5.85, 5.37 tha^{-1}, and trial IPNS plots were 4.56, 5.84 and 5.45 tha^{-1}, and yield of farmers' practice were 4.11, 4.82 and 4.75 tha^{-1}, respectively at Madaripur sadar upazilla during 2020-2021.

Total rice (system) yield:

Average yield, rice equivalent yield and total rice (system) yield as influenced by different treatments has been presented in Table 47. The highest total rice (system) yield of 21.26 t ha^{-1} yr^{-1} was obtained from treatment combination (BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan57 with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach) and lowest total rice (system) yield of 17.31 t ha^{-1} yr^{-1} was obtained from treatment combination of BARI Khesari-3, Sabujpata (Local-1), BRRI dhan71 with farmer' practices.

Table 47. Average yield, rice equivalent yield and total rice (system) yield (t ha^{-1} yr^{-1}) of Grasspea- Gimakolmi-T. *aman* at sadar upazila of Madaripur.

Treatment combination	Average yield of crops in the pattern (tha^{-1})			Rice equivalent yield of the pattern (tha^{-1})		Total rice (system) yield (t ha^{-1} yr^{-1})
	Grasspea	Gimakolmi	T. *aman*	Grasspea	Gimakolmi	
V1F1	1.45b-d	59.33ab	4.50d	3.32	12.36	20.18
V1F2	1.65a-c	62.00a	4.56d	3.78	12.92	21.26
V1F3	1.31d	57.00a-c	4.11e	3.01	11.88	18.99
V2F1	1.74ab	48.33de	5.85a	3.99	10.07	19.91
V2F2	1.82a	50.67cd	5.84a	4.17	10.56	20.57
V2F3	1.48b-d	43.67e	4.82c	3.39	9.098	17.31
V3F1	1.36cd	49.0de	5.37b	3.12	10.21	18.69
V3F2	1.52a-d	56.67a-c	5.45b	3.48	11.81	20.74
V3F3	1.25d	53b-d	4.75cd	2.86	11.04	18.66

- V1= BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan 57; V2= BARI Khesari-3, Sabujpata (Local-1), BRRI dhan 71; V3= Khesari (Local), Golden seed (Local-2), BRRI dhan 75; F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices

Total variable cost, gross return, gross margin and MBCR analysis

The benefit cost analysis of Grasspea-Gimakolmi-T. *aman* cropping pattern, highest gross return and gross margin of 5,10,190 and 3,15,745 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination (BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan57 with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach and the lowest gross return and gross margin of 4,15,430 and 1,98,816 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination of BARI Khesari-3, Sabujpata (Local-1), BRRI dhan71 with farmer' practices. The highest marginal benefit cost ratio of 2.74

was found from treatment combination RFD on STB + 5 tha^{-1} cowdung; IPNS approach with varieties BARI Khesari-3, Sabujpata (Local-1), BRRI dhan71 at Madaripur sadar upazila, Madaripur.

Table 48. Gross return, total variable cost, gross margin and MBCR of Grasspea- Gimakolmi-T. *aman* at Madaripur sadar upazila, Madaripur.

Treatment combination	Gross return (Tk ha^{-1} yr^{-1})	Total variable cost (Tk ha^{-1} yr^{-1})	Gross margin (Tk ha^{-1} yr^{-1})	MBCR
V1F1	484400	219408	264992	2.21
V1F2	510190	194445	315745	2.62
V1F3	455690	236633	219057	1.93
V2F1	477750	189821	287929	2.52
V2F2	493610	177622	315988	2.78
V2F3	415430	216614	198816	1.92
V3F1	448680	203451	245229	2.21
V3F2	497750	199314	298436	2.5
V3F3	447750	233351	214399	1.92

Note: Price: Khesari = 55 Tk/kg^{-1}, Gimakolmi-1 = 5Tk/kg, Rice = 30 Tk kg^{-1}, Urea = 16 Tk kg^{-1}, TSP = 25 Tk kg^{-1} , MoP = 15 Tk kg^{-1} , Gypsum = 12 Tk kg^{-1}, Zinc sulphate = 200 Tk kg^{-1}, Boric acid: 220 Tk kg^{-1}, Labour = Tk. 500 day^{-1}, Land preparation for all crops 3 times ploughing and laddering = Tk 1000 $bigha^{-1}$, Irrigation for T. *aman* = Tk. 800 $bigha^{-1}$; V1: BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan 57; V2: BARI Khesari-3, Sabujpata (Local-1), BRRI dhan 71 ; V3: Khesari (Local), Golden seed (Local-2), BRRI dhan 75; F_1: Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2: RFD on STB + 5 t ha^{-1} cowdung (IPNS approach); F_3: Farmers practices

Soil fertility status

Nutrient uptake by grain and straw of all crops of the cropping pattern were influenced by different fertilizer treatments. The initial soil as well as in soil after completion of Grasspea-Gimakolmi-T. *aman* cropping cycle, the average soil fertility status were no appreciable change or mostly unchanged. The organic matter content of the soil increased due to biomass addition of the leguminous crops. Somewhere it was changed positively and may be sustained in the study area of AEZ-12.

Table 49. Post soil physical, chemical and microbial population of sadar upazila Madaripur.

Post soil chemical data of the experimental plots											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Kalkini upazila	8.11	1.71	23.77	3.89	0.21	0.088	9	11	0.37	98.55	0.88
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfug^{-1}soil		
Kalkini upazila	7	29	64	15	$4x10^3$	$5x10^5$	$3.6x10^5$

Fig 14. Effect of test grasspea, gimakolmi, and T. *aman* varieties with integrated nutrient management system in Grasspea-Gimakolmi-T. *aman* pattern at sadar upazila Madaripur.

Activity-5:

Varietal intensification and integrated plant nutrition systems on Grasspea–Gimakolmi -T. *aman* cropping at pattern Kalkini upazila, Madaripur.

❖ **Location: Kalkini upazila, Madaripur**

The initial farmer's field soil results in Kalkini upazila showed that organic matter from 1.74%, pH 8.19, Total N (0.09%), calcium (21.06 meq 100 g^{-1}), magnesium (3.83 meq 100 g^{-1}), potassium (0.35 meq 100 g^{-1}), phosphorus (12 µg g^{-1}), iron (88 µg g^{-1}), zinc (0.92 µg g^{-1}), and boron (0.61 µg g^{-1}). Besides, initial soil microbial properties of experimental plots results showed that *Rhizobium* from ($2.3x10^4$ $cfug^{-1}$soil), PSB from ($2.7x10^3$ $cfug^{-1}$soil) and *Azotobacter* from ($2.3x10^5$ $cfug^{-1}$soil) in Kalkini upazilla, Madaripur.

Table 50. Initial soil physical, chemical and microbial population of Kalkini upazila, Madaripur.

Initial chemical data of soil in the experimental plots											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Kalkini	8.19	1.74	21.06	3.83	0.35	0.093	12	27	0.61	88	0.92
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfug^{-1}soil		
Kalkini upazilla	13	26	58	16	2.3x10^4	2.7x10^3	2.3x10^5

❖ **1st Crop Grasspea**

Pod plant^{-1}, seed pod^{-1}, 100 seed wt, stover yield and seed yield of Khesari varieties were tried with recommended fertilizer dose (RFD) from inorganic source as per soil test basis (STB), RFD on STB + 5 t ha^{-1} cowdung (IPNS approach) and farmers' practice, being presented in Table 51. Yield of grasspea varieties (BARI Khesari-3, BARI Khesari-5 and Khesari (Local) under trial RFD plots were 1.54, 1.65, 1.43 t ha^{-1}, and trial IPNS plots were 1.61, 1.74 and 1.54 t ha^{-1}, and yield of farmers' practice were 1.38, 1.57 and 1.29 tha^{-1}, respectively at Kalkini upazila during 2019-2021.

Table 51. Performance of grasspea varieties under integrated nutrient management system at Kalkini upazila, Madaripur 2019-21.

Treatment combination		Crop characteristics and yield				
Variety	Fertilizer dose	Pod plant^{-1}	Seed pod^{-1}	100 seed wt. (g)	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})
BARI Khesari-5	F1	24.90b	7.37de	4.88b	3.85ab	1.54ab
	F2	29.87a	9.00c	5.02a	3.97a	1.61ab
	F3	24.20c	6.67e	3.89c	3.51d	1.38ab
BARI Khesari-3	F1	21.30f	10.70ab	3.52e	3.57cd	1.65ab
	F2	23.40d	11.43a	3.61d	3.08f	1.74a
	F3	23.10d	10.27b	3.62d	3.44de	1.57ab
Khesari (Local)	F1	21.17f	7.97d	3.14f	3.75bc	1.43ab
	F2	22.30e	8.33cd	3.13f	3.89ab	1.54ab
	F3	19.17g	7.74d	3.09f	3.26ef	1.29b
CV(%)		1.26	6.62	1.22	3.29	16.04

* F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices.

2nd Crop Gimakolmi

Yield of different gimakolmi varieties under trial plots (RFD, IPNS, and farmers' practice) were presented in Table 52. Leaf yield of gimakolmi varieties (BARI gimakolmi-1, Sabuj pata (Local) and Goldern seed (Local) under trial RFD plots were 66.33, 55.00, 52.33 tha^{-1}, and trial IPNS plots were 68.33, 53.00, 55.34 tha^{-1}, and leaf yield of farmers' practice were 60.67, 51.67 and 49.00 tha^{-1}, respectively at Kalkini upazila during 2019-2021.

Table 52. Performance of gimakolmi varieties under integrated nutrient management system at Kalkini upazila 2019-21.

Treatment combination		Crop characteristics and yield		
Variety	Fertilizer dose	plant height (cm)	Leaf stem^{-1}	Biomass (t ha^{-1})
BARI Gimakolmi-1	F1	24.33ab	11.80b	66.33ab
	F2	24.45ab	12.33ab	68.33a
	F3	19.33cd	9.67d	60.67bc
Sabujpata (Local-1)	F1	26.34ab	10.67c	55.00cd
	F2	28.01a	10.33cd	53.00d
	F3	24.67ab	8.67e	51.67d
Golden seed (Local-2)	F1	23.33bc	12.0ab	52.33d
	F2	23.67abc	12.66a	55.34cd
	F3	18.01d	9.67d	49.00d
CV (%)		11.15	3.84	6.73

3rd Crop T. *aman*

Yield performance of different T. *aman* rice varieties under trial plots (RFD, IPNS and farmers' practice) were presented in Table 53. Yield of tested T. *aman* varieties (BRRI dhan57, BRRI dhan71 and BRRI dhan75) under RFD plots were 3.77, 5.48, 4.95 tha^{-1}, and trial IPNS plots were 4.02, 5.59 and 5.32 tha^{-1}, and yield of farmers' practice were 3.35, 5.23 and 4.38 tha^{-1}, respectively at Kalkini upazila during 2019-21.

Table 53. Performance of T. *aman* varieties under integrated nutrient management system at Kalkini upazila 2019-21.

Treatment combination		Crop characteristics and yield					
Variety	Fertilizer dose	Plant height (cm)	Panicle m^{-2}	Grain panicle^{-1} (no)	1000 grain wt. (g)	Straw yield (t ha^{-1})	Grain yield(tha^{-1})
BRRI dhan 57	F1	117de	314.01de	23.23b	22.33c	5.11d	3.77e
	F2	127ab	312.66e	29.60a	29.66a	5.80a-c	4.02e
	F3	114ef	317.70bc	21.51c	20.33cd	5.26cd	3.35f
BRRI dhan 71	F1	119cd	315.71cd	19.67d	20.01d	5.53b-d	5.48ab
	F2	125b	318.33b	20.70cd	27.01b	5.90ab	5.59a
	F3	113f	322.01a	17.33e	17.01e	5.53b-d	5.23bc
BRRI dhan 75	F1	121c	288.01g	21.70bc	20.31cd	6.04ab	4.95c
	F2	128a	290.33g	29.07a	28.33ab	6.19a	5.32ab
	F3	116de	300.01f	20.71cd	17.67e	6.07ab	4.38d
CV(%)		1.32	0.44	3.80	5.28	6.22	4.17

Total rice (system) yield:

Average yield, rice equivalent yield and total rice (system) yield as influenced by different treatments has been presented in Table 54. The highest total rice (system) yield of 21.95 t $ha^{-1}yr^{-1}$ was obtained from treatment combination (BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan57 with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach) and lowest total rice (system) yield of 17.54 t $ha^{-1}yr^{-1}$ was obtained from treatment combination of Khesari (Local), Golden seed (Local-2), BRRI dhan75 with farmer' practices.

Table 54. Average yield, rice equivalent yield and total rice (system) yield of Grasspea-Gimakolmi-T. *aman* at Kalkini upazila, Madaripur.

Treatment combination	Average yield of crops in the pattern (tha^{-1})			Rice equivalent yield of the pattern (tha^{-1})		Total rice (system) yield ($t\ ha^{-1}\ yr^{-1}$)
	Grasspea	Gimakolmi	T. *aman*	Grasspea	Gimakolmi	
V1F1	1.54ab	66.33ab	3.77e	3.53	13.82	21.12
V1F2	1.61ab	68.33a	4.02e	3.69	14.24	21.95
V1F3	1.38ab	60.67bc	3.35f	3.16	12.64	19.15
V2F1	1.65ab	55.00cd	5.48ab	3.78	11.46	20.72
V2F2	1.74a	53.00d	5.59a	3.99	11.04	20.62
V2F3	1.57ab	51.67d	5.23bc	3.6	10.76	19.59
V3F1	1.43ab	52.33d	4.95c	3.28	10.9	19.13
V3F2	1.54ab	55.34cd	5.32ab	3.53	11.53	20.38
V3F3	1.29b	49.00d	4.38d	2.96	10.21	17.54

❖ V1= BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan 57; V2= BARI Khesari-3, Sabujpata (Local-1), BRRI dhan 71; V3= Khesari (Local), Golden seed (Local-2), BRRI dhan 75; F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach);F_3 = Farmers practices

Total variable cost, gross return, gross margin and MBCR analysis

The benefit cost analysis of Grasspea-Gimakolmi-T. *aman* cropping pattern, highest gross return and gross margin of 5,26,680 and 3,07,363 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination (BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan57 with RFD on STB + 5 t ha^{-1} cowdung; IPNS approach) and the lowest gross return and gross margin of 4,21,070 and 2,03,755 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination of Khesari (Local), Golden seed (Local-2), BRRI dhan75 with farmer' practices. The highest marginal benefit cost ratio of 2.53 was found from treatment combination RFD on STB + 5 t ha^{-1} cowdung; IPNS approach with varieties BARI Khesari-3, Sabujpata (Local-1), BRRI dhan71 at Kalkini upazila, Madaripur.

Table 55. Gross return, total variable cost, gross margin and MBCR of Grasspea- Gimakolmi-T. *aman* at Kalkini upazila, Madaripur.

Treatment combination	Gross return (Tk ha^{-1} yr^{-1})	Total variable cost (Tk ha^{-1} yr^{-1})	Gross margin (Tk ha^{-1} yr^{-1})	MBCR
V1F1	506830	257351	249479	1.97
V1F2	526680	219317	307363	2.4
V1F3	459650	276614	183036	1.66
V2F1	497270	219941	277329	2.26
V2F2	494860	195345	299515	2.53
V2F3	470220	257354	212866	1.83
V3F1	459100	209921	249179	2.19
V3F2	489080	206224	282856	2.37
V3F3	421070	217315	203755	1.94

Note: Price: Khesari = 55 Tk/kg^{-1}, Gimakolmi-1 = 5Tk/kg, Rice = 30 Tk kg^{-1}, Urea = 16 Tk kg^{-1}, TSP = 25 Tk kg^{-1} , MoP = 15 Tk kg^{-1} , Gypsum = 12 Tk kg^{-1}, Zinc sulphate = 200 Tk kg^{-1}, Boric acid: 220 Tk kg^{-1}, Labour = Tk. 500 day^{-1}, Land preparation for all crops 3 times ploughing and laddering = Tk 1000 $bigha^{-1}$, Irrigation for T. *aman* = Tk. 800 $bigha^{-1}$; V1: BARI Khesari-5, BARI Gimakolmi-1, BRRI dhan 57; V2: BARI Khesari-3, Sabujpata (Local-1), BRRI dhan 71 ; V3: Khesari (Local), Golden seed (Local-2), BRRI dhan 75; F_1: Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2: RFD on STB + 5 t ha^{-1} cowdung (IPNS approach); F_3: Farmers practices

Soil fertility status

Nutrient uptake by grain and straw of all crops of the cropping pattern were influenced by different fertilizer treatments. The initial soil as well as in soil after completion of Grasspea-Gimakolmi-T. *aman* cropping cycle, the average soil fertility status were no appreciable change or mostly unchanged. The organic matter content of the soil increased due to biomass addition of the leguminous crops. Somewhere it was changed positively. As phosphorus and potassium showed negative balance, more phosphorus and potassium is to be added to improve soil fertility status and may be sustained in the study area of AEZ-12.

Table 56. Post soil physical, chemical and microbial population of Kalkini upazila, Madaripur.

Chemical data of the experimental plots (Post soil, Kalkini upazila, Madaripur)											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				μg g^{-1}				
Kalkini	8.11	1.71	22.77	3.89	0.21	0.088	10	11	0.37	95.55	0.78
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfug^{-1}soil		
Kalkini upazila	12	27	65	16	5x10^{3}	3.5x10^{5}	3.5x10^{5}

Fig 15: Effect of test grasspea, gimakolmi, T. *aman* varieties with integrated nutrient management system in Grasspea-Gimakolmi-T. *aman* cropping cycle at Kalkini upazila

Activity-6:

Varietal intensification and integrated plant nutrition systems on Sweet gourd–Sesame-T. *aman* cropping pattern at Bagerhat sadar upazila, Bagerhat.

❖ **Sweet Gourd – Sesame - T. *aman* cropping pattern**

The initial farmer's field soil results in sadar upazila Bagerhat showed that organic matter from 1.58%, pH 7.19, Total N (0.09%), calcium (21.06 meq 100 g^{-1}), magnesium (2.02 meq 100 g^{-1}), potassium (0.09 meq 100 g^{-1}), phosphorus (33 µg g^{-1}), iron (93.35 µg g^{-1}), zinc (0.87 µg g^{-1}), and boron (0.45 µg g^{-1}). Besides, initial soil microbial properties of experimental plots results showed that *Rhizobium* from (3.1x10^{5} cfug^{-1}soil), PSB from (4.6x10^{5} cfug^{-1}soil) and *Azotobacter* from (3.9x 10^{4} cfug^{-1}soil) in sadar upazila Bagerhat.

Table 57. Initial soil physical, chemical and microbial population of sadar upazila Bagerhat.

Chemical data of soil in the experimental plots (initial, sadar upazila Bagerhat.)											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				μg g^{-1}				
Bagerhat sadar	7.91	1.58	21.06	2.02	0.099	0.09	33	13	0.45	93.35	0.87
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of soil in the experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfug^{-1}soil		
Bagerhat sadar	4	57	39	14	$3.1x10^5$	$4.6x10^5$	$3.9x10^4$

❖ 1st Crop Sweet Gourd:

Sweet Gourd (*Cucurbita maxima)* has a thick, orange or yellow shell, creased from the stem to the bottom, containing the seeds and pulp. It has a very versatile use for cooking. Among varied vegetables, sweet gourd is appreciated by consumers because of its fruits, tender stems, leaves and even flowers used as vegetables both at green and ripen stages. It is relatively a richer source of energy, carbohydrates and vitamins, especially that of high carotinoid contents and minerals. This crop is therefore thought to have potentiality to solve malnutrition problem of mass people of Bangladesh to certain extent particularly vulnerable groups in respect of vitamin-A requirement. Production of sweet gourd in Bangladesh is increasing day by day.

Table 58. Performance of sweet gourd varieties under integrated nutrient management system at sadar upazila of Bagerhat 2019-21.

Treatment combination		Crop characteristics and yield				
Variety	Fertilizer dose	Plant height (cm)	Fruit/ vine	Fruit/ plant	Fruit wt. (kg)	yield (tha^{-1})
BMK-2	F1	403.33c	4.10ab	4.17cd	3.70ab	27.35de
	F2	423.67ab	3.97a-d	4.88a	3.67ab	30.66cd
	F3	391.67d	3.72d	3.88d	3.10cd	25.05e
BHMK-2	F1	423.33ab	3.71d	4.45bc	3.63ab	39.53ab
	F2	428.34a	4.02a-c	4.93a	3.77ab	42.13a
	F3	394.33cd	3.27e	3.88d	2.99d	34.47bc
BHMK-3	F1	413.67b	3.87b-d	3.90d	3.42bc	39.85ab
	F2	425.67a	4.18a	4.20cd	3.94a	40.02a
	F3	398cd	3.75cd	4.66ab	2.95d	34.83bc
CV(%)		1.41	4.49	4.14	6.07	8.94

* BMK = BARI Mistikumra; BHMK = BARI Hybrid Mistikumra, * F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices.

Commercial farming of sweet gourd is popularizing throughout the country. Both the production area and production is increasing frequently throughout the recent years (BBS, 2013). Plant height, Fruit vine^{-1}, Fruit plant^{-1}, Fruit wt and yield of sweet gourd varieties were tried with RFD, IPNS and farmers' practice, being presented in Table 58. Yield of sweet gourd varieties (BARI Mistikumra-2, BARI Hybrid Mistikumra-2, BARI Hybrid Mistikumra-3) under trial RFD plots were 27.35, 39.53 and 40.03 tha^{-1}, and trial IPNS plots were 30.66, 42.13 and 40.02 tha^{-1}, and yield of farmers' practice were 25.05, 34.47 and 34.83 tha^{-1}, respectively in Bagerhat sadar upazila during 2019-2021.

2nd Crop Sesame:

Sesame (*Sesamum indicum* L.) is one of the important oil crops with drought tolerant crops in Bangladesh. It's extremely susceptible to water logging. It is mainly grown in Kharif-1 season which is the dry-wet transition period due to start of monsoon rain. Sometimes create water logged due to heavy monsoon rainfall. Sesame crops damaged due to heavy rainfall. Pod plant^{-1}, seed pod^{-1}, 100 seed wt, straw yield and seed yield of sesame varieties under trial plots (RFD, IPNS and farmers' practice) were presented in Table 59. Yield of sesame varieties (BARI Til 4, BARI Til 3 and BINA Til 4) under trial RFD plots were 1.30, 1.41, 1.39 tha^{-1}, and trial IPNS plots were 1.38, 1.41 and 1.45 tha^{-1} and yield of farmers' practice were 1.08, 1.12 and 1.11, respectively in Bagerhat sadar upazila during 2019-2021.

Table 59. Performance of sesame varieties under integrated nutrient management system at sadar upazila of Bagerhat 2019-2021.

Treatment combination		Crop characteristics and yield				
Variety	Fertilizer dose	Pod plant^{-1}	Seed pod^{-1}	100 seed wt. (g)	Straw Yield (t ha^{-1})	Seed yield (tha^{-1})
BARI Til 4	F1	21.33b-d	24.0c	3.04ab	2.68ab	1.30a
	F2	24.67ab	29.33ab	3.09ab	2.84a	1.38a
	F3	18.11d	24.67bc	2.78c	2.21b	1.08b
BARI Til 3	F1	27.67a	31.67a	2.94b	2.82a	1.41a
	F2	27.33a	33.0a	3.10ab	2.84a	1.41a
	F3	20.67b-d	23.67c	2.78c	2.69ab	1.12b
BINA Til 4	F1	24.0a-c	24.0c	2.97b	2.90a	1.39a
	F2	24.67ab	28.67a-c	3.16a	2.84a	1.45a
	F3	18.33cd	24.0c	2.72c	2.73ab	1.11b
CV (%)		10.11	7.16	3.08	11.60	7.75

3rd Crop T. *aman*:

T. *aman* (*Oryza sativa* L.) is an important cereal crop and is generally grown in Kharif-2 season in Bangladesh. Plant height, panicle m^{-2}, grain $panicle^{-1}$, 1000 grain wt, straw yield and grain yield of T. *aman* varieties under trial plots (RFD, IPNS and farmers' practice) were presented in Table 60. Yield of T. *aman* varieties (BRRI dhan57, BRRI dhan71 and BRRI dhan75) under trial RFD plots were 4.57, 5.35, 4.72 tha^{-1} and trial IPNS plots were 4. 82, 5.59, and 4.83 tha^{-1} and yield of farmers' practice were 4.36, 4.95 and 3.66 tha^{-1}, respectively in Bagerhat sadar upazila during 2019-2021.

Table 60. Performance of T. *aman* varieties under integrated nutrient management system at sadar upazila of Bagerhat 2019-2021.

Treatment combination		Crop characteristics and yield				
Variety	Fertilizer dose	Plant height	Panicle m^{-2}	1000 grain wt. (g)	Straw yield (t ha^{-1})	Grain yield (tha^{-1})
BRRI dhan 57	F1	123.30bc	161.01b	18.01d	6.13c	4.57a-c
	F2	136.10b	168.00ab	19.02c	6.68a	4.82a-c
	F3	110.33d	152.30c	17.87d	5.94d	4.36bc
BRRI dhan 71	F1	129.33bc	154.01c	20.08b	6.28b	5.35ab
	F2	139.43b	159.60bc	21.07a	6.67a	5.59a
	F3	115.34c	148.60c	19.02c	5.98d	4.95ab
BRRI dhan 75	F1	134.30b	177.61a	19.96b	5.96d	4.72a-c
	F2	145.34a	179.31a	20.21b	6.10c	4.83a-c
	F3	125.01d	163.40b	18.04d	5.80e	3.66c
CV(%)		2.87	1.09	1.79	1.03	14.69

Total Rice (system) yield:

Average yield, rice equivalent yield and total rice (system) yield as influenced by different treatments has been presented in Table 61. The highest total rice (system) yield of 26.08 t ha^{-1} yr^{-1} was obtained from treatment combination (BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach) and lowest total rice (system) yield of 17.05 t $ha^{-1}yr^{-1}$ was obtained from treatment combination of BMK = BARI Mistikumra-2, BARI Til-4, BRRI dhan57 with farmer' practices.

Table 61. Average yield, rice equivalent yield and total rice (system) yield (t $ha^{-1}yr^{-1}$) of Sweet gourd-Sesame-T. *aman* at sadar upazila of Bagerhat 2019-2021.

Treatment combination	Average yield of crops in the pattern (tha^{-1})			Rice equivalent yield of the pattern (tha^{-1})		Total rice (system) yield (t $ha^{-1}yr^{-1}$)
	Sweet gourd	Sesame	T. *aman*	Sweet gourd	Sesame	
V1F1	27.35de	1.30a	4.57a-c	11.4	2.71	18.67
V1F2	30.66cd	1.38a	4.82a-c	12.78	2.88	20.47
V1F3	25.05e	1.08b	4.36bc	10.44	2.25	17.05
V2F1	39.53ab	1.41a	5.35ab	16.47	2.94	24.76
V2F2	42.13a	1.41a	5.59a	17.55	2.94	26.08
V2F3	34.47bc	1.12b	4.95ab	14.36	2.33	21.65
V3F1	39.85ab	1.39a	4.72a-c	16.6	2.9	24.22
V3F2	40.02a	1.45a	4.83a-c	16.68	3.02	24.53
V3F3	34.83bc	1.11b	3.66c	14.51	2.31	20.49

❖ V1= BMK = BARI Mistikumra-2, BARI Til-4, BRRI dhan57; V2= BHMK = BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71; V3= BHMK = BARI Hybrid Mistikumra-3, BINA Til-4, BRRI dhan75; F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices

Total variable cost, gross return, gross margin and MBCR analysis

The benefit cost analysis of Sweet gourd-Sesame-T. *aman* cropping pattern, highest gross return and gross margin of 6,25,960 and 3,82,306 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination (BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach) and the lowest gross return and gross margin of 4,09,140 and 1,71,586 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination of BARI Mistikumra-2, BARI Til-4, BRRI dhan57 with farmer' practices. The highest marginal benefit cost ratio of 2.57 was found from treatment combination RFD on STB + 5 t ha^{-1} cowdung; IPNS approach with varieties BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 at Bagerhat sadar upazila, Bagerhat.

Table 62. Gross return, total variable cost, gross margin and MBCR of Sweet gourd-Sesame-T. *aman* pattern at sadar upazila of Bagerhat 2019-2021.

Treatment combination	Gross return (Tk ha^{-1} yr^{-1})	Total variable cost (Tk ha^{-1} yr^{-1})	Gross margin (Tk ha^{-1} yr^{-1})	MBCR
V1F1	448180	251551	196629	1.78
V1F2	491280	233543	257737	2.1
V1F3	409140	237554	171586	1.72
V2F1	594200	238554	355646	2.49
V2F2	625960	243654	382306	2.57
V2F3	519500	264645	254855	1.96
V3F1	581280	248554	332726	2.34
V3F2	588620	241827	346793	2.43
V3F3	491640	271914	219726	1.81

Note: Price: Sweet gourd=10 Tk/kg, Sesame = 50Tk/kg, Rice = 30 Tk kg^{-1}, Urea = 16 Tk kg^{-1}, TSP = 25 Tk kg^{-1} , MoP = 15 Tk kg^{-1} , Gypsum = 12 Tk kg^{-1}, Zinc sulphate = 200 Tk kg^{-1}, Boric acid: 220 Tk kg^{-1}, Labour = Tk. 500 day^{-1}, Land preparation for all crops 3 times ploughing and laddering = Tk 1000 $bigha^{-1}$, Irrigation for T. *aman* = Tk. 800 ha^{-1}; V1: BARI Mistikumra-2, BARI Til-4, BRRI dhan57; V2: BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71; V3: BARI Hybrid Mistikumra-3, BINA Til-4, BRRI dhan75; F_1: Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2: RFD on STB + 5 t ha^{-1} cowdung (IPNS approach); F_3: Farmers practices

Soil fertility status

Nutrient uptake by grain and straw of all crops of the cropping pattern were influenced by different fertilizer treatments. The initial soil as well as in soil after completion of Sweet gourd-Sesame-T. *aman* cropping cycle, the average soil fertility status were mostly unchanged. Somewhere it was changed positively

Table 63. Post soil physical, chemical and microbial population of sadar upazila Bagerhat.

Chemical data of the experimental plots (Post, sadar upazilla Bagerhat)											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Bagerhat sadar	8.11	1.71	22.77	3.89	0.21	0.088	10	11	0.37	95.55	0.78
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfug^{-1}soil		
Bagerhat sadar	4	58	38	15	$5x10^3$	$4.5x10^5$	$4.5x10^5$

Fig 16: Effect of test sweet gourd, sesame, T. *aman* varieties with integrated nutrient management system in Sweet gourd-Sesame-T. *aman* cropping cycle at sadar upazila Bagerhat

Activity-7:

Varietal intensification and integrated plant nutrition systems on Sweet gourd–Sesame-T. *aman* cropping pattern at Mollarhat upzila, Bagerhat.

➢ **Sweet gourd–Sesame-T. *aman* pattern at Mollarhat upzila, Bagerhat**

The initial farmer's field soil results in Mollarhat upzila showed that organic matter from 1.49%, pH 8.21, Total N (0.08%), calcium (11.12 meq 100 g^{-1}), magnesium (1.94 meq 100 g^{-1}), potassium (0.16 meq 100 g^{-1}), phosphorus (14 µg g^{-1}), iron (97.21 µg g^{-1}), zinc (85 µg g^{-1}), and boron (0.48 µg g^{-1}). Besides, initial soil microbial properties of experimental plots results showed that *Rhizobium* from ($2.8x10^4$ $cfug^{-1}$soil), PSB from ($3.2x10^4$ $cfug^{-1}$soil) and *Azotobacter* from ($4.6x\ 10^5$ $cfug^{-1}$soil) in Mollarhat upzila, Bagerhat.

Table 64. Initial soil physical, chemical and microbial population of Mollarhat upazila Bagerhat.

Initial chemical data of soil in the experimental plots											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				µg g^{-1}				
Mollarhat	8.21	1.49	11.12	1.94	0.16	0.08	14	14	0.48	97.21	85
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of soil in the experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				$cfug^{-1}soil$		
Mollarhat	8	61	31	16	$2.8x10^4$	$3.2x10^4$	$4.6x10^5$

❖ **1st Crop Sweet Gourd:**

Plant height, Fruit $vine^{-1}$, Fruit $plant^{-1}$, Fruit wt and yield of sweet gourd varieties were tried with RFD, IPNS and farmers' practice, being presented in Table 65. Yield of sweet gourd varieties (BARI Mistikumra-2, BARI Hybrid Mistikumra-2, BARI Hybrid Mistikumra-3) under trial RFD plots were 23.22, 35.78 and 37.62 tha^{-1}, and trial IPNS plots were 26.08, 38.65 and 39.02 tha^{-1}, and yield of farmers' practice were 19.57, 32.74 and 33.49 tha^{-1}, respectively in Mollarhat upazila during 2019-2021.

Table 65. Performance of sweet gourd varieties under integrated nutrient management system at Mollarhat upazila, Bagerhat 2019-2021.

Treatment combination		Crop characteristics and yield				
Variety	Fertilizer dose	Plant height (cm)	Fruit $vine^{-1}$	Fruit $plant^{-1}$	Fruit wt. (kg)	yield (tha^{-1})
BMK-2	F1	323.33e	4.09a	3.90cd	2.83bc	23.22d
	F2	383.40b	3.97a-c	4.19bc	2.93b	26.08d
	F3	306.67f	3.72bc	4.66a	2.55d	19.57e
BHMK-2	F1	365.0c	3.71bc	4.29b	3.63a	35.78bc
	F2	375.0bc	4.02ab	4.93a	3.77a	38.65ab
	F3	347.33d	3.85a-c	3.77d	2.99b	32.74c
BHMK-3	F1	400.67a	3.99ab	4.17bc	2.92b	37.62ab
	F2	411.67a	4.04a	4.88a	2.96b	39.02a
	F3	350.0d	3.67c	3.88cd	2.64cd	33.49c
CV(%)		2.29	4.63	4.17	4.18	5.88

* BMK = BARI Mistikumra; BHMK = BARI Hybrid Mistikumra, F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices.

2nd Crop Sesame:

Pod $plant^{-1}$, seed pod^{-1}, 100 seed wt, straw yield and seed yield of sesame varieties under trial plots (RFD, IPNS and farmers' practice) were presented in Table 66. Yield of sesame varieties (BARI Til 4, BARI Til 3 and BINA Til 4) under trial RFD plots were 1.27, 1.43, 1.28 tha^{-1}, and trial IPNS plots were 1.43, 1.54 and 1.28 tha^{-1} and yield of farmers' practice were 0.99, 1.07 and 1.01, respectively in Mollarhat upazila during 2019-2021.

Table 66. Performance of sesame varieties under integrated nutrient management system at Mollarhat upazila, Bagerhat 2019-2021.

Treatment combination		Crop characteristics and yield				
Variety	Fertilizer dose	Pod plant^{-1}	Seed pod^{-1}	100 seed wt. (g)	Straw Yield (t ha^{-1})	Seed yield (tha^{-1})
BARI Til 4	F1	29.0ab	17.37de	4.88b	2.57ab	1.27b
	F2	30.67ab	19c	5.02a	2.69a	1.43ab
	F3	24.33b	14.66e	3.89c	2.21b	0.99c
BARI Til 3	F1	27.67a	20.7ab	3.52e	2.82a	1.43ab
	F2	30.0a	21.43a	3.61d	2.88a	1.54a
	F3	25.0b	18.27b	3.62d	2.62ab	1.07c
BINA Til 4	F1	26.33b	17.97d	3.14f	2.91a	1.28b
	F2	29.67ab	18.33cd	3.13f	3.04a	1.34b
	F3	24.0b	14.74d	3.09f	2.56ab	1.01c
CV (%)		11.68	6.91	3.04	10.41	7.72

3rd Crop T. *aman*:

Plant height, panicle m^{-2}, grain panicle^{-1}, 1000 grain wt, straw yield and grain yield of T. *aman* varieties under trial plots (RFD, IPNS and farmers' practice) were presented in Table 67. Yield of T. *aman* varieties (BRRI dhan57, BRRI dhan71 and BRRI dhan75) under trial RFD plots were 4.40, 5.47, 4.72 tha^{-1} and trial IPNS plots were 4.63, 5.56, and 4.96 tha^{-1} and yield of farmers' practice were 3.85, 4.69 and 4.33 tha^{-1}, respectively in Mollarhat upazila during 2019-2021.

Table 67. Performance of T. *aman* varieties under integrated nutrient management system at Mollarhat upazila, Bagerhat 2019-2021.

Treatment combination		Mollarhat upazila, Bagerhat				
Variety	Fertilizer dose	Plant height	Panicle m^{-2}	1000 grain wt. (g)	Straw yield (t ha^{-1})	Grain yield (tha^{-1})
BRRI dhan 57	F1	120.3c	251d	21.68c	5.49def	4.40bc
	F2	126c	266.3c	27.67a	5.99a-d	4.63a-c
	F3	118c	319.7a	19.33d	5.03f	3.85c
BRRI dhan 71	F1	124.3c	233.3h	21.67c	5.67b-e	5.47ab
	F2	138b	245.4f	28.0a	6.20ab	5.56a
	F3	127.6ab	280.3b	20.34d	5.29ef	4.69a-c
BRRI dhan 75	F1	136.3a	248e	20.33d	6.06a-c	4.72a-c
	F2	141.3a	240.3g	25.67b	6.23a	4.96a-c
	F3	133.7b	280.7b	20.33d	5.59c-f	4.33bc
CV(%)		1.74	1.31	2.93	5.64	13.97

* F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1} cowdung (IPNS approach); F_3 = Farmers practices

Total rice (system) yield:

Average yield, rice equivalent yield and total rice (system) yield as influenced by different treatments has been presented in Table 68. The highest total rice (system) yield of 24.87 t ha^{-1} yr^{-1} was obtained from treatment combination (BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 with RFD on STB + 5 t ha^{-1} cowdung; IPNS approach) and lowest total rice (system) yield of 14.07 t $ha^{-1}yr^{-1}$ was obtained from treatment combination of BMK = BARI Mistikumra-2, BARI Til-4, BRRI dhan57 with farmer' practices.

Table 68. Average yield, rice equivalent yield and total rice (system) yield of Sweet gourd-Sesame-T. *aman* at Mollarhat upazila, Bagerhat.

Treatment combination	Average yield of crops in the pattern (tha^{-1})			Rice equivalent yield of the pattern (tha^{-1})		Total rice (system) yield (t ha^{-1} yr^{-1})
	Sweet gourd	Sesame	T. aman	Sweet gourd	Sesame	
V1F1	23.22d	1.27b	4.40bc	9.66	2.65	16.72
V1F2	26.08d	1.43ab	4.63abc	10.87	2.98	18.48
V1F3	19.57e	0.99c	3.85c	8.154	2.06	14.07
V2F1	35.78bc	1.43ab	5.47ab	14.91	2.98	23.36
V2F2	38.65ab	1.54a	5.56a	16.11	3.21	24.87
V2F3	32.74c	1.07c	4.69abc	13.64	2.23	20.56
V3F1	37.62ab	1.28b	4.72abc	15.68	2.67	23.06
V3F2	39.02a	1.34b	4.96abc	16.26	2.79	24.01
V3F3	33.49c	1.01c	4.33bc	13.95	2.11	20.39

❖ V1= BMK = BARI Mistikumra-2, BARI Til-4, BRRI dhan57; V2= BHMK = BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71; V3= BHMK = BARI Hybrid Mistikumra-3, BINA Til-4, BRRI dhan75; F_1 = Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2 = RFD on STB + 5 t ha^{-1}cowdung (IPNS approach); F_3 = Farmers practices

Total variable cost, gross return, gross margin and MBCR analysis

The benefit cost analysis of Sweet gourd-Sesame-T. *aman* cropping pattern, highest gross return and gross margin of 5,96,940 and 3,61,536 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination (BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 with RFD on STB + 5 t ha^{-1}cowdung; IPNS approach) and the lowest gross return and gross margin of 3,37,600 and 98,296 (Tk $ha^{-1}yr^{-1}$) were obtained from treatment combination of BARI Mistikumra-2, BARI Til-4, BRRI dhan57 with farmer' practices. The highest marginal benefit cost ratio of 2.54 was found from treatment combination RFD on STB + 5 t ha^{-1} cowdung; IPNS approach with varieties BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71 at Mollarhat upazila, Bagerhat.

Table 69. Gross return, total variable cost, gross margin and MBCR of Sweet gourd-Sesame-T. *aman* pattern at at Mollarhat upazila, Bagerhat 2019-2021.

Treatment combination	Gross return (Tk ha^{-1} yr^{-1})	Total variable cost (Tk ha^{-1} yr^{-1})	Gross margin (Tk ha^{-1} yr^{-1})	MBCR
V1F1	401300	243301	157999	1.65
V1F2	443420	225293	218127	1.97
V1F3	337600	239304	98296	1.41
V2F1	560580	230304	330276	2.43
V2F2	596940	235404	361536	2.54
V2F3	493460	256395	237065	1.92
V3F1	553480	240304	313176	2.3
V3F2	576240	233577	342663	2.47
V3F3	489320	253664	235656	1.93

Note: Price: Sweet gourd=10 Tk/kg, Sesame = 50Tk/kg, Rice = 30 Tk kg^{-1}, Urea = 16 Tk kg^{-1}, TSP = 25 Tk kg^{-1} , MoP = 15 Tk kg^{-1} , Gypsum = 12 Tk kg^{-1}, Zinc sulphate = 200 Tk kg^{-1}, Boric acid: 220 Tk kg^{-1}, Labour = Tk. 500 day^{-1}, Land preparation for all crops 3 times ploughing and laddering = Tk 1000 $bigha^{-1}$, Irrigation for T. *aman* = Tk. 800 ha^{-1}; V1: BARI Mistikumra-2, BARI Til-4, BRRI dhan57; V2: BARI Hybrid Mistikumra-2, BARI Til-3, BRRI dhan71; V3: BARI Hybrid Mistikumra-3, BINA Til-4, BRRI dhan75; F_1: Recommended Fertilizer Dose (RFD) from inorganic source as per STB; F_2: RFD on STB + 5 t ha^{-1} cowdung (IPNS approach); F_3: Farmers practices

Soil fertility status

Nutrient uptake by grain and straw of all crops of the cropping pattern were influenced by different fertilizer treatments. The initial soil as well as in soil after completion of Sweet gourd-Sesame-T. *aman* cropping cycle, the average soil fertility status were no appreciable change.

Table 70. Post soil physical, chemical and microbial population of Mollarhat upazilla Bagerhat.

Chemical data of the experimental plots (Post, Mollarhat upazilla Bagerhat)											
Location	pH	OM %	Ca	Mg	K	Total N%	P	S	B	Fe	Zn
			meq 100 g^{-1}				μg g^{-1}				
Bagerhat sadar	8.11	1.71	22.77	3.89	0.21	0.088	10	11	0.37	95.55	0.78
Critical level	-	-	2	0.50	0.12	-	10	10	0.20	4.0	0.60

Physical and microbial status of experimental plots							
Location	Sand	Silt	Clay	Moisture	*Rhizobium*	PSB	*Azotobacter*
	%				cfug^{-1}soil		
Bagerhat sadar	8	62	37	16	5 x10^5	4.5x10^5	5 x10^5

.

Fig 17: Effect of test sweet gourd, sesame, T. *aman* varieties with integrated nutrient management system in Sweet gourd-Sesame-T. *aman* cropping cycle at Mollarhat upazilla Bagerhat

Component-3: Agarian Research Foundation

Results and discussions:

Activity-1

Baseline survey report on Constraints to Crop Intensification Growing Dry Season Cropping in Tidal Floodplain of Jhalokathi and Pirojpur Districts

Household size: Size of the household varies from 2 to 10. Average farm family size is 5.03. The household profile of the sample farmers is in consistent with the Agriculture Census Report of 2008 (BBS 2011). Earning members (i.e. the number of family members engaged in farming or any other profession) in an average household is 1.45. In other words, livelihood of farm families depends on the earnings of less than 30% of the total family members.

Farmer's experience in farming: Age of the respondent farmers varied from 28 to 69 years with an average age of 47 years. Young farmers (<40 years) constituted only 19% of total farming population suggesting that most farmers are of middle age to old age. It is conceivable that with expansion of schooling (education) facilities in rural areas youth are finding better employment opportunity outside the farms, and youth are no longer interested in farming. The

findings are in consistence with the results of Begum et al. (2019). Average farming experience of the respondents is about 27 years. This was expected since age of majority farmers exceeds 45 years in age.

Farmer's literacy: Over 80% of the respondent farmers are literate and only 19.4% farmers can not read or write. Of the total respondent farmers, 29% and 13% were S.S.C. and H.S.C. passed, respectively and none of the respondent farmers are graduate. Literacy rate in Rajapur and Kawkhali upazila seems higher than average literacy of the country (BBS, 2011).

Farmers' major occupation, annual income and income source:

Baseline survey also captured the information on the household source of income and livelihood strategy of farming communities. Survey included the farmers only. Interestingly, farming is the major occupation and source of livelihood of 68% of the respondents; while it was the secondary occupation of 19% of the respondents. None of the respondents engaged in fishing, wage labor, agriculture labor, or rickshaw pulling as major occupation. Poultry farming is the main income source of 6% farmers while business is the major occupation of 13% respondents.

Annual income of households: Farmers' annual income varies enormously among the households. In the present survey it varied from Tk. 50,000 to Tk. 532,000 giving an average of Tk.174,387. The highest contribution to total household income comes from fishery and livestock (Tk. 67097) pushing crop sector to second position (Tk. 53,694). However, a few farmers adopt livestock and fishery on commercial basis, but relatively much higher income accrued from this sub-sector makes the sectoral contribution distorted. Rice is the major crop contributing to the sub-sector and product being low, often lower than production cost contribution of crop sector is marginalized.

Farmer's land holdings: Every farmer interviewed owns land; but the size of land holding varies enormously. Land holding per house hold (HH) ranged between 0.54 acres and 32.00 acres with an average of 3.35 acres. All the farmer HHs own homestead areas varying from 0.025 acres to 2.00 acres. However, 35% of the HHs surveyed do not have agricultural land for crop growing. Farmers having no ownership of land either rent-in for crop growing or cultivate land on share cropping basis.

Livelihood strategy of small farmer having inadequate land: Based on land ownership, respondent farmers can be grouped into (i) tenant and (ii) non-tenant (land owner). Forty percent of the respondents are tenant farmers. Nineteen percent (19%) of the households have sufficient land area to support livelihood but 77% farmers reported that the land they own does not support their livelihood throughout the year. Households having not enough land to support livelihood

resort either to wage earner as labor, or share cropping or cultivate other farmers' or land owners' land on seasonal/annual basis. It was gathered that the percentages of such small land holders are 22% in wage earning, 22% as share cropper and 26% cultivating land owner's land either on seasonal or on annual basis.

Farmers' ownership of farm machinery, implements, farm animals:

Survey looked at the farmers' assets and income in order to make an assessment of their capability and efficiency in farming. Of 31 farm households, 2 farmers own tractors (one each), 1 farmer owns a thresher, and none of the farmers owns power tiller or reaper. Three STWs, one DTW and one LLP (low lift pump) are in operation on communal basis. In Jhalakati and Pirojpur districts farmers still use draft animals and country plows. Survey revealed that for land tillage 5 households own draft animals, plows, 3 HHs are having bullocks and 3 HHs have buffaloes. 23 HHs own khonta a traditional implement for earth work. 21 farm families' rear cows and it is reasonable to imagine that these cows are also used in tillage operation. For income generation, 15 HHs rear duck, 18 HHs rear chicken.

Crops and cropping

Survey revealed that in the preceding year (2019) 29% farmers planted dry season crops after harvesting transplanted aman rice. However, area planted to dry season crops was much low. Farmers grow varieties of dry season crops, albeit the area planted to dry season crops is much less compared with wet season crops. Transplanted aman is the major crop in southern coastal districts. 100% farmers grow T. Aman rice during wet season. Only 26% of farmers grow transplanted aus rice. Aman rice yields about 10% higher than aus rice. Despite higher production cost associated with boro rice compared with aman rice, getting lower yield of boro might be the reason that most farmers do not grow boro rice during dry season.

Khesari is commonly grown in the southern districts, although area planted to khesari registered a downtrend during recent years (Begum et al., 2019). Khesari yield of 206.37 kg/ha as reported by the farmers is too low to support production cost even. More farmers (55%) planted mungbean in their fields, but an average yield that the farmers reported (439.38 kg/ha) is also much low. Sweet potato and sweet gourd were planted by 6% and 3% farmers, respectively. Compared with other crops, productivity of sweet potato (30.348 t/ha) and sweet gourd (6.175 t/ha) was better. But the area planted to these two crops too small to make direct comparison with mungbean, khesari or boro rice.

Farmer's choice of major crops:

While 100% farmers grow transplanted aman in the wet season with 87% farmers taking Aman rice as major crop. 74% farmers grow both wet season and dry season crops. Only 10% farmers

take dry season crops as their major crops. Conducting an intensive survey Ibrahim et al. (2017) showed that single crop of transplanted aman rice is the most dominant cropping pattern in Barisal region covering 13.4% of net cropped area.

Cropping intensity estimate:

Farmer's average agricultural landholding is 3.348 acres of which 1.424 acres remain fallow in dry season but in the wet season the fallow area per household comes down to 0.185 acres. Taking the fallow areas of both the seasons together, it can be shown that the cropping intensity in Rajapur and Kawkhali upazila is 152%.

Problems in growing dry season crops: Farmers' experiences

The survey questionnaire focused on why the farmers are not growing crops during the dry season. Late harvesting of aman rice was pointed to main reason for not growing dry season crops. In the tidal floodplain, HYV aman rice is not planted due to inundation of land. During wet season farmers grow local varieties of aman rice (e.g., Lalmota, Sadamota, Moulata) grow tall can tolerate inundation (Ullah et al., 2016). In addition to planting of late maturing aman rice varieties, slow land drainage also impedes timely planting dry season crops. 35% of respondents are of opinion that dry season crops are not profitable while 19% respondents said that growing dry season crops in Rajapur and Kawkhali are very labor intensive. Analyzing historical data set on non-tidal river water level Gafur and Akbar (2019) showed that the slow relatively high water level in November and early December during recent years might have cause slow drainage in early dry season impeding timely planting of khesari. Weed infestation has been identified as a major problem in growing dry season crops in the tidal floodplain of Jhalakati and Pirojpur districts. Among the sample farmers 68% relay planted khesari during 2019-20 season (Table). 71% of respondents had weed infestation in their crops and 65% farmers practiced weeding of which 39% employed family labors and 6% deployed hired labors. Cyclone and tidal surge are two most damaging extreme climate events that the farmers southern coastal districts. Cyclones occurring October-November not only damages crops, properties and lives; but also delays planting of subsequent crops. Respondent farmers (84%) rank cyclone as No. 1 among the most damaging natural calamities. Over 77% farmers had their T. aman crop damaged by cyclones during the previous 3 years. Nearly 81% farmers' had their aman crop damaged to the extent 50% or more while 4% farmers' aman crop was totally damaged. In a land of no water scarcity drought is a regular phenomenon. To overcome drought stress, 36% farmers irrigate crops, mostly boro rice. Surface water is available for irrigating crops in the dry season. Deep tube wells (DTW) are not operational perhaps due to aquifer polluted with salinity. Low lift pump

(LLP) is used for irrigating crops on communal basis organizing farmers into groups. Irrigation to dry season crops through LLP was applied in 35% farmers' plots. The easiest and no-cost conventional practice of applying irrigation is allowing overbank flow into the fields when river/canal water level rises. 10% farmers applied irrigation overflowing riverbanks. 10% farmers resorted to conventional practice of irrigation.

Khesari and Mungbean – farmers' two preferred crops grow in dry season

68% of farmers in Rajapur (Jhalokathi) and Kawkhali (Pirojpur) planted khesari and mungbean in the previous dry season. It is apparent that many of the farmers growing khesari also planted mungbean; but the total area committed to these two crops per household is <1.00 acre suggesting that although a great majority of farmers grow khesari and mungbean but the area coverage with these two crops remains low and thus the cropping intensity in these two districts remains the lowest in the country. Farmers mentioned that excessive rain (54%) at or prior to khesari planting time caused delay in planting khesari. Many of the farmers opted not to plant khesari late in the season. Drought, weed control difficulties, and excessive labor engagement are also problems for growing mungbean.

Labor crisis

90% respondents reported that crop production suffers due to shortage of family labors. Survey focused on identification of the biophysical and socio-economic constraints to growing dry season crops in two southern districts. A full range of socio-economic survey was neither intended nor was possible because of budgetary limitation. The farmers we sampled and talked to are all male and female family members usually do not engage in field activities although farmer's female counter part more than equally participates in post-harvest processing. Shortage of farm labors and high wage rate thus can be the major limitation in crop intensification in Jhalokathi and Pirojpur districts. The project area (Rajapur and Kawkhali) represents truly agrarian communities in the tidal floodplain ecosystem of southern districts. Majority of the population are engaged in farming growing crops. Family size compares with national average; but annual income of the farmers is low. Majority farmers (77%) fail to earn livelihood through farming. Alternative livelihood strategy of the smallholders are (a) wage earning as labor, (c) farming as share croppers, (d) cultivating land of large or small farmers on seasonal/annual basis. Transplanted aman rice-fallow is the major cropping system. Tidal flooding in wet season presents problems in adopting HYV rice. Invariably all farmers grow rice planting indigenous varieties aman rice. A few farmers (29%) grow crops in dry season but area planted to dry season is too small. Cropping intensity is thus low (152%). Crop production technologies developed and adopted for rabi crops elsewhere may not be appropriate for tidal floodplain

ecosystem. Perspective of designing and developing technologies for dry season crops in this region should be different in view of differences in ecosystem and farmers' socio-economic conditions of Jhalakati and Pirojpur district.

Acitivity-2

Grasspea Trials in first year during 2019-20:

Dates of relay planting seeds and harvesting, and yields of grasspea are presented in Table 71. Earlier planted grasspea yielded better compared with yields of grasspea planted one week later. However, the overall yield of grasspea was low that ranged between 127 kg and 449 kg per ha across plots and between two planting dates. Overall mean grain yield was 294 kg per ha which is too low compared with national average of 1,194 kg/ha (BBS, 2020). Differences in seed yield due to variation in planting dates are shown in Figure 18. Seed yield of grasspea ranged between 277 kg and 449 kg per ha with an average of 374 kg/ha in earlier planted crop. Delay in planting by one week reduced grain yield substantially. Grasspea yield recorded for second planting varied between 127.24 kg and 187.12 kg giving and average yield of 159.68 kg; reduction in yield due to late planting was being 57.22%.

Table 71. Planting and harvesting date, and seed yield of grasspea relay-planted with aman rice in Uttampur (Rajapur) during 2019-20 growing season

Variety	Farmers Name	Sowing Date	Harvesting Date	Yield (kg/33dec)	Remarks
BARI Khesari-3	Miraj	16 Nov	17 Mar	50	Well germinated
	Kamal	16 Nov	17 Mar	60	Do
	Maman	16 Nov	16 Mar	58	Do
	Sultan	16 Nov	16 Mar	45	Do
	Jalil	16 Nov	16 Mar	37	Water logged in some areas
	Jalil 2	23 Nov	17 Mar	25	Do
	Badsha	23 Nov	18 Mar	17	Do
	Zulfiquar	23 Nov	18 Mar	22	Do
	Monju	30 Nov	-	00	Damaged due to heavy rainfall
	Harun 1	30 Nov	-	00	Do
	Harun 2	30 Nov	-	00	Do

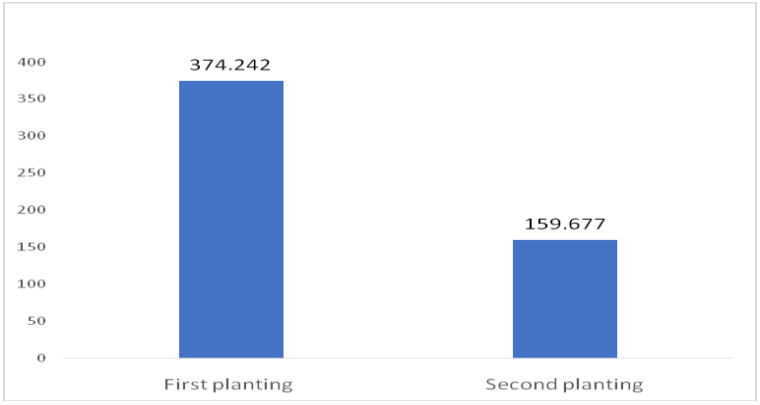


Figure 18. Planting time effect on grain yield (kg/ha) of grasspea

Mungbean trials in first year during 2019-20:

Varieties, planting time and seed yield of mungbean by 30 farmers in four locations of two districts (Jhalokati and Pirojpur) are given in Table 72. Data presented in Fig. 19 shows mungbean yield taking two harvests for farmers of Bheronbaria, and single harvest of other three locations. Mungbean yield varied across locations. As expected, the highest seed yield (690 kg ha^{-1}) of mungbean was obtained in Bheronbaria. Inter-plot variation in mungbean yield (673.64 kg and 718.55 kg ha^{-1}) was also small in the location. The yield is closer to regional average yield (742 kg/ha) but lower than national average yield (821 kg ha^{-1}) (BBS, 2020). A single farmer planted BU Mung 5 in Challishkahnia. The variety flowered a week earlier than other variety (BARI Mung-6) that facilitated two pickings while the other farmers growing BARI Mung-6 could not make second picking. BU Mug 5 produced 426 kg ha^{-1}, an increase of 62.14 compared with average yield in location Challishkahnia. In view of increasing risk of crop damage due to overbank flooding and excessive rain, short duration variety BU Mung 5 could be a variety for adapting to climate change in the southern district. The average second highest yield (263.12 kg ha^{-1}) was recorded in Challishkahnia (Rajapur). However, there was enormous variation in yield across farms within the location. It ranged between 142.21 kg and 426.64 kg ha^{-1}. In other two locations (Bhitabaria and Sialkati of Pirojpur district), mungbean yields varied a little between the locations. Average yields recorded for the locations– Bhitabaria and Sialkati were 88.32 kg and 94.31kg ha^{-1}, respectively.

Variation in mungbean yield between two locations in Jhalokati districts was due to differences in number of pickings. Popular variety BARI Mung-6 was planted in all the farms except in one plot where BU Mung 5 was planted. The variety is fairly determinate in terms of pod maturity (Haque et al., 2003; Mondal et al., 2011), and normally harvested in two successive pickings. Agro-ecological conditions in two locations of Jhalokati district are similar. The difference in yield between Beronbaria and Challishkahnia might be due to difference in the number of pickings. Mungbean yields in other two locations (Bhitabaria and Sialkati) were much lower compared with the yield obtained in Challishkahnia. There was a single picking of mungbean in these three locations. Given the yields of two pickings are equal, the probable mungbean yield would have have been less than 200 kg ha^{-1} in both the locations in pirojpur district. However, mungbean yield in the first picking is proportionately higher compared with second picking. This suggests a very low yield of mungbean which may not justify cost of production. Rahman et al. (2019) also reported that growing mungbean in Jhalokati and Pirojpur districts was uneconomic.

Table 72. Farmers, varieties planted, planting and harvesting dates, and yield of BARI Mung-6, 2020.

Farmers Name	Address	Sowing Date	Harvesting Date	Yield (kg/33dec)
Barek Sikder	Bheronbaria, Nalcity, Jhalokathi	11 Feb	25 Apr & 18 May	52+38= 90
Shafiqul Majhee		11 Feb	25 Apr & 18 May	55+41= 96
Jalil Majhee		08 Feb	25 Apr &18 May	51+39= 90
Faruque Majhee		07 Feb	25 Apr &18 May	53+42= 95
Nesahar Majhee		09 Feb	25 Apr &18 Ma	51+39= 90
Quddus Mantu	Challish Kahnia, Rajapur, Jhalokathi	10 Feb	29 Apr	50
Dulal Miah		12 Feb	29-30 Apr	52
Khalil Miah		07 Feb	29-30 Apr	26
Majid Khan		10 Feb	29-30 Apr	38
Idris Miah		14 Feb	19 Apr & 18 May	40+17= 57
Ferdaus		12 Feb	29-30 Apr	41
Majibur Rahman		10 Feb	29-30 Apr	39
Roni Miah		11 Feb	29-30 Apr	35
Sujan		11 Feb	29-30 Apr	37
Anwar		11 Feb	29-30 Apr	19
Pervin Begum		10 Feb	29-30 Apr	41
Sima		12 Feb	29-30 Apr	27
Mahinur		12 Feb	29-30 Apr	28
Abul Bashar		09 Feb	29-30 Apr	23
Monir		09 Feb	29-30 Apr	20
Sahidul	Bhitabaria, Bhandaria, Pirojpur	09 Feb	29 Apr & 05 May	11+2= 13 kg
Delwar Hossain		14 Feb	3o Apr & 7 May	09+2= 11 kg
Shajahan Howlader		12 Feb	30 Apr & 6 May	09+1= 10kg
Aminul Islam		11 Feb	29 Apr & 5 May	10+3= 13 kg
Basir Ahmed		14 Feb	29 Apr & 5 May	10+2= 12 kg
Mozammel Haq	Sialkathi, Kawkhali, Pirojpur	09 Feb	1 May & 10 May	12+5= 17 kg
Kamrul Hasan		11 Feb	1 May & 7 May	10+2= 12 kg
Sentu Howlader		14 Feb	1 May & 10 May	10+2= 12 kg
Shohag Ahmed		12 Feb	1 May & 10 May	8+2= 10 kg
Zipul Hasan		14 Feb	1 May & 8 May	10+2= 12 kg

Activity-3

Aman rice trials in second year during 2020:

An additional exploratory trial was conducted during the second year project period in 2020. Based on seasonal changes in hydrological conditions in relation to topographical positions of crop fields (toposequence), ARF introduced a long-saturated, fine-grain rice variety Kataribhog in relatively higher elevation along the river Jangalia in Uttampur (Rajapur). The Kataribhog variety was thought to be a relatively early maturing variety. Because of longer plant type, risked growing the variety comparing with traditional Sadamota and Moulata rice varieties with dispused replications. The experimental crop encountered no unusual climatic hazards during the growing season. The farmers were purposely selected and no statistical design was followed

primarily because of unequal sample size and variation in land topography. Transplanted aman rice was harvested between 17 November to through 5 January 2021 and data on grain yield recorded. Yield data were subjected to descriptive analysis giving mean yield, range and SE (±). Table 73 presents the number of farmers growing specific rice variety, average yield and range of each yield with standard error. Variety Sadamota gave the highest yield (1,996 kg ha^{-1}) while the lowest yield (1,497 kg ha^{-1}) was recorded for variety Kataribhog (Table 73). Irrespective of varieties, average rice grain yield varied between 1,497 kg and 2,245 kg ha^{-1}, a variation of about 50% relative to the lowest yielding Kataribhog. Average yield of Moulata was 1,871 kg ha^{-1}. Variation in grain yield among the three varieties was 33%. A pattern of yield variation among the varieties was discernible. It appears that longer the growth duration, higher was the grain yield. There was substantial variation in grain yields of variety in Sadamota across farmers' fields that ranged between 1,496 and 2,296, a variation of about 25%. Grain yields of Moulata varied a little across farms. However, unequal sample sizes of varieties Moulata and Sadamota, and non-replicated Kataribhog did not allow statistical analysis.

Table 73. Yield of three varieties of aman rice grown in tidal floodplain (Uttampur, Rajapur), 2020.

Rice variety	Farmers participated	Average field duration (days)*	Average grain yield (kg ha^{-1})	Range (kg ha^{-1})	SE(±)
Kataribhog	12	117	1,497	1,080-1,736	305
Moulata	18	151	1,871	1,597-2,059	287
Sadamota	15	164	1,996	1,496-2,296	558

*Field duration refers to transplanting to harvest. Seedling age (60 days) is to be added to find growth duration.

Apparently newly introduced aromatic fine grain rice variety Kataribhog produced lower yields; but two important outcomes might be of value. Earlier harvest of Kataribhog presents beneficial effect on timely planting of relay-cropped grasspea. Moreover, earlier release of land lends farmers the opportunity of growing dry season crops. Apart from that, fine grain rice of Kataribhog fetches premium price.

Activity-4

Grasspea trials in second year during 2020-21:

As was in previous year, a trial of growing grasspea during post-monsoon, early dry season was conducted to evaluate yields in the tidal floodplain. Influence of planting date on grass yield at two locations is presented in Table 74. Grasspea seed yield varied a little between the locations. It tended to increase with delay in planting; December 5 planting giving relatively higher yield. The magnitude of difference in yield either due to planting date or location was little. The

variations in yield across farmers' plots were also minimal. As evidenced from Fig. 3 the overall grasspea yield (1,806.97 kg ha^{-1}) averaged over planting dates and locations, was appreciably good. Irrespective of planting dates, grasspea yield varied a little between the locations (1825 and 1789 kg ha^{-1}). Variations in yield range and standard errors (Table 74) also indicate uniformity in grasspea yields across farmers within each location excepting in the case of 5 December planting in Bheronbaria. In both the locations, grasspea increased progressively and consistently with increase in planting time (Table 74) and the trend varied a little between the locations (Fig. 19). Average yield difference due to variation in planting dates, however, did not exceed 7%. Overall mean yield of grasspea across planting dates and between locations was 1,806.97 kg ha^{-1} which is much higher than national average (BBS 2021). Grasspea crop suffered heavily due to cyclone in November, 2019 whereas the crop experienced no environmental aberration during 2020-21 growing season. Barishal region experienced no-rain weather November 2020 through mid-May 2021. Seeds were planted at three times along the micro-topographical gradients (toposequence) and it is probable that the crop planted later on relatively lower elevation had better soil moisture than in the higher toposequence which might have favored good growth and seed yield formation.

Table 74. Planting date effect on the seed yield of grasspea planted in two locations, 2020-21.

Location	Planting date	Harvesting date	Average yield (kg ha^{-1})	Range (kg ha^{-1})	SE (±).
Uttampur	15 Nov 2020	08-12 Mar 2021	1,753.5	1,662-1,871	87.94
	25 Nov 2020	17-20 Mar 2021	1,801	1,751-1,856	52.68
	5 Dec 2020	17-25 Mar 2021	1,921	1,856-1,961	56.79
Bheronbaria	15 Nov 2020	08-12 Mar 2021	1,719	1,647 – 1,796	74.63
	25 Nov 2020	17-20 Mar 2021	1,831	1,725 – 1,925	78.58
	5 Dec 2020	17-25 Mar 2021	1,816.3	1,747-1,946	153.40

Fig 19: Grasspea trial in Bheronbaria during 2020-21

Mungbean seed yield during 2021:

As was done in the previous year, planting time effect of the productivity of two improved varieties (BARI Mung-6 and BU Mung 5) was evaluated conducting an on-farm trial in two villages (Palot and Bheronbaria) in Rajapur and Nalchityupazila respectively of Jhalokathi and Pirojpur district in 2021 growing season. The river Bishkhali flows between the villages. Both planting time and location had significant influence on the seed yield of mungbean. Interaction effect on planting time and location on mungbean yield was also significant. Seeds of variety BU Mung 5 inadequate so only one site sown at Palot (Rajapur). The major mungbean variety (BARI Mung-6), mungbean yield was higher in Palot (1,683kg ha^{-1}) than in Bheronbaria (1,466 kg ha^{-1}). Regardless of locations, the overall performance of mungbean during 2021 dry season was reasonable. In Palot, second planting tended to produce higher seed yield (1,770 kg ha^{-1}) compared with first planting (1,687 kg ha^{-1}). Late planted mungbean produced the lowest yield (1,593 kg ha^{-1}). In Bheronbaria, however, first planting was done on 25 February which was the second planting date in Palot. Mungbean yield significantly decreased in second and third planting in Bheronbaria. Progressive yield decrease with planting time in Bheronbaria than in Palot. Late planting produced 27% lower yield than first planting while the extent of yield reduction due to late planting in was much lower (10%) for Bheronbaria. In the first planting, yield difference between the two locations was not appreciably high.

Table 75. List of farmers participating in mungbean trial in two locations during dry season, 2021

Palot, Rajapur			**Bheronbaria, Nalchity**	
Kanchan Molla	Anisur Rahman	Razzaque Master	KalamJomaddar	Zahid Sikder
Khalilur Rahman 1	Pervin	Abdur Rob	ShohagMajhi	Siraj Howlader
Kazi Abul Bashar	Mamun	Rezwan	Russel	Nurul Islam
Khalilur Rahman 2	Sohel	Rahim	Shah Alam	Mujib Howlader
Kazi Shakur	Moniruzzaman	Mojibor	Jalil Majhi	Moqbul Sikder
Rafiqul Islam	Abul Kalam	Siddiqur Rahman	Faruque	
Ripon	Mizanur Rahman	Babul	Idris Howlader	
Chand Mia	Sumon	Montu Mia	Sultan Majhi	
Sabuz	Kabir	AKM Bari	BarekSikder	
Khalilur Rahman 3	Altaf Hossain	Motaleb Jomaddar	MotalebJomaddar	

Table 76. Experimental variables and replications of the trial conducted in two locations, Dry season, 2021

Location	**Variety(ies) used**	**Replications**	**Planting dates**
Palot, Rajapur	BARI Mung-6 BU mug 5	28 02	16 Jan 2021, 25 Jan 2021, 5 Feb 2021, and 16 Jan 2021 (for BU Mug 5).
Bheronbaria	BARI Mung-6	15	25 Jan 2021, 3 Feb 2021, 10 Feb 2021

In Palot, two varieties BARI Mung-6 and BU mug 5 were planted. Figure 22 shows the variation in yield between the two varieties. BARI Mung-6 produced significantly higher yield (1,633 kg ha^{-1}) than BU mug 5 (1,466 kg ha^{-1}) where, BARI Mung-6 produced nearly 13% higher seed yield. The results are in contrast with that of previous years. From 2020 growing season results it was observed that because relatively shorter growth duration BU mug 5 yielded higher giving two successive harvests prior to cyclone and rainstorm affected second harvest of BARI Mung-6. This year there was no rain during the long growing season, but atmospheric drought seems to have affected little in growth and yield formation of mungbean. Although drought affected both the varieties making stunted growth in the beginning, the crop sustained growth probably taking advantage of the upward soil water flux due to groundwater recharge through seepage of tidal water from the nearby Bishkhali river. This happened in both the locations. Compared with first year's trial, second year trial gave higher yields of both grasspea and mungbean in both the locations regardless of treatment differences which might be attributed to prevailing weather conditions. Introduction of Kataribhog in aman season and its early harvest allowed timely planting of grasspea but did not bring any yield benefit to grasspea. Early onset of dry season due to no-rain situation during November 2020 through mid-May 2021 favored early planting of mungbean (mid-Jnuary) to avoid weather hazard toward end of growing season. Early planting and prevailing weather enhanced mungbean yield. Relay cropping of grasspea with transplanted aman and growing of high yielding varieties of mungbean could be an important option for increasing cropping intensity and thereby increasing production and farm income.

Fig. 20: Mungbean field in 2021

12. Research highlight (title of the sub-project, background, objectives, methodology, key findings, and key words):

Component-1: Soil Science Division, BARI

12.1 Improvement of crop production and cropping system

Title: Increasing crop productivity and intensity of Mustard-Mungbean-T. Aman cropping pattern through integrated nutrient management at Gopalgonj district

Background

Bangladesh is one of the highest populous countries of the world with the annual growth rate of about 1.37% (BBS, 2019). On the other hand, available agricultural land of Bangladesh is decreasing with an alarming rate of about 1% per year (Hossain et al., 2014). Rate of cropland shifting to non-agricultural land (housing, industry, etc.) is formidable as it is associated with the food security of the country (Islam et al., 2018). Meeting the challenge of ensuring food security through horizontal expansion of land is not possible due to decrease in agricultural land. So intensifying land use system through multiple cropping or by growing more and more crops on the same piece of land in a calendar year is a promising option to feed this teeming millions. Rice based cropping system consisting of Boro-Fallow-T. Aman is a popular cropping pattern in Gopalgonj distract. Inclusion of short duration and high yielding Mustard and short duration of T. Aman variety in this cropping pattern could increase the cropping intensity up to 300% as well as improve the socio-economic condition of the farmer. Aziz et al. (2013) reported that multiple cropping system effects soil carbon and nitrogen status, and also improve soil functional properties. Nevertheless, continuous cropping cause's nutrient mining from soil while a blanket fertilizer dose for all regions without considering the soil nutrient status leads to tremendous damage to soil, environment and economy. Sultana et al. (2015) opined that actual recommended fertilizer dose is higher than actual need of fertilizer and this gap creates soil nutrient imbalance. As soil fertility is a major determinant for the success and failure of a crop production system, time demands a suitable fertilizer recommendation based on soil testing for promising four crops based cropping pattern which is agronomically feasible and economically profitable.

Objectives

- To increase the crop productivity and intensity producing three crops over the same piece of land by using improve varieties and optimum nutrient management practices in a year.

Methodology:

There are different types of cropping pattern exist in different locations, where dominent cropping patterns were considered for the replace by alternate profitable cropping pattern. To increase crop productivity, three cropping patterns were considered for development at Gopalgonj district tested site. The cropping cycle was three crops (Mustard, Mungbean, T. *aman*) and nine varieties and three fertilizer levels (F_1 = Recommended Fertilizer Dose, RFD from inorganic source as per soil test bases, STB; F_2 = RFD on STB + 5 t ha^{-1} cowdung, integrated plant nutrient system, IPNS approach; F_3 = Farmers practices consisting of nine treatments and three replications. Methodology has descriped details in the methodology section.

Key findings

The whole pattern average total rice (system) yield/rice equivalent yield of 16.18 t $ha^{-1}yr^{-1}$ was obtained from Mustard-Mungbean-T. *aman* (BARI Sarisha-14, BARI Mung-6, BRRI dhan71) and lowest was 11.74 t $ha^{-1}yr^{-1}$ existing pattern. The benefit cost analysis of cropping pattern, gross return and gross margin of 3,88,519 and 2,10,496 (Tk $ha^{-1}yr^{-1}$) and benefit cost ratio of 2.10 were obtained from improved Mustard-Mungbean-T. *aman* pattern at sadar upazila of Gopalganj. Nutrient uptake by grain and straw of all crops of the cropping pattern were influenced by different fertilizer treatments. The initial soil as well as in soil after completion of Mustard-Mungbean-T. *aman* cropping cycle, the average soil fertility status were no appreciable change or mostly unchanged. The organic matter content of the soil increased due to biomass addition of the leguminous crops. Somewhere it was changed positively. As potassium showed negative balance, more potassium is to be added to improve soil fertility status and may be sustained in the study area of AEZ-12 and AEZ-14.

Key words: Cropping pattern, Crop productivity, Cropping intensity, Rice equivalent yield

Component-2: Oilseed Research Center, BARI

12.2 Improvement of crop production and cropping system

Title: Improvement of alternate cropping pattern instead of existing cropping pattern in Low Ganges River Floodplain (Madaripur district)

Background

Bangladesh is the world's most densely populated country. The total cultivable land area is currently 7.95 million hectares (BBS, 2016), and it is decreasing at a rate of one percent per

year. There is relatively little potential for growing cultivable land, but there is potential for raising cropping intensity from 194 to 400% by upgrading the current cropping pattern. Short-duration crop such as Mustard, Sesame, Grasspea, high value vegetables, Boro, and Aus rice could be incorporated into a rice-based cropping scheme. Sustainable crop production in Bangladesh is becoming increasingly essential in national issues such as food security, proverity reduction, and employment, thanks to improvements in cropping patterns in rice-based cropping systems. Several research institutes have developed a number of high yielding/short duration/salt/drought tolerance crop varieties that can be used to increase cropping intensity and productivity. This study on cropping pattern improvement was undertaken to evaluate the feasibility of growing more than two crops in terms of productivity and in a year in a piece of land by incorporating new crops into the existing new cropping pattern in order to produce more food within a limited area.

Objectives

a) To increase the cropping intensity producing three or four crops over the same piece of land in a year.
b) To increase the production efficiency of the individual crop by using improves varieties and optimum management practices.
c) To increase farmer's income and employment opportunity in agricultural.

Methodology:

There are different types of cropping pattern exist in different locations, where dominent patterns, more prominent cropping patterns were considered for the improvement or replace by alternate profitable cropping pattern. Three cropping patterns were considered for development at Madaripur district tested site under under unfavorable eco-system of AEZ-12. The Boro-Fallow-T. *aman*, Rabi-Jute-Fallow, Wheat-Jute-T. *aman* cropping pattern against Mustard-Mungbean-T. *aman* was tested at Madaripur district.

Key findings

Improved Pattern (IP): Mustard var. (BARI Sarisha-14)–Mungbean var. (BARI Mung-6) -T. *aman* var. (BRRI dhan71)

Existing Pattern (EP): Boro var. (BRRI dhan28) –Jute var. (Indian/Local) -T. *aman* var. (Local)

The whole pattern average total rice (system) yield/rice equivalent yield of 15.90 t $ha^{-1}yr^{-1}$ was obtained from Mustard-Mungbean-T. *aman* (BARI Sarisha-14, BARI Mung-6, BRRI dhan71) and lowest was 12.25 t $ha^{-1}yr^{-1}$ in existing pattern. Mustard-Mungbean-T. *aman* cropping pattern showed gross return and gross margin of 3,81,490 and 2,16,869 (Tk $ha^{-1}yr^{-1}$) with the marginal

benefit cost ratio of 2.32 from improved Mustard-Mungbean-T. *aman* pattern at Madaripur district.

Key words: cropping pattern, crop productivity, cropping intensity, Rice equivalent yield

12.2.1 Validation and crop production in cropping pattern

Title: Mustard-Mungbean-T. *aman* cropping pattern with integrated nutrient management for increasing cropping intensity and productivity in south central regions

Background

Bangladesh has achieved a remarkable progress in increasing crop production. Madaripur district is located under high ganges river floodplain. The cropping intensity of this area is 255% and about 88% lands are medium high to low land (10-12%) remain fallow after harvesting of T. *aman* rice. Mustard-Mungbean-T. *aman* is one of the dominant cropping pattern in high ganges river floodplain soil. Long term soil fertility monitoring under a specific cropping system would be of great help in determining a better soil fertility management program for sustained productivity. Bangladesh Rice Research Institute (BRRI) has recommended T. *aman*-Mustard-Boro cropping pattern for the irrigated ecosystem (BARC, 2001) with the inclusion of 70-75 days local mustard (var. Tori-7) in between T. *aman* and Boro rice. But the farmers harvest poor yield from local var. Tori-7 that can be increased by introducing high yielding varieties (Basak et al., 2007). Bangladesh Agricultural Research Institute (BARI) has developed high yielding mustard varieties, BARI Sarisha-14 and BARI Sarisha-17, respectively and has been recommended for T. *aman* (BRRI dhan71, BRRI dhan57)- Mustard-Boro cropping sequence (Mondal et al., 2011). Crop duration of BARI developed short duration mustard varieties is 80-85 days, whereas BRRI and BINA has developed short/medium duration rice varieties. With this view, the present study was undertaken with the following objectives.

Objectives:

a) To evaluate varietal performance of mustard, mungbean and T. *aman* in Mustard-Mungbean-T. *aman* cropping pattern
b) To adjudge judicious fertilizer recommendation for Mustard-Mungbean-T. *aman* cropping pattern and monitoring soil health in Madaripur sadar and kalkini upazilla
c) To increase production, farm productivity and income generation in south central coastal regions.

Methodology:

This field trial has been conducted in Low Ganges River Floodplain Soils of Madaripur sadar and kalkini upazilla AEZ-12 during 2020-2022. The cropping cycle of Mustard-Mungbean-T.

aman was conducted with mungbean as the first crop in the pattern. After harvest, T. *aman* was sown in both the locations and then mustard. The experiment was laid out in a randomized complete block design with dispused three replications. The experimental plot size was 5m x 4m in both the locations. The cropping cycle was three crops (Mustard, Mungbean, T. *aman*) and nine varieties (Mustard: BARI Sarisha-14, BARI Sarisha-17, BARI Sarisha-11; Mungbean: BARI Mungbean-6, BARI Mungbean-8, BINA Mungbean-8; T. *aman*: BRRI dhan 57, BRRI dhan 71 and BRRI dhan 75) and three fertilizer levels (F_1 = Recommended Fertilizer Dose, RFD from inorganic source as per soil test bases, STB; F_2 = RFD on STB + 5 t ha^{-1} cowdung, integrated plant nutrient system, IPNS approach; F_3 = Farmers practices) consisting of nine treatments and three replications. Urea, TSP, MoP, gypsum, Zinc sulphate, boric acid were used as a source of N, P, K, S, Zn and B, respectively. In case of mustard, mungbean, T. *aman* all P, K, S, Zn and B were applied as basal during final land preparation. Cowdung@ 5 t ha^{-1} was applied before ploughing and laddering as treatment only. The entire quantity of P, K, S, Zn (as per STB), was applied during the final land preparation. Nitrogen was applied in three equal splits at seedling establishment stage 5-7 day after transplanting (DAT), active tillering stage (25-30 DAT) and 5-7 days before panicle initiation stage (45-50 DAT). The seedlings of three varieties of T. *aman* rice were transplanted in row to row 25 cm and hill to hill 15 cm spacing. Yield parameters data were recorded at certain growth stages of all the crops of the pattern.

Key findings

From the three crop varieties and three fertilizer levels trials, it was observed that IPNS based fertilized plots yielded higher than farmers practices and BARI Sarisha-14 (1.69 tha^{-1}), BARI Mung-6 (1.79 tha^{-1}), and BRRI dhan71 (5.60 tha^{-1}) yielded higher than BARI Sarisha-17 (1.60 tha^{-1} BINA Mung-8 (1.60 tha^{-1}), BRRI dhan57 (5.51 tha^{-1}) at Madaripur sadar and Kalkini upazilla, Madaripur.

Key words: Cropping pattern, productivity, integrated plant nutrient system, recommended fertilizer dose,

12.2.2 Validation and crop production in cropping pattern

Title: Sweet gourd–Sesame-T. *aman* cropping pattern with integrated nutrient management for increasing crop productivity at Bagerhat (coastal) region

Background

Sweet Gourd (*Cucurbita maxima)* has a thick, orange or yellow shell, creased from the stem to the bottom, containing the seeds and pulp. It has a very versatile use for cooking. Among varied

vegetables, sweet gourd is appreciated by consumers because of its fruits, tender stems, leaves and even flowers used as vegetables both at green and ripen stages. It is relatively a richer source of energy, carbohydrates and vitamins, especially that of high carotenoid contents and minerals. This crop is therefore thought to have potentiality to solve malnutrition problem of mass people of Bangladesh to certain extent particularly vulnerable groups in respect of vitamin-A requirement. Sesame (*Sesamum indicum* L.) is another important oil crops with drought tolerant crops in Bangladesh. It contains 5.3% water, 5.2% minerals, 2.9% fibre, 18.3% protein, 43.3% fat and 25% carbohydrate per 100 g edible portion and is extremely susceptible to water logging. It is mainly grown in Kharif-1 season which is the dry-wet transition period due to start of monsoon rain. Sometimes create water logged due to heavy monsoon rainfall. There are a several number of cropping patterns in Bangladesh and are mainly rice based and vary on agro-ecological conditions. In Bagerhat, robi season crops were hampered due to stringent water/flash flood located under high ganges river floodplain. The cropping intensity of this area is 255% and about 88% lands are medium high to low land remain 10-12% lands fallow after after harvesting of T. *aman* rice. Mustard-Mungbean-T. *aman* is one of the dominant cropping pattern in high ganges river floodplain soil. Long term soil fertility monitoring under a specific cropping system would be of great help in determining a better soil fertility management program for sustained productivity. Bangladesh Agricultural Research Institute (BARI) has developed high yielding mustard varieties, BARI Sarisha-14 and BARI Sarisha-17, respectively and has been recommended for T. Aman (BRRI dhan71, BRRI dhan57)- Mustard-Boro cropping sequence (Mondal *et al.,* 2011). Crop duration of BARI developed short duration mustard varieties is 80-85 days, whereas BRRI and BINA has developed short/medium duration rice varieties. With this view, the present study was undertaken with the following objectives.

Objectives:

a) To evaluate varietal performance of sweet gourd, sesame and T. *aman* to increase production, farm productivity and income generation in Bagerhat sadar and Mollarhat upazilla of Bagerhat.
b) To adjudge judicious fertilizer recommendation for Sweet gourd - Sesame - T. *aman* cropping pattern and monitoring soil health in Bagerhat sadar and Mollarhat upazilla of Bagerhat.

Methodology:

The cropping cycle of Sweet gourd-Sesame -T. *aman* was conducted with sesame as first crop in the pattern. After harvest, T. *aman* rice and sweet gourd were sown in Bagerhat sadar and Mollarhat upazilla in selected farmers' fields. The experiment was laid out in a randomized

complete block design with dispused three replications. The experimental plot size was 5m x 4m in both the locations. There were three crop varieties (Sweet gourd: BARI Mistikumra-2, BARI Hybrid Mistikumra-2, BARI Hybrid Mistikumra-3; Sesame: BARI Til-3, BARI Til-4, BINA Til-4; T. *aman*: BRRI dhan 57, BRRI dhan 71 and BRRI dhan 75) and three fertilizer levels (F_1 = Recommended Fertilizer Dose, RFD from inorganic source as per soil test bases, STB; F_2 = RFD on STB + 5 t ha^{-1} cowdung, integrated plant nutrient system, IPNS approach; F_3 = Farmers practices) comprising of nine treatments. Urea, TSP, MOP, gypsum, Zinc sulphate, boric acid were used as a source of N, P, K, S, Zn and B, respectively. Cowdung @ 5 tha^{-1} was applied before final land preparation. The entire quantity of P, K, S, Zn and B (as per STB), was applied during the final land preparation. Nitrogen was applied in three equal splits at seedling establishment stage 5-7 day after transplanting (DAT), active tillering stage (25-30 DAT) and 5-7 days before panicle initiation stage (45-50 DAT). The seedlings age of three varieties of T. aman rice were transplanted in row to row 25 cm and hill to hill 15 cm spacing. All the intercultural operations such as irrigation, weeding, insect and diseases control etc were done as and when necessary. The sweet gourd seeds were sown on 15-27 November, 2020 in Bagerhat sadar and Mollarhat upazilla, respectively. Yield parameters data were recorded at certain growth stages of all the crops of the pattern.

Key findings

In case of Bagerhat sadar and Mollarhat upazilla locations, Sweet gourd-Sesame-T. *aman* cropping pattern trials, it was observed that IPNS based fertilized plots yielded higher than farmers practices and BARI Hybrid Mustikumra-2 (41.00 tha^{-1}), BARI Til-3 (1.77 tha^{-1}) and BRRI dhan71 (5.62 tha^{-1}) yielded higher than BARI Hybrid Mustikumra-3 (35.11 tha^{-1}), BARI Mustikumra-2 (29.77 tha^{-1}), BINA Til-4 (1.56 tha^{-1}), BARI Til-4 (1.56 tha^{-1}), BRRI dhan57 (4.46 tha^{-1}) and BRRI dhan75 (4.49 tha^{-1}).

Key words:
Cropping pattern, productivity, integrated plant nutrient system, recommended fertilizer dose,

12.2.3 Validation and crop production in cropping pattern

Title: Grasspea-Gimakolmi-T. *aman* cropping pattern with integrated nutrient management for increasing cropping intensity and productivity in south central coastal region

Background

Grasspea (*Lathyrus sativus* L.) is a major pulse crop and known as " Khesari" in Bangladesh. It requires no major costs as a robi crop and is easy to cultivate under relay cropping system with

rice as a cheap source of high protein and fodder. Moreover, it has an important role for improving soil fertility by adding around 67 kgha^{-1} nitrogen through biological nitrogen fixation in a single season (Wang et al., 2000). Madaripur district is located under low ganges river floodplain. The cropping intensity of this area is 255% and about 88% lands are medium high to low land remain 10-12% lands fallow after after harvesting of T. *aman* rice. Mustard-Mungbean-T. *aman* is one of the dominant cropping pattern in low ganges river floodplain soil. Long term soil fertility monitoring under a specific cropping system would be of great help in determining a better soil fertility management program for sustained productivity. Bangladesh Agricultural Research Institute (BARI) has developed high yielding mustard varieties, BARI Sarisha-14 and BARI Sarisha-17, respectively and has been recommended for T. *aman* (BRRI dhan71, BRRI dhan57)- Mustard-Boro cropping sequence (Mondal *et al.,* 2011). Crop duration of BARI developed short duration varieties is 80-85 days, whereas BRRI and BINA has developed short/medium duration rice varieties. With this view, the present study was undertaken with the following objectives.

Objectives:

a) To evaluate varietal performance of grasspea (khesari), gimakolmi and T. *aman* and to increase production, farm productivity and income generation in south central coastal regions.
b) To adjudge judicious fertilizer recommendation for Grasspea–Gimakolmi-T. *aman* cropping pattern and monitoring soil health

Methodology:

In Madaripur sadar and Kalkini upazilla the cropping cycle of Grasspea-Gimakolmi-T. *aman* were conducted with the sowing of gimakolmi as the first crop during 18-25 April, 2019. The experiment was laid out in a randomized complete block design with dispused three replications. The experimental plot size was 6m x 5m in both the locations. The cropping cycle was three crops (Grasspea, Gimakolmi, T. *aman*) and nine varieties (Grasspea: BARI Khesari-5, BARI Khesari-3, Khesari (Local); Gimakolmi: BARI Gimakolmi-1, Subij pata (Local), Golden Line (Local); T. *aman*: BRRI dhan 57, BRRI dhan 71 and BRRI dhan 75) and three fertilizer levels (F_1 = Recommended Fertilizer Dose, RFD from inorganic source as per soil test bases, STB; F_2 = RFD on STB + 5 t ha^{-1} cowdung, integrated plant nutrient system, IPNS approach; F_3 = Farmers practices) consisting of nine treatments and three replications. Urea, TSP, MoP, gypsum, Zinc sulphate, boric acid were used as a source of N, P, K, S, Zn and B, respectively. In case of grasspea, gimakolmi, T. *aman* all P, K, S, Zn and B were applied as basal during final land preparation. Cowdung@ 5 t ha^{-1} was applied before ploughing and laddering as treatment only. All the intercultural operations such as irrigation, weeding, insect control etc were done as

and when necessary. The total biomass was incorporated in the soil after harvest of grasspea. The same sequence was maintained in T. *aman* rice for fertilizer treatments. The entire quantity of P, K, S, Zn (as per STB), was applied during the final land preparation. Nitrogen was applied in three equal splits at seedling establishment stage 5-7 day after transplanting (DAT), active tillering stage (25-30 DAT) and 5-7 days before panicle initiation stage (45-50 DAT). The seedlings of three varieties of T. aman rice were transplanted in row to row 25 cm and hill to hill 15 cm spacing. Yield parameters data were recorded at certain growth stages of all the crops of the pattern.

Key findings

From the three crop varieties and three fertilizer levels trials, it was observed that IPNS based fertilized plots yielded higher than farmers practices and BARI Khesari-3 (1.77 tha^{-1}), BARI Gimakolmi-1 (68.33 tha^{-1}) and BRRI dhan71 (5.60 tha^{-1}) yielded higher than local Khesari (1.49 tha^{-1}) and gimakolmi, BRRI dhan57 (5.51 tha^{-1}) and BRRI dhan75 (5.49 tha^{-1}) at Madaripur sadar and Kalkini upazilla.

Key words:
Cropping pattern, productivity, integrated plant nutrient system, recommended fertilizer dose,

12.2.4 Validation and crop production in cropping pattern

Title: Validation and crop production program with short duration and high yielding verities in cropping system at Farmers' field

Background

The Bangladesh Agricultural Research Institute and National Agricultural Research System Institutes have developed a huge number of crop varieties that are high yielding, hybrid, short duration, and salt tolerance. During 2019-2022, this project study was undertaken with several crops, including new varities of mustard, grasspea, mungbean, gimakolmi, sweet gourd, sesame and T. *aman*, in order to find suitable crops. During the following years, the determined suitable types were put into production at each location. The production programe is the more straight forward by our mega new varieties and integrated management practice with popular method of disseminating new technology and motivating farmers at Madaripur region.

Objectives:

1. To create impact in the local farmers on high yielding or high value crops and varieties.
2. To increase productivity and farmers' income

Methodology:

Validation and different crop production was conducted four upazillas' (Madaripur sadar, Kalkini upazilla, Bagarhat sadar and Mollarhat upazilla) and sixteen farmers' field at Madaripur and Bagerhat district. Several crops such as mustard, grasspea, mungbean, gimakolmi, sweet gourd, sesame and T. *aman* varieties were produced under three cropping patterns. Urea, TSP, MoP, gypsum, Zinc sulphate, boric acid were used as a source of N, P, K, S, Zn and B, respectively. All P, K, S, Zn and B were applied as basal during final land preparation. Cowdung@ 5 t ha^{-1} was applied before ploughing and laddering as treatment only. All the intercultural operations such as irrigation, weeding, insect control etc were done as and when necessary. The total biomass was incorporated in the soil after harvest of grasspea. The same sequence was maintained in T. *aman* rice for fertilizer treatments. The entire quantity of P, K, S, Zn (as per STB), was applied during the final land preparation. Nitrogen was applied in three equal splits at seedling establishment stage 5-7 day after transplanting (DAT), active tillering stage (25-30 DAT) and 5-7 days before panicle initiation stage (45-50 DAT). The seedlings of three varieties of T. aman rice were transplanted in row to row 25 cm and hill to hill 15 cm spacing. Yield parameters data were recorded at certain growth stages of all the crops of the pattern.

Key finding

Crop production program with high yielding crop varieties showed better performance in terms of higher yield and gross return. This program has created positive impact on total income enhancement. However, location-wise findings under production program are given below-

Location: Madaripur sadar upazilla, Madaripur

Mustard: Var. BARI Sarisha-14 gave the highest seed yield (1.72 tha^{-1}) followed by var. BARI Sarisha-17 seed yield (1.51 tha^{-1}). Farmers' are interested in cultivating var. BARI Sarisha-14.

Mungbean: Var. BARI Mung-6 gave the highest seed yield (1.79 tha^{-1}) followed by var. BINA Mung-8 seed yield (1.19 tha^{-1}). Farmers' are interested in cultivating var. BARI Mung-6.

Khesari: Var. BARI Khesari-3 gave the highest seed yield (1.82 tha^{-1}) followed by var. Khesari (local) seed yield (1.25 tha^{-1}). Farmers' are interested in cultivating var. BARI Khesari-3.

T. *aman*: Var. BRRI dhan71 gave the highest grain yield (5.61 tha^{-1}) followed by var. BRRI dhan57 grain yield (3.96 tha^{-1}). Farmers' are interested in cultivating var. BRRI dhan71.

Location: Kalkini upazilla, Madaripur

Mustard: Var. BARI Sarisha-17 gave the highest seed yield (1.71 tha^{-1}) followed by var. BARI Sarisha-14 seed yield (1.46 tha^{-1}). Farmers' are interested in cultivating var. BARI Sarisha-17.

Mungbean: Var. BARI Mung-6 gave the highest seed yield (1.76 tha^{-1}) followed by var. BINA Mung-8 seed yield (1.40 tha^{-1}). Farmers' are interested in cultivating var. BARI Mung-6.

Khesari: Var. BARI Khesari-3 gave the highest seed yield (1.74 tha^{-1}) followed by var. Khesari (local). Farmers' are interested in cultivating var. BARI Khesari-3.

T. *aman*: Var. BRRI dhan71 gave the highest grain yield (5.48 tha^{-1}) followed by var. BRRI dhan57 grain yield (3.09 tha^{-1}). Farmers' are interested in cultivating var. BRRI dhan71.

Location: Bagerhat sadar upazilla, Bagerhat

Sweet gourd: Var. BARI Hybrid Mistikumra-2 gave the highest fruit yield (42.13 tha^{-1}) followed by var. BARI Mistikumra-2 fruit yield (25.05 tha^{-1}). Farmers' are interested in cultivating var. BARI Hybrid Mistikumra-2.

Sesame: Var. BARI Til-3 gave the highest seed yield (1.41 tha^{-1}) followed by var. BINA Til-4 seed yield (1.08 tha^{-1}). Farmers' are interested in cultivating var. BARI Til-3.

T. *aman*: Var. BRRI dhan71 gave the highest grain yield (5.49 tha^{-1}) followed by var. BRRI dhan57 grain yield (3.66 tha^{-1}). Farmers' are interested in cultivating var. BRRI dhan71.

Location: Mollarhat upazilla, Bagerhat

Sweet gourd: Var. BARI Hybrid Mistikumra-3 gave the highest fruit yield (39.02 tha^{-1}) followed by var. BARI Mistikumra-2 fruit yield (19.57 tha^{-1}). Farmers' are interested in cultivating var. BARI Hybrid Mistikumra-3.

Sesame: Var. BARI Til-3 gave the highest seed yield (1.54 tha^{-1}) followed by var. BINA Til-4 seed yield (0.99 tha^{-1}). Farmers' are interested in cultivating var. BARI Til-3.

T. *aman*: Var. BRRI dhan71 gave the highest grain yield (5.49 tha^{-1}) followed by var. BRRI dhan57 grain yield (3.85 tha^{-1}). Farmers' are interested in cultivating var. BRRI dhan71 because of short duration.

Key words: Productivity, profitability, variety, yield

B. Implementation Status

1. Procurement (component wise):

Coordinator component

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Office equipment i) Laptop ii) Laser printer	 1 1	 60,000 20,000	 1 1	 60,000 20,000	100%
Total		80,000		80,000	

Component-1: Soil Science Division, BARI

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Office equipment					
i) Laptop	02	120000	02	120000	Good condition
ii) Desktop	01	60000	01	60000	Good condition
iii) Camera	02	50000	02	50000	Good condition
iv) Laser printer	02	40000	02	40000	Good condition
(b) Lab equipment					
i) GPS machine	02	110000	02	110000	Good condition
ii) pH meter (portable)					
(c) Field equipment					
i) Bicycle	02	20000	02	20000	Good condition
ii) Motor cycle	01	150000	01	150000	Good condition
d) Furniture					
i) Executive Table	02	40000	02	40000	Good condition
ii) Executive Chair	02	20000	02	20000	Good condition
iii) File Cabinet	02	40000	02	40000	Good condition
iv) Steel Almira	02	48000	02	48000	Good condition
v) Visitor/Front Chair	08	32000	08	32000	Good condition
vi) Computer Table	02	10000	02	10000	Good condition
vii) Computer chair	02	7000	02	7000	Good condition
Total				7,47,000	

Component-2: Oilseed Research Center component, BARI

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Office equipment					
i) Laptop	1	60,000	1	60,000	
ii) Desktop computer	1	60,000	1	60,000	100%
iii) Camera	1	25,000	1	25,000	
iv) UPS	1	10,000	1	10,000	
(b) Lab equipment					
i) GPS machin	1	55,000	1	55,000	
ii) pH meter (portable)	1	50,000	1	50,000	100%
(c) Field equipment					
i) Bicycle	2	20,000	2	20,000	
(d) Furniture					
i) Executive Table	1	20,000	1	20,000	
ii) Executive Chair	1	10,000	1	10,000	100%
iii) Steel Almira	1	24,000	1	24,000	
iv) Visitor/Front Chair	1	4,000	1	4,000	
Total		3,50,000		3,50,000	

.

Component-3: Agarian Research Foundation

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Office equipment	5 items	1,20,000	5 items	1,23,500	
(b) Field equipment (Bicycle)	-	20,000	-	-	
(c) Other capital items	5 items	1,05,000	5 items	1,20,000	
Total		2,45,000		2,43,500	

2. Establishment/renovation facilities: Not applicable

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

Training/study tour/ seminar/workshop/conference organized (component wise):
Coordinator component, BARI

Description	Number of participant			Duration (Days/ weeks / months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop (Inception)	16	84	100	1 day	100% Achievement
(c) Others (if any)	-	-	-	-	

.

Fig 21: Inception workshop was held on Reasonal Agricultural Research Station Rohmatpur, Barishal.

Fig 22: Inception workshop was held on Reasonal Agricultural Research Station Rohmatpur, Barishal.

Component-1: Soil Science Division, BARI (Not applicable)

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	-	-	-	-	
(b) Workshop	-	-	-	-	
(c) Others (if any)	-	-	-	-	

Component-2: Oilseed Research Center, BARI

Description	Number of participant			Duration (Days)	Remarks
	Male	Female	Total		
(a) Training (1st and 2nd year)					
i) Farmers' training (2 batch)	18	7	50	1 day	100% Achievement
ii) Farmers' training (2 batch)	17	8	50	1 day	
(b) Workshop	-	-	-	-	
(c)Others (if any)					100% Achievement
i) Field day (2 batch)	38	12	50	1 day	

.

Fig 23. Improving farmers' knowledge and skill through training, conducting on-farm trials at Madaripur sadar upzilla.

Fig 24. Improving farmers' knowledge and skill through training, conducting on-farm trials at Kalkini upzilla in Madaripur.

Fig 25. Improving farmers' knowledge and skill through training, conducting on-farm trials at Mollarhat upzilla in Bagerhat.

Training

Fig 26. Improving farmers' knowledge and skill through **training**, conducting on-farm trials at sadar upzilla of Madaripur.

Field day:

Fig 27. Improving farmers' knowledge and skill through **field day**, conducting on-farm trials at Mollarhat upzilla, Bagerhat.

Fig 28. Improving farmers' knowledge and skill through **field day**, conducting on-farm trials at sadar upzilla of Madaripur.

Field Day

Fig 29. Improving farmers' knowledge and skill through **field day**, conducting on-farm trials at Kalkini upzilla, Madaripur.

Fig 30. Improving farmers' knowledge and skill through field day, conducting on-farm trials at sadar upzilla of Madaripur.

Fig 31. Improving farmers' knowledge and skill through field day, conducting on-farm trials at sadar upzilla of Bagerhat.

Component-3: Agarian Research Foundation

Training/study tour/seminar/workshop/conference organized:

Description	Number of participant			Duration (Days)	Remarks
	Male	Female	Total		
(a) Training (Farmers' training on mungbean and grasspea)	26	04	30	A day long training	Venue of DAE, Rajapur upazila
(b) Workshop	-	-	-	-	
(c) Others (if any)	-	-	-	-	

Fig 1: AD, DAE, participated in the farmers training

C. Financial and Physical Progress

Component wise Total Budget

(Tk)

Components	**Total approved budget**	**Fund received**	**Actual expenditure**	**Balance/ unspent**	**Physical progress (%)**	**Reasons for deviation**
Coordinator Office, Director Research Wing, BARI	1145000	10,05000	10,05000	0	100%	
Soil Science Division, BARI, Gazipur	7100000	4872662	4872662	0	0	
Oilseed Division, BARI, Gazipur	4877000	4874285	4874285	0	100%	
Agrarian Research Foundation (ARF)	3650000	3198377	3198377	0	100%	
Grand Total	**16772000**	**13950324**	**13950324**	0	100%	

Coordinator component, BARI

Items of expenditure/ activities	**Total approved budget**	**Fund received**	**Actual expenditure**	**Balance/ unspent**	**Physical progress (%)**	**Reasons for deviation**
a. Contractual staff salary	447693	442429	442429	0	100%	
b. Field research/lab expenses and supplies	0	0	0	0	0	
c. Operating expenses	137396	133660	133660	0	100%	
d. Vehicle hire and fuel, oil & maintenance	9950	9950	9950	0	100%	
e. Training/workshop/ seminar etc.	230000	100000	100000	0	100%	
f. Publications and printing	150000	149000	149000	0	100%	
g. Miscellaneous	89961	89961	89961	0	100%	
h. Capital expenses	80000	80000	80000	0	100%	
Total	1145000	10,05000	10,05000	0	100%	

Component-1: Soil Science Division, BARI

Items of expenditure/ activities	**Total approved budget**	**Fund received**	**Actual expenditure**	**Balance/ unspent**	**Physical progress (%)**	**Reasons for deviation**
a. Contractual Staff Salary	1029211	919096	919096	0	100%	
b. Field Research / Lab expenses and supplies	3508263	1946902	1946902	0	100%	
c. Operating Expenses	628740	366149	366149	0	100%	
d. Vehicle Hire and Fuel, Oil & Maintenance	677089	467846	467846	0	100%	
e. Training/ Workshop/ Seminar etc.	150000	125000	125000	0	100%	
f. Publications and printing	50000	13818	13818	0	100%	
g. Miscellaneous	210297	186851	186851	0	100%	
h. Capital Expenses	846400	847000	847000	0	100%	
Total	**7100000**	**4872662**	**4872662**	0		

Component-2: Oilseed Research Center, BARI

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	1098622	1098097	1098097	0	100%	
b. Field research/lab expenses and supplies	1998912	1998912	1998912	0	100%	
c. Operating expenses	535365	535335	535335	0	100%	
d. Vehicle hire and fuel, oil & maintenance	426280	424120	424120	0	100%	
e. Training/workshop/ seminar etc.	240000	240000	240000	0	100%	
f. Publications and printing	80000	80000	80000	0	100%	
g. Miscellaneous	149621	149621	149621	0	100%	
h. Capital expenses	348200	348200	348200	0	100%	
Total	**4877000**	**4874285**	**4874285**	**0**	100.00	

Component-3: Agarian Research Foundation

Items of expenditure/ activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
a. Contractual staff salary	1201375	1201375	1201375	0	100%	
b. Field research/lab expenses and supplies	1235663	1099040	1099040	0	100%	
c. Operating expenses	370000	270000	270000	0	100%	
d. Vehicle hire and fuel, oil & maintenance	300000	200000	200000	0	100%	
e. Training/workshop/ seminar etc.	150000	75000	75000	0	100%	
f. Publications and printing	60000	40000	40000	0	100%	
g. Miscellaneous	87962	67962	67962	0	100%	
h. Capital expenses	245000	245000	245000	0	100%	
Total	**3650000**	**3198377**	**3198377**	**0**	100.00	

D. Achievement of Sub-project by Objectives (Tangible form): Technology generated/ developed

Component-1(Soil Science Division, BARI)

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
1. To monitor the changes in physico-chemical properties of soils under climate vulnerable area of south central coastal region.	1. Determine soil physical properties, 2. Determinesoil chemical properties	All soil samples from Gopalganj and Barishal were collected and analyzed	Soil fertility status isfind out.
2. To asses soil microbial populations and their seasonal variation from the crop intensification under the changing climate.	1.Determine soil microbial populations and their seasonal variation	All soil samples from Gopalganj and Barishal were collected and analyzed	Soil fertility status is find out.
3. To develop integrated nutrient management packages for high yielding oilseed, pulses vegetables varieties under climate vulnerable area of south central coastal region.	High yield and high value of twenty one varieties of seven different crops with integrated plant nutrition systems bring under the production programs under the project activities.	The mustard varieties such as BARI Sarisha-14, BARI Sarisha-17, mungbean var. BARI Mung-6, grasspea var. BARI Khesari-3, BARI Khesari-5, BARI Gimakolmi-1, sesame var. BARI Til-3, sweet gourd var. BARI Hybrid Mistikura-2, and rice var. BRRI dhan71 were successfully accepted by the farmers'.	More expansion of BARI varieties and increasing cropping intensity and total crop productivity and economic return in south central coastal region
4. To improve farmers' knowledge and skill through training, on-farm trials and demonstrations on improved agricultural production technologies in south central coastal districts.	More intensive cropping systems specific to locations and agro-ecological settings are developed, and farmers' knowledge and skill improved by training, on-farm trials and demonstrations.	Better production technologies for growing lowland rice are developed. Farmers' income and socio-economic conditions are increased in south central coastal region	More expansion of BARI release high yield, tolerant varieties and increasing farmers income through training, on-farm trials and demonstrations

Component-2: (Oilseed Research Center, BARI)

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
General objectives Contribute to enhancing and sustaining food security and farmer's livelihood improvement in the south central coastal region.	Development of innovative suitable and profitable technologies in cropping system and to income enhancement of farmers'.	High yield and high value of twenty one varieties of seven different crops were identified in improve cropping pattern in south central coastal region.	Proper utilization of south central coastal region and higher income creates more acces to food and nutrition.
Specific objectives a. Introduce high yielding oilseed, pulses, and vegetables varieties after T. *aman* rice in south central coastal region.	Cropping pattern development/improvement with varietal intensification and integrated plant nutrition systems in south central coastal region using farm resources judiciously- 1. Mustard-Mungbean-T. aman 2.Grasspea-Gimakolmi-T. aman 3.Sweet gourd–Sesame-T. *aman*	Rice system/ equivalent yield of improvement cropping pattern increased by 70-90% over existing one in different location	Increasing cropping intensity and total crop system productivity in south central coastal region
b. Identify best management practices for high yielding oilseed, pulses, vegetables production of south central coastal region.	High yield and high value of twenty one varieties of seven different crops with integrated plant nutrition systems bring under the production programs under the project activities.	The mustard varieties such as BARI Sarisha-14, BARI Sarisha-17, mungbean var. BARI Mung-6, grasspea var. BARI Khesari-3, BARI Khesari-5, BARI Gimakolmi-1, sesame var. BARI Til-3, sweet gourd var. BARI Hybrid Mistikura-2, and rice var. BRRI dhan71 were successfully accepted by the farmers'.	More expansion of BARI varieties and increasing cropping intensity and total crop system productivity and economic return in south central coastal region
c. Improve farmers' knowledge and skill through training, on-farm trials and demonstrations on improved agricultural production technologies in south central coastal districts.	More intensive cropping systems specific to locations and agro-ecological settings are developed, tested and validated and farmers' knowledge and skill improved by training, on-farm trials and demonstrations.	Better production technologies for growing lowland rice are developed and adaptation to high yield crops and tolerant varieties are identified. Farmers' income and socio-economic conditions are increased in south central coastal region	More expansion of BARI release high yield, tolerant varieties and increasing farmers income through training, on-farm trials and demonstrations

Component-3 (Agarian Research Foundation)

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
Increasing farm income through intensive crop production and improving farmers' knowledge and skill through training, conducting on-farm trials and demonstrations on improved agricultural production technologies in south central coastal region.	1. ARF introduced a long-statured, fine-grain rice variety Kataribhog in relatively higher elevation in coastal area along with traditional long duration rice like Sadamota and Moulata as comparison study. 2. Field Trials on different planting time with short duration mungbean variety.	1. Comparatively short duration fine rice like Kataribhog may useful in flood-free land to introduce grasspea successfully in proper planting time as relay cropping in aman rice field for higher income. 2.Planting time had significant influence on mungbean yield. Although short duration mungbean produced less yield, but farmers may able to harvest at least one pick more.	1. Although Kataribhog produced lower yields, but early harvests of Kataribhog helps for cropping intensity through timely planting of relay-cropped grasspea. In addition, Kataribhog fetches premium price. 2. Early planting of mungbean with short duration variety may ensure higher yield.

E: Information/Knowledge generated/Policy generated

Component-1: Oilseed Research Center, BARI

Not applicable

Component-2: Oilseed Research Center, BARI

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
General objectives Contribute to enhancing and sustaining food security and farmer's livelihood improvement in the south central coastal region.	-Provide formal and informal training -Visit development cropping system in respective location.	-Build up capacity of scientists, DAE personnel and farmers' -Gain knowledge on crop selection for cropping system technology	South central coastal region suitable high value crops have been expanded. Farmers' group based production system also developed.
Specific objectives d. Introduce high yielding oilseed, pulses, and vegetables varieties after T. *aman* rice in south central coastal region.	Improvement of alternate cropping pattern instead of existing cropping pattern in Low Ganges River Floodplain	Improved pattern were tested and 40-60% higher REY was obtained compared to existing pattern.	Modern and high yielding crops varieties have been expanded.
e. Identify best management practices for high yielding oilseed, pulses, vegetables production of south central coastal region.	Mustard-Mungbean-T. *aman* cropping pattern with integrated nutrient management for increasing system productivity in south central coastal regions Sweet gourd–Sesame-T. *aman* cropping pattern with integrated nutrient management for increasing system productivity in Tidal Floodplain (coastal) regions Grasspea - Gimakolmi -T. *aman* cropping pattern with integrated nutrient management for increasing system productivity in south central coastal regions	The following varieties were successfully accepted by the farmers' in tested location- The mustard varieties such as BARI Sarisha-14, BARI Sarisha-17, mungbean var. BARI Mung-6, grasspea var. BARI Khesari-3, BARI Khesari-5, BARI Gimakolmi-1, sesame var. BARI Til-3, sweet gourd var. BARI Hybrid Mistikura-2, and rice var. BRRI dhan71 were successfully accepted by the farmers'.	Modern, short duration and high yielding crops varieties have been expanded.
f. Improve farmers' knowledge and skill through training, on-farm trials and demonstrations on improved agricultural production technologies in south central coastal districts.	Developed technologies were used in pattern and judicial use of all farm resources. Regular observation on production and income	Production program, training, field day and demonstration were done on new technologies. Farmers' profit might be earned by selling the more crops	Farmers' knowledge and social status improved Income, family nutrition of farmers' could be increased/raised.

Component-3

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
Increasing farm income through intensive crop production and improving farmers' knowledge and skill through training, conducting on-farm trials and demonstrations on improved agricultural production technologies in south central coastal region.	1. Established trials on long-statured, fine-grain rice variety Kataribhog relatively in higher elevation in coastal area along with traditional long duration rice like Sadamota and Moulata as comparison study. 2. Field Trials on different planting time with short duration mungbean variety.	1. Comparatively short duration fine rice like Kataribhog may useful in flood-free land to introduce grasspea successfully in proper planting time as relay cropping in aman rice field for higher income. 2. Planting time had significant influence on mungbean yield. Although short duration mungbean produced less yield, but farmers may able to harvest at least one pick more.	1. Although Kataribhog produced lower yields, but early harvests of Kataribhog helps to enhance cropping intensity through timely planting of relay-cropped grasspea. In addition, Kataribhog fetches premium price. 2. Early planting of mungbean with short duration variety may ensure higher yield in changed climate.

F. Materials Development/Publication made under the Sub-project

Component-1(Soil Science Division, BARI)

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaf letlflyer etc.			
Video clip/TV program			
News Paper/Popular Article			
Other publications, if any			

Component-2: Oilseed Research Center, BARI

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet etc.	Booklet-01	Completed	মাদারীপুর অঞ্চলে একই জমিতে বছরে তিনি ফসল সরষিা-মুগডাল-রোপা আমন ধান ফসল ধারা একটি লাভজনক প্রযুক্তি
Journal publication	Journal-01	Acepted and Published very soon	Enhancement of crop productivity of Mustard-Mungbean-T. Aman croppping pattern through new varieties with integrated nutrient management. Bangladesh Journal of Agril. Research.
Video clip/TV program		TV program-02	
Popular Article		News Paper-03	
Other publications, if any			

TV media

TV media

Component-3

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet leaflet/flyer etc.		**01**	
Journal publication	Socio-Economic and Biophysical Constraints of Dry Season Cropping in Tidal Floodplain of Bangladesh. Journal of Applied Agricultural Economics and Policy Analysis. 2019, Vol. 2, No. 1,40-46 (DOI:10.12691/jaaepa-2-1-6)		
Video clip/TV program			
News Paper/Popular Article		**01**	Popular article on “Mungbean cultivation at coastal region”. (Samakal; 12 July 2020)
Other publications, if any			

G. Description of generated Technology/Knowledge/Policy

Component 2:Oilseed Research Center, BARI

Technology Factsheet

Fact sheet-1

Title: Mustard–Mungbean-T. *aman* cropping pattern with integrated nutrient management for increasing cropping intensity and productivity at Madaripur and Gopalgonj regions

Introduction:

Bangladesh has achieved a remarkable progress in increasing food production. Although, there has been a great success in rice production and about to self sufficient in food grain production, but increasing population in future when the natural resources, land and water are shrinking and degrading. Horizontal expansion is very limited, but increase in crop production could be possible with vertical expansion through increasing crop yield per unit area and by reducing production losses. A cropping pattern is the yearly sequence, temporal and spatial arrangement of crops in a given land area. There are some scopes of increasing cropping intensity (250%) by improving the existing cropping patterns by inclusion of short duration of BARI and BRRI release high yielding varieties viz., oilseed crops, pulses, tuber crop, vegetables, T. Aus/Aman/Boro rice in the rice based cropping systern.

Description

Field duration of cropping pattern mainly depends on individual duration of component crops. In farmer's existing cropping pattern farmers used Tori-7 as mustard variety, BRRI dhan-29 in

Sl. No.	Item	Mustard–Mungbean-T. *aman* cropping pattern		
1.	Crop	Mustard	Mungbean	T. *aman*
2.	Variety	BARI Sarisha-14 BARI Sarisha-17 BARI Sarisha-11	BARI Mung-6 BARI Mung-8 BINA Mung-8	BRRI dhan57 BRRI dhan71 BRRI dhan75
3.	Sowing/Planting time	3rd week of October	15-20 March	16-28 August
4.	Sowing/Planting method	Line/Broadcast	Line/Broadcast	Seedling
5.	Seed rate (Kg/ha)	6-7	15-18	Seedling age=20-25d Spacing= 20cm x15 cm
6.	Plot size	5m x 4m	5m x 4m	6m x 5m
7.	Fertilizer dose	Fertilizer : 3 level F_1 = Recommended Fertilizer Dose (RFD) from inorganic source on STB F_2 = RFD on STB + 5 t ha^{-1} cowdung (IPNS approach)		

		F_3 = Farmers practices Recommended dose Mustard: N_{120} P_{46} K_{122} S_{26} Zn_3 B_2 kg ha^{-1}; Mungbean: N_{24} P_{22} K_{24} S_{14} Zn_2 B_2 kg ha^{-1}; T. aman: N_{120} P_{26} K_{100} S_{15} $Zn2_2$ kg ha^{-1}		
8.	Ploughing (no)	3-4	2-3	3
9.	Irrigation (no)	3	1	3
10.	Weeding (no)	2	3	2
11.	Pesticide application (no)	1	1	2
12.	Harvesting time	10-20 February	20-25 July	10-20 October
13.	Yield (tha^{-1})	1.65-1.70	1.55-1.60	5.55-5.60

Boro and Pajam in Aman season. On the other hand in improved pattern BARI Sarisha-14 was used as mustard variety, BRRI dhan-71 was used in Aman. As a result, production efficiency and land use efficiency was higher in improved cropping pattern than existing cropping pattern. Though turnaround time in improved pattern is very crucial so all inputs including land preparation should be done in proper time. Ensuring the use of technology will increase crop density and productivity through the use of fallow dunes. Soil fertility and productivity will be maintained because of legume crop production.

Suitable location:

The technology is suitable in the medium high land of Madaripur, Faridpur district and Low Ganges River Floodplain (AEZ-12) areas.

Benefit of the technology

Considering total system productivity of improved cropping pattern Mustard–Mungbean-T. *aman* recommended fertilizer dose on soil test base with 5 t ha^{-1} cowdung; IPNS approach based fertilizer plots yield was better than farmers practice and BARI Sarisha-14 (1.72 tha^{-1}), BARI Mung-6 (1.69 tha^{-1}) and BRRI dhan71 (5.61tha^{-1}) yielded higher than farmers practice. The total rice (system) yield was 15.90 $tha^{-1}yr^{-1}$ and the benefit cost analysis of gross return, gross margin, and benefit cost ratio were 3,81,490 (Tk ha^{-1} yr^{-1}), 2,16,869 (Tk ha^{-1} yr^{-1}), and 2.32.

Name and contract address of author:
Dr. Md. Shakhawat Hossain
Senior Scientific Officer, Research Wing, BARI
Mobile: 01781539300
Email: *shakhawatbari@yahoo.com*

Mustard

Mungbean

T. *aman*

Fact sheet-2

Title: Grasspea-Gimakolmi-T. *aman* cropping pattern with integrated nutrient management for increasing cropping intensity and productivity in south coastal regions

Introduction:

The cropping system of Bangladesh is usually rice-based as well as diversified, includes tuber crops, pulses, oilseed, vegetables, and other winter cereals like maize and wheat. In the Low Ganges River tract of Bangladesh, T. Boro-T. Aman-potato (dry season rice, mustard-jute-T. aman are the major cropping systems. The productivity and sustainability of rice-based systems are threatened because of inefficient use of inputs, resources, climate change, energy crisis and rising fuel prices, the rising cost of cultivation and emerging socioeconomic changes such as urbanization, migration of labour, preference of nonagricultural work as well as declining soil fertility. Besides, farmers' withdrawal of huge groundwater during the T. Boro rice cultivation, caused the lowering of water tables. Ensuring the use of technology will increase crop density and productivity through the use of fallow dunes. Therefore, an alternative cropping system is needed that will reduce the production cost, increase crop productivity, reduce adverse effects on the environment as well as sustainable food production. One potential way of achieving this is to switch short duration T. Aman (BRRI dhan57) in place of long duration T. aman variety, include high yielding cultivar, discard the T. Boro rice in the existing cropping system and introduce the high value profitable crops in the rice based cropping system.

Description:

The cropping cycle of Grasspea-Gimakolmi-T. *aman* was conducted with the sowing of gimakolmi as the first crop. The next crop was T. *aman* and after harvest of T. aman grasspea

Sl. No.	Item	Grasspea–Gimakolmi-T. *aman* cropping pattern		
1.	Crop	Grasspea	Gimakolmi	T. *aman*
2.	Variety	BARI Khesari -5 BARI Khesari -3 Khesari (Local)	BARI Gimakolmi-1 Subij pata (Local) Golden Line (Local)	BRRI dhan57 BRRI dhan71 BRRI dhan75
3.	Sowing/Planting time	2nd-3rd week of October	13-21 March	16-28 August
4.	Sowing/Planting method	Line/Broadcast	Line/Broadcast	Seedling
5.	Seed rate (Kg/ha)	35-40	-	Seedling age=20-25d

				Spacing= 20cm x15 cm
6.	Plot size	5m x 4m	6m x 5m	6m x 5m
7.	Fertilizer dose	Fertilizer : 3 level F_1 = Recommended Fertilizer Dose (RFD) from inorganic source on STB F_2 = RFD on STB + 5 t ha^{-1} cowdung (IPNS approach) F_3 = Farmers practices Recommended dose Grasspea: N_{20} P_{20} K_{24} S_{12} kg ha^{-1}; Gimakolmi: N_{115} P_{40} K_{55} S_{19} kg ha^{-1}; T. aman: N_{120} P_{26} K_{100} S_{15} $Zn2_2$ kg ha^{-1}		
8.	Ploughing (no)	3-4	2-3	3
9.	Irrigation (no)	-	3	3
10.	Weeding (no)	2	3	2
11.	Pesticide application (no)	1	1	2
12.	Harvesting time	15-25 February	10-15 June	05-10 October
13.	Yield (tha^{-1})	1.65-1.74	60.55-68.33	5.50-5.60

was sown in improving pattern. The experiment was laid out in a randomized complete block design with three replications. The cropping cycle was three crops (Grasspea, Gimakolmi, T. *aman*) consisting of nine varieties, and three fertilizer levels consisting of nine treatments, and three replications. The seedlings of three varieties of T. *aman* rice were transplanted in row to row 25 cm and hill to hill 15 cm spacing.

Suitable location/ecosystem:
The technology is suitable in the medium high land of Madaripur, Gopalgong, Faridpur district and Low Ganges River Floodplain (AEZ-12) areas.

Benefit of the technology
Considering total system productivity of improved cropping pattern Grasspea–Gimakolmi-T. *aman* recommended fertilizer dose on soil test base with 5 t ha^{-1} cowdung; IPNS approach based fertilizer plots yield was better than farmers practice and BARI Khesari -3 (1.74 tha^{-1}), BARI Gimakolmi-1 (68.33 tha^{-1}) and BRRI dhan71 (5.59 tha^{-1}) yielded higher than farmers practice. The total rice (system) yield was 21.95 $tha^{-1}yr^{-1}$ and the benefit cost analysis of gross return, gross margin, and benefit cost ratio were 5,26,680 (Tk ha^{-1} yr^{-1}), 3,07,363 (Tk ha^{-1} yr^{-1}), and 2.41.

Name and contract address of author:
Dr. Md. Shakhawat Hossain
Senior Scientific Officer, Research Wing, BARI
Mobile: 01781539300
Email: *shakhawatbari@yahoo.com*


Grasspea


Gimakolmi


T. *aman*

Fact sheet-3

Title: Development of high-value sweet gourd production in Sweet gourd–Sesame-T. *aman* cropping pattern in south central coastal regions

Introduction:

The dominant cropping pattern practiced in coastal areas is Robi crop-Fallow-T. rice. Late harvesting of T-aman rice and delay tidal floodwater recession triggers about 40-45% and 30-35% of fallow land during rabi and Kharif-1 season. The major field crop of south coastal reagion of Bangladesh is rice (Aman). Farmers cultivate both local and HYV varieties in aman season, respectively. Of the rice varieties, BRRI dhan57, BRRI dhan71 is the most popular HYV rice variety compared with other HYV. But in aman season, cultivation of local rice varieties is popular compared with those of HYV ones. Widely cultivated local aman rice varieties are Jati, Gunshi, Hogla, Hoglapata, Chapal, Moynamoti etc. Actually farmers like to cultivate local varieties in aman season because of their indigenous characters like taller plant height accompanied with insect, disease, waterlogging and salt tolerance capacity and better taste despite their low yield performance compared with higher yields of YHV. Further crops like jute, sweet gourd, sesame, groundnut, mustard, and vegetables specially the winter ones are also being cultivated medium high land in limited scale.

Description:

Sweet Gourd is a very versatile use for cooking and among varied vegetables, it is appreciated by consumers because of its fruits, tender stems, leaves and even flowers used as vegetables

Sl. No.	Item	Sweet gourd–Sesame-T. *aman* cropping pattern		
1.	Crop	Sweet gourd	Sesame	T. *aman*
2.	Variety	BARI Mistikumra-2 BARI Hybrid Mistikumra-2 BARI Hybrid Mistikumra-3	BARI Til-3 BARI Til-4 BINA Til-4	BRRI dhan57 BRRI dhan71 BRRI dhan75
3.	Sowing/Planting time	2nd-3rd week of October is best	13-21 March	16-28 August
4.	Sowing/Planting method	Pit	Broadcast	Seedling
5.	Seed rate (Kg/ha)	5-6	7-8	Seedling age=20-25d

				Spacing= 20cm x15 cm
6.	Plot size	5m x 5m	5m x 5m	6m x 5m
7.	Fertilizer dose	Fertilizer : 3 level F_1 = Recommended Fertilizer Dose (RFD) from inorganic source on STB F_2 = RFD on STB + 5 t ha^{-1} cowdung (IPNS approach) F_3 = Farmers practices Recommended dose Sweet gourd: N_{95} P_{45} K_{75} S_{26} Zn_3 B_2 kg ha^{-1}; Sesame: N_{95} P_{40} K_{75} S_{25} Zn_2 B_2 kg ha^{-1}; T. aman: N_{120} P_{26} K_{100} S_{15} Zn_2 kg ha^{-1}		
8.	Ploughing (no)	3-4	2-3	3
9.	Irrigation (no)	3-4	1	3
10.	Weeding (no)	2	3	2
11.	Pesticide application (no)	1	1	2
12.	Harvesting time	15-25 March	10-15 July	05-10 October
13.	Yield (tha^{-1})	36-41	1.35-1.39	5.12-5.25

both at green and ripen stages. Cultivation of BARI-develop Hybrid Mistikumra under improved management increased the yield by 39% and net income by 35% as compared to conventional varieties. Ensuring the use of technology will increase crop density and productivity through the use of fallow dunes.

Suitable location/ecosystem:
The technology is suitable in the medium high land of Bagerhat, Khulna district and Tidal Floodplain (AEZ-) areas and unfavorable ecosystem.

Benefit of the technology
Considering total system productivity of improved cropping pattern Sweet gourd–Sesame-T. *aman* recommended fertilizer dose on soil test base with 5 t ha^{-1} cowdung; IPNS approach based fertilizer plots yield was better than farmers practice and BARI Hybrid Mustikumra-2 (41.00 tha^{-1}), BARI Til-3 (1.77 tha^{-1}) and BRRI dhan71 (5.62 tha^{-1}) yielded higher than farmers practice. The total rice (system) yield was 24.87 $tha^{-1}yr^{-1}$ and the benefit cost analysis of gross return, gross margin, and benefit cost ratio were 5,96,940 (Tk ha^{-1} yr^{-1}), 3,61,536 (Tk ha^{-1} yr^{-1}), and 2.54.

Name and contract address of author:
Dr. Md. Shakhawat Hossain
Senior Scientific Officer, Research Wing, BARI
Mobile: 01781539300
Email: *shakhawatbari@yahoo.com*

Sweet gourd

Sesame

T. *aman*

Fact sheet-3

Title of the technology: **Crops in fallow land at coastal region**

Introduction

More than one third farm households in the coastal area are now cultivating only one crop in a calendar year, i.e. aman rice during monsoon while most of the cultivable land remains almost barren in dry season. As a result, cropping intensity in coastal area is very minimum compared to national average. In coastal area, a large number of households are suffering from malnutrition while it retards child growth. Most of the households in this area not having balance diet, remain undernourished and become easily susceptible to disease. Pulses crops likes lentil, mungbean, grass pea, cowpea, etc. are the traditional pulses crops of Bangladesh and was grown well in Bangladesh including coastal belt. Pulses having high nutritive value which consumed mainly as *dal* along with rice as one of the most popular dish called *dal-bhat*. These crops remain staple food-stuffs to this day but their production in coastal area is declining due to untimely as well as unexpected rainfall in dry season, water-logging situation in coastal-belt as well as increased salinity in the south due to climate change. Pulses in Bangladesh are the only source of nutrition in the family diet of poor households. Thus, production of pulses would be good means to improve household food and nutrition security. Pulses are suitable for standing cropping process as it needs less time or less term, less input and aridity tolerant quality. To alleviate human malnutrition for the poorest segment of the country's population, pulses have been identified as crops with excellent potential.

Description/Justifications

Thus, climate-smart technology of pulses production should be developed for dry season which may introduce in aman (monsoon) rice-based cropping system at coastal Bangladesh. The main biophysical impediments to increasing pulses cultivation in Bangladesh relate to late harvest of aman rice. Generally, farmers go for winter crops like pulses cultivation after harvesting of aman rice. The proper time to cultivate most of pulses crops is in November. But due to presence of

aman rice crops in most of the lands in November, farmers have no scope to avail the right time to cultivate such winter crops.

S**uitable location/ecosystem:** Entire coastal region may applicable for this system.

Benefits

ARF conducted a research with fine grain premier rice variety Kataribhog along with traditional rice variety Sadamota and Moulata where it was found that Kataribhog produced 20-25% lower yield, but the variety matured at least two weeks earlier which enabled farmers timely planting of grasspea as relay-cropping in aman rice field. After harvesting of aman rice, as sole crop of mungbean cultivation in different planting time, it was found that the higher yield (1,770 kg ha^{-1}) was ensured from 25 January planting time which was much earlier than farmers' practices. Normally, in coastal region, farmers are cultivation mungbean in February. BU mug 5 yielded higher giving successive harvests prior to Cyclone and rainstorm affected second harvest of BARI Mung-6. Although yielding capacity of BARI Mung-6 is higher, but shorter duration variety may suitable in such hazard condition which is now occurred very often.

Contact address of author:

Md. Mahirul Islam Biswas, Research Associate, Agarian Research Foundation

Cell phone: 01715-333154, Email: *mahirul71@gmail.com*

H. Technology/Knowledge generation/Policy Support (as applied)

i. Immediate impact on generated technology (commodity & non-commodity)

- ❖ Increase vegetables, cereals, pules, and oilseed crop production as well as farmers' income could be possible in coastal region of six districts
- ❖ Increases high value crops production as well as farmers' income could be enhanced and creates women employment opportunitie for coastal region.

ii. Generation of new knowledge that help in developing more technology in future

- ➢ More effort should be given in generation of technology in future in coastal region.
- ➢ Mustard and mungbean can be contributed to reduce the deficit of imported pulse and edible oil.
- ➢ Cultivation of high value and HYV of vegetables, oil crops, and pulse crop in develop pattern will be helpful to increase total productivity in coastal regions.

iii. Technology transferred that help increased agricultural productivity and farmers' income

- ✓ Three crop based improve/ alternate cropping pattern (Mustard–Mungbean-T. *aman* , and rice based pattern with high yield of crops like Khesari, blackgram, and vegetables etc) could enhanced crop productivity an increase cropping intensity in coastal region.

- ✓ Integrated nutrient management with best management packages for high yielding oilseed, pulses, and vegetables crop to be highlighted as per sub-project objectives.
- ✓ More on-farm/demonstration trail to be given in collabotation with extension personels'.
- ✓ More fact sheet/ bulletin about best management practices for high yielding oil seed, pulses, and vegetables crop may be given to DAE/ PO's for dissemination of the technology.

iv. Policy support

- ❖ Agricultural productivity and income could be posible as well as livelihood parameters could be improved in coastal region integrated nutrient management with best management pakages for high yieldind oilseed, pulses, and vegetables crop.
- ❖ Government policy should be strengthened in respect of cropping system activity as well as envionmental issues.

I. Information regarding Desk and Field Monitoring

i. Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.)

- ➢ Coordinating component/unit, BARI was done properly.

ii. Field Monitoring (date & no. of visit, name and addresses of team visit and output)

Component-2: Oilseed Research Center, BARI

Location: Madaripur Sadar & Kalkini Upazilla, Madaripur

Date	No. of visit	Name and addresses of team visit	Output
22-02-2022 & 23-2-2022	1	Dr. Md. Harunur Rashid, Director, PIU-BARC, NATP-2	Visitors express their high satisfaction and suggested for farmers and BARI team further improvement and dissemination of activities
		Mr. Mohammad Shahidul Islam, Procurement Specialist	
		Dr. Mohammad Abdullah Al Faroque, Assistant Manager (Administration)	
		Mr. Md. Ashequar Rahman, Assistant Manager (Accountants)	
		Mr. Munshi Mamunur Rahman, Documentation Associate	

Fig 1. Members of the monitoring team visited the project activities at Madaripur sadar and Kalkini upazila, Madaripur

Location: Bagerhat sadar and Mollarhat Upazilla, Bagerhat

Date	No. of visit	Name and addresses of team visit	Output
25-02-2022	1	Dr. Md. Harunur Rashid, Director, PIU-BARC, NATP-2	Visitors express their high satisfaction and suggested for farmers and BARI team further improvement and dissemination of activities
		Mr. Mohammad Shahidul Islam, Procurement Specialist	
		Dr. Mohammad Abdullah Al Faroque, Assistant Manager (Administration)	
		Mr. Md. Ashequar Rahman, Assistant Manager (Accountants)	
		Mr. Munshi Mamunur Rahman, Documentation Associate	

.

Fig 2. Members of the monitoring team visited the project activities at Bagerhat sadar and Mollarhat upazila, Bagerhat

iii) Enviromental data

(a) <u>Weather data of Madaripur district from May 2020 to April 2021</u>

Average rainfall (mm) and temperature (^{O}C) of Madaripur from May 2020 to April 2021

Month	Date	Max. Temp.	Min. Temp.	Total Rainfall	RH (%)	Sunshine (hrs./day)	Cloud (hrs./day)
		Average (^{O}C)		(mm)	Average		
July 2020	1-31 July	32.83	28.4	284.7	81.3	5.26	8.10
August 2020	1-31 Aug	32.50	27.16	82.56	82.16	3.1	9.66
September 2020	1-30 Sept	32.76	26.77	188	77.76	4.76	7.6
October 2020	1-31 Oct	31.80	26.36	49.0	72.53	6.43	5.0
November 2020	1-30 Nov	25.13	20.26	20.9	77.7	5.53	5.47
December 2020	1-31 Dec	24.0	17.83	80.0	84.70	5.0	5.63

January 2021	1-31 Jan	24.43	15.0	0.0	75.17	5.2	5.6
Febrary 2021	1-28 Feb	24.67	13.9	24.0	74.23	7.27	3.93
March 2021	1-31 Mar	33.43	19.53	0.0	76.63	7.53	4.43
April 2021	1-30 April	34.13	26.83	10.0	71.3	7.0	5.6
May 2021	1-30 May	35.47	27.33	30	70.9	6.8	5.3
June 2021	1-30 June	35.65	28.81	200	75	5.64	7.8

(b) Average rainfall (mm) and temperature (^{O}C) of Bagerhat from May 2020 to April 2021

Month	Date	Max. Temp.	Min. Temp.	Total Rainfall	RH (%)	Sunshine (hrs./day)	Cloud (hrs./day)
		Average (^{O}C)		(mm)	Average		
July 2020	1-31 July	32.0	26.9	409.1	83.3	4.16	7.10
August 2020	1-31 Aug	32.2	26.8	438.6	85.26	3.41	8.66
September 2020	1-30 Sept	31.8	26.0	287.1	75.16	4.76	6.46
October 2020	1-31 Oct	32.6	24.2	337.2	70.53	7.43	4.9
November 2020	1-30 Nov	31.1	19.0	0.8	76.7	5.93	4.47
December 2020	1-31 Dec	27.7	16.7	104.7	83.70	4.0	4.63
January 2021	1-31 Jan	28.9	16.1	4.4	60.17	5.82	4.6
Febrary 2021	1-28 Feb	31.1	17.3	56.1	65.23	6.37	3.23
March 2021	1-31 Mar	39.1	21.7	6.0	66.63	6.83	4.73
April 2021	1-30 April	39.7	25.1	3.3	69.3	7.30	4.6
May 2021	1-30 May	35.9	26.6	389.5	85.9	5.28	3.3
June 2021	1-30 June	31.9	25.9	543.1	86.6	4.73	5.8

(c) Average rainfall (mm) and temperature (^{O}C) of Gopalgonj from May 2020 to April 2021

Month	Date	Max. Temp.	Min. Temp.	Total Rainfall	RH (%)	Sunshine (hrs./day)	Cloud (hrs./day)
		Average (^{O}C)		(mm)	Average		
July 2020	1-31 July	34.83	27.4	408.8	81.3	5.26	8.18
August 2020	1-31 Aug	33.50	26.16	446.5	82.16	3.17	9.67
September 2020	1-30 Sept	34.76	25.77	277.65	77.76	4.76	7.63
October 2020	1-31 Oct	27.80	23.36	333.76	72.53	6.43	5.06
November 2020	1-30 Nov	25.13	18.26	0	77.7	5.53	5.45
December 2020	1-31 Dec	23.0	16.83	0	84.70	5.08	5.67
January 2021	1-31 Jan	24.43	14.0	0	75.17	5.25	5.63

Febrary 2021	1-28 Feb	24.67	18.9	0	74.23	7.27	3.91
March 2021	1-31 Mar	33.43	22.53	0	76.63	7.53	4.49
April 2021	1-30 April	35.13	25.83	214.44	71.3	7.05	5.4
May 2021	1-30 May	36.47	26.34	317.82	70.9	6.81	6.3
June 2021	1-30 June	33.67	27.85	583.45	75	5.64	7.9

(d) Average rainfall (mm) and temperature (^{O}C) of Barishal from May 2020 to April 2021

Month	Date	Max. Temp.	Min. Temp.	Total Rainfall	RH (%)	Sunshine (hrs./day)	Cloud (hrs./day)
		Average (^{O}C)		(mm)	Average		
July 2020	1-31 July	31.88	26.12	397.60	91.3	5.26	8.10
August 2020	1-31 Aug	31.54	26.13	274.50	82.16	3.1	9.66
September 2020	1-30 Sept	32.03	25.11	220.65	83.76	4.76	7.6
October 2020	1-31 Oct	33.91	23.74	285.21	84.53	6.43	5.0
November 2020	1-30 Nov	29.69	19.19	2.30	87.7	5.53	5.47
December 2020	1-31 Dec	25.63	12.83	0	84.70	5.0	5.63
January 2021	1-31 Jan	23.66	12.75	81.10	75.17	5.2	5.6
Febrary 2021	1-28 Feb	24.29	12.83	0	79.23	7.27	3.93
March 2021	1-31 Mar	34.05	22.86	2.40	84.63	7.53	4.43
April 2021	1-30 April	35.05	25.23	8.00	79.3	7.0	5.6
May 2021	1-30 May	35.47	27.33	32.1	75.9	6.8	5.3
June 2021	1-30 June	35.65	28.81	5.00	74	5.64	7.8

J. Sub-project Auditing (covers all types of audit performed)

Coordinator Component, BARI

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
GoB	No observation	5,50,000.00	30 June, 2020	Satisfactory
GoB	No observation	3,50,000.00	30 June, 2021	Satisfactory
GoB	No observation	2,50,000.00	30 June, 2022	Satisfactory

Component-1: Soil Science Division, BARI

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
GoB	No observation	20,87,500.00	30 June, 2020	Satisfactory
GoB	No observation	19,87,500.00	30 June, 2021	Satisfactory

GoB	No observation	18,87,000.00	30 June, 2022	Satisfactory

Component-2: Oilseed Research Center, BARI

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
GoB	No observation	16,87,510.00	30 June, 2020	Satisfactory
GoB	No observation	12,80,890.00	30 June, 2021	Satisfactory
GoB	No observation	14,21,000.00	30 June, 2022	Satisfactory

Component-3: Agarian Research Foundation

Types of audit	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
GoB	No observation	12,80,000.00	30 June, 2020	Satisfactory
GoB	No observation	12,80,000.00	30 June, 2021	Satisfactory
GoB	No observation	10,01,000.00	30 June, 2022	Satisfactory

K. Lessons Learned:

- To utilize fallow or unfavourable coastal land/ areas to produce suitable high value crops and increase farm income.
- Develop and improved cropping pattern with integrated nutrient management for increasing total system productivity and economic return in south central coastal region.
- Motivational program/training/group discusion/development of LSP would be helpful for wide scale adaption of cropping system technology.

L. Challenges (if any):

- Some challenges are defined in relation to climate change.
- Lack of proper knowledge on mordern agricultural production technology of the coastal farmers'.
- Lack of training facilities for fermers' scientific staff and personels' on develop technology.
- Soil nutrient management should be given priority in the coastal area
- Lack of labour, high yield and quality seed, planting materials, inputs in cropping season.
- Due to COVID-19 is the major constrained for proper visit trial plots physically. However, Field Assistants are visiting trial plots from the beginning of the program as per planned activities and collected data and relevant information accordingly while component (PI)

office always communicating with the field office and farm households through mobile phone.

M. Suggestions for Future Planning (if any):

- ❖ Local Service Provider used to establish at each location for sustainable mechanization, seed/seedling, inputs, and supply exchange system.
- ❖ Market channels needs to develop for ensuring maximum price of farmers' product.
- ❖ Soil health needs to be well addressed in case of three crops pattern.
- ❖ Multidisciplinary team including agronomist, soil scientist, entomologist, pathologist, economist and farmers' should be engaged for the development of variable cropping system technoloies.
- ❖ More training programs for famers' on production and management as well as integrated nutrient management technologies aspects..
- ❖ Strengthening of research for development of short duration high yielding varieties, pest and disease management technologies.

N. Concluding Remarks

- ❖ Improve cropping system research and development activities should be strengthened in coastal region.
- ❖ Strong linkage should be developed among the NARS, DAE, Agriculture University and NGOs for dissemination of the technology.
- ❖ This type of research project should be continued at least 5 years to get better findings for the improvement of the said areas.

O. References:

Aziz, I., T. Mahmood, K. R. Islam and E. Ashraf. 2013. Estimation of cropping system impacts on C and N status of soil. Int. J. Agric. Appl. Sci. **5(1):** 1-7.

Alam, M. J., E. Humphreys, M. A. R. Sarkar and Y. Sudhir. 2017. Intensification and diversification increase land and water productivity and profitability of rice-based cropping systems on the High Ganges River Floodplain of Bangladesh. Field Crops Res. **209:** 10–26.

Bangladesh Agricultural Research Council (BARC). 2011. Planning for the Use of Fallow Land in Southern Region of Bangladesh (in Bangla). Bangladesh Agricultural Research Council, Dhaka. 64 pp

Bangladesh Bureau of Statistics (BBS). 2011. Household Income and Expenditure Survey 2000. Ministry of Planning, Government of Bangladesh, Dhaka

Bangladesh Bureau of Statistics (BBS). 2017. Yearbook of Agricultural Statistics 2016. Ministry of Planning, Government of Bangladesh, Dhaka.

Bangladesh Bureau of Statistics (BBS). 2017. Yearbook of Agricultural Statistics 2016. Ministry of Planning, Government of Bangladesh, Dhaka.

DAE (Department of Agriculture Extension). 2016. Department of Agriculture Extension, Paper presented in the regional research extension review and program planning workshop, Kushtia.

Food and Agriculture Organization of the United Nations (FAO). 2013. Master Plan for Agricultural Development in the Southern Region of Bangladesh. Dhaka, 104 pp.

Hamid, A. 2010. Rice production in tidal ecosystem. Farmers fail to harness the benefits of green revolution, pp.1-7. In Crop Production in the Coastal Ecosystem: Challenges and Opportunities, Agrarian Research Foundation, Dhaka.

Hamid, A., M. J.Ullah, M. A. Siddique, M. A. Akbar, M. M. Rahman, M. G. Neogi, M. F. H. Mollah, M. A.Razzaque and M. A. Hossain. 2016. Improving Rice Yield in Tidal Floodplain: Optimizing Seedling Age and Transplanting Date, Agriculture, Forestry and Fisheries. **5:** 48-56. doi: 10.11648/j.aff.20160503.14

Hamid, A., M. Ullah, M. Haque, M.H. Mollah, and Rahman, M. 2015. Improving Grain Yield of Indigenous Rice in Tidal Floodplain of Southern Bangladesh: Effect of Seedling Age and Transplanting Method. Agricultural Sciences, **6**: 1538-1546.

Huq, N., J. Huge, E. Boon and A.K. Gain. 2015. Climate change impact in agricultural communities in rural areas of coastal Bangladesh: A tale of many stories. Sustainability **7:** 8437-8460

Hossain, I., R. I. Mondal, M. J. Islam, A. Aziz, A. S. M. M. R. Khan and F. Begum. 2014. Four crop based cropping pattern studies for increasing cropping intensity and productivity in Rajshahi region of Bangladesh. *Bangladesh Agron. J.* **17(2):** 55-60.

Islam, M. A., M. E. Haq, M. K. Hossain and M. S. Hossen. 2015. Investigation of formalin and ethepon in some fruits of three local markets of Mymensingh district using gas chromatograph. J. Bangladesh Agril Uni. **13:** 7–12.

Islam, M. A., S. Parvin and M. A. Faruk. 2017. Impacts of riverbank erosion hazards in the Brahmaputra floodplain areas of Mymensingh in Bangladesh. *Prog. Agri.* **28:** 73-83.

Mondal, R. I., F. Begum, A. Aziz and S. H. Sharif. 2015. Crop sequences for increasing cropping intensity and productivity. SAARC J. Agril. **13(1):** 135- 147.

Nazrul, M. I., M. K. Hasan and M. R. I. Mondal. 2017. Production potential and economics of mungbean in rice based cropping pattern in Sylhet region under AEZ 20. Bangladesh J. Agril. Res. **42(3):** 413-424.

Poulton, P.L. 2011. Sustainable intensification of Rabi cropping in southern Bangladesh using wheat and mungbean. ACIAR Technical Reports No. 78. Australian Centre for International Agricultural Research: Canberra. 256 pp

Rahman, S. and M.H. Kazal. 2015. Determinants of crop diversity in the regions of Bangladesh (1990-2008). Singapore J. Tropical Geogr. *http://hdl.handle. net/ 10026.1 /3774*

Saha, D., M.S.S.Hossain, M.S. Mondal and R.Rahman. 2016. Agricultural adaptation practices in coastal Bangladesh: Response to climate change impacts. J. Modern Sci Technol. **4:** 63-74.

Soil Resource Development Institute (SRDI). 2010. Saline Soils of Bangladesh. Ministry of Agriculture, Government of Bangladesh, Dhaka. pp.60

Sultana, J., M. N. A. Siddique and M. R. Abdullah. 2015. Fertilizer recommendation for Agriculture: practice, practicalities and adaptation in Bangladesh and Netherlands. Int. J. Bus. Manag. Soc. Res. **1(1):** 21-40.

Ullah, M.J. ,M. A. Islam, M. H. Rashid, M. M. Rahman, M. A. Siddique, M. A. Akbar, M. A.Razzaque, M. F. H. Mollah and A. Hamid. 2016. Evaluation of Indigenous and High Yielding Rice Varieties for Growing in Tidal Floodplain Ecosystem of Southern Bangladesh, Agriculture, Forestry and Fisheries. Vol. 5, No. **6:** 237-242.

Signature of the Coordinator
Date …….

Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal