PROJECT COMPLETION REPORT (PCR) - Compiled

Project Title: Validation and Up scaling of Resource Conservation Technologies (RCTs) for Improving Productivity in the Drought Prone Areas.

Code Number: TF 08-NR

Project Duration: 36 Months; From: 20 May 2013 to 19 May 2016

CGP Project: KGF BKGET 1st Call

Submitted to:
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Date: 31 May 2016

T A B L E O F C O N T E N T S

Sl. No.	Acronyms	Full names of Abbreviations
1	AD	Additional Director
2	BARI	Bangladesh Agricultural Research Institute
3	BRRI	Bangladesh Rice Research Institute
4	BINA	Bangladesh Institute of Nuclear Agriculture
5	BCR	Benefit Cost Ratio
6	CA	Conservation Agriculture
7	CV	Co-efficient of Variation
8	DAE	Department of Agriculture Extension
9	DAS	Days After Sowing
10	DD	Deputy Director
11	FA	Field Assistant
12	FP	Farmers practice
13	KGF	Krishi Gobeshona Foundation
14	NGOs	Non Government Organization
15	RCTs	Resource Conservation Technologies
16	RB	Raised bed
17	SA	Scientific Assistant
18	SSA	Senior Scientific Assistant
19	SAAO	Sub Assistant Agriculture Officer
20	TGW	Thousand Grain Weight
21	TSW	Thousand Seed Weight

Project Completion Report on Validation and Up scaling of Resource Conservation Technologies (RCTs) for Improving Productivity in the Drought Prone Areas

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Project Duration: 36 Months; From: 20 May 2013 to 19 May 2016

A. Basic Project Information:

i. Project ID No. (FRP): TF 08-NR
ii. Project Title: Validation and Up scaling of Resource Conservation Technologies (RCTs) for Improving Productivity in the Drought Prone Areas
iii. Name of Coordinator with designation (if applicable): Not applicable
iv. Name of Principal Investigator with designation: Dr Md. Ilias Hossain, Principal Scientific Officer
v. Name of Co-investigator with designation (if any) : Not applicable
vi. Name of the applying organization with address: Bangladesh Agricultural Research Institute, Joydebpur, Gazipur
vii. Name of associate/collaborating organization(s), if any: Not applicable
viii. Project duration (months): 36 ; From: 20 May 2013 to 19 May 2016
ix. Project commencement date (As per MoU) : 20 May 2013
x. Project locations/sites with name: Paba and Godagari Upazila at Rajshahi District and Nachole upazila at Chapainawabgonj district
   i. Project size (no. of participatory farmers/site; No. of Upazila covered: Three
   Total no. of sites/locations: 03

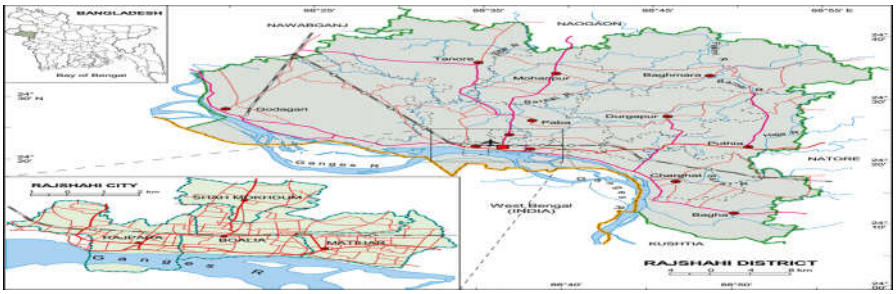

Figure 1: Map of Rajshahi district with indicate three location

Total no. of Farmers involved: 300 for three years (100 for each site)
Land area per farmer used in decimal: 33 decimal
Total land area used in decimal: 9900
Crop season: Rabi, Kharif 1& Kharif 2
Crop varieties used: Wheat- BARI Gom 26, 27 & 28, Lentil- BARI Masur-6 & 7, Maize- Hybrid NK 40, Chickpea- BARI Chola 9, Tamn rice- BRRI Dhan 56, 57, 62

xi. Project cost (total): TK 34.986 lac (Year-1: TK 9.92916 lac, Year-2: TK. 10.92445 lac Year-3: TK. 14.13239 lac)
xii. Fund received in TK. 33.57296 lac & Expenditure made in TK. 34.98600 lac (Committed expenditure: TK.1.41304) during the reporting period.

B. Summary/Executive Summary:

Climatic variation is more pronounced in the drought prone areas of Bangladesh which have a profound effect on agriculture and livelihoods of rural communities. In Bangladesh the north-west part of Rajshahi division is different from other parts of the country due to its undulating topography having compact and low fertile soils. The region experienced high temperature with limited soil moisture storage along with low and erratic rainfall (BMDA, 2011). Crop production in this region is challenging and productivity and cropping intensity have very low over other parts. So, it can possible to mitigate and adaptation of climatic variation and increase productivity and cropping intensity by resource conservation technologies (RCTs). It also save irrigation water about 25-30% also save production cost about 60%. However, RCTs have an alternate option to increase productivity, reduce irrigation and production cost and increase farmers income & livelihood in drought prone area.

The project aimed with four specific objectives focusing to increase cropping intensity & system productivity under drought prone areas, reduce production cost for crops and cropping pattern, increase water use efficiency in drought prone area and improve knowledge and skill of the farmers and to create awareness among the farmers of the project sites through resource conserving technologies (RCTs).

A large number of on-farm adaptive and up-scaling trials had conducted by the resource conservation technologies to improve crop productivity and cropping intensity for drought prone areas. The project activities have carried out in a participatory approach in the farmers field at three locations with 150 (One hundred fifty)) farmers for each location of three Upazila. There are 450 (Four hundred fifty) farmers have involved in the project activities in three Upazila of drought prone areas in Rajshahi and Chapainawabgonj district. The drought prone Upazilas are Paba and Godagari under Rajshahi district and Nachole in Chapai district.

An inception workshop has carried out on resource conserving technologies (RCTs) for familiar of the said workshop. Participatory training program had conducted among the farmers and concerned SA/SSA/SAAO/NGOs personnel to trained on RCTs technologies. Project activities will be carried out in a participatory way. Some drought tolerant crop varieties already selected compared with existing variety of farmers for different crops. Shorter growth duration of heat tolerant Taman rice have included for timely planting of Rabi crops.

A total number of 450 farmers each having 33 decimal of land had been selected under three upazilas for conduct on-farm participatory research with up scaling trials of resource conserving technologies for improving cropping productivity and inputs saving. A total of

four hundred fifty both validation and up scaling trials have been conducted in three Upazila to the farmers field on wheat, lentil, mungbean, rice, sesame, maize and chickpea. Among them, 130 validations 320 up scaling trials have been done on different crops for three Upazila under RCTs technology. Low water requirement and heat tolerant crops were used in the trials for three Upazila under RCTs technology. Result revealed that for both validation and up scaling trials have 10-20% yield advantages for all crops under RCTs technology over farmers practice. Included mungbean and sesame crops between two cereals for utilization on fallow land, as a result, increased 100-200% cropping intensity in the drought prone areas. Four works like ploughing, seeding, furrow making and laddering completely done by one pass as a result reduced production cost about 45-50%. Time of irrigation reduced about 30-35% and increased water use efficiency about 20% from conventional as a results 30-35% water saved from RCTs technologies over farmers practice.

From three years both validation and up scaling trials a lot of tremendous findings and interest among the farmers of drought prone areas. Farmers were very happy to see the performance of RCTs technology for their crop production. They saved the irrigation water and reduce production cost with scarifying yield. Firstly farmers did not believe this technology that in zero or less soil disturbances a good result will be found but when they practically used, they astonish to see the performance of this technology. Farmers observed at least three crops grow in a year instead of one or two crop. They saved irrigation water which was burning issue in that location and cost of production was very high in their traditional system. After two or three years crop cycles they found directly the following benefits to use this technology that cropping intensity increased by 100-200%, saved production cost by 45-50%, save irrigation water by 30-.35% in the studied areas. About 15-20 ton seeds and 10-15 thousand ton grains of different crops was added in national production. Soil fertility and productivity increased in farmer's field due to 30% straw retention from both wheat and rice and full residue retention from mungbean crop. Two bed planters and one strip tillage machine have already bought by the local service provider (LSP) and they used this machine for commercial basis. Created leadership among the farmers and LSP for use this machine and they earn lot of money. As results, Farmer's income increased which improved their livelihood and going their children to the school. About 1205 farmers trained up on RCTs technologies and modern crop production packages; as a result, knowledge and skill of the farmers have increased.

C. Introduction.

Climatic variations have a profound effect on agriculture and livelihoods of rural communities. The effect of climatic variation is more pronounced in the drought prone areas of Bangladesh. In Bangladesh the north-west part of Rajshahi division is different from other parts of the country due to its undulating topography having compact and low fertile soils. The region experienced high temperature with limited soil moisture storage along with low and erratic rainfall (BMDA, 2011). The climate of Bangladesh would change throughout this century because the atmosphere already has elevated levels of greenhouse gas. Bangladesh's drought-prone areas are warmer and drier than 50 years back ago (Selvaraju and Baas, 2007) and current projections suggest that Bangladesh will become hotter, its night will be warmer and it will face frequent droughts due to increased rainfall variations. Global circulation model (GCM) analysis indicates that the average temperature of Bangladesh will increase by 1.4^{o}C (±0.16) by 2050. Rajshahi meteorological data analysis also indicates that minimum temperature is increasing and winter is becoming warmer. From 2005 to 2011 the average increase of minimum temperature is more than 3^{o}C (Ali *et al,.* 2011). The projection also suggests that Bangladesh is likely to face more hot days and heat waves, longer dry sell and higher drought risk. Moisture holding capacity of drought prone area is low, soil is poor due to critical organic matter contents and low infiltration of water (Adham *et al.,* 2010; Ali *et al.* 2007). Drought prone area regularly experienced hot dry spell during April-May and mercury often goes above 40^{o}C (Zuberi, 2009). Potential evapo-transpiration is higher than precipitation in five months (January-May) resulting in water stress or drought for the growing crops. Farmers normally grow only one crop of Taman rice under rainfed condition in each year. Moreover, recent report indicates that ground water level of Chapai-Nawabganj district within Barind region rapidly falling due to over exploitation through deep tube well (Selvaraju *et al.,* 2006) and the deep tube wells have far less command area than expected and also irrigation cost is higher than that of other areas. From secondary data, it is reported that 40-57% yields reduce due to drought in drought prone area. Now cropping intensity in the drought prone area is about 130%. It is possible to increase cropping intensity from 130 to 300% by using appropriate RCTs techniques for improving crops productivity.

The concept of '**Conservation Agriculture'** which is rooted in giving a practical shape to a scientifically proven basic guiding principles has globally emerged as a way to achieve sustainability goals. The basic guiding principles that can leverage a change from the conventional agricultural system include:

Developing and promoting a system of raising crops with minimum soil disturbance through operations involving direct seeding of crops in untilled soils.

Keeping the soil surface covered by practices such as leaving and maintaining crop residues cover on the soil and /or growing cover crops.

Adopting pest and disease free diversified crop sequencing, spatially and temporally.

Farming practice based on these basic principles when adopted in an integrated fashion over a period of time contribute to sustainable increases in crop productivity, improving soil health, biodiversity and in reversing processes contributing to land and water degradation. Barind areas are the land where soils are heavy clay, dissected and acidic (pH 5.5) in nature. There are no rains from September to March but heavy rains in June to August. In Barind areas about 75,000 hectares of land remains fallow after Taman harvest due to lack of irrigation (BMDA Annual Report, 2010). Farmers kept Taman straw within 10-15 days for drying. As a result, farmers did not grow any Rabi crops due to optimum moisture. Near about 60,000 ponds goes through run in Rabi season. So we can easily give one or two irrigation for Rabi crops and can brings 40,000 ha land under Rabi crops. Also we can grow more food grain from Barind soil by Power tiller Operated Seeder (PTOS) with utilizing initial soil moisture. As a result, food production and farmers income will be increased. After harvest of Taman, 3-5 days remains optimum soil moisture for seed germination and we can easily grow wheat, chickpea, and other Rabi crops by PTOS. Because, we can easily ploughing, seeding and laddering at a time by this seeding machine.

Raised bed cultivation facilitates more optimum planting time by providing timelier field access because of better drainage. This system has many advantages such as reducing the seed rate, increasing crop yield, requiring less water imparting higher N use efficiency, and reducing crop lodging over the conventional sowing systems (Hobbs *et al*,1997). Conservation farming provides important benefits to the environment and economic benefits for the farmer. It aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustained agricultural production. Conservation farming is practice for the modernization of agriculture. It is commonly based on soil tillage. Conventional tillage techniques considerably increase soil degradation by compaction, erosion and river contamination with sediments, fertilizers and pesticides. In addition, conventional tillage techniques increase the emission of CO_2 into the atmosphere, contributing to global warning. It reduces the

sustainability of agriculture by lowering soil organic matter and fertility, along with further negative environmental effects as decrease in biodiversity.

However, research findings of BARI at drought prone area for mitigating the effect of drought shows that adjustment of Taman rice variety and planting time associated with proper water saving/water harvesting technology could improve the system productivity in an economic and sustainable fashion. RCTs technology facilitates for higher crop yields, saving production cost, labor and irrigation water with increasing cropping intensity and improving productivity. However, all those technologies need on-farm verification across drought prone area at farmer's level under the changing climatic conditions in a broader perspective before robust up-scaling. Under the above circumstances, the project is to be implemented to investigate the effect of RCTs technologies for sustainable crop production in different drought prone areas.

D. Specific project objective(s): (As per FRP/PIR)

- To increase cropping intensity & system productivity under drought prone areas
- To reduce cost of production for the small poor farmers
- To increase water use efficiency in drought prone area
- To improve knowledge and skill on RCTs of the poor farmers

E. Detailed Technical Report:

a. Statement of the Researchable Problem:

Climatic variations have a profound effect on agriculture and livelihoods of rural communities. The effect of climatic variation is more pronounced in the drought prone areas of Bangladesh. In Bangladesh the north-west part of Rajshahi division is different from other parts of the country due to its undulating topography having compact and low fertile soils. The region experienced high temperature with limited soil moisture storage along with low and erratic rainfall (BMDA, 2011). The last ten years mean rainfall was 1032±210 which is much lower than long term average rainfall (1508±312 mm). Moreover in the last three years consecutively lower precipitation was obtained; 1048 mm in 2009, 816 mm in 2010 and 1134 mm in 2011 which have seriously hampered rice cultivation, producing lower yield without supplementary irrigation and causing great concern because of downing of aquifer and scarcity of households water in dry season. The demand of food production is increasing day by day along with the increasing of high population. Now food problem is the burning issue in South Asia due to lack of food shortage with less production. To meet up the food security, potential yield and cropping intensity should be increased. To increase wheat production in the country, adoption of the resource conserving technologies (RCTs), especially power tiller

operated seeder and bed planter is very useful for quick finishing of planting operation and achieve crop diversification using less soil moisture. Barind tract is the region where 75,000 hectare of land is fallow after T.aman harvest due to lack of germination soil moisture and irrigation water (Annual report, BMDA, 2009). Farmers of this area kept 10-15 days of T aman straw on the same land for drying. After that there is no moisture there and farmers did not grow any rabi crops after T aman harvest. They are also facing trouble doing agricultural operations due to labor shortage especially during planting season. As a result, they grow wheat in late and gets very low yield. Conserving tillage machinery such as bed planter and power tiller operated seeder (PTOS) are the alternate ways to ensure timely planting, meet up labor shortage, keep crop production at economic level and enhance cropping intensity. Conservation farming provides important benefits to the environment and economic benefits for the farmer. It aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustained agricultural production. About 20-30 % of net cultivable area in Barind area remains fallow after harvest of Aman rice due to unavailable of initial soil moisture and water scarcity. To use this fallow land and increase cropping intensity need conservation agriculture based RCTs technology for improving crops productivity. RCTs reduced production cost, saved irrigation water with scarifying yield. Transplanted aman-fallow-fallow is the most dominant cropping pattern in the areas of Nachole district. Introduction of mungbean and sesame crops in to the existing cropping patterns by RCTs technology in the drought prone areas of Rajshahi and Nachole district may become a worthy effort to utilize these lands.

b. Research Approaches and Methodologies:

Approaches:

On-farm adaptive trials and up-scaling trials will be conducted by the resource conservation technologies to improve crop productivity and cropping intensity for drought prone areas. The project activities will be carried out in a participatory approach in the farmers field at three locations with 100 (one hundred) farmers for each location of three Upazila. There are 300 (three hundred) farmers will be involved in the project activities in three Upazila of drought prone areas in Rajshahi district. The drought prone Upazila are Paba and Godagari under Rajshahi district and Nachole in Chapainawabgnj district.

Methodologies:

Activity 1: Procurement of the lab and office equipments

One auger for collection of soil sample and one laptop also bought for conducting the project activities.

Activity 2: Establishment of forty two validation and one hundred fifty eight up scaling trials were conducted on different crops under RCTs technology in the farmer's field

a. Forty two validation and one hundred fifty eight up scaling trials were conducted on different crops through RCTs technology in a participatory way. Some drought tolerant rice, wheat, lentil, chickpea, maize, sesame and mungbean varieties were used compared with existing variety of farmers under RCTs technology.
b. All the field operations regarding production practices have been done by participatory farmers.
c. Regular monitoring of crop performance, weather and crop data recording and farmers reaction has been taken properly

Activity 3: Participatory training program on RCTs technology

Three participatory training programs for crop management through RCTs technologies already conducted with 300 farmers, 6 local leaders, 10 SAAO from DAE and Mass Media personnel. Leaflet has been supplied to the participants. One participatory trainer training program was conducted among the FA/ SSA/SA/ SAAO/NGOs/ Others for wheat, maize, chickpea, lentil, sesame and mungbean crops management through RCTs technologies on RCTs technology. 25 FA, 15 SAAO, 5 NGOs, 5 SA, SSA, local leaders and Mass Media personnel were presented in the training program. Leaflet has been supplied among the participants on resource conservation technology (RCTs).

Activity 4: Participatory field day or farmers rally among the participants for lentil, wheat and maize production under RCTs technology

Three participatory field day or farmers rally was conducted on wheat, maize and lentil crops under RCTs technologies among the participatory farmers. 300 farmers, 6 local leaders, 15 SAAO, DD & AD from DAE, 3 FA from KGF project, 5 NGOs and 6 Mass Media personnel were presented in the field day. Leaflet has been supplied among the participants on resource conservation technology (RCTs) and all participants visited the field and observed the performance on raised bed and strip till technology.

Details research activities

Activity 1: Establishment of lentil using residual soil moisture through raised bed and strip till systems

High yielding lentil variety like BARI Lentil 6, 7 were sown with raised bed system just after harvesting of Taman rice for utilizing residual soil moisture. Forty five up scaling trials were conducted in Godagari and Paba Upazila in Rajshahi district and Nachole at Chapai distrits. Each plot was one bigha or 33 decimal. All management practices have done for supporting the normal growth of the crops. Eighteen validation trials were conducted in Godagari and Paba Upazila in Rajshahi district and Nachole at Chapai district for showing results among the participatory farmers.

Data to be recorded:

1. Soil moisture monitoring at 15 days interval
2. Time of irrigation & cost under new technology and farmers practice
3. Yield and yield components
4. Weather data (Max. & Min. Temp and Rainfall)
5. Cost of production,
6. Economic analysis
7. Farmers reaction regarding our technology and others

Statistical tool: T. test (comparison between yield of trial plot and non-participatory farmers plot) by MSTAT-C software

Location: Godagari and Paba Upazila in Rajshahi district and Nachole at Chapai district.

Activity 2: Validation trials of wheat-mungbean-Taman rice cropping pattern under bed planting system using minimum irrigation water

Eighteen validation trials were conducted through raised bed technology on Taman rice variety like BINA Dhan 7, BRRI Dhan 56 and 57 (Drought resistant variety) with unpuddled condition at Godagari, Paba and Nachole Upazila to utilizing minimum irrigation water. Each plot was 33 decimal. All management practices have done for supporting the normal growth of the crops. After harvest of Taman, twenty two validations trials were conducted of wheat by raised bed and strip till system with initial soil moisture. Comparison would be made with control plot/farmers plot adjacent to experimental plot. Heat tolerant wheat varieties like BARI Gom 26, 28 and BARI Gom 30 were used. All other management practices were done for supporting the normal growth of the crops. Eighteen validation trials were conducted in Godagari and Paba Upazila in Rajshahi district and Nachole at Chapai district for showing results among the participatory farmers.

Data to be recorded:

1. Soil moisture monitoring at 15 days interval
2. Time of irrigation & cost under new technology and farmers practice
3. Yield and yield components
4. Weather data (Max. & Min. Temp. and Rainfall)
5. Cost of production,
6. Economic analysis
7. Farmers reaction regarding bed planting and others

Statistical tool: T. test (Comparison would be made with control plot/farmers plot adjacent to trial plot) by MSTAT-C software

Location: Nachole in Chapai District and Paba and Godagari Upazila in Rajshahi district.

]Activity 3: Establishment of heat/drought tolerant wheat varieties through bed planting and strip till using residual soil moisture

One hundred ten up scaling trials were conducted after harvest of Taman rice in Godagari, and Paba Upazila in Rajshahi district and Nachole at Chapai district. Heat tolerant wheat varieties like BARI Gom 26, BARI Gom 28 and BARI Gom 30 have used with raised bed and strip till technology for utilizing residual soil moisture. Ploughing, furrow making, seeding and laddering have done just one pass tillage operation with raised bed and strip till system. Each plot has 33 decimal. All management practices have done by farmer's participatory approaches for supporting advice of scientist. Twenty two validation trials were conducted at every Upazila for showing and comparing results among the farmers.

Data to be recorded:

1. Soil moisture monitoring at 15 days interval
2. Time of irrigation & cost under new technology and farmers practice
3. Yield and yield components
4. Weather data (Max. & Min. Temp. and Rainfall)
5. Cost of production,
6. Economic analysis
7. Farmers reaction regarding our technology and others

Statistical tool: T. test (comparison between yield of trial plot and non-participatory farmers plot) by MSTAT-C software

c. Results and Benefits:

(i). List objective-wise activities clearly, resulting in specific output(s), such as

Specific Project Objective(s)	Planned activities performed against each objective	State progress made clearly during the reporting period against each activity	Outputs/results achieved during this period
1. To increase cropping intensity & system productivity under drought prone areas	Included pulse, oilseed, maize crops in the cropping pattern	Already six crops like wheat, mungbean, Taman two cycles harvested and reporting the data	1. Cropping intensity increased 100-200%. 2. System productivity increased 15-20%

2 To reduce production cost for crops and cropping pattern	Ploughing, seeding, furrow making and laddering four works did at a time	Saved 40% time from seeding and 50% from labor. So, average 45% save from seeding cost	Saved production cost 15000 taka/ha from three crops
3. To increase water use efficiency in drought prone area	Saved 30% time during irrigation, Saved labor during irrigation	Half an hour time saved per bigha over conventional that mean 30% saved water over conventional	Saved irrigation water about 30-35% over FP
4. To improve knowledge & skill and to create awareness among the farmers	Farmers, NGOs, SAAO and local personnel training on RCTs technology	Gathered much knowledge about RCTs on lentil, rice and wheat production by RCTs technology	1205 personnel trained up on RCTs technology and they used this technology for different crops.

(ii). Outputs/Results:

Brief description of different parameter in the study areas

Weather parameters (Rainfall)

From figure 1.we found that month wise total rainfall from 2013 to 2015 in Nachole upazila , Chapai district was almost zero from Nov, Dec, Jan and Feb and was very minimum from the month of March to June. Maximum rainfall occurs from July to October in all three years but. It was unpredictable and uneven rainfall in the crops growing period in those areas. As a results, it also hampers our crop production. Only August to October was maximum rains but it also hamper crop production due to late rainfall.

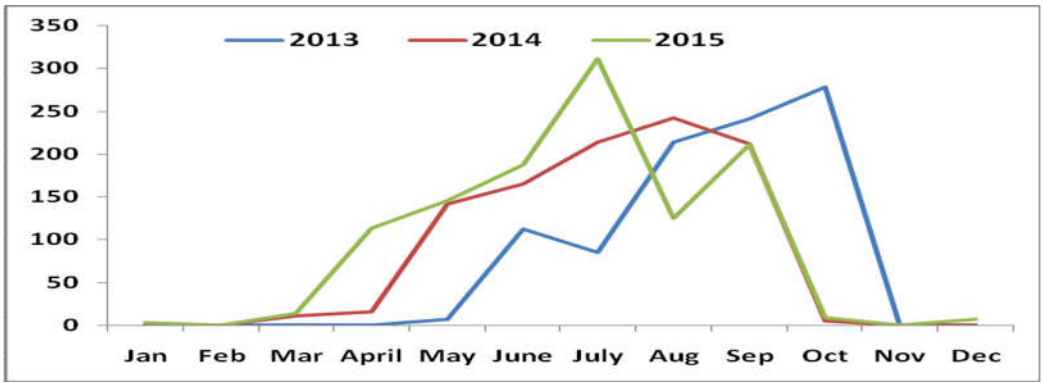

Figure 1. Month wise total rainfall from 2013 to 2015 in Nachole upazila , Chapai district

From figure 2.we found that month wise total rainfall from 2013 to 2015 in Godagari upazila , Rajshahi district was almost zero from Nov, Dec, Jan and Feb in all three year and was very minimum from the month of March to June. Maximum rainfall occurs from July to October in all three years but. It was unpredictable and uneven rainfall in the crops growing period in those areas. As results, it also hampers our crop production. Only August to October was maximum rains but it also hamper crop production due to late rainfall.

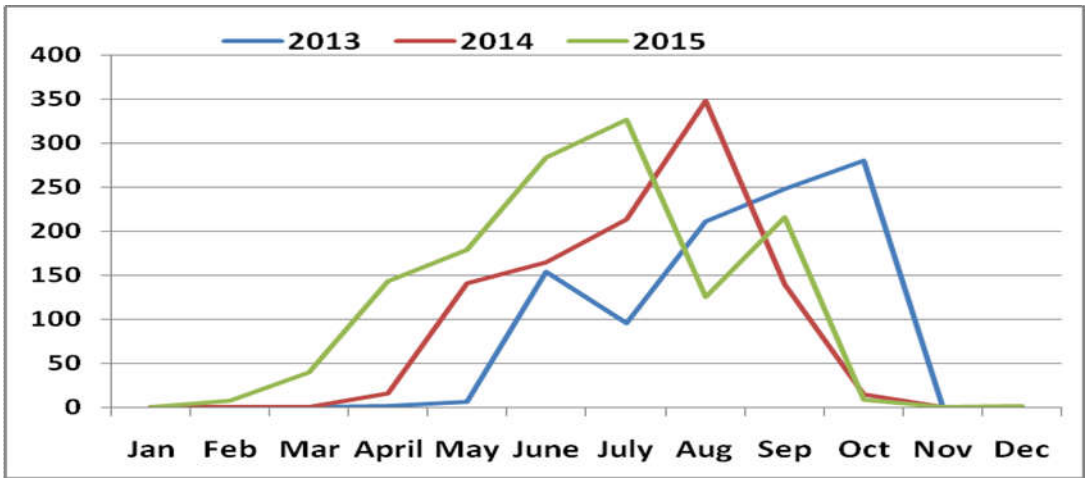

Figure 2. Month wise total rainfall from 2013 to 2015 in Godagari upazila, Rajshahi district

Maimum and minimum temperature from 2013 to 2015 in the study areas

From figure 3. we found that maximum temperature of Nachole upazila was found in the month of May to July and sometimes it was above 45^0C in May in all three years and minimum was in January and it was below 4^0C. So, it was hamper for crop production and creats new pathogen and insects with new diseases. These temperature was unpredictable and creates registant among the pathogen and insects which hampers low yield in our crops. High temperature hamper to rise ground water table and also hamper in drinking water.

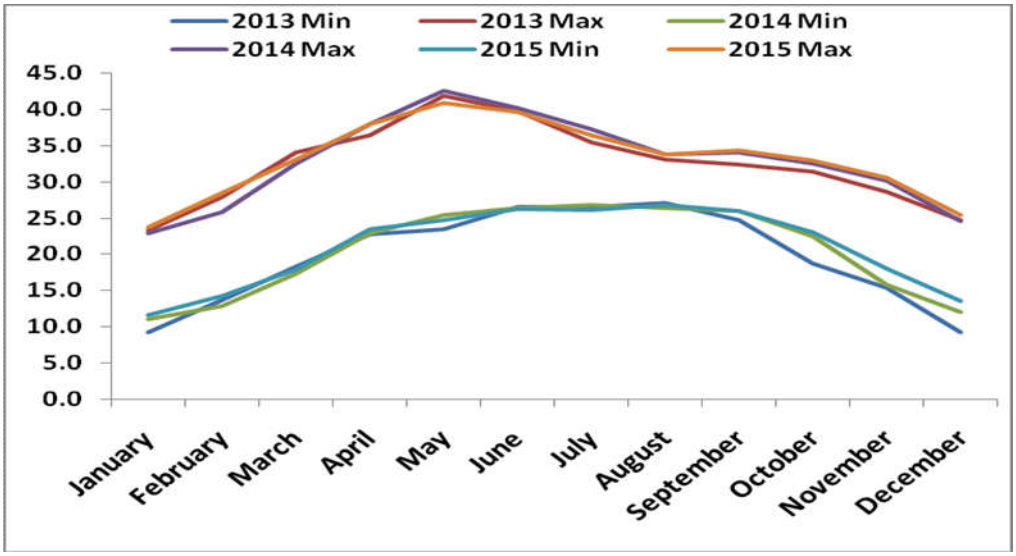

Figure 3. Month wise max. & min temp from 2013 to 2015 in Nachole upazila , Chapai district

From figure 4. we found that maximum temperature of Godagari upazila in Rajshahi district was found in the month of May to July and sometimes it was above 45^0C in May in all three years and minimum was in January and it was below 4 -5^0C. So, it was hamper for crop production and creats new pathogen and insects with new diseases. These temperature was

unpredictable and creates registant among the pathogen and insects which hampers low yield in our crops. High temperature hamper to rise ground water table and also hamper in drinking water.

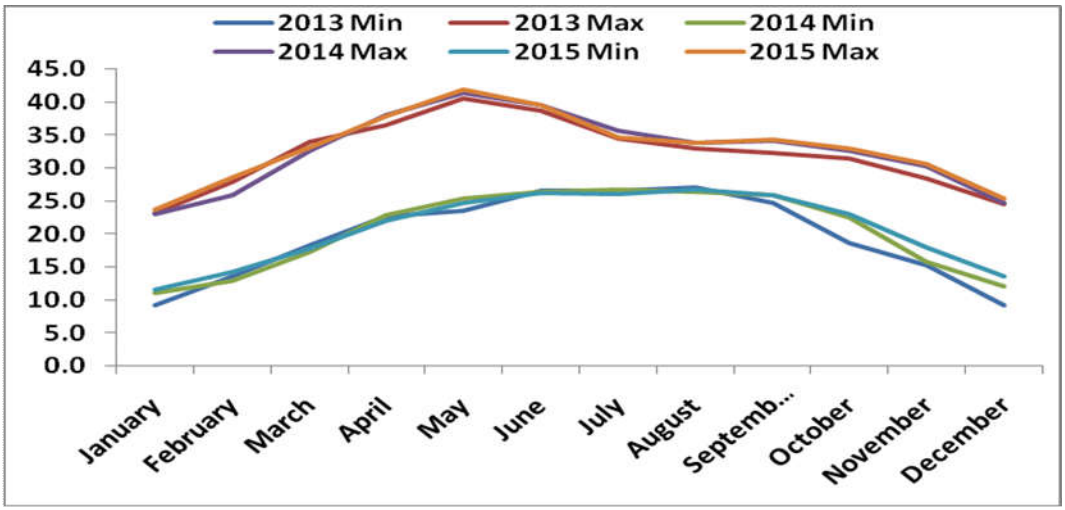

Figure 4. Month wise max. & min temp from 2013 to 2015 in Godagari upazila, Rajshahi district

Ground water table in Godagari Upazila

From figure 5. we found that ground water table in Godagari Upazila was increased every year. From the graph showed that from the year of 1985 to 2005 ground water table was 25 feet but last seven years it was increased 65-70 feet. So, it was the matter of think about in those areas for crop production. Sometimes farmers did not get any water from deep tube well in that area. They depends only rain water for their crop production.

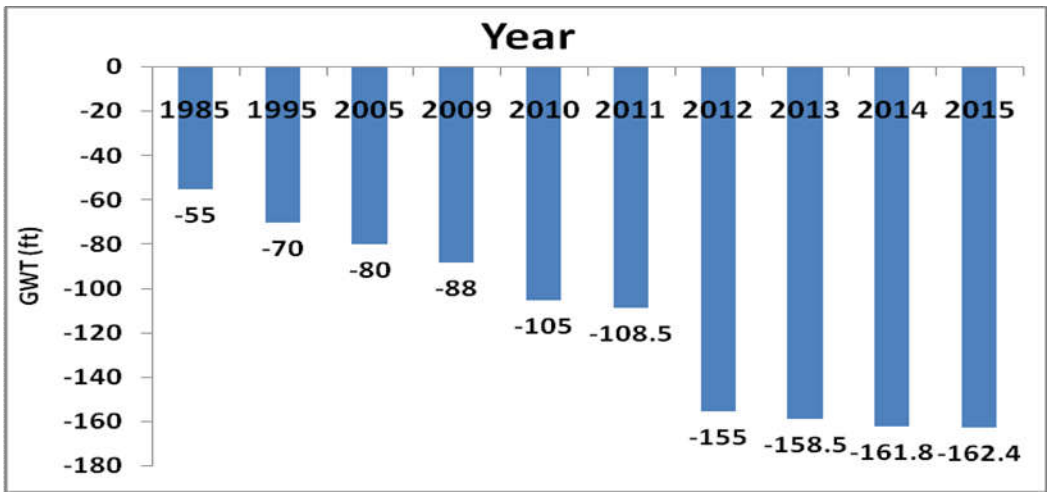

Figure 5. Ground water table from 1985 to 2015 in Godagari Upazila (Source: Public health, Rajshahi)

Highlight of Research Findings.

Requirement of Irrigation water

Amount of irrigation water required at different growth stages of rice, wheat and mungbean varied remarkably between the conventional method and beds both the years. The conventional method received the highest amount of water at every irrigation time (Figure 4).The total amount of irrigation water required for conventional method was 320, 350 ,155 liters 15 m^{-2} in wheat, rice , mungbean respectively . But in beds the total amount of irrigation water 240, 270, 110 liters 15 m^{-2} in wheat, rice, mungbean respectively. The total water saved by beds over conventional method was 25 %, 23%, 29% respectively


Figure 6. Irrigation water requirement both in raised bed over conventional

Seeding cost performance

Cost components of different operations in crop cultivation between conventional method and raised bed system were shown in Table 1. Wheat crop was considered in this cost comparison. Seeding cost by raised bed was much less than the conventional planting method. Planting cost of wheat 870 taka per bigha and 6525 taka per hectare that means seeding cost save about 45-50% through RCTs technology

Table 1. Comparative findings for wheat production cost under RCTs technology

Land preparation	300	600
Sowing & lathering	-	200
Seeds	560	700
Irrigation/hours	420 (3 times)	650 (3 times)
Total	1280	2150

Save= 870 Tk/ 33 decimal=6525 Tk/ha, Save cost about 45 to 50%

Results of T aman rice

Yield and yield components of T aman rice positively responded to different tillage options (Table 2). Average two validation trials results showed that maximum tiller hill^{-1} (19.5), panicle length (28.7 cm), grains panicle^{-1}(152.7) and 1000 grain weight (24.05) were obtained from raised bed system and minimum tiller hill^{-1} (13.4), panicle length (25.2 cm), grains panicle^{-1}(137.4) and 1000 grain weight (23.40) were obtained farmers practice. Maximum grain yield (4.52 t/ha) was found from raised bed and minimum (4.14 t/ha) from farmers practice. Yield increase percentages (8.4%) were higher over farmers practice.

Figure 1: Taman rice seedlings on raised bed in Belghoris Charghat. Rajshahi

Table 2: Yield & yield attributes of T aman under RCTs technology in Middle Shahpur, Charghat (Validation trials)

Technology	Farmers	Tiller hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	1000 grain wt(g)	Grain yield (t/ha)	Yield increase over FP (%)
Raised bed	06	19.5	28.7	152.7	24.05	4.52	8.4
Farmers practice		13.4	25.2	137.4	23.40	4.14	-
T-Test		**	*	**	ns	**	

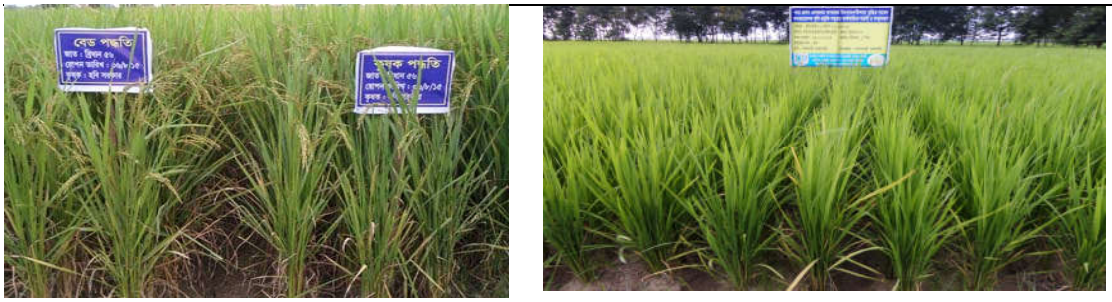

Figure 2: Taman rice on bed vs farmers practice in Taldhari, Godagari. Rajshahi

Taman rice yield was higher under resource conservation technologies at middle Shahpur, Charghat Upazila in both the varieties (Table 2). The yield of BRRI Dhan 56 (4.41 t/ha) and BRRI Dhan 57 (4.11 t/ha) were found higher from raised bed system and (3.87 t/ha) & (3.89 t/ha) from farmers practice and yield increased (8.84 & 8.02 %) were higher under raised bed

over farmers practice. So, farmers got higher productivity also higher benefit from RCTs technology over their own practice.

Table 2: Average T aman rice yield under RCTs technology in Middle Shahpur, Charghat (15 up scaling trials)

Varieties	Farmers	T aman yield (t/ha)		Yield increase over FP (%)
		Raised bed	Farmers practice	
BRRI Dhan 56	08	4.41	4.02	8.84
BRRI Dhan 57	07	4.11	3.78	8.02
T-Test		**	**	**

Figure 3: Taman rice on bed vs farmers practice in Shahpur, Charghat. Rajshahi

From Table 3 all economical parameters were higher from raised bed system over farmer's practices. Maximum gross margin (51430) was found raised bed method and minimum (41400) from farmers practices. Maximum benefit cost ratio (2.03) was found from RCTs technology over farmer's practices

Table 3. Economic analysis of Taman rice under RCTs technology

Treatment	Yield (t/ha)	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
Raised bed	4.26	76680	25250	51430	2.03
Farmers plot	3.90	70200	28800	41400	1.44

Yield and yield components of T aman rice positively responded to different tillage options (Table 4). Average two validation trials results showed that maximum tiller hill^{-1} (17.8), panicle length (26.4 cm), grains panicle^{-1}(143.2) and 1000 grain weight (22.4) were obtained from raised bed system and minimum tiller hill^{-1} (11.5), panicle length (23.7 cm), grains panicle^{-1}(129.1) and 1000 grain weight (20.7) were obtained farmers practice. Maximum grain yield (4.14 t/ha) was found from raised bed and minimum (3.72 t/ha) from farmers practice. Yield increase percentages (10.14%) were higher over farmers practice.

Table 4: Yield & yield attributes of T aman under RCTs technology in Alimgonj, Paba (Validation trials)

Treatment	Farmers	Tiller hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	TGW (g)	Grain yield (t/ha)	Yield increase over FP (%)
Raised bed	06	17.8	26.4	143.2	22.4	4.14	10.14
FP		11.5	23.7	129.1	20.7	3.72	-
T-Test		**	*	**	*	**	

Taman rice yield was higher under resource conservation technologies at Taldhari, Godagari Upazila in both the varieties (Table 5). BINA Dhan 7 (4.14 t/ha) and BRRI Dhan 57 (4.21 t/ha) were found under raised bed system and (3.77 t/ha) & (3.89 t/ha) from farmers practice and yield increased (8.93 & 7.60 %) under raised bed over farmers practice. So, farmers got higher yield from RCTs technology over their own practice.

Figure 4: BRRI Dhan 57 and Guti Swarna under raised bed and FP

Table 5: Average T aman rice yield under RCTs technology at Alimgonj, Paba (10 up scaling trials)

Varieties	Farmers	T aman yield (t/ha)		Yield increase over FP (%)
		Raised bed	Farmers practice	
BINA Dhan 7	05	4.14**	3.77	8.93
BRRI Dhan 57	05	4.21**	3.89	7.60

**= significant yield difference between RB and FP

From Table 6 all economical parameters were higher from raised bed system over farmer's practices. Maximum gross margin (49810) was found raised bed method and minimum (40140) from farmers practices. Maximum benefit cost ratio (1.97) was found from RCTs technology over farmer's practices.

Table 6. Economic analysis of Taman rice under RCTs technology at Alimgong, Paba

Treatment	Grain yield (t/ha)	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
Raised bed	4.17	75060	25250	49810	1.97
Farmers plot	3.83	68940	28800	40140	1.39

Yield and yield components of T aman rice positively responded to different tillage options (Table 7). Average two validation trials results showed that maximum tiller hill^{-1} (17.4), panicle length (25.4 cm), grains panicle^{-1}(132.6) and 1000 grain weight (22.15) were obtained from raised bed system and minimum tiller hill^{-1} (12.3), panicle length (22.7 cm), grains panicle^{-1}(112.4) and 1000 grain weight (20.73) were obtained from farmers practice. Maximum grain yield (4.24 t/ha) was found from raised bed and minimum (3.81 t/ha) from farmers practice. Yield increase percentages (10.14%) were higher over farmers practice.

Table 7: Yield & yield attributes of T aman under RCTs technology in Taldhari, Godagari (Validation trials)

Technologies	Farmers	Tiller hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	1000 grain wt(g)	Grain yield (t/ha)	Yield increase over FP (%)
Raised bed	06	17.4	25.4	132.6	22.15	4.24	10.14
Farmers practice		12.3	22.7	112.4	20.73	3.81	-
T-Test		**	*	**	*	**	

Taman rice yield was higher under resource conservation technologies at middle Shahpur, Charghat Upazila in both the varieties (Table 8). BRRI Dhan 56 (4.38 t/ha) and BRRI Dhan 57 (4.19 t/ha) were found under raised bed system and (4.08 t/ha) & (3.83 t/ha) from farmers practice and yield increased (8.44 & 8.59%) under raised bed over farmers practice. So, farmers got higher yield from RCTs technology over their own practice.

Table 8: Average T aman rice yield under RCTs technology in Taldhari, Godagari (10 up scaling trials)

Varieties	Farmers	T aman yield (t/ha)		Yield increase over FP (%)
		Raised bed	FP	
BRRI Dhan 56	05	4.38	4.01*	8.44
BRRI Dhan 57	05	4.19	3.83*	8.59

From Table 9 all economical parameters were higher from raised bed system over farmer's practices. Maximum gross margin (51790) was found raised bed method and minimum

(42300) from farmers practices. Maximum benefit cost ratio (2.05) was found from RCTs technology over farmer's practices.

Table 9. Economic analysis of Taman rice under RCTs technology at Taldhari, Godagari

Treatment	Grain yield (t/ha)	Gross return ($Tk\ ha^{-1}$)	Total variable cost ($Tk\ ha^{-1}$)	Gross margin ($Tk\ ha^{-1}$)	BCR
Raised bed	4.28	77040	25250	51790	2.05
Farmers plot	3.95	71100	28800	42300	1.46

Effect of tillage options on grain yield of three locations in drought prone areas

Grain yield of Taman rice was significant under different tillage options in three locations ($P \leq 0.05$) (Figure-5). The highest grain yield of Taman rice was observed in unpuddled transplanting in strip till system (4.45 t ha^{-1}) followed by unpuddled transplanting in bed system (4.2 t ha^{-1}) in all location and the lowest grain yield was also found from in direct seeded rice (DSR) and it was similar to conventional practices (CT) in all three location. The crop grown in strip and bed system got more light, air and also had border effect and resulted to better growth and yield. In strip tillage, plant grows in line and it is easy to do all intercultural operation. As the soil is not disturbed in ST system, soil aeration is done well compared to other systems and resulted to good yield.

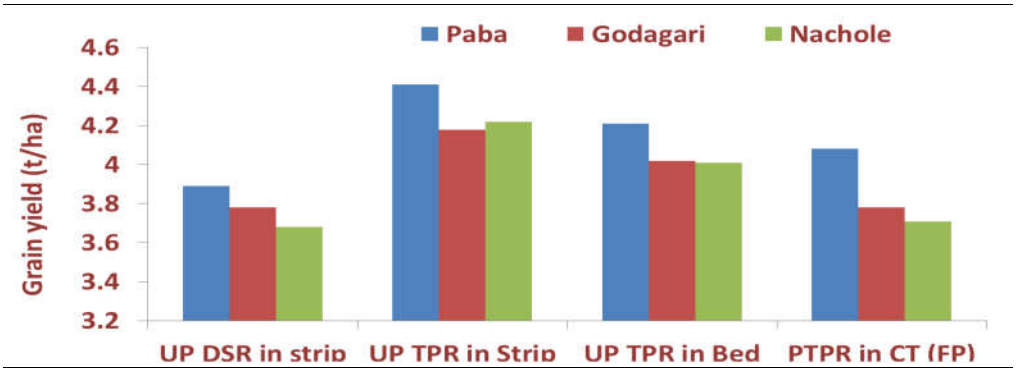

Figure 5. Grain yield of T. aman rice under different tillage options in three locations

Grain yield of Taman rice was significant under different tillage options in five farmer's field. ($P \leq 0.05$) (Figure-6). The highest grain yield of Taman rice was observed in unpuddled transplanting in bed planting system in all farmers field and the lowest grain yield was also found from conventional practices (CT) in all the farmers. 12-15% yield increase was also observed from all farmers in Bijoynagar, Godagari, Rajshahi. The crop grown in bed system got more light, air and also had border effect and resulted to better growth and yield. As the soil is not disturbed in bed system, soil aeration is done well compared to other systems and resulted to good yield.

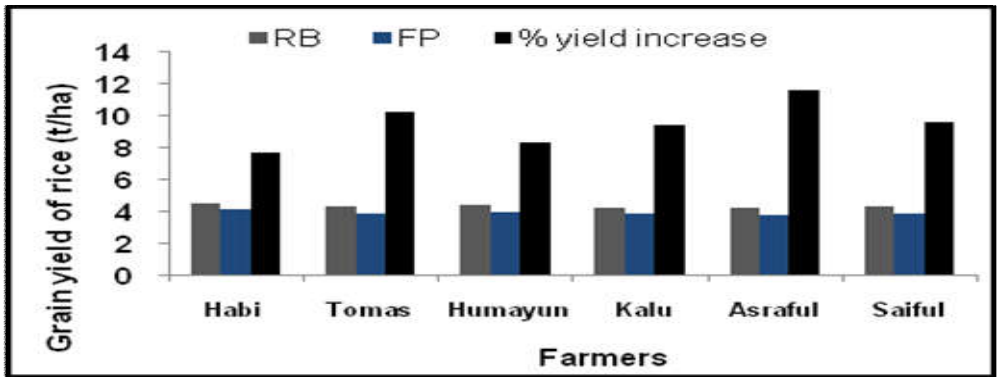

Figure 6. Grain yield & percent yield increase of T. aman rice under different tillage options at Bijoynagor, Godagari, Rajshahi

Grain yield of Taman rice was significantly affected by different tillage options in five farmer's field. ($P \leq 0.05$) (Figure-7). The highest grain yield of Taman rice was observed in unpuddled transplanting in bed planting system and the lowest grain yield was also found from conventional practices (CT) in all the farmers. 10-12% yield increase was also observed from all farmers field in Nachole, Chapainawabgonj. The crop grown in bed system got more light, air and also had border effect and resulted to better growth and yield. As the soil is not disturbed in bed system, soil aeration is done well compared to other systems and resulted to good yield.

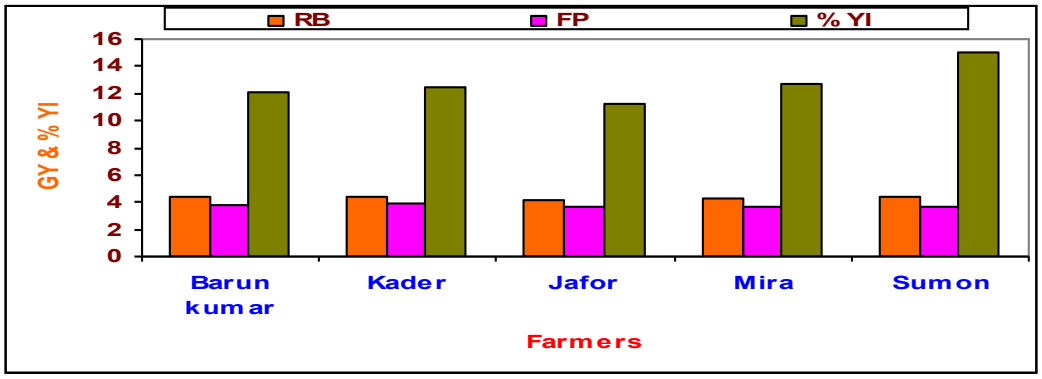

Figure 7. Grain yield % yield increase of Taman rice under tillage options in five farmers

Figure 8. Crop performance of Taman rice under different tillage options in five farmers

The performance of Taman rice variety BRRI Dhan 56 at Alimgonj, Paba, Rajshahi in presented in Table 10. Maximum grain yield of was found from strip till method (4.21 t-ha^{-1}) followed by raised bed (4.01 t- ha^{-1}). The lowest yield (3.74 t- ha^{-1}) was found from conventional method. The gross margin of strip till method was Tk. 28710 ha^{-1} and BCR was 1.81 (Table-10) followed by Tk. 27700 and BCR was 1.78 and there was no significant different between strip and raised bed method. The lowest gross margin was Tk. 17900 ha^{-1} and BCR was 1.46 from conventional method.

Table 10: Agro-economic performance of up scaling trials of Taman rice under different tillage options at Alimgonj, Paba, Rajshahi

Tillage options	No. of farmers	Area (Bigha)	Yield (t-ha^{-1})	GR (Tk ha^{-1})	TVC (Tk ha^{-1})	GM (Tk ha^{-1})	BCR
Raised bed	8	8	4.01	63100	35400	27700	1.78
Strip till	6	6	4.21	63810	35100	28710	1.81
Conv.	6	6	3.74	56100	38200	17900	1.46

The performance of Taman rice variety BRRI Dhan 56 at Bijoynagar, Godagari, Rajshahi in presented in Table 11. Maximum grain yield of was found from strip till method (4.17 t-ha^{-1})

followed by raised bed (4.03 t- ha^{-1}). The lowest yield (3.77 t- ha^{-1}) was found from conventional method. The gross margin of strip till method was Tk. 27450 ha^{-1} and BCR was 1.78 (Table-11) followed by raised bed systems Tk. 25050 and BCR was 1.70 and there was no significant different between strip till and raised bed method. The lowest gross margin was Tk. 18350 ha^{-1} and BCR was 1.48 from conventional method.

Table 11: Agro-economic performance of up scaling trials of Taman rice under different tillage options at Bijoynagar, Godagari, Rajshahi

Tillage options	No. of farmers	Area (Bigha)	Yield (t-ha^{-1})	GR (Tk ha^{-1})	TVC (Tk ha^{-1})	GM (Tk ha^{-1})	BCR
Raised bed	8	8	4.03	60450	35400	25050	1.70
Strip till	6	6	4.17	62550	35100	27450	1.78
Conv.	6	6	3.77	56550	38200	18350	1.48

The performance of Taman rice variety BRRI Dhan 56 at Bahrail, Nachole and Chapai in presented in Table 12. Maximum grain yield of was found from strip till method (4.12 t-ha^{-1}) followed by raised bed (4.03 t- ha^{-1}). The lowest yield (3.8 t-ha^{-1}) was found from conventional method. The gross margin of strip till method was Tk. 26700 ha^{-1} and BCR was 1.76 (Table-12) followed by Tk. 25050 and BCR was 1.70 from raised bed method and there was no significant different between strip and raised bed method. The lowest gross margin was Tk. 20000 ha^{-1} and BCR was 1.52 from conventional method.

Table 12: Agro- economic performance of up scaling trials of Taman rice under different tillage options at Bahrail, Nachole and Chapainawabnonj

Tillage options	No. of farmers	Area (Bigha)	Yield (t-ha^{-1})	GR (Tk ha^{-1})	TVC (Tk ha^{-1})	GM (Tk ha^{-1})	BCR
Raised bed	8	8	4.03	60450	35400	25050	1.70
Strip till	6	6	4.12	61800	35100	26700	1.76
Conv.	6	6	3.88	58200	38200	20000	1.52

Soil moisture monitoring was 15 days interval from sowing to maturity stage of the chickpea crop (Table 13). Soil moisture decrease from sowing to harvesting and it was decrease up to 90 DAS and farmers used no irrigation for chickpea crop in Barind region.

Table 13: Changes in soil moisture of chickpea field as influenced by various treatments at different tillage practices during 2014-15.

Treatment	Days after sowing (DAS)						
	0	15	30	45	60	75	90
Raised bed	26.25	24.85	21.86	20.13	17.58	16.18	14.86
FP	26.81	24.13	21.05	19.86	16.85	15.78	13.93

Figure 9. Crop performance of chickpea under strip tillage method in five farmers

For Chickpea

Yield and yield components of chickpea responded significantly to different tillage practices after harvest of T. Aman rice (Table 14). Maximum pods plant^{-1} (48.1) was obtained from strip till method and the minimum (45.9) was in FP. Maximum seeds pods$_{-1}$ (1.75) and thousand seed weight (18.3 g) was obtained from strip till method. Maximum seed yield (2.63 t ha^{-1}) was obtained from strip till method and minimum (2.21 t ha^{-1}) in FP. Yield increase (15.6%) was found from strip till method over farmers practice.

Table 14: Yield and yield component of chickpea as influenced by strip till at Taldhari, Godagari during 2014-15 (Validation trials)

Treatment	Farmers	Pods plant^{-1}	Seeds pod^{-1}	TSW (g)	Seed yield (t/ha-1)	% Yield increase over FP
Strip till	06	43.8	1.35	16.6	2.71	17.4
FP		40.7	1.15	14.7	2.32	-
T-Test		*	*	*	**	

Yield and yield components of chickpea responded significantly to different tillage practices after harvest of T. Aman rice (Table 15). Maximum pods plant^{-1} (48.1) was obtained from strip till method and the minimum (45.9) was in FP. Maximum seeds pods^{-1} (1.75) was found from strip till method and minimum (1.58) was found from FP. Maximum thousand seed weight (18.3 g) was obtained from strip till method and minimum (17.8) was in FP. Maximum seed yield and (2.69 t/ha) was obtained from strip till method and minimum (2.31 t/ha) were found from FP. Average two years results, yield increase (18.9%) was found from strip till method over farmers practice.

Figure 10. Chickpea on farmers field by strip till VS conventional method

Table 15: Yield and yield component of chickpea as influenced by RCTs technology at Alimgong, Paba during 2014-15 (Up scaling trials)

Treatment	Farmers	Pods plant^{-1}	Seeds pod^{-1}	TSW (g)	Seed yield (t/ha^{-1})	Yield increase (%) over FP
Strip	6	48.1	1.75	18.3	2.69	18.9
FP	6	45.9	1.58	17.8	2.31	-
T-Test		*	**	*	**	

Soil moisture monitoring was 15 days interval from sowing to maturity stage of the lentil crop (Table 16). Soil moisture decrease from sowing to harvesting and it was decrease up to 90 DAS and farmers used no irrigation for lentil crop in Barind region.

Farmer's reaction

Farmers were very much impressed to get higher yield from raised bed method over farmers practice. Farmers also got more income from raised bed systems. As higher yield was found from selected treatment so it would be economically viable and profitable.

Table 16: Changes in soil moisture of lentil field influenced by various treatments at different tillage practices during 2014-15.

Treatment	Days after sowing (DAS)						
	0	15	30	45	60	75	90
Raised bed	26.50	23.55	21.50	19.16	17.58	15.85	14.81
FP	26.08	23.02	20.28	18.56	16.23	14.51	13.25

For lentil crop

Yield and yield components of lentil responded significantly to different tillage practices after harvest of T. Aman rice (Table 17). Maximum pod plant^{-1} (99.1) was found in raised bed system and minimum pod plant^{-1} (80.6) was found from FP. Maximum seed pod^{-1} (1.90) was obtained from raised bed system and minimum (1.33) was from FP. Maximum thousand seed weight (16.7 g) was obtained from raised bed system and minimum (13.9 g) from FP. Maximum seed yield (1.98 t/ha) was obtained from raised bed system and minimum (1.41 t/ha) in 2014-15 from FP. Yield increase (29.4%) was found from raised bed system over FP.

Table 17: Yield and yield component of lentil as influenced by RCTs technology at Alimgonj, Paba during 2014-16 (validation trials)

Treatment	Farmers	Pods plant^{-1}	Seeds pod^{-1}	TSW (g)	Seed yield (t/ha^{-1})	% Yield increase over FP
RB	06	99.1	1.90	16.7	1.98	29.4
FP		80.6	1.33	13.9	1.41	-
T-Test		**	**	**	**	

Figure 11. Crop performance of lentil under raised bed over conventional method in five farmers

Yield and yield components of lentil responded significantly to different tillage practices after harvest of T. Aman rice (Table 18). Maximum pod plant^{-1} (105.5) was found in raised bed system and minimum pod plant^{-1} (95.8) was found in FP. Maximum seed pod^{-1} (1.96) was obtained from raised bed system and the minimum (1.43) was in FP. Maximum thousand seed weight (16.7 g) was obtained from raised bed system and minimum (14.01) was found from FP. Maximum seed yield (2.07 t/ha) were obtained from raised bed system and minimum and (1.42 t/ha) from FP. Yield increase (32.3%) was found from raised bed system over FP

Table 18: Yield and yield component of lentil as influenced by RCTs technology at Basantapur, Godagari during 2014-15 (up scaling trials)

Treatment	Farmers	Pods plant^{-1}	Seeds pod^{-1}	TSW (g)	Seed yield (t/ha^{-1})	% Yield increase over FP
RB	10	105.5	1.96	16.7	2.07	32.3
FP	10	95.8	1.43	14.01	1.42	-
T-Test		**	**	*	**	

Figure 12: Lentil performance on bed vs farmers practice in Taldhari, Godagari. Rajshahi

Farmer's reaction

Farmers were very much impressed to get higher yield from raised bed method over farmers practice. Farmers also got more income from raised bed systems. As higher yield was found from selected treatment so it would be economically viable and profitable.

For wheat

Soil moisture

Soil moisture monitoring was 15 days interval from sowing to maturity stage of the wheat crops (Table 19). Soil moisture decrease up to 20 DAS but after 1st irrigation it was increases. But after 30 DAS soil moisture was again decrease up to 90 DAS and farmers used only one irrigation for wheat crop in Barind region.

Table 19. Changes in soil moisture of wheat field influenced by various treatments at different tillage practices during 2014-15

Treatment	Days after sowing (DAS)						
	0	15	30	45	60	75	90
Raised bed	25.09	22.45	24.36	22.37	19.43	16.81	14.85
FP	25.52	22.16	25.08	21.78	18.23	15.85	13.95

Yield and yield components of wheat responded significantly to different tillage practices after harvest of T. Aman rice (Table 20) among 18 farmers. Maximum spike m^{-2} (403.0) was found in the raised bed system and minimum of (361.9) was observed in farmers practice. Maximum grains $spike^{-1}$ (56.6) was found in raised bed system and minimum grains $spike^{-1}$ (47.5) was found in FP. Maximum thousand grains weight (47.2 g) was obtained from raised bed system and minimum (42.3 g) from FP. Maximum grain yield and (4.68 t/ha) was obtained from raised bed system and minimum and (3.82 t/ha) in from FP. Yield increase (22.7%) was found from raised bed system over FP.

Table 20. Yield and yield components of wheat as influenced by RCTs technology during 2014-15 (Validation trials)

Treatment	Farmers	Spikes m^{-2}	Grains $spike^{-1}$	TGW (g)	Grain yield (t ha^{-1})	Av. yield increase over FP (%)
RB	18	403.0	56.6	47.2	4.68	22.7
FP		361.9	47.5	42.3	3.82	-
T-Test		**	**	*	**	

Figure 13: Wheat on bed vs farmers practice in Taldhari, Godagari. Rajshahi

Yield and yield components of wheat responded significantly to different tillage practices after harvest of T. Aman rice (Table 21) among 60 farmers. Maximum spike m^{-2} (389) was found in the raised bed system and minimum of (352) was observed in farmers practice. Maximum grains $spike^{-1}$ (55.4) was found in raised bed system and minimum grains $spike^{-1}$ (48.3) was found in FP. Maximum thousand grains weight (47.3 g) was obtained from raised bed system and minimum (43.5 g) from FP. Maximum grain yield (4.52 t ha^{-1}) was obtained from raised bed system and minimum (3.91 t ha^{-1}) from FP. Yield increase (17.5%) was found from raised bed system over FP

Table 21. Yield and yield components of wheat as influenced by RCTs technology during 2014-15 (up scaling trials)

Treatment	Farmers	Spikes m^{-2}	Grains $spike^{-1}$	TGW (g)	Grain yield (t ha^{-1})	Yield increase over FP (%)
RB	30	389	55.4	47.3	4.52	17.5
FP	30	352	48.3	43.5	3.91	-
T-Test		*	**	*	**	

Figure 14: Wheat on bed vs farmers practice in Bijoynagar, Godagari. Rajshahi

Economic performance

The maximum gross margin (85200) was found from raised bed system and minimum (57935) was obtained from farmer practice (Table 22). The highest BCR (1.67) was obtained from raised bed system and lowest (1.48) was also found from farmers practice.

Table 22. Cost and return analysis for wheat as influenced by RCTs technology (Validation trials)

Treatment	Yield (t/ha)		Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)	BCR
	Grain	Straw				
Raised bed	4.58	5.76	109500	24300	85200	1.67
FP	3.45	4.51	86250	28315	57935	1.48

Farmer's reaction

Farmers were very much impressed to get higher yield from raised bed method over farmers practice. Farmers also got more income from raised bed systems. As higher yield was found from selected treatment so it would be economically viable and profitable.

Soil moisture in maize

Soil moisture monitoring was 15 days interval from sowing to maturity stage of the maize crop (Table 23). Soil moisture decrease up to 30 DAS but after 1st irrigation it was increases. But after 45 DAS soil moisture was again decrease up to 90 DAS and farmers used only one or two irrigation for maize crop in Barind region.

Table 23. Changes in soil moisture of maize field influenced by various treatments at different tillage practices during 2014-15

Treatment	Days after sowing (DAS)						
	0	15	30	45	60	75	90
RB	27.10	25.58	23.74	26.54	22.45	18.25	15.26
FP	27.25	24.80	22.85	26.73	21.65	17.05	14.52

Yield and yield attributes of maize crops under different tillage practices were significantly deferred in the Barind condition (Table 24). Maximum cob length (21.1 cm) was found from raised bed system and lowest (17.07 cm) was found from FP. Maximum grains/cob was found from raised bed (517.3) and lowest was (482.6) from FP. Highest thousand grains weight (286.4 g) was found from raised bed system. The higher grain yield (8.41 t/ha) from raised bed systems and the lowest grain yield (6.72 t/ha) was found from farmers practice. Yield increase (25.9%) from raise bed over farmers practice.

Table 24: Yield and yield contributing character of maize in different tillage practices during 2014-15 (validation trials)

Treatment	Farmers	Cob length (cm)	Grains /cob	Grain wt/cob (g)	TGW (g)	Grain yield (t/ha)	% Yield increase over FP
Raised bed	06	21.1	517.3	177.8	286.4	8.41	25.9%
FP		17.07	482.6	162.1	275.6	6.72	-
T-Test		*	**	*	*	**	

Figure 15: Maize on strip till vs farmers practice in Bijoynagar, Godagari. Rajshahi

Yield and yield attributes of maize crops under different tillage practices were significantly deferred in the Barind condition (Table 25). Maximum cob length (20.8 cm) was found fromed bed system and lowest (17.4 cm) was found from FP. Maximum grains/cob was

found from raised bed (489.5) and lowest was (471.6) from FP. Highest thousand grains weight (282.5 g) was found from raised bed system. The higher grain yield (7.62 t/ha) from raised bed systems and the lowest grain yield (6.98 t/ha) was found from farmers practice. Yield increase (14.7%) from raise bed over farmers practice.

Table 25: Yield and yield contributing character of maize in different tillage practices during 2014-15 (up scaling trials)

Treatment	Farmers	Cob length (cm)	Grains /cob	Grain wt/cob (g)	TGW (g)	Grain yield (t/ha)	% Yield increase over FP
Raised bed	12	20.8	489.5	172.4	282.5	7.62	14.7%
FP		17.4	471.6	167.3	276.4	6.98	-
T-Test		*	**	*	*	**	

Yield and yield attributes of maize crops under different tillage practices were significantly deferred in the Barind condition (Table 26). Maximum cob length (21.3 cm) was found from strip till method and lowest (18.2 cm) was found from FP. Maximum grains/cob was found strip till method (492.5) and lowest was (477.6) from FP. Highest thousand grains weight (288.5 g) was found from strip till method. The higher grain yield (7.92 t/ha) from strip till method and the lowest grain yield (7.04 t/ha) was found from farmers practice. Yield increase (12.7%) from strip till method over farmers practice

Table 26: Yield and yield contributing character of maize in different tillage practices during 2014-15 (Validation trials)

Treatment	Farmers	Cob length (cm)	Grains /cob	Grain wt/cob (g)	TGW (g)	Grain yield (t/ha)	% Yield increase over FP
Strip till	06	21.3	492.5	178.4	288.5	7.92	12.7%
FP		18.2	477.6	169.3	279.4	7.04	-
T-Test		*	**	*	*	*	

Figure 16: Maize on strip till vs farmers practice in Rajabari, Godagari. Rajshahi

Economic performance

The maximum gross margin (97370 taka) was found from raised bed system and minimum (72870 taka) was obtained from farmer practice (Table 27). The highest BCR (2.10) was obtained from raised bed system and lowest (1.78) was also found from farmers practice

Table 27: Cost and return analysis for maize as influenced by raised bed and farmer practice at Basantapur, Godagari during 2014-15

Treatment	Yield (t ha^{-1})	Gross return (Tk ha^{-1})	Total cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
Raised bed	8.47	146460	44590	97370	2.10
FP	6.97	117460	49890	72870	1.78

Farmer's reaction

Farmers were very much happy to get higher yield from raised bed over farmers practice. Farmers got large size cob as well as higher number of seeds/cob both from raised bed and strip till method. As higher yield was found from raised bed and strip till method so it would be economically viable and profitable.

For mungbean crop

Yield and yield components of mungbean responded significantly to different tillage practices after harvest of wheat (Table 28). Maximum pod plant^{-1} (41.5) was found in raised bed system and minimum pod plant^{-1} (36.4) was found from FP. Maximum seed pod^{-1} (12.8) was obtained from raised bed system and minimum (12.3) was from FP. Maximum thousand seed weight (43.5 g) was obtained from raised bed system and minimum (41.2 g) from FP. Maximum seed yield (1.28 t/ha) was obtained from raised bed system and minimum (0.89 t/ha) from FP. Yield increase (30.4%) was found from raised bed system over FP.

Table 28: Yield and yield component of mungbean as influenced by RCTs technology at Alimgonj, Paba during 2013-14 (validation trials)

Treatment	Farmers	Pods plant^{-1}	Seeds pod^{-1}	TSW (g)	Seed yield (t/ha^{-1})	% Yield increase over FP
RB	06	41.5	12.8	43.5	1.28	30.4
FP		36.4	12.3	41.2	0.89	-
T-Test		**	*	*	**	

Figure 17: Mungbean on bed vs farmers practice in Bijoynagar, Godagari. Rajshahi

Yield and yield components of mungbean responded significantly to different tillage practices after harvest of wheat (Table 29). Maximum pod plant^{-1} (36.8) was found in raised bed system and minimum pod plant^{-1} (33.7) was found in FP. Maximum seed pod^{-1} (11.9) was obtained from raised bed system and the minimum (10.5) was in FP. Maximum thousand seed weight (39.7 g) was obtained from raised bed system and minimum (37.2) was found from FP. Maximum seed yield (1.07 t/ha) were obtained from raised bed system and minimum and (0.78 t/ha) from FP. Yield increase (27.1%) was found from raised bed system over FP.

Table 29: Yield and yield component of mungbean as influenced by RCTs technology at Charghat and Godagari Upazila during 2013-14 (up scaling trials)

Treatment	Farmers	Pods plant^{-1}	Seeds pod^{-1}	TSW (g)	Seed yield (t/ha^{-1})	% Yield increase over FP
RB	20	36.8	11.9	39.7	1.07	27.1
FP	20	33.7	10.5	37.2	0.78	-
T-Test		*	*	*	*	

Farmer's reaction

Farmers were very much impressed to get higher yield from raised bed method over farmers practice. Farmers also got more income from raised bed systems. As higher yield was found from raised bed system so it would be economically viable and profitable for mungbean crop.

Field day in wheat, lentil and maize

Three field days were arranged on wheat, lentil and maize crops under raised bed technology in rabi season. About 300 farmers (Male, Female), 30 Sub Assistant Agriculture Officer, NGOs personnel, Deputy Director from Extension, Executive Director, Program Director and Scientists from BRRI, Rajshahi and other personnel from different office were attained these field day. During field visit farmers were kin interest for new heat tolerant wheat varieties like BARI Gom 26 27 and 28. These three varieties were better performance from raised bed system over farmers practice. In case of lentil BARI Chola 9 was better performance in raised bed system over FP. Maximum yield was found from strip till method from chickpea and maize over farmers practice. Farmers were keen interest to see the performance of both chickpea and maize under strip till method over their own practice in same variety

Figure 18: Field days on wheat under raised bed in Taldhari, Godagari. Rajshahi

Field days on Taman rice and sesame

Four field days were arranged on Taman rice. mungbean and sesame crops under raised bed and strip till technology in kharif 1 and kharif 2 season. About 320 farmers (Male, Female), 30 Sub Assistant Agriculture Officer, 8 NGOs personnel, Director of research from BARI, BARI Board member, Deputy Director from Extension, Executive Director, Program Director and Scientists from BRRI, Rajshahi and other personnel from different office were attained these field day. During field visit farmers were kin interest for new heat tolerant rice, mungbean and sesame varieties with new technology. These varieties were better performance from raised bed system and strip till system over farmers practice. Maximum yield was found from strip till and raised bed method on all crops over farmers practice. Farmers were keen interest to see the performance of both rice and sesame under strip till and raised bed method over their own practice in same variety.

Figure 19: Field days on Taman rice under raised bed vs farmers practice in Nachole, Chapai

Figure 20: Field days on sesame under raised bed vs farmers practice in Alimgong, Paba

Figure 21: New strip tillage bought by the LSP in Bijoynagar which observed by program Director of KGF & Senior program Officer with lentil sowing performance

(iii). Benefit/Outcome:

Increased cropping intensity, farmer's skill and knowledge, reduced cultivation and irrigation cost with average 15% inputs save in drought prone area.

d. Technology Developed:

The project validated the up scaling of RCTs technology in rice based cropping system in drought prone areas in Rajshahi and Chapai district. Results of three years study revealed and proved that RCTs is water and inputs saving technology and well adopted by drought prone farmers and thus need to be disseminating in other drought prone areas.

e. Publications made/under process:

Two leaflets have been published (attached) on raised bed and strip till method for crop production in drought prone areas. Drafts for technical bulletin and প্রযুক্তি বার্তা have been prepared for publication.

f. Training/workshop organized:

Worksho	Date	Venue	Title	Participants
A. Inception Workshop				
1.	08/6/2013	RWRC, BARI, Seminar room, Shyampur, Rajshahi	Introduction the project of "Validation and up scaling of resource conservation technology for improving productivity in drought prone areas".	50
B. SAAO/FA/SA/NGOs Training				
2.	25/1/2014	RWRC, BARI, Seminar room, Shyampur, Rajshahi	Production Technology on heat & drought tolerant wheat varieties by RCTs	80
C. Farmers training				
3.	15/10/2013	Shahpur, Charghat, Rajshahi	Production Technology on heat & drought tolerant wheat varieties by RCTs	100
4.	20/10/2014	Bijoynagar, Godagari, Rajshahi	Production Technology on heat & drought tolerant wheat varieties by RCTs	100
5.	05/01/2015	RWRC, BARI, Rajshahi	Management Technology on wheat production by RCTs	100
4.	8/3/2015	Rajabari, Godagari, Rajshahi	Production technology of mungbean and sesame by RCTs	100
5.	19/4/2015	Bohrail, Nachole, Chapai	Production technology of mungbean and sesame by RCTs	100
6.	4/01/2016	Bohrail, Nachole, Chapai	Production technology of chickpea and lentil by RCTs	100
7.	5/1/2016	Bohrail, Nachole, Chapai	Management Technology on wheat production by RCTs	100
8.	20/01/2016	Bijoynagar, Godagari, Rajshahi	Production technology of chickpea and lentil by RCTs	100
9.	29/02/2016	Rajabari, Godagari, Rajshahi	Production technology of mungbean and sesame by RCTs	100
10.	30/02/2016	Bohrail, Nachole, Chapai	Production technology of mungbean and sesame by RCTs	100
C. Ending workshop				
11.	07/4/2014	RWRC, BARI, Rajshahi	Findings of the Project "validation and up scaling of RCTs technology for improving productivity in drought prone areas"	100

g. Graduate Studies: Not applicable

h. Linkages Developed:

The personnel of Department of Agriculture Extension and some NGOs personnel of Rajshahi and Chapainawabgonj district were closely involved in technology dissemination activities of the project and also involved on training program under RCTs technologies. Some local leaders, Local service providers, Mass media personnel and teachers were also involved in technology disseminating activities of the project.

i. Equipment/Appliances Purchased:

Serial Number	Name of the equipments	Number	Price
	Lab & Field equipments		
1.	Digital soil pH & moisture meter	01	30,000
2.	Auger	01	15,000
3.	Thermometer	01	10,000
4.	Balance	01	5,000
5.	Dongfeng power tiller	01	1,15,000
6.	Bed planter	01	50,000
7.	Seeder	01	55,000
8.	Power sprayer	01	12,000
	Total		**2,92,000**
	Office equipments		
1	Laptop	01	50,000
2	Camera	01	15,000
3	Internet modem	01	5,000
4	**Total**		**70,000**

F. Highlight of Research Findings

Results of the research indicated that Resource conservation technologies"RCTs" is suitable for drought prone areas of Rajshahi and Chapainawabgonj districts. Increased cropping intensity by 300% instead of 100% through incorporation of wheat and mungbean. Saved production cost by 40-50% with sacrifying yield. Increased rice yield by 5-10% with unpuddled condition over farmers practice. Wheat and maize yield increased by 10-15%, Lentil, mungbean and sesame yield increased by 15-25% from RCTs over conventional. Saved irrigation water by 30-35% without sacrifying yield in drought prone areas. Increased farmers income and livelihood for using RCTs technology to the marginal and poor farmers. Soil health improved for using 30% crop residue and full residue retention from mungbean crops in rice based cropping system in drought prone areas. Already one bed planter and one strip tillage bought by the Local service provider and earn income from using this machine Farmer's income increased and livelihood improved through introduction of resource conservation technology in drought prone areas of Rajshahi and Chapai district.

G. Conclusion

From two years study, it may be concluded that there are opportunities to increase cropping intensity, land productivity and farmers income in drought prone areas of Rajshhai and chapai districts. This may be achieved by adopting alternative cropping pattern rice- wheat-mungbean instead of farmers cropping pattern rice- fallow- fallow in studied areas through resource conservation technologies. The alternative cropping pattern with using RCTs improve soil quality in drought prone areas. Therefore special attention has to be given to RCTs for improving productivity with soil fertility in drought prone areas. So, RCTs is a very promising technology for improving crops productivity in drought prone areas in Bangladesh.

H. Recommendation

Resource conservation technologies with low water requirement crops are an appropriate technology for improving productivity in drought prone areas.

I. Financial Statement: Fund received and Expenditure made during the project period.

(In thousand Tk)

Particulars/Line Items					Actual Fig. in Tk.			
A. Fund Received in Installment								
1st install.	**2nd Install.**	**3rd install.**	**4th Install.**	**5th install.**	**6th install.**	**7th install.**	**8th install**	**Total**
272600	408900	545200	490130	471760	449432	382448	336826	**3357296**

Sl. No	Particulars/Line Items	Approved Total Budget	Exp. up to previous Report (From May 13 to April 15)	Current Exp. (Reporting period) From May 15 to May 16)	Committed Exp. up to May 2016	Cumulative Exp.	Rest of Budgeted Amount
	B. I. Expenditure: Recurring (Operational cost)	1	2	3	4	5=(2+4)	6=(1-5)
1.	1.1 Remuneration for Contractual Field Assistant consolidated)	**990**	**466.467**	**336.000**	**0**	**802.467**	**0**
	1.2 Remuneration of Accounting /data entry operator (part time basis consolidated)	**36**	**20.50**	**12.000**	**0**	**32.5**	**0**
2.	2.1 Research & Development (R&D) related cost.	1150.7	**720.252**	**450.448**	**0**	**1170.700**	**0**
3.	Maintenance and repairing of lab. /field equipment, etc.	70	**26.333**	**23.667**	**0**	**50.000**	**0**
4.	Training	250.8	**145.20**	**136.400**	**30.800**	**312.400**	**0**
5.	Workshop/Seminar/Field day/Meeting etc.	280.8	**128.40**	**144.000**	**56.400**	**328.800**	**0**
6.	6.1 Travel expenses (TA/DA) as per own organizational rules (Public Sector)	**169.920**	**127.697**	**50.465**	**53191**	**231.353**	**0**
	6.2 Vehicle hiring/oil & fuel for organization's Vehicle for travel.	**0**	**0**	**20.000**	**0**	**20.000**	**0**
7.	Office supplies and contingency cost for stationeries, publications, printing of reports, internet, service, mailing etc.	**188.380**	**95.213**	**92.254**	**0.913**	**188.380**	**0**
	B.I. Sub-total B.I (1-9)	***3136.600***	***1730.062***	***1265.234***	***141.304***	***3136.600***	**0**
B. II:	**Non-recurring (Capital cost)**						
10.	Equipment & Appliances (upon approval of KGF)						
	10.1. Lab. and Field Equipment	**292**	**285.299**	**6.701**	**0**	**292.000**	**0**
	10.2. Office Equipment	**70**	**70.000**	**0**	**0**	**70.000**	**0**
	B.II. Sub-total (10)	***362***	***355.299***	***6.701***	***0***	***362.000***	**0**
Grand Total Expenditure: GT(B.I+B.II)		**3498.6**	**2085.361**	**1271.935**	**141.304**	**3498.600**	**0**

Balance (A-GT)= (3357296-3357296)=0

as per Bank Statement = 0

Committed expenditure : 141.304

G. (1) Financial Progress: (a) Fund Received in Tk: 3357.296 (b) Fund utilized as per SoE in Tk. 3498.600 % achieved $\frac{3498.600}{3357.296}$ **X 100=104.2 (Committed Exp. 141.304)**

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Signature of PI with seal

J. Self Assessment of the Project

1. Have you been able to achieve all specific objectives of your project? Yes
2. Who is/are the target beneficiary group/s of your project output/result? Farmers
3. How the project outputs/results obtained would benefit the target beneficiary group/s? and how these could be transferred to the that/those target group/s?

   The results obtained from validation and up scaling trials would be benefited to the target beneficiary farmers if it is possible to make wider up-scaling of the RCTs technology. However, need further efforts from GOs, NGOs and other stakeholders of the RCTs technology and this technology are necessary for quick dissemination of the drought prone areas.
4. Do you think that you have successfully completed the project? Yes.

   The project has successfully completed as it is evident from published news in the Daily News paper and broadcasted from NTN, Channel I. The Daily News paper "The daily Sonar Bangla" described the impact introduce of RCTs technology is a promising and alternet technology in existing rice based cropping pattern in drought prone areas on increasing cropping intensity, productivity and income and livelihood of the farmers of Rajshahi and Chapai district. The news published in The daily newspaper attached below (Annex-6 in compiled Report)
5. Please describe briefly the outcome/benefit and likely impact of your project on the productivity, policy, society, economy and environment.

   The cropping intensity and system productivity was increased by RCTs technology from the alternative cropping pattern over the existing farmers cropping pattern. RCTs saved irrigation water, reducing production cost with increasing yield. The cultivation of high yielding drought and heat tolerant wheat varieties after harvest of aman rice increased the income of farmers in drought prone areas in Rajshahi and Chapai district. We develop wheat-mungbean-rice alternative cropping pattern is found economical which would improve the livelihood of rural people. Incorporation of legume crop mungbean of the cropping pattern improved soil quality. This technology had no environmental hazards as it was operated with less disturb of the soil, residue retention and viable crop diversification in the drought prone areas.

K. Acknowledgement:

I am grateful to KGF for funding and providing technical support required for successfully completing the project. I am also acknowledging with thanks to farmers, extension

personnel and media personnel and others to disseminate the new technology in drought prone areas.

L. Endorsement:

Principal Investigator (PI)

Name: **Dr. Md. Ilias Hossain**

Signature:

Seal:

Date:

Head of Organization/Authorized Person

Name: **Dr. Mohammad Jalal Uddin**
Director (Research)

Signature:

Seal:

Date: