Project ID: 811

Competitive Research Grant

Sub-Project Completion Report

on

Development and Dissemination of Fertilizer Deep Placement Applicator for Increasing Fertilizer Use Efficiency and Farm Productivity

Project Duration

May 2017 to September 2018

Regional Agricultural Research Station
Bangladesh Agricultural Research Institute
Rahmatpur, Barishal-8211

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

September 2018

Competitive Research Grant

Sub-Project Completion Report

on

Development and Dissemination of Fertilizer Deep Placement Applicator for Increasing Fertilizer Use Efficiency and Farm Productivity

Project Duration

May 2017 to September 2018

Regional Agricultural Research Station
Bangladesh Agricultural Research Institute
Rahmatpur, Barishal-8211

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

September 2018

Citation
Development and Dissemination of Fertilizer Deep Placement Applicator for Increasing Fertilizer Use Efficiency and Farm Productivity

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

Edited and Published 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 CRG sub-project has successfully been completed by Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal-8211 using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thanks to the World Bank for arranging the grand fund and supervising the CRGs 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 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 made it possible, deserve thanks. Our thanks are due to the PIU-BARC, NATP 2, NRM Division, BARC and their team for their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for 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: September 2018

Printed by: pdf version

Acronyms

CRG	:	Competitive Research Grant
GoB	:	Government of Bangladesh
USAID	:	United States Agency for International Development
PIU	:	Project Implementation Unit
BARC	:	Bangladesh Agricultural Research Council
NATP	:	National Agricultural Technology Program
BARI	:	Bangladesh Agricultural Research Institute
BRRI	:	Bangladesh Rice Research Institute
IFDC	:	International Fertilizer Development Centre
LoA	:	Letter of Agreement
FDP	:	Fertilizer Deep Placement
AAPI	:	Accelerating Agriculture Productivity Improvement
PVC	:	Polyvinyl Chloride
DMRT	:	Duncan's Multiple Range Test
UAO	:	Upazila Agricultural Officer
DAE	:	Department of Agricultural Extension
USG	:	Urea Super Granule
NPK	:	Nitrogen Phosphorus Potassium
Pis	:	Pieces
cm	:	centimeter
CV	:	Coefficient of Variation
mm	:	millimeter
BHM	:	BARI Hybrid Maize

Table of Contents

Executive Summary

The sub-project entitled, "**Development and Dissemination of Fertilizer Deep Placement Applicator for Increasing Fertilizer Use Efficiency and Farm Productivity**" was implemented in three districts viz., Faridpur (Faridpur Sadar and Modhukhali upazilas), Barisal (Babuganj, Agoiljhora) and Bhola (Bhola Sadar) districts during May-2017 to September-2018 under PIU-BARC, NATP-2 project. In this regard, a series of works were executed on different types of fertilizer applicator, laboratory testing, designing, modification and retesting of fertilizer applicator under laboratory condition, field test, modification and redesign of fertilizer applicator, production of prototype of fertilizer applicator and demonstration of field performance of fertilizer applicator as per the project work plan. The deep placements of prilled urea was done by newly designed different types of applicator (as developed under this sub-project) in different upland crops (maize, potato, brinjal, chili, cauliflower, cabbage, tomato, bottle gourd, sweet gourd and snake gourd) and wetland crops (T.*aman* and *Boro* rice) in the project areas. The design of single row prilled urea applicator was given in the methodology section. The newly designed applicator was sent to the manufacturer. After completing the production of the prototype some were distributed to the farmers of the selected project locations. The research equipment (Digital Moisture Meter and Digital pH Meter) were procured as per "Annual Procurement Plan (2017-18)". Data were collected on Aus rice, Aman rice and Rabi crops (maize, potato cauliflower, cabbage, tomato, bottle gourd, sweet gourd) from different areas of the project locations. The collected data were analyzed statistically and were interpreted accordingly. The results of all crops were described in the results and discussion section along with the economic analysis. Among all treatments the deep placement treatments gave the higher results in all crops. The yield increase percentage was high in the deep placement treatments. But the rice cultivation was not economically viable for the farmers due to high production cost and low market price. Some field days were arranged at the farmers' field to show the findings of the research directly to the farmers and the DAE personnel.

The sub-project reports (Inception report, quarterly report, half yearly report, annual report and project completion report) were prepared using the research findings and submitted to the PIU-BARC, NATP-2.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG Sub-Project:

Development and Dissemination of Fertilizer Deep Placement Applicator for Increasing Fertilizer Use Efficiency and Farm Productivity

2. Implementing Organization:

Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal-8211

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

a. Principal Investigator:

Dr. Md. Abdul Wohab, Chief Scientific Officer, Regional Agricultural Research, Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal-8211.
Tel.: 0432-773361; Cell: 01711288081; E-mail: m.wohab@yahoo.com

b. Co-principal Investigators (Full address with phone and e-mail) :

I. Dr. Md. Alimur Rahman, Senior Scientific Officer (Agronomy), Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal-8211. Tel.: 0432-773361; Cell: 01712158612; E-mail: alimur@bari.gov.bd

II. Sk. Shamshul Alam Kamar, Scientific Officer (Agricultural Engineering), Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal-8211. Tel.: 0432-773361; Cell: 01724461414; E-mail: alamkamar91@gmail.com

4. Sub-project budget (Tk):

4.1 Total: 34,98,218/- (Taka thirty four lakh ninety eight thousand two hundred eighteen only)

4.2 Revised: 34,98,218/- (Taka thirty four lakh ninety eight thousand two hundred eighteen only)

5. Duration of the sub-project:

5.1 Start date (based on LoA signed): 14 May, 2017

5.2 End date: 30 September, 2018

6. Justification of undertaking the sub-project:

The global population is expected to increase from more than 7 billion today to 9.2 billion by 2050 that creating enormous challenges for the worlds to provide adequate quantities of nutritious food, fertilizer management practice is more important. Fertilizer deep placement (FDP) technology is used in several developing countries to increase the crop yields and income with using less amount of fertilizer. FDP also has a favorable impact on local and national economic development while reducing environmental damage to the atmosphere and water supply.

Fertilizer deep placement (FDP) is an innovative, proven fertilizer application technology that reduces farmers fertilizer expenses (because they use less), increases yields and decreases the negative environmental impacts of fertilizers. FDP is more effective than the tradition method of applying fertilizer by surface broadcasting across a field. When urea is broadcast in paddled rice field, a large proportion of the nitrogen (N) is wasted when it converts to harmful greenhouse gases that contribute to atmospheric population and global warming. Additional

amounts are converted to nitrate, which are mobile in the soil and can contaminate ground water. N also can pollute nearby water ways if paddy water escapes the containing bounds around the field. FDP urea is deep placed into the soil, where majority remains in the forms of ammonium which is much less mobile than nitrates. As a consequence, more N is available to the rice plant through its growth cycle. Consequently, N losses to the atmosphere, ground water and water ways are drastically reduced. Only 4% of N is lost to the environment, compared with 35% when N is applied via broadcasting. Two third is absorbed by the rice grain and straw compared to one third when the broadcast application method is used.

Urea is emerged as an important nitrogen fertilizer for rice production, in Bangladesh. Statistics indicatives that about 80% of total urea in used for rice production. But only 15 to 35% of the total N is used by the rice plant. N loss caused due to ammonia volatilizations, de-nitrification, run off, seepage and matching. FDP reduces wastage of urea about 35% and increase rice yield by 15-20%.While FDP has been used most widely on rice, field trials indicate that the technology is applicable to cereal and vegetable crops which are dependent on N for full growth, as well as other crops such as potatoes, sunflower and maize. Yields increase about 15-20% with 15-20% less N application. N requirement of vegetable is very high. Use of FDP in vegetable production is more effective than prilled urea broadcast. The growth of vegetable is more uniform and better quality. Economic benefit of fertilizer is more in FDP than broadcast practice.

International Fertilizer Development Centre (IFDC) has conducted 5 years project on ‘Accelerating Agriculture Productivity Improvement (AAPI) in 22 districts of Bangladesh. Through AAPI, about 1800 briquette machine have distributed to the briquette manufacturer. But, due to lack of appropriate applicator, the FDP technology could not sustain. In the project, IFDC used only urea briquette for deep placement. Now, different fertilizer factories are producing bold size urea granules. This bold size urea can be used for deep placement in different crop production by using a well-designed prilled urea applicator.

FDP is a proven technology for growing rice and other crops. Generally, 1.8 g and 2.7 g sizes of urea briquette are used for crop production. But, these sizes of urea briquette are placed at wider spacing (40 cm) along the rows. When urea briquette is placed at the center of 4 hills, specially, when briquettes are placed by using applicator, proper spacing are not maintained. Sometimes, spacing along the rows may vary 15-20% or urea briquettes may not place at the center of 4 hills. As a result, plant growth is not uniform and green. Plant becomes yellowish which reduce crop yield. But use of prilled urea continuously in furrows at proper depth and rate can increase crop yield. Moreover, production of briquette from prilled urea is difficult and cost involvement. It is not easily available to the farmers. Therefore, development of a prilled urea applicator for deep placement is also important.

7. Sub-project Goal:

The goal of this project is to increase fertilizer use efficiency and crop yield by fertilizer deep placement using fertilizer applicator.

8. Sub-project objectives:

i. To develop and promote fertilizer applicator for fertilizer deep placement.
ii. To increase fertilizer use efficiency by fertilizer deep placement under the soil.
iii. To increase crop production with saving of fertilizer and environment pollution.

9. Implementation locations:

District	Upzilla
Faridpur	Faridpur Sadar, Modhukhali
Barisal	Babuganj, Agoiljhora
Bhola	Bhola Sadar

10. Methodology:

Different types of fertilizer applicator available in the country were collected. Five types of applicator which were collected:

1. IFDC Injector type applicator
2. IFDC Single row USG applicator
3. BARI Double row USG applicator
4. BRRI Double row prilled urea applicator
5. BRRI Double row USG applicator

The laboratory and field performances were conducted at the workshop of RARS, Rahmatpur, Barishal. Based on the test results, best applicator was selected for use at farmers' fields. Necessary modifications (fertilizer meter, delivery system, hopper size and gasket etc) were done to the applicator for proper use under field condition. As the designed applicator was prilled urea applicator, continuous dropping was needed for prilled urea. So the metering device was modified for continuous dropping of prilled urea. The delivery system was continuous, for that the fertilizer loss was high at the end of each row. Clutching system was induced with the handle for preventing the fertilizer loss at the end of every row. The hopper size was small, we modified the hopper and the size was increased than the previous applicators. Final design of the prilled urea applicator were fixed and send to the manufacturer. After manufacturing, the applicators were distributed to the farmer level.

Crops which was used in the project area were;

i. Upland crops: Maize, potato, cauliflower, cabbage, tomato, sweet gourd and bottle gourd.

ii.Wetland crop: Rice (T *Aus*, T.*Aman* & *Boro*)

Types of Applicator which were developed:

i. Single row prilled urea applicator for wet land rice

ii.Injector type prilled urea applicator for upland vegetables

Single row prilled urea applicator was developed for wetland crop. The other applicator was tested under laboratory condition. On the basis of laboratory and field tests results, the design of the upland prilled urea applicator was finalized.

Field performance test of IFDC Single row USG applicator

Field performance test of Single row USG applicator was conducted at RARS, Rahmatpur, Barishal. Paddy seedlings were transplanted just after puddling of land. Applicator test was conducted 10 days after transplantation. The main objectives of this test were; spacing of USG along the row, depth of placement, missing of USG, broken of USG. According to the test results the necessary modifications were done in those points. Test was conducted in different water depth. Two types of furrow openers were used to compare their USG placement performances. The test results were given in Table 11.1 at results and discussion section.

Figure 10.1. Field Performance test of IFDC Single row USG Applicator

Field performance test of Single row prilled urea applicator

Field performance test of newly developed single row prilled urea applicator was conducted at RARS, Rahmatpur, Barishal. Applicator test was conducted 10 days after transplanting. The main objectives of this test were; depth of placement, missing of urea and fertilizer rate fixation and delivery system. Test was conducted in different water depth. Two types of furrow openers were used to compare, how accurately the narrow furrow closed. A test was done for 10 revolutions for fixing the metering device. According to the test results necessary modifications were done in the selected topics. The test results were given in Table 11.2 at results and discussion section.

Figure 10.2. Field Performance test of Single row Prilled Urea Applicator

Design and specification of single row prilled urea applicator:

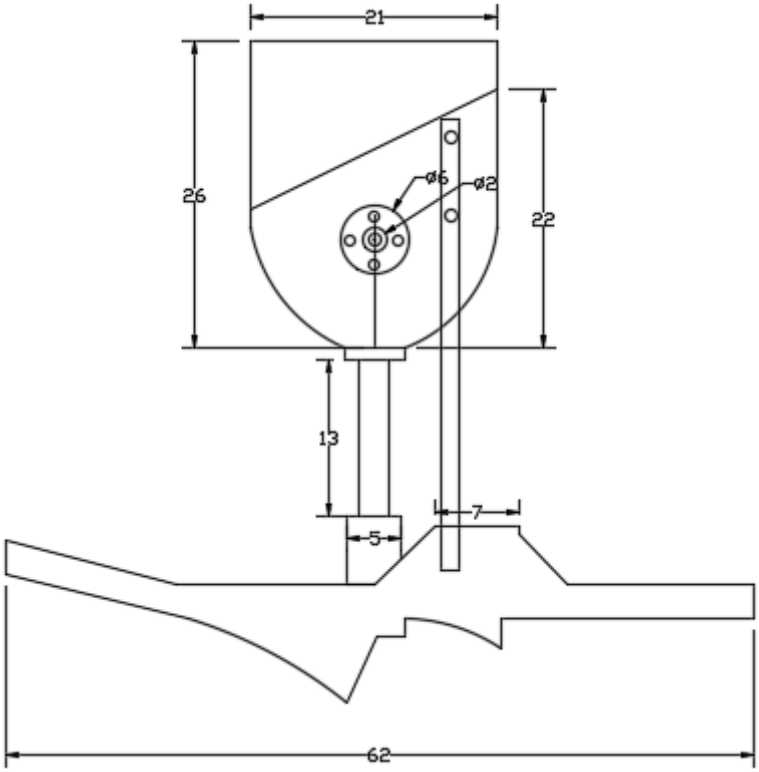

Figure 10.3. Side view of applicator with dimension

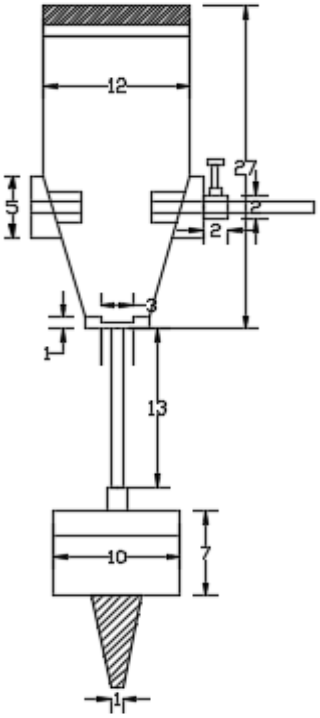

Figure 10.4. Front view of applicator with dimension

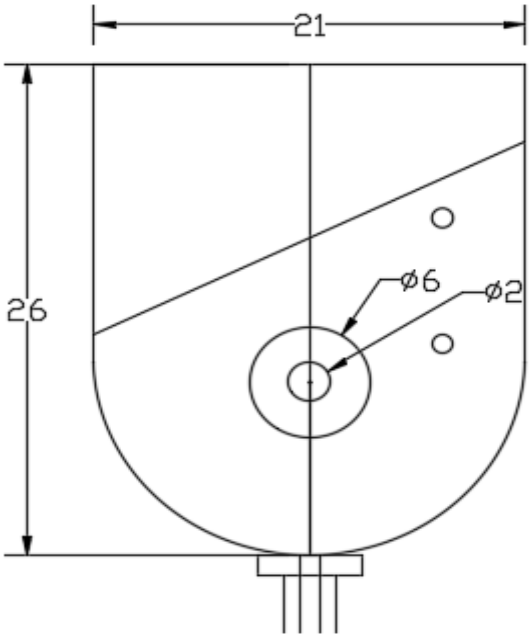

Figure 10.5. Side view of Hopper with dimension

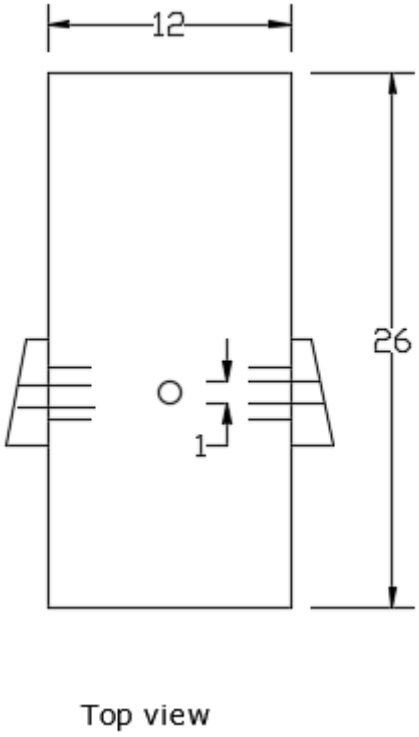

Figure 10.6. Top view of Hopper with dimension

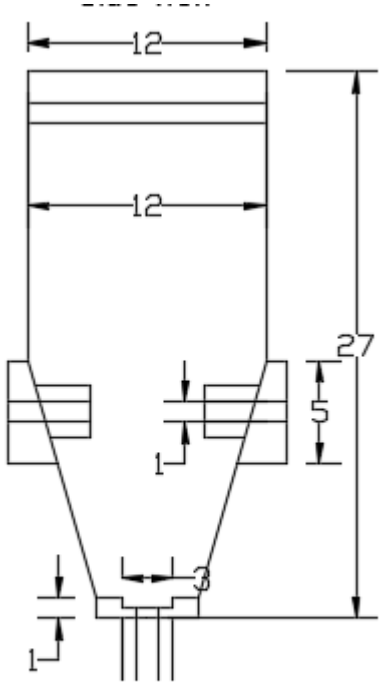

Figure 10.7. Front view of Hopper with dimension

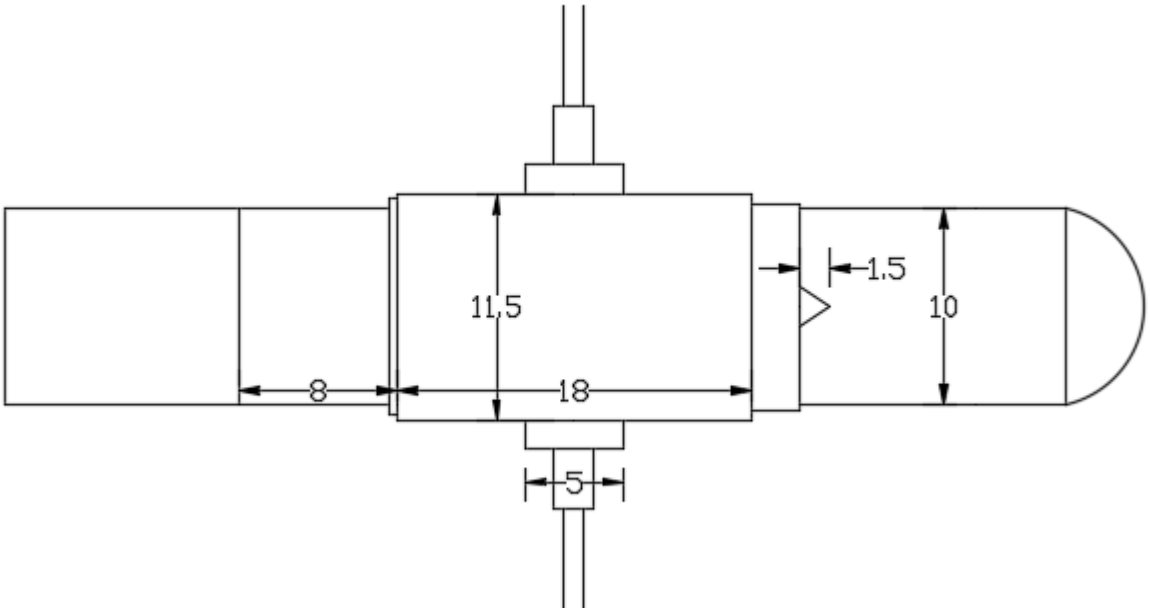

Figure 10.8. Top view of Float with dimension

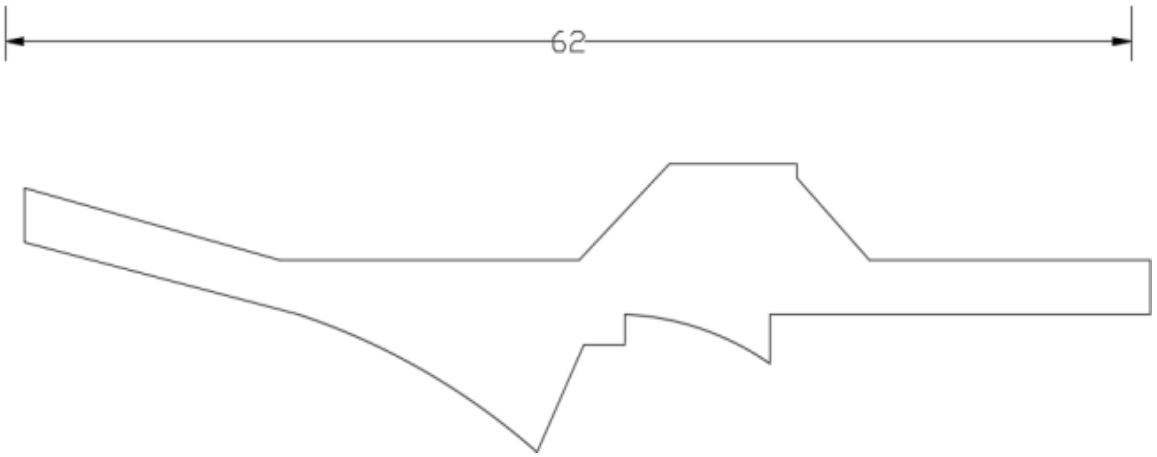

Figure 10.9. Side view of float with dimension

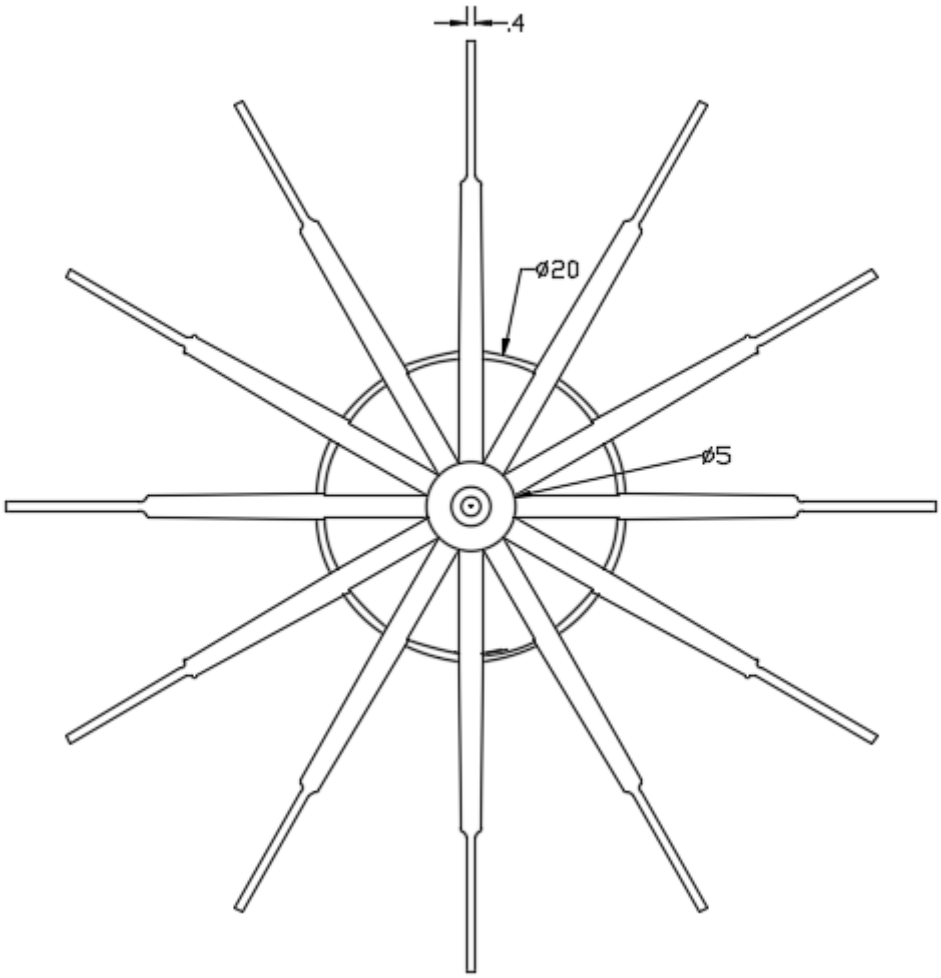

Figure 10.10. Side view of wheel with dimension

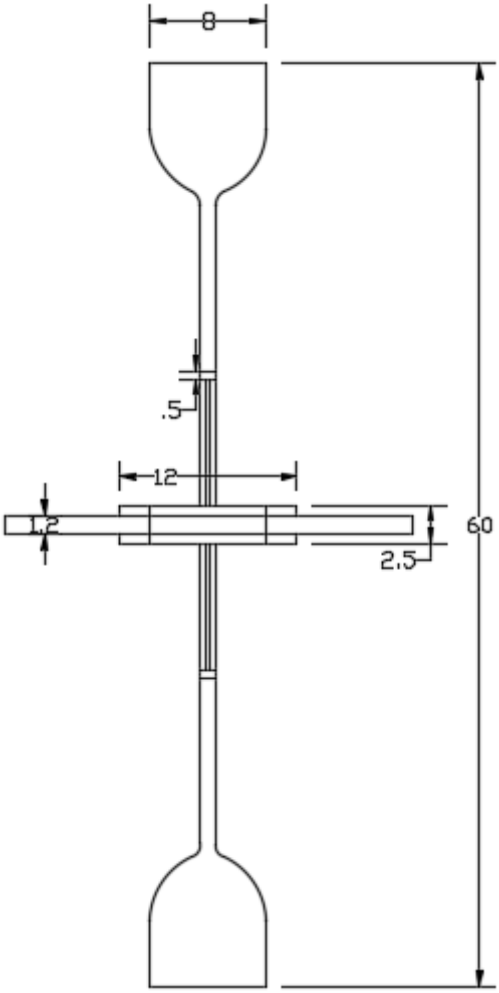

Figure 10.11. Front view of wheel with dimension

Modification of Injector applicator for Vegetable Production

Injector type USG urea applicator was modified and tested for vegetable production. After modification, applicator was tested in laboratory and field condition. The applicator was tested for Guti placement in vegetable production.

Modification of rubber gasket: A thin rubber sheet was used at the bottom of the applicator for holding the USG before punching into the soil. Silicon and PVC sheet of different thickness were used for making gasket at the delivery point of the applicator. Different sizes of hole were made at the centre of gasket. Six splits at the center of hole performed better than five splits. Silicon rubber sheet of 1.5 mm thickness performed better than PVC rubber sheet. Thirty gaskets were fabricated for extensive field test. Significant important modifications were done on gasket for vegetable production. Extensive field test required for final design of gasket. The test results were given in Table 11.3 at results and discussion section.

Figure 10.12. Modified gasket

Field performance test of IFDC Injector applicator for vegetable production

After modification of gasket, field performance test of IFDC injector type applicator was conducted at RARS, Rahmatpur, Barishal. In IFDC injector applicators having 14 mm hole at the center of 1.5 mm thick silicon gasket were tested at 4 different farmers' field. The vegetables were cauliflower, cabbage bottle gourd and tomato. IFDC injector applicator performed well in both dry and wet condition. The total area covered by IFDC injector applicator was 576 m^2 (14.4 decimal). Average field capacity was 81 m^2 (2.0 decimal) per hour. During test, 2.7 g size Guti was used. To cover these areas, each applicator was pushed about 1200 times. After used, it was observed that the hole of gasket was enlarged but it could be used in more areas. The test results were given in Table 11.4 at results and discussion section.

Figure 10.13. Field Performance Test of IFDC Injector applicator

Field performance test of prilled urea injector applicator for vegetable production

Injector type prilled urea applicator was developed. The applicator was tested in the laboratory and also in the field. There were some modification needed for the applicator and that was done completely. Gasket was the problem for injector type applicator, for avoiding this gasket we used a metallic cone for penetrating the applicator into the soil. The test results were given in Table 11.5 at results and discussion section.

Delivery cone

Metering Device (3.4 g USG)

Metering Device (2.7 g USG)

Handle

Figure 10.14. Different parts and full setting of punch type prilled urea applicator

The treatment of urea fertilizer application techniques were T_1 = Farmers' Practice, T_2 = Prilled Urea Deep Placement, and T_3 = USG Deep placement.

Data Collection and Analysis:

The experimental data were collected crop wise in different seasons from every location. The data were analyzed statistically and means were separated through Duncan's Multiple Range Test (DMRT) method.

11. Results and Discussion:

Farmer selection method and type of sample farmers:

The survey was conducted at three districts of the selected project locations. The survey was conducted with 120 sample farmers at the selected project sites. The farmers were selected as random basis. According to the succession of Upazila Agricultural Officer (UAO) of respective location the Rice cum vegetable growing farmers were selected from every upazila. The survey results were described below:

SI No			
	Name of the districts	:	Faridpur (Sadar and Modhukhali), Barishal (Babuganj and Agoiljhara), Bhola (Sadar upazila)
1.	Number farmers	:	120 (40 farmers from each location)
2.	Number of farmers used USG	:	69 out of 120
3.	Number of farmers used NPK	:	06 out of 120
4.	Number of farmers used urea broadcasting	:	45 out of 120
5.	Number of farmers used machine for USG deep placement	:	04 out of 120
6.	Number of farmers used hand for deep placing USG	:	71 out of 75
7.	The Agency/Organization/Project helped the farmers to introduce with USG	:	IFDC (AAPI project)
8.	In which crops USG used largely	:	Rice, maize, bottlegourd, brinjal, papaya, chili, tomato, ladies finger, snake gourd, sweet gourd, jinga, bitter gourd, indian spinach
9.	Other crops	:	Coconut, dragon, banana, mehgoni
10.	Obstructions in using USG now a days	:	- Shortage in supply of USG/NPK at local market - Low quality of USG/NPG available in local market - Labor intensive - Need easy machines for application

Survay at Bhola

Survey at Barishal

Survey at Faridpur

Figure 11.1. Survey at different locations of project area

Table 11.1. Field performance test results of Single row USG applicator

Test run distance-20 m; Number of Guti required to drop-51; Water condition-No water; Speed of operation-1.5-2.0 km/hr

No. of Guti dropped	No. of Guti picked up	No. of Guti not picked up	No. of Guti missed to drop	Missing (%)	Furrow opener type
44	41	3	7	14	Backward delivery
49	47	2	2	4	
48	46	2	3	6	
Test run distance-18 m; Number of Guti required to drop-46; Water condition-No water; Speed of operation-1.5-2.0 km/hr.					
43	39	4	3	6.5	Direct/straight drop
44	42	2	2	4.3	
Test run distance-17.5 m; Number of Guti required to drop-44; Water condition-1-2 cm; Speed of operation-1.5-2.0 km/hr.					
41	34	7	3	6.8	Backward delivery
42	41	1	2	4.5	
42	37	5	2	4.5	
Test run distance-20 m; Number of Guti required to drop-51; Water condition-2-4 cm; Speed of operation-1.5-2.0 km/hr.					
49	38	11	2	4	Direct/straight drop
49	38	11	2	4	
50	47	3	1	2	
49	40	9	2	4	Backward delivery
48	44	4	3	6	
49	34	15	2	4	
Test run distance-18 m; Number of Guti required to drop-46; Water condition-1-2 cm; Speed of operation-1.5-2.0 km/hr.					
No. of Guti dropped	No. of Guti picked up	No. of Guti not picked up	No. of Guti missed to drop	Missing (%)	Furrow opener type
45	43	2	1	2	Backward drop
44	41	3	2	4	
43	38	5	3	6.5	

- No broken of Guti during Laboratory and field test.
- Depth of Guti placement; 5-6 cm
- Missing of Guti was reduced by using experienced operator.
- More research needed for direct/straight furrow development.

Table 11.2. Field performance test results of Single row prilled urea applicator

SI No	Parameters	Performance test in Plot-1
1	Length of plot (m)	40
2	Width of plot (m)	15
3	Area (sq m)	600
4	Depth of water (cm)	3
5	Fertilizer Required (kg/Plot)	11.83
6	Fertilizer Applied (kg/plot)	9.47
7	Depth of placement (cm)	7
8	Time Required (minute)	43
9	Field Capacity (ha/hr)	0.075
10	Time Required (Single Pass) (sec)	78.73
11	Time Required (Double Pass) (sec)	170

Table 11.3. Test results of gasket of IFDC injector type applicator

Material	Thickness (mm)	Hole size (mm)	Results
Silicon rubber sheet	1.5	12	Tear during testing on bed
	-	14	Performed well during laboratory and field test
	-	16	1.8 g Guti could not control.
PVC rubber sheet	1.0	12	Performed well during laboratory and field test
	1.0	14	1.8 g Guti could not be controled.
	1.0	16	1.8 g Guti could not control.
	1.5	12	Hard to push stick. 1.8 g Guti could not be controled.
	1.5	14	Hard to push stick. Small size Guti (1.8 g) could not control.
	1.5	16	1.8 g Guti could not control.

Table 11.4. Field performance test results of IFDC Injector applicator for vegetable production

Sl. No.	Crop	Area covered (m^2)	Guti application rate (kg/ha)	Field capacity m^2/hr (decimal/hr)	Number of guti/plant	Total push number by the applicator
1.	Cauliflower	112	268	89 (2.8)	3	1165
2.	Cauliflower	99	303	101 (2.5)	3	1080
3.	Tomato	105	190	56.52 (4.37)	3	750
4.	Cauliflower	102	294	73.52 (3.4)	3	1125
5.	Bottle gourd	60	417	-	2	920
6.	Cabbage	98	265	85 (2.94)	3	966

Table 11.5. Field performance test results of prilled urea Injector applicator for vegetable production

Sl. No.	Crop	Area covered (m^2)	Prilled Urea application rate (kg/ha)	Field capacity m^2 (decimal)	Amount of prilled urea/plant	Total push number by the applicator
1.	Cauliflower	112	268	89 (2.8)	3	1165
2.	Cauliflower	99	303	101 (2.5)	3	1080
3.	Tomato	105	190	56.52 (4.37)	3	750
4.	Cauliflower	102	294	73.52 (3.4)	3	1125
5.	Bottle gourd	60	417	-	2	920
6.	Cabbage	98	265	85 (2.94)	3	966

The results of the field experiments for different crops in different project locations were described below:

Summer Tomato

The experiment was conducted at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal. For this experiment, BARI Tomato-8 was used. According to the following treatments, all other fertilizers were applied as per BARI recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates are given in Table 11.6.

Table 11.6. Fertilizer rate for summer tomato

Name of Fertilizer	Amount
Recommended non-urea fertilizers and manure	
Cowdung	15000 kg/ha
TSP	250 kg/ha
MoP: Basal	100 kg/ha
1^{st} top dress	80 kg/ha
2^{nd} top dress	80 kg/ha
For Farmer Practice (T_1)	
Urea: 1^{st} top dress	150 kg/ha
2^{nd} top dress	150 kg/ha
3^{rd} top dress	150 kg/ha
For Prilled Urea Deep Placement (T_2)	10.8 g / plant
USG (T_3) : (1.8 g)	6 pis / plant

It was observed from the Table 11.7 that the number of fruits/plant, individual fruit weight, fruit diameter and yield data varied significantly among the treatments. The number of fruits/plant was highest (424) at T_2 treatment but individual fruit weight was highest (54.6 g) at T_1 and fruit diameter was highest (4.50 cm) at T_1. The yield was found highest (28.40 t/ha) at T_2 treatment.

Table 11.7. Yield and yield contributing characters of BARI Tomato-8 as influenced by different fertilizer treatments

Treatments	No of fruit/plant	Individual fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Yield (t/ha)
T_1	326a	54.6a	4.04a	4.50a	20.84c
T_2	424b	46.4b	3.60a	4.33b	28.40a
T_3	378c	45.2b	4.36a	4.36b	26.15b
CV (%)	8.24	6.13	6.41	1.22	8.25
F-test	*	*	-	*	**

* - 5% level of significance, **- 1% level of significance

From Table 11.8, it was observed that the highest (2.10) Benefit Cost Ratio (BCR) was found at T_2 treatment and the lowest (1.43) was at T_1 (Farmer practice) treatment. The second highest BCR was 1.92 at treatment T_3. In case of deep placement treatments (T_2 & T_3) the labor cost was lower than T_1 (Farmer practice) for summer tomato cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmers apply fertilizers only one time. The net return was observed (Table 11.8) highest (BDT 744642.00) at T_2, the second highest was (BDT 627928.00) at T_3 and at farmer practice (T_1) the net return was BDT 314010.00.

Table 11.8. Economic analysis of all locations among different treatments of summer tomato cultivation

Treatment	T_1	T_2	T_3
Tillage cost (tk/ha)	6192.00	6192.00	6192.00
Fertilizer cost (tk/ha)	21672.00	18490.00	22704.00
Labor cost (tk/ha)	543434.00	493984.00	493984.00
Irrigation cost (tk/ha)	1978.00	1978.00	1978.00
Input cost (tk/ha)	149726.00	149726.00	149726.00
Pesticide Cost (tk/ha)	4988.00	4988.00	4988.00
Total cost (tk/ha)	727990.00	675358.00	679572.00
Yield (t/ha)	20.84	28.40	26.15
Gross Return (tk/ha)	1042000.00	1420000.00	1307500.00
Net Return (tk/ha)	314010.00	744642.00	627928.00
Benefit Cost Ratio (BCR)	1.43	2.10	1.92

Aus Rice

The experiment was conducted at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal on *Aus* season where BRRI dhan48 was used. According to the following treatments, all other fertilizers were applied as per BRRI recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates are given below in Table 11.9:

Table 11.9. Fertilizer Rate for *Aus* Rice

Name of Fertilizer	Amount
Recommended non-urea fertilizers	
TSP (Basal)	52 kg/ha
MoP (Basal)	82 kg/ha
For Farmer Practice (T_1)	
Urea: Basal dose	45 kg/ha
1st top dress	45 kg/ha
2nd top dress	45 kg/ha
For Prilled Urea Deep Placement (T_2)	135 kg / ha
USG (T_3): (1.8 g)	1 pis guti within four hill

It was observed that plant height, number of hill/sq meter and plant/hill varied insignificantly among the treatments (Table 11.10). But number of effective tiller/plant, number of filled grain/panicle and yield significantly varied among the treatments. The plant height, hill/sq. meter, plant/hill was highest (75.33cm, 30, 14) in both the T_2 and T_3 treatments. The values of other parameters (effective tiller/plant, number of grain/panicle and yield) were the highest (2.33, 147.33, 3.19 t/ha) in treatment T_3. The highest yield was obtained from T_3 followed by T_2 and the lowest yield was found in treatment T_1. In case of both T_2 and T_3 treatments, urea fertilizer placed 6-7 cm deep into the soil, where majority remains in the forms of ammonium which was much less mobile than nitrates (T_1).

Table 11.10. Yield and yield contributing characters of BRRI dhan48 as influenced by different fertilizer treatments

Treatment	Plant height (cm)	Hill/ sq. meter (no.)	Plant/ hill (no.)	Effective tiller/plant (no.)	Filled grain/panicle (no.)	Grain Yield (t/ha)
T_1	77.67	28	12	1.00	99.00	2.44c
T_2	75.33	30	14	1.67	142.00	3.11b
T_3	75.33	30	14	2.33	147.33	3.19a
CV (%)	7.66	3.41	8.66	9.69	10.49	8.34
F-test	-	-	-	*	*	*

* - 5% level of significance

From Table 11.11, it was observed that the BCR was found negative in all cases. It was the real situation of the farmers. If there were no subsidy in rice production the farmers will get nothing from rice cultivation. Among all three treatments T_3 gave the highest (0.89) BCR which was near to 1.00.

Table 11.11. Economic analysis of all locations among different treatments of aus rice cultivation

Treatment	T_1	T_2	T_3
Tillage cost (tk/ha)	5500.00	5500.00	5500.00
Fertilizer cost (tk/ha)	4780.00	4780.00	5320.00
Labor cost (tk/ha)	58381.82	55639.39	55639.39
Irrigation cost (tk/ha)	1500.00	1500.00	1500.00
Input cost (tk/ha)	1000.00	1000.00	1000.00
Pesticide Cost (tk/ha)	2500.00	2500.00	2500.00

Total cost (tk/ha)	73661.82	70919.39	71459.39
Yield (t/ha)	2.44	3.11	3.19
Gross Return (tk/ha)	48800.00	62200.00	63800.00
Net Return (tk/ha)	-24861.82	-8719.39	-7659.39
Benefit Cost Ratio (BCR)	0.66	0.88	0.89

T. *Aman* Rice

For T. *Aman* rice experiments, BRRI dhan73 was used as a variety. The experiment was conducted at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal. According to the following treatments, all other fertilizers were applied as per BRRI recommended dose except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates are given below in Table 11.12:

Table 11.12. Fertilizer rate for T. *Aman* rice

Name of Fertilizer	Amount
Recommended non-urea fertilizers	
TSP (Basal)	52 kg/ha
MoP (Basal)	82 kg/ha
Zypsum (Basal)	60 kg/ha
For Farmer Practice (T_1)	
Urea: Basal dose	50 kg/ha
1st top dress	50 kg/ha
2nd top dress	50 kg/ha
For Prilled Urea Deep Placement (T_2)	135 kg / ha
USG (T_3): (1.8 g)	1 pis guti within four hill

In Table 11.13, it was observed that the plant height, number of hill/sq meter, and plant/hill varied insignificantly among the treatments. But number of effective tiller/plant, number of grain/panicle and yield significantly differed among the treatments. The plant/hill and number of filled grain/panicle were highest (13.67 and 139.67) in T_2. The effective tiller/plant and yield were the highest (2.07 and 4.07 t/ha) in treatment T_3.

Table 11.13. Yield and yield contributing characters of BRRI dhan73 as influenced by different fertilizer treatments (RARS, Rahmatpur, Barishal)

Treatment	Plant height (cm)	Hill/ sq. meter (no.)	Plant/hill (no.)	Effective tiller/plant (no.)	Filled grain/panicle (no.)	Plot yield (t/ha)
T_1	90.67	28.33	13.00	1.00b	77.00b	3.05
T_2	92.00	25.00	13.67	1.33a	139.67a	3.95
T_3	94.00	25.67	13.00	2.07a	135.00a	4.07
CV (%)	4.07	3.26	15.78	0.69	16.88	4.34
F-test	-	-	-	*	*	-

* - 5% level of significance

The experiment was conducted at the farmers' field of Babugonj Upazilla. For Aman rice experiments, BRRI dhan22 was used. According to the following treatments, all other fertilizers were applied as per BRRI recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates were given at table 11.12.

It was observed from the Table 11.14 that the plant height, hill/sq. meter, and plant/hill differed insignificantly among the treatments. But number of effective tiller/plant, number of filled grain/panicle and yield varied significantly among the treatments. The plant height was the highest in treatment T_3. Number of hill/square meter and plant/hill were the highest (16.67cm and 16.67) in T_2 treatment. Number of filled grain/panicle was highest (222.00) in T_2. Other parameters (effective tiller/plant and yield) were the highest (2.67 and 3.97 t/ha) in T_3 treatment.

Table 11.14. Yield and yield contributing characters of BRRI dhan22 as influenced by different fertilizer treatments

Treatment	Plant height (cm)	Hill/sq. meter (no.)	Plant / hill (no.)	Effective tiller/plant (no.)	Filled Grain/Panicle (no.)	Plot Yield (t/ha)
T_1	111.00	14.67	15.67	1.07b	140.00b	3.37a
T_2	110.00	16.67	16.67	1.67a	222.00a	3.66b
T_3	115.00	15.33	11.33	2.67a	164.67b	3.97c
CV (%)	8.32	12.78	33.68	6.59	9.09	9.60
F-test	-	-	-	*	*	*

* - 5% level of significance

The experiment was conducted at the farmers' field of Babugonj Upazilla. For Aman rice experiments, variety of BRRI dhan41 was used. According to the following treatments, all other fertilizers were applied as per BRRI recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates were given at table 11.12.

It was observed from the table 11.15 that all parameters varied insignificantly among the treatments. The plant height was highest (124.33 cm) at treatment T_2. Number of hill/sq meter and plant/hill were highest (21.33 and 17.33) respectively at T_1 and T_2 treatment, repectively. Number of filled grain/panicle was highest (173.00) at T_1. In case of other parameters (effective tiller/plant and yield) were highest (1.33 and 4.13 t/ha) in treatment T_3.

Table 11.15. Yield and yield contributing characters of BRRI dhan 41 as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatment	Plant height (cm)	Hill/sq meter (no.)	Plant/hill (no.)	Effective tiller/plant (no.)	Filled grain/panicle (no.)	Plot yield (t/ha)
T_1	117.00	21.33	10.67	1.00	173.00	3.57
T_2	124.33	18.33	17.33	1.00	169.00	4.05
T_3	120.33	18.33	16.67	1.33	138.00	4.13
CV (%)	2.44	14.07	22.55	26.85	8.04	6.343

From Table 11.16, it was observed that the highest (1.15) Benefit Cost Ratio (BCR) was found at T_3 treatment and the lowest (0.91) was at T_1 (Farmer practice) treatment. The second highest BCR was 1.11 at treatment T_2. In case of deep placement treatments (T_2 & T_3) the labor cost was lower than T_1 (Farmer practice) for rice cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmers apply fertilizers only one time. The net return was observed (Table 11.16) highest (BDT 10304.00) at T_3, the second highest was (BDT 7714.00) and at the farmer practice (T_1) cultivation of Aman rice is a loss project.

Table 11.16. Average economic analysis of all locations among different treatments of T. aman rice cultivation

Treatment	T_1	T_2	T_3
Tillage cost (tk/ha)	5500.00	5500.00	5500.00
Fertilizer cost (tk/ha)	5620.00	5380.00	6190.00
Labor cost (tk/ha)	58381.82	55639.39	55639.39
Irrigation cost (tk/ha)	0.00	0.00	0.00
Input cost (tk/ha)	1000.00	1000.00	1000.00
Pesticide Cost (tk/ha)	2500.00	2500.00	2500.00
Total cost (tk/ha)	73001.82	70019.39	70829.39
Yield (t/ha)	3.33	3.89	4.06
Gross Return (tk/ha)	66600.00	77733.33	81133.33
Net Return (tk/ha)	-6402	7714	10304
Benefit Cost Ratio (BCR)	0.91	1.11	1.15

Cauliflower:

The experiment was conducted at the farmers' field of Babuganj and Agoiljhara Upzilla of Barishal District. Modhukhali upzilla of Faridpur district. For cauliflower experiments hybrid (snowbox, autumn queen, candet and tropical star) seeds were used at all locations. According to the following treatments, all other fertilizers were applied as per BARI recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates were given in Table 11.17.

Table 11.17. Fertilizer rate for Cauliflower Cultivation

Name of Fertilizer	Amount (kg/ha)
Recommended non-urea fertilizers	
TSP (Basal)	100
MoP (Basal)	200
Zypsum (Basal)	125
Zinc (Basal)	5
For Farmer Practice (T_1)	
Urea: Basal	
1st top dress	117.5
2nd top dress	117.5
For Prilled Urea Deep Placement (T_2)	235
USG (T_3): (2.7 g)	235

This experiment was conducted at the farmers' field of Babuganj upzilla under Barishal district. The farmer name was Md. Altab Hossain, Village: Pangsa, Upzilla: Babuganj, District: Barishal. It was observed from Table 11.18 that all parameters differed significantly among the treatments except plant population. The curd circumference was the highest (82.11 cm) at treatment T_3. Curd diameter was found highest (26.12 cm) at T_3 treatment but curd length was the highest (26.60 cm) at T_1. The other parameters (Individual curd weight and curd yield) were the highest (1642.50 g and 108.37 t/ha) in treatment T_3.

Table 11.18. Yield and yield contributing characters of cauliflower as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatments	Initial Pl.pop/ Plot	Final pl. pop/plot	Curd circumference (cm)	Curd diameter (cm)	Curd length (cm)	Individual curd weight (g)	Curd yield (t /ha)
T_1	32	24.25	80.31a	25.55a	26.60a	1350.00c	89.18c
T_2	32	25.75	68.53b	21.80b	23.87c	1510.00b	99.84b
T_3	32	26.00	82.11a	26.12a	24.96b	1642.50a	108.37a
CV (%)	7.51	8.45	3.26	3.26	0.84	1.83	1.88
F-test	--	--	*	*	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Babuganj upzilla under Barishal district. The farmer name was Md. Tofazzal, Village: Notunhat, Upzilla: Babuganj, District: Barishal. It was observed from table 11.19 that curd length, Individual curd weight and curd yield significantly differed among the treatments. The other parameters statistically insignificant. The curd circumference was the highest (73.01 cm) at treatment T_3. Curd diameter and curd length were found highest (23.23 and 27.50 cm) at T_3 treatment. In case of other parameters (Individual curd weight and curd yield) were the highest (1890.00 g and 62.40 t/ha) in treatment T_3.

Table 11.19. Yield and yield contributing characters of cauliflower as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatments	Initial Pl.pop/ Plot	Final Pl. pop/Plot	Curd circumference (cm)	Curd diameter (cm)	Curd length (cm)	Individual curd weight (g)	Curd yield (t/ha)
T_1	64	38.00	69.17	22.01	24.28b	1496.67c	49.34c
T_2	64	44.67	68.16	21.68	25.61ab	1650.00b	54.75b
T_3	64	47.33	73.01	23.23	27.50a	1890.00a	62.40a
CV (%)	7.133	8.43	7.03	7.04	3.93	1.66	1.43
F-test	--	--	--	--	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Agoiljhara upzilla under Barishal district. The farmer name was Md. Khalil, Village: Fulossri, Upzilla: Agoiljhara, District: Barishal. It was observed from Table 11.20 that curd length, Individual curd weight and curd yield significantly differed among the treatments. Statistically the other parameters varied insignificantly. The curd circumference was the highest (78.73 cm) at treatment T_1. Curd diameter and curd length were found the highest (25.05 and 26.05 cm) at T_1 treatment. In case of other parameters (Individual curd weight and curd yield) were the highest (1677.50 g and 49.84 t/ha) in treatment T_3.

Table 11.20. Yield and yield contributing characters of cauliflower as influenced by different fertilizer treatments (Agoiljhara, Barishal)

Treatments	Initial Pl.pop/ Plot	Final Pl. pop/Plot	Curd circumference (cm)	Curd diameter (cm)	Curd length (cm)	Individual curd weight (g)	Curd yield (t /ha)
T_1	56	48.50	78.73	25.05	26.05a	1343.75c	40.49c
T_2	56	49.25	70.24	22.35	22.35c	1591.00b	47.23b
T_3	56	50.50	71.65	22.80	24.50b	1677.50a	49.84a

CV (%)		2.84	6.04	6.03	0.88	2.85	3.03
F-test	-	-	-	-	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Agoiljhara upzilla under Barishal district. The farmer name was Sokhanath, Village: Jobarpar, Upzilla: Agoiljhara, District: Barishal. It can be observed from Table 11.21 that curd length, Individual curd weight and curd yield differed significantly among the treatments. Statistically significant differences were observed in other parameters. The curd circumference was highest (70.02 cm) at treatment T_3. Curd diameter and curd length were found the highest (22.28 and 26.89 cm) at T_3 treatment. Individual curd weight and curd yield were the highest (1815.00 g and 60.71 t/ha) in treatment T_3.

Table 11.21. Yield and yield contributing characters of cauliflower as influenced by different fertilizer treatments (Agoiljhara, Barishal)

Treatments	Initial Pl.pop/ Plot	Final Pl. pop/Plot	Curd circumference (cm)	Curd diameter (cm)	Curd length (cm)	Individual curd weight (g)	Curd yield (t /ha)
T_1	64	38.00	52.89	16.83	12.92	1143.33b	37.79c
T_2	64	44.67	69.91	22.24	23.54	1690.00a	55.57b
T_3	64	47.33	70.02	22.28	26.89	1815.00a	60.71a
CV (%)	11.95	8.43	12.19	12.19	23.61	3.97	1.51
F-test	--	--	--	--	--	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of modhukhali upzilla under Faridpur district. It was observed from Table 11.22 that curd circumference and curd yield differed significantly among the treatments. Statistically significant differences were observed in other parameters. The curd circumference was the highest (52.25 cm) at treatment T_3. Curd diameter and curd length were found highest (16.63 and 17.18 cm) at T_3 treatment. Individual curd weight and curd yield were the highest (999.25 g and 43.49 t/ha) in treatment T_3.

Table 11.22. Yield and yield contributing characters of cauliflower as influenced by different fertilizer treatments (Modhukhali, Faridpur)

Treatments	Initial Pl.pop/ Plot	Final Pl. pop/Plot	Curd circumference (cm)	Curd diameter (cm)	Curd length (cm)	Individual curd weight (g)	Curd yield (t /ha)
T_1	355	348.25	51.19ab	16.32b	16.99	915.00	39.82b
T_2	355	348.25	50.25b	15.99c	16.52	892.50	38.84b
T_3	355	348.25	52.25a	16.63a	17.18	999.25	43.49a
CV (%)	16.87	16.34	1.14	3.18	6.83	9.59	1.56
F-test	--	--	*	--	--	--	*

* - 5% level of significance

From Table 11.23, it was observed that the highest (1.38) Benefit Cost Ratio (BCR) was found at T_3 treatment and the lowest (1.04) was at T_1 (Farmer practice) treatment. The second highest BCR was 1.23 at treatment T_2. In case of deep placement treatments (T_2 & T_3) the labor cost was lower than T_1 (Farmer practice) for cauliflower cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmers apply fertilizers only one time. The net return was observed (Table

11.23) highest (BDT 126044.00) at T_3, the second highest was (BDT 76682.00) and at the farmer practice (T_1) cultivation of cauliflower is BDT 14368.00.

Table 11.23. Average economic analysis of all locations among different treatments of cauliflower cultivation

Treatment	T_1	T_2	T_3
Tillage cost (tk/ha)	6000.00	6000.00	6000.00
Fertilizer cost (tk/ha)	11560.00	11560.00	12030.00
Labor cost (tk/ha)	312340.00	305480.00	295660.00
Irrigation cost (tk/ha)	5000.00	5000.00	5000.00
Input cost (tk/ha)	5000.00	5000.00	5000.00
Pesticide Cost (tk/ha)	5000.00	5000.00	5000.00
Total cost (tk/ha)	344900.00	338040.00	328690.00
Yield (t/ha)	51.32	59.25	64.96
Gross Return (tk/ha)	359268.00	414722.00	454734.00
Net Return (tk/ha)	14368.00	76682.00	126044.00
Benefit Cost Ratio (BCR)	1.04	1.23	1.38

Cabbage

The experiment was conducted at the farmers' field of Babuganj and Agoiljhara Upzillas of Barishal district and Sadar upzilla of Faridpur district. For cauliflower experiments hybrid (Green 621, Atals-70, Snow box and Maharaja) seeds were used. According to the following treatments, all other fertilizers were applied as per BARI recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates are given in Table 11.24 below:

Table 11.24. Fertilizer rate for Cabbage Cultivation

Name of Fertilizer	**Amount (kg/ha)**
Recommended non-urea fertilizers	
TSP (Basal)	250
MoP (Basal)	250
Zypsum (Basal)	100
Boron (Basal)	6
For Farmer Practice (T_1)	
Urea: Basal	
1st top dress	157
2nd top dress	157
For Prilled Urea Deep Placement (T_2)	314
USG (T_3): (2.7 g)	314

This experiment was conducted at the farmers' field of Agoijhara upzilla under Barishal district. The farmer name was Sokhanath, Village: Jobarpar, Upzilla: Agoiljhara, District: Barishal. It was observed from Table 11.25 that all parameters differed significantly among the treatments. The head circumference was the highest (69.97 cm) in treatment T_3. Head diameter and head length were found highest (22.26 and 24.68 cm) at T_3 treatment. Individual head weight and head yield were highest (1740.00 g and 28.77 t/ha) in treatment T_3.

Table 11.25. Yield and yield contributing characters of cabbage as influenced by different fertilizer treatments (Agoiljhara, Barishal)

Treatments	Initial Pl. pop/ Plot	Final Pl. pop/Plot	Head circumference (cm)	Head diameter (cm)	Head length (cm)	Individual head weight (g)	Head yield (t /ha)
T_1	64	38.00	48.53c	15.44c	17.19c	1206.67c	19.92c
T_2	64	44.67	59.65b	18.98b	21.04b	1483.33b	24.57b
T_3	64	47.33	69.97a	22.26a	24.68a	1740.00a	28.77a
CV (%)	2.84	8.43	2.68	2.68	2.68	2.68	3.04
F-test	-	-	*	*	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Babuganj upzilla under Barishal district. The farmer name was Md. Anowar, Village: Notunhat, Upzilla: Babuganj, District: Barishal. It was observed from Table 11.26 that head length and Individual head weight differed significantly among the treatments. Statistically significant differences were observed in other parameters. The head circumference was highest (137.88 cm) at treatment T_3. Head diameter and head length were found highest (43.87 and 50.86 cm) at T_3 treatment. Individual head weight and yield were highest (3583.33 g and 118.05 t/ha) in treatment T_3.

Table 11.26. Yield and yield contributing characters of cabbage as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatments	Initial Pl. pop/ Plot	Final Pl. pop/Plot	Head circumference (cm)	Head diameter (cm)	Head length (cm)	Individual head wt (g)	Yield (t/ha)
T_1	48	38.00	122.92	39.11	43.36b	3056.67b	83.61
T_2	48	44.67	120.91	38.47	42.65b	3006.67b	99.64
T_3	48	47.33	137.88	43.87	50.86a	3583.33a	118.05
CV (%)	7.84	8.43	6.71	6.71	3.90	3.90	14.81
F-test	-	-	-	-	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Babuganj upzilla under Barishal district. The farmer name was Md. Tapon, Village: Pangsa, Upzilla: Babuganj, District: Barishal. It was observed from table 11.27 that head length, Individual head weight and yield differed significantly among the treatments. Statistically insignificant differences were observed in other parameters. The head circumference was highest (114.29 cm) in treatment T_3. Head diameter and head length were found the highest (36.36 and 25.16 cm) in T_3 treatment. Individual head weight and yield were the highest (1773.33 g and 58.55 t/ha) in treatment T_3.

Table 11.27. Yield and yield contributing characters of cabbage as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatments	Initial Pl. pop/ Plot	Final Pl. pop/Plot	Head circumference (cm)	Head diameter (cm)	Head length (cm)	Individual head weight (g)	Yield (t/ha)
T_1	32	29.67	53.18	16.92	18.76c	1322.67c	44.25c
T_2	32	32.00	65.95	20.98	23.27b	1640.00b	54.06b
T_3	32	32.00	114.29	36.36	25.16a	1773.33a	58.55a
CV (%)	16.37	16.37	27.36	27.36	0.99	0.98	0.99
F-test		-	-	-	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Faridpur sadar upzilla of Faridpur district. It was observed from Table 11.28 that head diameter, Individual head weight and yield significantly differed among the treatments. Statistically insignificant differences were observed in other parameters. The head circumference was highest (59.56 cm) at treatment T_3. Head diameter and head length were found highest (16.82 and 17.78 cm) at T_3 treatment. Individual head weight and head yield were highest (1.26 kg and 55.40 t/ha) in treatment T_3.

Table 11.28. Yield and yield contributing characters of cabbage as influenced by different fertilizer treatments (Faridpur sadar, Faridpur)

Treatments	Initial Pl. pop/ Plot	Final Pl. pop/Plot	Head circumference (cm)	Head diameter (cm)	Head length (cm)	Individual head weight (g)	Yield (t/ha)
T_1	360	351.67	52.50	16.74a	17.42	1.12b	49.35b
T_2	360	352.00	50.89	16.31b	17.01	1.09c	47.95c
T_3	360	352.00	59.56	16.82a	17.78	1.26a	55.40a
CV (%)	0.62	0.50	12.28	0.70	2.98	0.99	0.10
F-test	-	-	-	*	-	*	*

* - 5% level of significance

From Table 11.29, it was observed that the highest (1.39) Benefit Cost Ratio (BCR) was found at T_3 treatment and the lowest (1.00) was at T_1 (Farmer practice) treatment. The second highest BCR was 1.17 at treatment T_2. In case of deep placement treatments (T_2 & T_3) the labor cost was lower than T_1 (Farmer practice) for cabbage cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmers apply fertilizers only one time. The net return was observed (Table 11.29) highest (BDT 127664.50) at T_3, the second highest was (BDT 57845.00) and the at farmer practice (T_1) cultivation of cabbage is very negligible.

Table 11.29. Average economic analysis of all locations among different treatments of cabbage cultivation

Treatment	T_1	T_2	T_3
Tillage cost (tk/ha)	6000.00	6000.00	6000.00
Fertilizer cost (tk/ha)	11560.00	11560.00	12030.00
Labor cost (tk/ha)	312340.00	305480.00	295660.00
Irrigation cost (tk/ha)	5000.00	5000.00	5000.00
Input cost (tk/ha)	5000.00	5000.00	5000.00
Pesticide Cost (tk/ha)	5000.00	5000.00	5000.00
Total cost (tk/ha)	344900.00	338040.00	328690.00
Yield (t/ha)	49.28	56.56	65.19
Gross Return (tk/ha)	344975.75	395885.00	456354.50
Net Return (tk/ha)	75.75	57845.00	127664.50
Benefit Cost Ratio (BCR)	1.00	1.17	1.39

Bottle gourd

The experiment was conducted at the farmers' field of Faridpur sadar upzilla of Faridpur District. For bottlegourd experiments hybrid seeds were used for both locations. According to the following treatments, all other fertilizers were applied as per BARI recommendation except urea.

Urea fertilizer application system was varied among the treatments. The fertilizer rates were given in Table 11.30 below:

Table 11.30. Fertilizer rate for Bottle gourd Cultivation

Name of Fertilizer	Amount (kg/ha)
Recommended non-urea fertilizers	
TSP (Basal)	85
MoP (Basal)	100
Zypsum (Basal)	85
Zinc (Basal)	5
For Farmer Practice (T_1)	
Urea: Basal	
1st top dress	37
2nd top dress	37
For Prilled Urea Deep Placement (T_2)	75
USG (T_3): (1.8 g)	75

This experiment was conducted at the farmers' field of Faridpur sadar upzilla of Faridpur district. It was observed from Table 11.31 that number of fruit per plant, fruit length and diameter significantly differed among the treatments. Statistically insignificant differences were observed in other parameters. The number of fruits/plant was the highest (81.50) at treatment T_1. Fruit length and diameter were found highest (44.75 and 10.60 cm) at T_3 treatment. Individual fruit weight and fruit yield were observed highest (1.79 kg and 17.83 t/ha) in treatment T_3.

Table 11.31. Yield and yield contributing characters of bottlegourd as influenced by different fertilizer treatments (Faridpur sadar, Faridpur)

Treatments	No. of plant /plot	No. of Fruits /plant	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (kg)	Fruit yield (t/ha)
T_1	60	81.50a	38.60a	9.40a	1.51	15.38
T_2	60	78.00b	39.97b	10.17b	1.59	15.54
T_3	60	79.50c	44.75c	10.60c	1.79	17.83
CV (%)	0.50	0.73	0.68	2.77	7.08	6.16
F-test	-	*	*	*	-	-

* - 5% level of significance

From Table 11.32, it was observed that the highest (2.22) Benefit Cost Ratio (BCR) was found at T_3 treatment and the lowest (1.61) was at T_1 (Farmer practice) treatment. The second highest BCR was 1.81 at treatment T_2. In case of deep placement treatments (T_2 & T_3) the labor cost was lower than T_1 (Farmer practice) for potato cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmer apply fertilizers only one time. The net return was observed (Table 11.32) highest (BDT 440289.00) at T_3, the second highest was (BDT 312122.00) and the at farmer practice (T_1) cultivation of bottle gourd is BDT 262540.00.

Table 11.32. Economic analysis of all locations among different treatments of bottle gourd cultivation

Treatment	T_1	T_2	T_3
Tillage cost (tk/ha)	6175.00	6175.00	6175.00
Fertilizer cost (tk/ha)	65081.00	41869.00	39547.00
Labor cost (tk/ha)	343404.00	324234.00	301439.00
Irrigation cost (tk/ha)	5000.00	5000.00	5000.00
Input cost (tk/ha)	4500.00	4500.00	4500.00
Pesticide Cost (tk/ha)	5400.00	5400.00	5400.00
Total cost (tk/ha)	429560.00	387178.00	362061.00
Yield (t/ha)	15.38	15.54	17.83
Gross Return (tk/ha)	692100.00	699300.00	802350.00
Net Return (tk/ha)	262540.00	312122.00	440289.00
Benefit Cost Ratio (BCR)	1.61	1.81	2.22

Sweet gourd

The experiment was conducted at the farmers' field of Modhukhali upzilla of Faridpur district. For sweet gourd experiments, hybrid (Bengal sweet-2) seeds were used for both the locations. According to the following treatments, all other fertilizers were applied as per BARI recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates are given in Table 11.33 below:

Table 11.33. Fertilizer rate for Sweet gourd Cultivation

Name of Fertilizer	Amount (kg/ha)
Recommended non-urea fertilizers	
TSP (Basal)	100
MoP (Basal)	100
Zypsum (Basal)	100
Boron (Basal)	5
For Farmer Practice (T_1)	
Urea: Basal	
1^{st} top dress	40
2^{nd} top dress	40
For Prilled Urea Deep Placement (T_2)	80
USG (T_3): (1.8 g)	80

This experiment was conducted at the farmers' field of Modhukhali upzilla of Faridpur district. It was observed from Table 11.34 that number of fruit per plant, individual fruit weight, fruit diameter and yield differed significantly among the treatments. The number of fruits/plot was the highest (45.42) in treatment T_1. Individual fruit weight was found the highest (3.47 kg) in T_3 treatment. Other parameters like fruit diameter and fruit yield were the highest (21.36 cm and 20.82 t/ha) in treatment T_3.

Table 11.34. Yield and yield contributing characters of sweet gourd as influenced by different fertilizer treatments (Modhukhali, Faridpur)

Treatment	No of fruits/plot	Individual fruit weight (kg)	Fruit diameter (cm)	Yield (t/ha)
T_1	45.42a	2.97c	20.26c	18.05b
T_2	43.71b	3.17b	20.41b	18.48b
T_3	45.00ab	3.47a	21.36a	20.82a
CV (%)	1.295	0.360	0.056	2.718
F-test	*	*	*	*

* - 5% level of significance

From Table 11.35, it was observed that the highest (1.20) Benefit Cost Ratio (BCR) was found at T_3 treatment and the lowest (0.84) was at T_1 (Farmer practice) treatment. The second highest BCR was 1.02 at treatment T_2. In case of deep placement treatments (T_2 & T_3) the labor and fertilizer cost were lower than T_1 (Farmer practice) for potato cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmers apply fertilizers only one time. The net return was observed (Table 11.35) highest (BDT 52722) at T_3, the second highest was (BDT 5966) and the at farmer practice (T_1) cultivation of sweet gourd is a loss project.

Table 11.35. Economic analysis of all locations among different treatments of sweetgourd cultivation

Treatment	T_1	T_2	T_3
Tillage cost (tk/ha)	6175.00	6175.00	6175.00
Fertilizer cost (tk/ha)	61066.67	32833.33	28176.67
Labor cost (tk/ha)	235800.00	212500.00	205500.00
Irrigation cost (tk/ha)	10000.00	10000.00	10000.00
Input cost (tk/ha)	4726.00	4726.00	4726.00
Pesticide Cost (tk/ha)	5000.00	5000.00	5000.00
Total cost (tk/ha)	322767.67	271234.33	259577.67
Yield (t/ha)	18.05	18.48	20.82
Gross Return (tk/ha)	270750.00	277200.00	312300.00
Net Return (tk/ha)	-52017.67	5966.00	52722.00
Benefit Cost Ratio (BCR)	0.84	1.02	1.20

Potato

The experiment was conducted at the farmers' field of Babuganj upzilla of Barishal district, Sadar upzilla of Faridpur district and Sadar upzilla of Bhola district. For potato experiments, Cardinal, Astrix and BARI Alu-72 were used for all the locations. According to the following treatments, all other fertilizers were applied as per BARI recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates are given in Table 11.36 below:

Table 11.36. Fertilizer rate for potato Cultivation

Name of Fertilizer	Amount (kg/ha)
Recommended non-urea fertilizers	
TSP (Basal)	150
MoP (Basal)	270
Zypsum (Basal)	100
Boron (Basal)	5
Zinc (Basal)	17
For Farmer Practice (T_1)	
Urea: Basal	
1st top dress	65.5
2nd top dress	65.5
For Prilled Urea Deep Placement (T_2)	131
USG (T_3): (2.7 g)	131

This experiment was conducted at the farmers' field of Babuganj upzilla under Barishal district. The farmer name was Md. Monir, Village: khudrokathi, Upzilla: Babuganj, District: Barishal. It was observed from Table 11.37 that all parameters significantly differed among the treatments. The plant height was highest (105.00 cm) at treatment T_3. The numbers of tuber/hill and tuber weight/hill were found highest (16.13 and 780.33 gm) in T_3 treatment. In case of yield, the highest value (51.25 t/ha) was found in T_3 treatment.

Table 11.37. Yield and yield contributing characters of potato as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatment	Plant/ plot	Plant ht (cm)	Tuber/ hill	Tuber wt/hill (g)	Yield (t/ha)
T_1	1332	66.40c	13.33b	653.33c	45.33a
T_2	1332	98.27b	14.13b	726.87b	48.34c
T_3	1332	105.00a	16.13a	780.33a	51.25b
CV (%)		1.23	4.53	2.55	5.204
F-test	-	*	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Babuganj upzilla under Barishal district. The farmer name was Md. Khokon, Village: Nomorhat, Upzilla: Babuganj, District: Barishal. It was observed from Table 11.38 that all parameters differed significantly among the treatments. The plant height was highest (72.27 cm) in treatment T_3. Number of tuber/hill and tuber weight/hill were found the highest (13.67 and 713.67 g) in T_3 treatment. The highest yield (47.41 t/ha) was obtained from treatment T_3.

Table 11.38. Yield and yield contributing characters of potato as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatment	Plant/ plot	Plant ht (cm)	Tuber/ hill	Tuber wt/hill (g)	Yield (t/ha)
T_1	1332	57.53c	9.00c	504.07c	33.55c
T_2	1332	65.27b	12.00b	679.20b	45.16b
T_3	1332	72.27a	13.67a	713.67a	47.41a
CV (%)		1.93	1.82	0.62	9.69
F-test	-	*	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Bhola sadar upzilla under Bhola district. The farmer name was Md. Malek, Village: sundorkhali, Upzilla: Bhola sadar, District: Bhola. It was observed from table 11.39 that all parameters differed significantly among the treatments. The plant height was highest (69.93 cm) at treatment T_3. The numbers of tuber/hill and tuber weight/hill were found the highest (12.87 and 703.53 g) at T_3 treatment. In case of yield, treatment T_3 gave the highest value (46.91 t/ha).

Table 11.39. Yield and yield contributing characters of potato as influenced by different fertilizer treatments (Bhola Sadar, Bhola)

Treatment	Plant/ plot	Plant ht (cm)	Tuber/ hill	Tuber wt/hill (g)	Yield (t/ha)
T_1	1332	55.73c	8.73c	486.00b	31.27b
T_2	1332	62.73b	11.00b	669.87a	44.71a
T_3	1332	69.93a	12.87a	703.53a	46.91a
CV (%)		1.31	1.50	3.89	4.03
F-test	-	*	*	*	*

This experiment was conducted at the farmers' field of Faridpur sadar upzilla under Faridpur district. It was observed from table 11.40 that tuber weight/hill and yield parameters differed significantly among the treatments. The other parameters did not vary significantly. The plant height was the highest (52.20 cm) in treatment T_3. The numbers of tuber/hill and tuber weight/hill were found the highest (6.75 and 313.00 g) in T_1 and T_3 treatment. Treatment T_3 produced the highest yield (21.85 t/ha).

Table 11.40. Yield and yield contributing characters of potato as influenced by different fertilizer treatments (Faridpur sadar, Faridpur)

Treatment	Plant/ plot	Plant ht (cm)	Tuber/ hill	Tuber wt/hill (g)	Yield (t/ha)
T_1	418.00	50.23	6.75	283.50b	19.82
T_2	417.20	48.83	6.57	267.00c	19.21
T_3	418.30	52.20	6.60	313.00a	21.85
CV (%)	14.02	2.29	15.08	2.01	2.56
F-test	-	-	-	*	*

* - 5% level of significance

From Table 11.41, it was observed that the highest (1.40) Benefit Cost Ratio (BCR) was found at T_3 treatment and the lowest (0.92) was at T_1 (Farmer practice) treatment. The second highest BCR was 1.25 at treatment T_2. Average farm gate price was BDT 15 per kg. In case of deep placement treatments (T_2 & T_3) the labor cost was lower than T_1 (Farmer practice) for potato cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmers apply fertilizers only one time. The net return was observed (Table 11.41) highest (BDT 178198) at T_3, the second highest was (BDT 116282) and the at farmer practice (T_1) cultivation of potato is a loss project.

Table 11.41. Average economic analysis of all locations among different treatments of potato cultivation

Treatment	T_1	T_2	T_3
Tillage cost (Tk./ha)	6175	6175	6175
Fertilizer cost (Tk./ha)	61067	32833	28177
Labor cost (Tk./ha)	444600	414960	395200
Irrigation cost (Tk./ha)	15000	15000	15000
Pesticide Cost (Tk./ha)	5000	5000	5000

Treatment	T_1	T_2	T_3
Total cost (Tk./ha)	531841	473968	449552
Average Yield (t/ha)	32.49	39.35	41.85
Gross Return (Tk./ha)	487350	590250	627750
Net Return (Tk./ha)	-44491	116282	178198
Benefit Cost Ratio (BCR)	0.92	1.25	1.40

Maize

The experiment was conducted at the farmers' field of Babuganj upzilla of Barishal District and Sadar upzilla of Bhola district. For maize experiments BHM-7 and BHM-9 were used. According to the following treatments, all other fertilizers were applied as per BARI recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates are given in Table 11.42 below:

Table 11.42. Fertilizer rate for maize Cultivation

Name of Fertilizer	**Amount (kg/ha)**
Recommended non-urea fertilizers	
TSP (Basal)	280
MoP (Basal)	180
Zypsum (Basal)	220
Boron (Basal)	7
Zinc (Basal)	10
For Farmer Practice (T_1)	
Urea: Basal	287
1st top dress	143.5
2nd top dress	143.5
For Prilled Urea Deep Placement (T_2)	575
USG (T_3): (2.7 g)	575

This experiment was conducted at the farmers' field of Babuganj upzilla under Barishal district. The farmer name was Md. Monir Hossain, Village: khudrokathi, Upzilla: Babuganj, District: Barishal. It was observed from Table 11.43 that all parameters significantly differed among the treatments except plant height, cob length and cob diameter. The plant height was the highest (269.00 cm) in treatment T_3. Cob length and cob diameter were found the highest (18.50 and 15.67 cm) in treatment T_3 and T_2 respectively. The number of grain/cob was found the highest (605.33) at treatment T_3. In case of grain yield, straw yield and 100 grain weight, the result were found highest (10.93 t/ha, 16.18 t/ha and 35 g) in treatment T_3.

Table 11.43. Yield and yield contributing characters of maize (BHM-7) as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatment	Plant Height (cm)	Cob Length (cm)	Cob Diameter (cm)	No of Grain/cob	Grain Yield (t/ha)	Straw Yield (t/ha)	100 Grain Weight (g)
T_1	252.33	16.33	14.67	498.00b	9.24c	14.48b	32.00b
T_2	262.00	18.00	15.67	564.00a	10.59b	11.18c	33.67a
T_3	269.00	18.50	15.50	605.33a	10.93a	16.18a	35.00a
CV (%)	2.441	6.625	3.933	4.154	8.555	0.379	1.987
F-test	--	--	--	*	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Bhola sadar upzilla under Bhola district. The farmer name was Md. Moin Hossain, Village: Madhanagar, Upzilla: Bhola sadar, District: Bhola. It was observed from Table 11.44 that all parameters did not vary significantly among the treatments except the grain yield. The plant height was the highest (242.00 cm) in treatment T_3. Cob length was found highest (15.33 cm) at treatment T_3. Number of grain/cob was found highest (517.67) at treatment T_3. In case of grain yield and 100 grain weight, the results were found the highest (11.21 t/ha and 28.67 g) in treatment T_3. It can be noted that the farmers use 10% higher urea at farmer practice than other two treatments.

Table 11.44. Yield and yield contributing characters of maize (BHM-7) as influenced by different fertilizer treatments (Bhola sadar, Bhola)

Treatment	Plant height (cm)	Cob length (cm)	No of grains/cob	Grain Yield (t/ha)	100 grain weight (g)
T_1	227.67	14.27	486.67	8.85b	27.33
T_2	234.33	14.77	509.67	9.79ab	28.33
T_3	242.00	15.33	517.67	11.21a	28.67
CV (%)	6.32	4.22	2.48	6.85	3.46
F-test	-	-	-	*	-

* - 5% level of significance

From Table 11.45, it was observed that the highest (2.85) Benefit Cost Ratio (BCR) was found at T_3 treatment and the lowest (2.01) was at T_1 (Farmer practice) treatment. The second highest BCR was 2.45 at treatment T_2. Average farm gate price was BDT 15 per kg. In case of deep placement treatments (T_2 & T_3) the labor cost was lower than T_1 (Farmer practice) for potato cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmers apply fertilizers only one time. The net return was observed (Table 11.45) highest (BDT 107786.00) at T_3, the second highest was (BDT 90447.00) and the at farmer practice (T_1) cultivation of maize is BDT 68300.00.

Table 11.45. Average economic analysis of all locations among different treatments of maize cultivation

Treatment	T_1	T_2	T_3
Land preparation	9375.00	9375.00	9375.00
Seed (tk/ha)	6000.00	6000.00	6000.00
Fertilizer (tk/ha)	28800.00	25328.00	21189.00
Irrigation	3200.00	3200.00	3200.00
Labor	20000.00	18500.00	18500.00
Total Cost	67375.00	62403.00	58264.00
Yield (t/ha)	9.05	10.19	11.07
Gross Return (Tk./ha)	135675.00	152850.00	166050.00
Net Return (Tk./ha)	68300.00	90447.00	107786.00
Benefit Cost Ratio (BCR)	2.01	2.45	2.85

Tomato

The experiment was conducted at the farmers' field of Babuganj Upzilla of Barishal District and Bhola sadar upzilla of Bhola district. For tomato experiments hybrid variety (Bipul plus) was used. According to the following treatments, all other fertilizers were applied as per BARI

recommendation except urea. Urea fertilizer application system was varied among the treatments. The fertilizer rates are given in Table 11.46 below:

Table 11.46. Fertilizer rate for tomato Cultivation

Name of Fertilizer	Amount (kg/ha)
Recommended non-urea fertilizers	
TSP (Basal)	300
MoP (Basal)	300
Zypsum (Basal)	75
Boron (Basal)	8
For Farmer Practice (T_1)	
Urea: Basal	225
1st top dress	112.5
2nd top dress	112.5
For Prilled Urea Deep Placement (T_2)	450
USG (T_3): (2.7 g)	450

This experiment was conducted at the farmers' field of Babuganj upzilla under Barishal district. The farmer name was Md. Siddique, Village: Khanpura, Upzilla: Babuganj, District: Barishal. It can be observed from table 11.47 that all parameters differed significantly among the treatments. The number of fruits/plant was highest (352.33) at treatment T_3. Individual fruit weight was found highest (124.33 g) at T_3 treatment. In case of fruit length and diameter, highest value was found (6.87 and 14.81 cm) in treatment T_3. The yield was found highest (50.59 t/ha) in treatment T_3.

Table 11.47. Yield and yield contributing characters of tomato as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatment	No of plant/plot	Number of fruits/plant	Individual Fruit weight (g)	Fruit length (cm)	Fruit Diameter (cm)	Yield (t/ha)
T_1	600	306.33c	114.00c	6.68c	14.44b	38.34c
T_2	600	323.00b	121.37b	6.78b	14.81a	45.33b
T_3	600	352.33a	124.33a	6.87a	14.81a	50.59a
CV (%)		1.175	0.442	0.371	0.45	4.085
F-test		*	*	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Babuganj upzilla under Barishal district. The farmer name was Md. Mokter, Village: khanpura, Upzilla: Babuganj, District: Barishal. It was observed from Table 11.48 that all parameters significantly differed among the treatments. The number of fruits/plant was the highest (348.00) in treatment T_3. Individual fruit weight was found the highest (126.90 g) in T_3 treatment. In case of fruit length and diameter, the, highest value was found (6.93 and 14.93 cm) in treatment T_3. The yield was the highest (47.83 t/ha) in treatment T_3.

Table 11.48. Yield and yield contributing characters of tomato as influenced by different fertilizer treatments (Babuganj, Barishal)

Treatment	No of plant/plot	Number of fruits/plant	Individual fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Yield (t/ha)
T_1	600	300.67c	113.67c	6.61c	14.34c	38.65c
T_2	600	321.00b	122.00b	6.78b	14.76b	43.57b
T_3	600	348.00a	126.90a	6.93a	14.93a	47.83a
CV (%)		0.56	1.171	0.36	0.296	2.88
F-test		*	*	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Bhola sadar upzilla under Bhola district. The farmer name was Md. Mizanur Rahman, Village: Sundorkhali, Upzilla: Bhola Sadar, District: Bhola. It can be observed from Table 11.49 that all parameters significantly differed among the treatments except individual fruit weight. The number of fruits/plant was highest (67.67) in treatment T_2. Individual fruit weight was found highest (73.60 g) at T_3 treatment. In case of fruit length and diameter, the, highest value was found (6.93 and 14.93 cm) in treatment T_3. The yield was highest (79.66 t/ha) in treatment T_3.

Table 11.49. Yield and yield contributing characters of tomato as influenced by different fertilizer treatments (Bhola sadar, Bhola)

Treatment	No of plant/plot	No of fruits/plant	Individual Fruit Weight (g)	Fruit Length (cm)	Fruit Diameter (cm)	Yield (t/ha)
T_1	600	62.33b	72.40	6.61c	14.34c	73.57b
T_2	600	67.67a	70.30	6.78b	14.76b	77.55a
T_3	600	66.67a	73.60	6.93a	14.93a	79.66a
CV (%)		1.768	1.602	0.36	0.296	4.889
F-test	-	*	-	*	*	*

* - 5% level of significance

This experiment was conducted at the farmers' field of Bhola sadar upzilla under Bhola district. The farmer name was Md. Hares, Village: Modhajoynagar, Upzilla: Bhola sadar, District: Bhola. It was observed from Table 11.50 that all parameters significantly differed among the treatments except number of fruits/plant. The number of fruits/plant was highest (59.21) at treatment T_3. Individual fruit weight was found highest (72.20 g) at T_3 treatment. In case of fruit length and diameter, the highest value was found (6.87 and 14.81 cm) in treatment T_3. The yield was the highest (72.45 t/ha) in treatment T_3.

Table 11.50. Yield and yield contributing characters of tomato as influenced by different fertilizer treatments (Bhola sadar, Bhola)

Treatment	No of plant/plot	No of fruits/plant	Individual Fruit Weight (g)	Fruit Length (cm)	Fruit Diameter (cm)	Yield (t/ha)
T_1	600	63.05	66.70b	6.68c	14.44b	68.63b
T_2	600	58.56	69.20b	6.78b	14.81a	66.17c
T_3	600	59.21	72.20a	6.87a	14.81a	72.45a
CV (%)		9.297	1.694	0.371	0.45	4.048
F-test			*	*	*	*

* - 5% level of significance

From Table 11.51, it was observed that the highest (1.11) Benefit Cost Ratio (BCR) was found at T_3 treatment and the lowest (0.90) was at T_1 (Farmer practice) treatment. The

second highest BCR was 1.03 at treatment T_2. In case of deep placement treatments (T_2 & T_3) the labor cost was lower than T_1 (Farmer practice) for potato cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmers apply fertilizers only one time. The net return was observed (Table 11.51) highest (BDT 72018.00) at T_3, the second highest was (BDT 22502.00) and the at farmer practice (T_1) cultivation of tomato is a loss project.

Table 11.51. Average economic analysis of all locations among different treatments of tomato cultivation

Treatment	T_1	T_2	T_3
Tillage cost (tk/ha)	6192.00	6192.00	6192.00
Fertilizer cost (tk/ha)	21672.00	18490.00	22704.00
Labor cost (tk/ha)	543434.00	493984.00	493984.00
Irrigation cost (tk/ha)	1978.00	1978.00	1978.00
Input cost (tk/ha)	149726.00	149726.00	149726.00
Pesticide Cost (tk/ha)	4988.00	4988.00	4988.00
Total cost (tk/ha)	727990.00	675358.00	679572.00
Yield (t ha^{-1})	54.80	58.16	62.63
Gross Return (tk/ha)	657570.00	697860.00	751590.00
Net Return (tk/ha)	-70420.00	22502.00	72018.00
Benefit Cost Ratio (BCR)	0.90	1.03	1.11

Boro Rice

The experiment was conducted at farmer's field of Bhola sadar upzilla of Bhola districts, for *Boro* rice experiments, BRRI dhan28 was used. According to the following treatments, all other fertilizers were applied as per BRRI recommendation. Urea fertilizer application system was varied among the treatments. The fertilizer rates are given in Table 11.52 below:

Table 11.52. Fertilizer Rate for *Boro* Rice

Name of Fertilizer	Amount
Recommended non-urea fertilizers	
TSP (Basal)	52 kg/ha
MoP (Basal)	82 kg/ha
For Farmer Practice (T_1)	
Urea: Basal dose	107 kg/ha
1^{st} top dress	55 kg/ha
2^{nd} top dress	55 kg/ha
For Prilled Urea Deep Placement (T_2)	165 kg / ha
USG (T_3): (1.8 g)	1 pis within four hill

It was observed that hill/sq meter and plant/hill were not significant among the treatments (Table 11.53). The plant height, hill/sq meter and plant/hill were the highest (94.77 cm, 20 and 4) respectively at T_3 treatment. Other parameters (effective tiller/plant, number of filled grain/panicle, and yield) were the highest (3.41, 160.10 and 5.63 t/ha) in treatment T_3, respectively. In case of farmer practice the farmer use 30% higher urea than that of other two treatments.

Table 11.53. Yield and yield contributing characters of BRRI dhan28 as influenced by different fertilizer treatments (Bhola sadar, Bhola)

Treatment	Plant height (cm)	Hill/sq meter	Plant/hill	Effective tiller/plant	Panicle Length (cm)	No of Filled Grain/ Panicle	No of unfilled grain/ panicle	Yield (t/ha)
T_1	87.93b	20	4	3.32c	26.07b	147.80b	29.33a	5.18c
T_2	92.57a	20	4	3.37b	27.07a	155.00ab	25.00ab	5.49b
T_3	94.77a	20	4	3.41a	27.73a	160.10a	23.23b	5.63a
CV (%)	1.234	-	-	0.510	1.227	2.342	7.668	4.481
F-test	**	-	-	**	**	*	*	**

* - 5% level of significance, **- 1% level of significance

From Table 11.54, it was observed that the highest (1.04) Benefit Cost Ratio (BCR) was found at T_3 treatment and the lowest (0.94) was at T_1 (Farmer practice) treatment. The second highest BCR was 1.03 at treatment T_2. In case of deep placement treatments (T_2 & T_3) the labor cost was lower than T_1 (Farmer practice) for *Boro* cultivation. Because in every time farmers need labor to broadcast urea while in deep placement treatments farmers apply fertilizers only one time. The net return was observed (Table 11.54) highest (BDT 3621.00) at T_3, the second highest was (BDT 2331.00) and the at farmer practice (T_1) cultivation of tomato is a loss project.

Table 11.54. Average economic analysis of all locations among different treatments of tomato cultivation

Treatment	**T_1**	**T_2**	**T_3**
Tillage cost (tk/ha)	5500.00	5500.00	5500.00
Fertilizer cost (tk/ha)	5620.00	5380.00	6190.00
Labor cost (tk/ha)	58381.82	55639.39	55639.39
Irrigation cost (tk/ha)	10000.00	10000.00	10000.00
Input cost (tk/ha)	1000.00	1000.00	1000.00
Pesticide Cost (tk/ha)	2500.00	2500.00	2500.00
Total cost (tk/ha)	83001.82	80019.39	80829.39
Yield (t ha^{-1})	5.18	5.49	5.63
Gross Return (tk/ha)	77700.00	82350.00	84450.00
Net Return (tk/ha)	-5302.00	2331.00	3621.00
Benefit Cost Ratio (BCR)	0.94	1.03	1.04

12. Research highlights/findings:

- Single row prill urea applicator for rice has been designed, tested and manufactured under this sub project.
- Injector type prill urea applicator has been developed.
- Linkage has been developed in supplying packet USG to the local Fertilizer businessmen.
- For *Aus* rice, the yield increased 21.54% to 23.51% in urea deep placement than farmer practice.

- The yield of *Aman* rice increased 16.72% to 21.82% in urea deep placement than farmer practice.
- About 21.51% yield increased of different vegetables in urea deep placement than farmer practice.
- BCR was observed higher in deep placement treatments than farmer practice for all crops.

B. Implementation Position:

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		**Remark**
	Physical	Financial	Physical	Financial	
a. Office equipment	N\A	N\A	N\A	N\A	-
b. Lab & field equipment:					
i. Digital Moisture meter	2	1,10,000	2	1,10,000	100%
ii. Digital pH meter	1	30,000	2	30,000	100%
c. Other capital item	N\A	N\A	N\A	N\A	-

2. Establishment/renovation facilities:

Description of facilities	**Newly established**		**Upgraded/refurbished**		**Remarks**
	PP Target	**Achievement**	**PP Target**	**Achievement**	
N\A	N\A	N\A	N\A	N\A	N\A

3. Training/study tour/workshop/field day organized:

Description	**Number of participants**			**Duration (Days/weeks/months)**	**Remark**
	Male	**Female**	**Total**		
a. Training	N\A	N\A	N\A	N\A	
b. Study tour	N\A	N\A	N\A	N\A	
c. Workshop	N\A	N\A	N\A	N\A	
d. Field Day (5 nos)	65	35	100	1 day	

C. Financial and physical progress:

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	815441	803634	803634	0	100	
B. Field research/ lab expenses and supplies	1777459	1774587	1774587	0	100	
C. Operating expenses	382253	382103	382103	0	100	
D. Vehicle hire and fuel oil & maintenance	190021	190021	190021	0	100	
E. Training/Workshop/ field day	65000	65000	65000	0	100	
F. Publications and printing	60000	0	0	0	0	
G. Miscellaneous	68044	68044	68044	0	100	
H. Capital expense	140000	140000	140000	0	100	
Total	**3498218**	**3423389**	**3423389**	**0**	**100**	

D. Achievement of Sub-project by Objectives: (Tangible form)

Specific Objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product, obtained, visible, measurable)	Outcome (sort term effect of the research)
1. To develop and promote fertilizer applicator for fertilizer deep placement	i) Design, lab and field tests, and fabrication of the Single row prilled urea applicator. ii) Distribution of the Single row prilled urea applicator to the beneficiary farmers. iii) Design, lab and field tests, and fabrication of Injector type prilled urea applicator. iv) Distribution of the Injector type prilled urea applicator to the farmers	▪ Single row prilled urea applicator has already been developed. ▪ Injector type prilled urea applicator design has been already fixed but could not go for production due to lacking of fund. ▪ Ten pieces of injector type USG applicator have been distributed to the beneficiary farmers, so that they can apply USG by using this applicator	▪ Make easy of fertilizer deep placement due to using fertilizer applicator ▪ Proper growth and development of crop plants ▪ Increase of farmers' income.
2. To increase fertilizer use efficiency by fertilizer deep placement under the soil	i. Application of urea (USG & prilled) in deep soil by using developed fertilizer applicator. ii. Use of recommended dose of fertilizers in crop field.	▪ Deep placement of USG and prilled urea in upland and wet land crops for reducing the nitrogen loss. ▪ Total of 26 demonstrations on fertilizer deep placement have been implemented in five upazilas under three districts (Barishal, Faridpur, Bhola)	▪ Efficient use of chemical fertilizers by crop plants as a result better yield were observed at fertilizer deep placement treatments
3. To increase crop production with saving of fertilizer and environment pollution	i) Deep placement of urea (USG & prilled) through fertilizer applicator. ii) Minimum use of chemical fertilizers in crop field. iii) Crop husbandry taken as per recommendation of the cultivated crops. iv) Laboratory tests of soil and water samples as collected from the experimental fields.	▪ For Aus rice the yield was increased upto 21.54% to 23.51% at urea deep placement than farmer practice. ▪ For Aman rice the yield was increased upto 16.72% to 21.82 % at urea deep placement than farmer practice. ▪ About 21.51% yield was increased for Rabi crops at urea deep placement than farmer practice	▪ Increase of crop production ▪ Saving of fertilizers ▪ Saving of environment pollution due to deep placement of fertilizers.

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks
	Under preparation	Completed and published	
Leaflet	-	1	
Journal publication	1	1 (Completed and accepted to publish in Indian Society of Coastal Agriculture Research (ISCAR) within September, 2019)	Other 1 publication will be submitted for publication by 3 months
Information developed	-	-	

F. Technology/knowledge generation/Policy Support (as applied):

i. Generation of technology (commodity, Non-commodity):

1. Single type prill urea applicator for rice has already been developed through this project.
2. Design of punch type prill urea applicator for up land crop has already been done by this project.
3. Through this project, we supplied some quality USG to the businessmen and they were highly appreciated.
4. Now a days they are demanding this type of quality product (USG) throughout the year.

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

1. Design of punch type prill urea application is a new technology. It needs more fine tuning.
2. Deep placement of urea reduces water contamination, air pollution.

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

1. 10 pis of injector type USG applicator was distributed to the beneficiary farmers, so that they could apply USG by using this applicator and increase production and income. The farmers name, address, manufacturer and price were given below:

SI. No.	Name of the Farmer	Address	Manufacturer	Price
1.	Md. Hares	Vill: Modhajoynagar, Upa: Bhola sadar, Dist: Bhola	RFL	1000/-
2.	Md. Mizanur Rahman	Vill: Sundorkhali, Upa: Bhola sadar, Dist: Bhola	RFL	1000/-
3.	Md. Siddique	Vill: Khanpura, Upa: Babuganj, Dist: Barishal	RFL	1000/-
4.	Md. Monir Hossain Mridha	Vill: Khudrokathi, Upa: Babuganj, Dist: Barishal	RFL	1000/-
5.	Sokha Nath	Vill: Jobarpar, Upa:Agoiljhara, Dist:	RFL	1000/-

		Barishal		
6.	Md. Khalil Sikder	Vill: Fullossri, Upa: Agoiljhara, Dist: Barishal	RFL	1000/-
7.	Md. Toffazzal	Vill: Notunhat, Upa: Babuganj, Dist: Barishal	RFL	1000/-
8.	Md. Altab Hossin	Vill: Pangsa, Upa: Babuganj, Dist: Barishal	RFL	1000/-
9.	Md. Naser	Vill: Kartikpasha, Upa: Modhukgali, Dist: Faridpur	RFL	1000/-
10.	Md. Oli	Vill: hatikumrul, Upa: Sadar, Dist: Faridpur	RFL	1000/-

2. 10 pis of single row prill urea applicator for rice was distributed to the beneficiary farmers, so that they could apply prill urea by using this applicator and increase production and income. The farmers name, address, manufacturer and price were given below:

SI. No.	Name of the Farmer	Address	Manufacturer	Price
1.	Md. Hares	Vill: Modhajoynagar, Upa: Bhola sadar, Dist: Bhola	Alam Engineering Works	1500/-
2.	Md. Mizanur Rahman	Vill: Sundorkhali, Upa: Bhola sadar, Dist: Bhola	Alam Engineering Works	1500/-
3.	Md. Siddique	Vill: Khanpura, Upa: Babuganj, Dist: Barishal	Alam Engineering Works	1500/-
4.	Md. Monir Hossain Mridha	Vill: Khudrokathi, Upa: Babuganj, Dist: Barishal	Alam Engineering Works	1500/-
5.	Sokha Nath	Vill: Jobarpar, Upa:Agoiljhara, Dist: Barishal	Alam Engineering Works	1500/-
6.	Md. Khalil Sikder	Vill: Fullossri, Upa: Agoiljhara, Dist: Barishal	Alam Engineering Works	1500/-
7.	Md. Toffazzal	Vill: Notunhat, Upa: Babuganj, Dist: Barishal	Alam Engineering Works	1500/-
8.	Md. Altab Hossin	Vill: Pangsa, Upa: Babuganj, Dist: Barishal	Alam Engineering Works	1500/-
9.	Md. Naser	Vill: Kartikpasha, Upa: Modhukgali, Dist: Faridpur	Alam Engineering Works	1500/-
10.	Md. Oli	Vill: hatikumrul, Upa: Sadar, Dist: Faridpur	Alam Engineering Works	1500/-

iv. Policy support:

1. This newly designed machines need to distribute all over the country to the farmers level largely through DAE.
2. With the help of DAE personnel, it is needed to ensure Quality packed USG in the market level so that the farmers can use effectively.

G. Information regarding Desk and Field Monitoring:

i. Desk Monitoring: Done by NRM Division BARC and monitoring team of BARI

ii. Field Monitoring [time & No of visit, Team visit and Output]:

BARC monitoring team visited our project sites at 17th February, 2018.

H. Lesson Learned/Challenges (if any)

i. It was difficult to work in the tidal flooding areas because if the tidal water comes in the rice field the applicator machine was submerged.

ii. During designing of injector type prill urea applicator, it was a huge challenge for us to make a reverse punch system in the applicator.

iii. Unfavorable weather condition of the southern region in one of the major challenge for us to implement the project.

I. Challenges

i. It was a big challenge for us to minimize the production cost of the applicator machine.

ii. During rainy season it was difficult to get dry urea fertilizer for using in the applicator machine.

Counter signature of the Head of the organization/authorized representative and
Principal Investigator

Date

Seal