Project ID: 777

Competitive Research Grant (CRG)

Sub-Project Completion Report

on

Improvement of dry direct seeded *boro* rice based cropping pattern through climate smart technologies and its adoption in drought-prone areas

Project Duration

May 2016 to September 2018

Department of Agronomy
Bangladesh Agricultural University
Mymensingh, Bangladesh

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

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Acronyms

BAU	Bangladesh Agricultural University
BCR	Benefit cost ratio
BDT	Bangladesh taka
BMDA	Barind Multipurpose Development Authority
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
DAE	Department of Agricultural Extension
DDS	Dry direct seeding
DDSR	Dry direct seeded rice
FGD	Focus group discussion
LOA	Letter of agreement
MOC	Mustard oil cake
NATP	National Agricultural Technology Programme
NGO	Non-government organization
PCR	Project completion report
PP	Project proposal
PTR	Puddle transplanted rice
REY	Rice equivalent yield
SAAO	Sub-assistant Agricultural Officer
TC	Tricho-compost
Tk.	Taka
VC	Vermi-compost
VMP	Versatile multi-crop planter

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Executive Summary

The project was initiated to enhance adoption of the newly developed T. Aman –Mustard–DDS boro rice cropping pattern into the farming community and to improve the productivity of the pattern through incorporation of climate smart technologies. A block demonstration was established on 10 acres of land each at two locations at Sundarban village, Sadar Upazilla of Dinajpur and Khidra Kashipur village of Durgapur Upazilla, Rajshahi districts. The extension approaches included farmers training, field days, mass media and other extension tactics. The T. Aman rice (variety BRRI dhan57 and BRRI dhan72) was transplanted during 5-12 July and harvested during 5-8 Nov 2017 in Dinajpur site and 25-28 Oct 2017 in Rajshahi sites. The yield was 5.0 and 4.5 t/ha for BRRI dhan72 and BRRI dhan57, respectively. Mustard (cv. BARI sharisha 14) was sown on 17 Nov 2017 in Dinajpur and 27-29 Nov 2017 at Rajshahi site and harvested during 26-30 Feb 2018 in Rajshahi and during 14-23 Feb 2018 in Dinajpur site. The yields of mustard at Rajshahi and Dinajpur were 1.88 and 1.99 t ha^{-1}, respectively. Boro rice (var. BRRI dhan58 and BRRI dhan28) was sown in Dinajpur and Rajshahi, respectively during 23-25 Feb and 6-7 March 2018 and harvested on 19 and 24 June 2018 respectively at Dinajpur and Rajshahi sites. The yields of BRRI dhan28 and BRRI dhan58 were 5.20 and 7.50 t/ha, respectively. The DDS plots required 3-4 irrigations while the conventional plots required 15-17 irrigations to complete the crop production.

Ten rabi crops included under the study 1 are: (1) Mustard, (2) Potato, (3) Lentil, (4) Field pea, (5) Radish, (6) Cabbage, (7) French bean, (8) Carrot, (9) Tomato and (10) Chia. Under activity 2, the bio-amendments used are: (i) Trichocompost (TC) = T1, (ii) Vermi-compost (VC) = T2, (iii) Mustard oil cake (MOC) = T3, (iv) TC + MOC = T4, (v) VC + MOC = T5 and Control (no amendment) = T6. The performance of dry direct seeded boro rice was evaluated against the stated bio-amendments. Both the trials used BRRI dhan28 as test crop using RCB design with three replications. Results of Activity 1 revealed that yield of dry direct seeded boro rice cv. BRRI dhan28 did not differ significantly due to the species of crops grown in the previous rabi season. The highest system yield (yield of all the three crops) was obtained for tomato as rabi crop and the lowest for mustard as rabi crop (mentioned above). Activity 2 showed that application of tricho-compost and vermi-compost along with recommended fertilizers gave 16% higher yield of dry direct seeded boro rice (cv. BRRI dhan28) than the recommended fertilizers alone.

The baseline of the farmers' perception and attitude on dry direct seeded rice based cropping system were investigated through semi-structured questionnaire survey and FGD. The survey revealed that farmers were not aware of the new cropping pattern. Field demonstration, meeting, and training were conducted towards improving their awareness. The post-intervention survey and FGD were conducted and found their better attitude towards adoption of the new practice significantly improved. The FGD revealed that the fixed rate irrigation system and lack of availability of good quality seeding machine are the major constraints for adoption of the new technology. Thus, farmers' need based irrigation, community based block demonstration and availability of good quality seeding machine needs to be ensured for rapid adoption of the technology to sustain productivity with less water in drought prone areas of Bangladesh.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the sub-project**: Improvement of dry direct seeded boro rice based cropping pattern through climate smart technologies and its adoption in drought-prone areas

2. **Implementing organization:** Department of Agronomy, Bangladesh Agricultural University (BAU), Mymensingh-2202

3. Name and full address with phone, cell, and e-mail address of PI/Co-PI:

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4. Sub-project budget (Tk.):
   a. Total: 250000.00
   b. Revised (if any):

5. Duration of the project:
   a. Start date (based on LOA signed): May 2017
   b. End date : 30 September 2018

6. Justification of undertaking the sub-project:

Rice is the staple food and the main element of food security in Bangladesh. Annually 33.54 million metric tons of rice is produced in this country of which 55.38, 37.74 and 6.88% comes from Boro, Aman and Aus seasons, respectively. Rice is mostly cultivated by transplanting of seedling in the puddled soil. Boro rice requires irrigation for the whole season and Aus rice requires irrigation in the early growth stage while Aman rice is cultivated under rainfed condition. No irrigation is required in Aman season because it coincides with rainy season (June - October) while rainfall is generally scanty during boro season (January - May). Drought may occur during aman season at the reproductive phase due to lack of rainfall and this situation can be overcome by supplemental irrigation and use of short duration drought tolerant rice varieties. Aus rice requires irrigation during early growth stage but not in the later stage as rainfall occur in the later stages. In contrary,

Boro rice fully dependent upon irrigation water (1400 mm) mainly supplied from underground source. Lifting of such huge amount of water leads to decline of water table and causes serious environmental hazards. In practice, boro rice uses about 70% of the total water used in agriculture. At present the water scarcity from both surface and ground sources are looming and under this situation, Boro rice cultivation cannot be sustained. Realizing the fact the government is discouraging cultivation of Boro rice and encouraging cultivation of Aus rice or other low water requiring crops in the northwestern drought-prone region of Bangladesh. However, this shifting of Boro rice cultivation could jeopardize the food security of the country. Therefore, technologies and practices needed to be in place for sustaining Boro rice production while increasing cropping intensity with minimal water input especially in the drought prone areas.

Dry direct seeding cultivation of Boro rice assumed to need less than 50% irrigation water compared with that required in puddle transplanted method. Farm productivity and crop diversity of the pattern can be increased by cultivating some other Rabi crops as per demand of the farmers. The trials showed that DDS Boro required less than 50% irrigation compared to T. Boro. Nonetheless, Boro rice can also be cultivated even with much less water by incorporating some other technologies such as crop residue retention, bio-char amendment, tricho-compost application, seed priming, practicing strip tillage and mechanical sowing. Conservation agriculture is a climate smart recently introduced crop production practice which will help saving of fuel and labor for tillage and planting rather it would help rapid establishment of crops and would give higher yield at lower cost. Seed priming is also helpful in rapid establishment of crops. Therefore, there is a scope of increasing cropping intensity and diversity in the high and medium high lands in the drought prone areas by incorporating suitable crops in between two rice crops. The adoption of the dry direct seeded boro rice based cropping pattern(s) is therefore, required to ensure food security of the country.

7. **Sub-project goal:** Improving crop productivity for sustaining food security in the drought prone areas of Bangladesh using different climate smart technologies

8. **Sub-project objective(s):** The project has the following objectives:

a) To select suitable T. Aman - Rabi - DDS Boro cropping pattern(s) through farmer's participatory approach.
b) To evaluate the effect of different climate smart technologies on the agronomic efficiency and productivity of T. Aman – Mustard – DDS Boro pattern.
c) To increase awareness of the farmers to the DDS boro rice based cropping patterns towards adoption of the technology package.

Implementing location(s): Durgapur Upazilla of Rajshahi and Sadar Upazilla of Dinajpur

9. Methodology in brief:

The project was initiated with an aim of establishing a block demonstration on T. Aman – Mustard – DDS boro cropping pattern in two selected drought prone areas namely, Sundarban of Sadar Upazilla, Dinajpur and Khidra Kashipur of Durgapur Upazilla, Rajshahi districts of Bangladesh involving the farming community and relevant stakeholders to develop awareness in farmers and relevant stakeholders towards adoption of the dry direct seeded boro rice based cropping pattern. In addition to the block demonstration, two experiments included in the project were : (1) Selection

of suitable T. Aman rice - Rabi crop - DDS boro rice pattern(s) through farmers participatory approach and (2) productivity improvement through incorporation of different climate smart technologies in T. Aman – Mustard – DDS boro cropping pattern. The farmers and experimental fields for the demonstration and related experiments in both locations were selected by visiting the spot and discussing with the local farmers and extension personnel. The selected areas of Rajashai and Dinajpur districts were visited during 21-23 May 2017 and 24-26 May 2017, respectively and selection of farmers and the trial fields were finalized. Details of the activities conducted under the project have been described below.

Site description

The land was medium high with moderate drainage facilities and the soil was silt loam. The pH value was 6.5. Soil contained 1.78% organic matter, 0.14% total N, 1.98 µ g^{-1} available P, 0.10 meq $100g^{-1}$ exchangeable K and 4.56µg g^{-1} available S.

Activity 1: Selection of suitable T. aman rice – Rabi crop – DDS boro rice cropping patterns through farmers' participatory approach

Methodology: Ten rabi crops viz. 1) Mustard, 2) Potato, 3) Lentil, 4) Field pea, 5) Radish, 6) Cabbage, 7) French bean, 8) Carrot, 9) Tomato and 10) Chia were grown after T. Aman rice. The experiment used a RCB design with three replications. The unit plot size was 4.0 m x 2.5 m. The rabi crops were sown/transplanted on 20 Nov and 16 Dec 2017 in Dinajpur and Rajshahi sites, respectively. Rice (cv. BRRI dhan28) was sown on 16 March 2018 in Rajshahi site after harvest of the rabi crops using the same trial design. The seed (primed) was sown by hand at 25 cm x 15 cm spacing allocating 3-4 seeds $hill^{-1}$. Fertilizers were applied as per recommended rate and all the agronomic managements were done as and when needed. During the growing period of boro rice 4 irrigations were applied. It was not possible to establish the rabi crops due to unusual rainfall in October at Dinajpur so no boro rice established. Therefore, the trial was continued in Rajshahi but not in Dinajpur. The dry direct seeded rice was harvested on 24 June 2019 and the data on yield and related attributes were recorded following standard procedure.

Data recording:

(a) Data on rabi crops

(i) Yield of rabi crops
(ii) Rice equivalent yield from rabi crops

(b) Yield and yield components of dry direct seeded rice

i. Plant height (cm)
ii. Number of total tiller $hill^{-1}$
iii. Number of effective tiller $hill^{-1}$
iv. Number of non-effective tiller $hill^{-1}$
v. Panicle length (cm)
vi. Number of filled grains $panicle^{-1}$
vii. Number of unfilled grains $panicle^{-1}$

viii. 1000-grain weight (g)
ix. Grain yield (t ha^{-1})
x. Straw yield (t ha^{-1})

(c) Economics of cropping patterns
i. System yield (yield of all the crops in the pattern)
ii. Cost of production
iii. Gross return
iv. Benefit cost ratio (BCR)

Activity 2. Productivity improvement through incorporation of different climate smart technologies in T. Aman – Mustard – DDS boro pattern.

The experiment was conducted with rice cv. BRRI dhan28 following dry direct seeded system in the field at Rajshahi site (Khidra Kashipur, Durgapur) after the cultivation of T. aman (cv. BRRI dhan57) and mustard (cv. BARI sharisha14). The experiment involved five bio-amendment treatments viz. (i) Recommended Dose (RD) + Trichocompost (TC) (T1), (ii) RD + Vermi-compost (VC) (T2), (iii) RD + Mustard oil cake (MOC) (T3), (iv) RD + TC + MOC (T4), (v) RD + VC + MOC (T5) and (vi) Control (recommended rates of all fertilizers: Ref FRG 2012) T6. The trial was conducted in a RCBD with three replications. The unit plot size was 3.0 m x 2.5 m. Tricho-compost and Vermi-compost were applied at 3 t ha^{-1} while mustard oil cake was applied at 0.50 t ha^{-1}. Fertilizers were applied at recommended rates in the control plots as well as in other treatment imposed plots. The crop management was done with proper care as and when required. The trial was established in Rajshahi site but not in Dinajpur because of some heavy rainfall. The trial at Rajshahi was originally established on 10 March 2018 but it was totally damaged by inundation of land by water flooded from the surrounding puddle transplanted fields, then the second (actual) planting was done on 16 March 2018. Originally, there was a plan for studying the effect of Biochar on performance of rice but due to delayed purchase of the biochar-plant it was not possible to study the effect of biochar.

Crop management

BRRI dhan57 was cultivated before mustard. Twenty five days old seedling of BRRI dhan57 was transplanted in well puddled land at 25 cm x 15 cm spacing with three seedling $hill^{-1}$ on 12 July 2017. The *aman* rice was harvested on 5 November 2017. The mustard variety BARI Sharisha14 was sown on 27 November and harvested on 20 February 2018. The yield of BRRI dhan 57 was 4.5 t ha^{-1} while the yield of mustard was 2.00 t ha^{-1}. Seed of rice variety BRRI dhan28 was sown on 16 March 2018 by allocating five seeds $hill^{-1}$ at 25 cm x 15 cm spacing. The land was finally prepared on 15 March 2018. The land was fertilized with urea, triple super phosphate, muriate of potash and gypsum at the rate of 375 kg, 60 kg, 92 kg and 70 kg ha^{-1}, respectively. The whole amount of triple super phosphate, muriate of potash and gypsum were applied at the time of final land preparation. Urea was applied in three equal splits at 15, 30 and 45 days after sowing (DAS). Intercultural operations were done as and when needed. Panida 33EC was applied as pre-emergence herbicide @ 50 ml/10L of water on 17 March 2018. Two hand weedings were done on 8 March and 23 April 2018. Four irrigations were provided only to maintain the field at moist soil condition for successful crop growth and development. The crop was infested by Thrips which was controlled by applying of Diazinon @ 35 ml/10L of water. The crop was harvested at full maturity on 23 June 2018from central 1.8 mx1.5

m area of each plot to record the yields of grain, and straw. Finally, grain yields was adjusted to 14% moisture and converted to ton per hectare.

Data recording:

1. **Yield and yield components**

   i. Plant height (cm)
   ii. Number of total tiller hill^{-1}
   iii. Number of effective tiller hill^{-1}
   iv. Number of non-effective tiller hill^{-1}
   v. Panicle length (cm)
   vi. Number of filled grains panicle^{-1}
   vii. Number of unfilled grains panicle^{-1}
   viii. 1000-grain weight (g)
   ix. Grain yield (t ha^{-1})
   x. Straw yield (t ha^{-1})

2. **Soil related data**

   i. Soil pH
   ii. Soil phosphorus content
   iii. Soil potassium content
   iv. Bulk density
   v. Soil organic matter content(%)
   vi. Field capacity (%)

Soil was collected from 0 to 15 cm depth from experimental field by iron core. After 72 hours oven dry it was melted and sieved with 2 mm sieve. The soil powder was taken in the Hamboldt Soil Lab, BAU and pH was determined by Glass Electrode pH meter. Soil phosphorus, organic matter content was determined by Olsen (1965) method. Field capacity (%) of soil was determined following the formula given below. Soil with core was soaked with water about 48 hours and then the soil was allowed to air dry about 72 hours and weighted.

Statistical Analysis

The collected data in activity 1& 2 were compiled and tabulated in proper form and were subjected to statistical analysis. Data were analyzed using the analysis of variance (ANOVA) technique with the help of a computer package programme Statistix10 and mean differences were adjudged by Duncan's Multiple Range Test.

Activity 3. Adoption of dry direct seeded boro rice based cropping pattern in drought prone areas of Bangladesh

Methodology

Community based block demonstration of T. Aman – Mustard – DDS boro rice cropping pattern were established at the two selected drought prone areas namely, Sundarban of Sadar Upazilla of Dinajpur district and Khidra Kashipur of Durgapur Upazilla of Rajshahi district. The following activities were done under this programme. The activities included under this programmes were:

(i) Establishment of block demonstration of the T. Aman Rice – mustard – DDS boro rice cropping pattern at farmers' field.
(ii) Organizing training of the SAAO and farmers
(iii) Organizing field day, field visit, meeting, networking and mass media communication for awareness building
(iv) Conducted survey and focus group discussion (FGD) before and after intervention to determine the farmers' perception and awareness on the dry direct seeded boro rice based cropping pattern.

(i) Establishment of block demonstration

1. Establishment of T. Aman Demonstration:

Farmers of Rajshahi and Dinajpur sites were interested to cultivate BRRI dhan57 and BRRI dhan72, respectively during aman season although our plan was to introduce Binadhan-7 under the designated cropping pattern. Rice seeds were procured and seedlings were raised in the seed beds accordingly. The seedlings were transplanted during 5-12 July 2017 covering 30 bighas of land in each location. The land was contributed by 48 farmers in Khidra Kashipur, Rajshahi while that was provided by 14 farmers at Sundarban, Dinajpur site. The crop at Khidra Kashipur was harvested on 25-28 October 2017 while that at Sundarban site was harvested on 5-8 November 2017. The yield data was recorded by harvesting the crop from randomly selected five spots of 10 x10 m^2 area of the rice fields.

2. Establishment of Mustard Demonstration:

Mustard variety BARI sharisha-14 was cultivated in the demo plots (30 bighas at each site) during rabi season after harvest of T. Aman rice. Sowing was done by VMP (Versatile Multi-Crop Planter) in Rajshahi site while it was done by broadcasting after dry cultivation with power tiller in Dinajpur. Sowing was done on 17 November 2017 in Dinajpur while that was done during 27-29 November at Rajshahi site. The crop was harvested on 26 -30 February 2018 in Rajshahi and that was done during 14 – 23 February 2018 in Dinajpur.

3. Establishment of Dry direct seeded boro rice demonstration:

Boro rice was sown by VMP after harvest of mustard in both the locations. The pre-plant non-selective herbicide Glycel (Glyphosate) was applied to the field to clear the standing weeds. Rice variety BRRI dhan58 was sown on 8 acres of land at Dinajpur site during 23–25 February 2018, while the rice variety BRRI dhan28 was sown on 2.0 acres of land at Rajshahi site on 6-7 March 2018. All the crop management practices were done as per recommendation, as and when needed. In addition, transplanted rice was cultivated following conventional irrigation system on two acres of

land at Dinajpur and one acre of land at Rajshahi. Rest of the farmers did not allow their lands for dry direct seeding practice in Rajshahi site as they do not have confidence on the new technology.

(ii) Training of SAAO and Farmers

Training on dry direct seeded boro rice based cropping system was held on 30 May and 31 May 2018 at Rajshahi and Dinajpur sites, respectively. Sub-Assistant Agriculture Officers and Farmers of the project area participated in the training program.

(iii) Organizing Field Day

Field day was organized at Durgapur, Rajshahi on the day of harvesting of dry direct seeded rice. Crop cut was done by the local DAE agent along with the farmers participated in the trial.

(iv) Networking and awareness development:

Welcoming frequent visit of the DAE personnel, BMDA officials, NGO representatives, media personnel and farmers of the locality to see the activities and performance of the crops under the project. Media personnel covered the story in different daily newspapers, magazines and television channels.

(iv) Survey and focus group discussion (FGD) to study farmers' perception and awareness towards the DDS rice system

Methodology:

The perception and awareness of the farmers of the two study areas on dry direct seeded boro rice based cropping pattern was studied through semi-structured questionnaire survey and FGD. The FGD and questionnaire survey to assess the perception of the farmers at the outset of the study was conducted on 22 January and 28 January 2018 respectively at Rajshahi and Dinajpur sites. The post-intervention awareness of the farmer due to project intervention was explored through FGD and questionnaire survey on 26-27 at Rajshahi and 28-29 September in Dinajpur sites respectively. Data were collected though using semi-structured questionnaire from 120 farmers taking 60 from each location at the pre- and post-intervention stage. The FGD was conducted involving 30 participants and there were 2 FGDs in each location.

Ten rabi crops were used in the trial in between transplanted aman rice cv. BRRI dhan57 and dry direct seeded boro rice cv. BRRI dhan28. The rabi crops included were: (1) Mustard, (2) Potato, (3) Lentil, (4) Field pea, (5) Radish, (6) Cabbage, (7) French bean, (8) Carrot, (9) Tomato and (10) Chia. Therefore, ten cropping patterns were included under the study such as (1) T. aman rice – Mustard – DDS boro rice, (2) T. aman rice – Potato – DDS boro rice, (3) T. aman rice – Lentil – DDS boro rice, (4) T. aman rice – Field pea – DDS boro rice, (5) T. aman rice – Radish – DDS boro rice, (6) T. aman rice – Cabbage – DDS boro rice, (7) T. aman rice – French bean – DDS boro rice, (8) T. aman rice – Carrot – DDS boro rice, (9) T. aman rice – Tomato – DDS boro rice and (10) T. aman rice – Chia – DDS boro rice.

Data collection and Analysis

The collected data were compiled, coded, tabulated, cross tabulated and analysed in accordance with the objectives of the study. Statistical tests like mean, standard deviation, and standard errors were determined. To test the significant difference two mean values against each of the variables, paired t-test was employed, 5% level of probability was considered for accepting or rejecting any null hypothesis.

Thirty participants were involved each FGD. There were 6 groups involving 5 participants in each group who were given a semi-structured FGD check-list and asked them to write down their opinion against each of the question and put down their on brown paper supplied earlier to each group. At the end the opinion of each group was collected and scrutinized according to the tally marks put down against each of their opinion. Finally, the facilitators selected the vital opinions and ranked them.

10. Results and discussion:

Activity 1: Selection of suitable T. aman rice – Rabi crop – DDS boro rice cropping patterns through farmers' participatory approach

(i) Yield performance of boro rice after rabi crops

Preceding crop did not affect the grain yield of rice (cv. BRRI dhan28). The rice yield ranged between 4.96 t ha-1 and 7.41 t ha^{-1} (Table 2). The straw yield was not also differ significantly due to preceding rabi crops. The plant height, total tiller and effective tiller did not differ significantly although non-effective tiller varied significantly due to preceding rabi crops (Table 1). The highest number of non-effective tiller was found in plots with mustard as rabi crop. The lowest number of non-effective tiller was noted with lentil and carrot as rabi crop. Number of grain/panicle, sterile spikelet/panicle and weight of 1000-grain of BRRI dhan28 were not affected significantly due to rabi crops in the T. aman rice – rabi crops – DDS boro cropping pattern (Table 2).

Table 1. Effect of preceding rabi crops on plant height and tiller density of dry direct seeded boro rice cv. BRRI dhan28 in T. aman rice – rabi crops – DDS boro rice cropping pattern

Cropping pattern	Plant height (cm)	# Total tillers $hill^{-1}$	# Effective tillers $hill^{-1}$	# Non effective tillers/hill
1) T. aman rice – Mustard – DDS boro rice	106.7	17.33	14.67	2.66
2) T. aman rice – Potato – DDS boro rice	107.0	16.50	15.50	1.08
3) T. aman rice – Lentil – DDS boro rice	108.2	14.17	13.75	0.42
4) T. aman rice – Field pea – DDS boro rice	107.2	14.83	13.58	1.25
5) T. aman rice – Radish – DDS boro rice	109.0	15.58	14.66	0.92
6) T. aman rice – Cabbage – DDS boro rice	108.6	13.92	13.17	0.75
7) T. aman rice – French bean – DDS boro rice	111.3	19.17	16.83	2.33
8) T. aman rice – Carrot – DDS boro rice	105.0	16.50	16.08	0.42
9) T. aman rice – Tomato – DDS boro rice	113.0	18.25	16.75	1.50
10) T. aman rice – Chia – DDS boro rice	-	-	-	-
Level of sign.	ns	ns	ns	**
LSD	1.647	2.199	1.983	0.464
CV(%)	1.86	16.57	16.23	43.88

Table 2. Effect of preceding rabi crops on yield and related attributes of dry direct seeded boro rice cv. BRRI dhan28 in T. aman rice – rabi crops – DDS boro rice cropping pattern

Rabi crops	# Grains/ panicle	# Sterile spikelet /panicle	1000 grain wt. (g)	Grain yield t/ha	Straw yield t/ha
1) T. aman rice – Mustard – DDS boro rice	84.00	20.67	21.41	5.63	6.19
2) T. aman rice – Potato – DDS boro rice	84.20	23.13	21.28	4.96	6.34
3) T. aman rice – Lentil – DDS boro rice	87.77	24.67	21.46	5.12	5.88
4) T. aman rice – Field pea – DDS boro rice	81.63	21.30	21.12	7.41	6.09
5) T. aman rice – Radish – DDS boro rice	75.50	20.67	21.01	6.78	5.78
6) T. aman rice – Cabbage – DDS boro rice	74.53	20.83	20.74	5.48	5.63
7) T. aman rice – French bean – DDS boro rice	55.46	22.27	21.07	6.09	5.91
8) T. aman rice – Carrot – DDS boro rice	97.77	21.79	21.49	6.01	6.07
9) T. aman rice – Tomato – DDS boro rice	87.83	19.97	21.28	6.12	6.02
10) T. aman rice – Chia – DDS boro rice	-	-	-	-	-
Level of sign.	ns	ns	ns	ns	ns
LSD	12.953	3.469	0.333	1.096	0.473
CV(%)	19.59	19.59	1.93	22.52	9.67

(ii) Agro-economic productivity

Out of ten rabi crops planned to be tested, nine were fitted in between Aman and Boro Rice cropping patterns under the study. The rice equivalent yield (REY) of different rabi crops are presented in Table 3. The REY was found highest (7.50 t ha^{-1}) with potato and lowest with radish as rabi crop. The system yield was highest with tomato as rabi crop in the system (19.62 t/ha) and the lowest with mustard (14.63 t/ha) as preceding rabi crop. The gross cost of production of the three crops in the system was highest with potato (BDT 279150.00) mainly due to seed cost while lowest with carrot (BDT 165300.00). The benefit cost ratio (BCR) was the highest with tomato (1.99) and the lowest with cabbage (1.15). Based on the results it is evident that almost all the crops can be cultivated in between T. aman rice and DDS boro rice. So the rabi crop is to be selected based on the soil condition, weather of the season, input and market facilities.

Photo 1: Field view of rabi crop trial at Khidra Kashipur, Durgapur, Rajshahi

Photo 2: Field view of rabi crop trial at Sundarban, Dinajpur

Table 3. System productivity and benefit cost ratio (BCR) of different T. aman rice – rabi crop – DDS boro rice cropping patterns as influenced by the 10 rabi crops

Rabi crops	Rabi crop yield (t/ha)	REY of the rabi crop (t/ha)	DDS boro rice yield (t/ha)	System yield (t ha^{-1})	Gross cost of the system	BCR of the pattern
1. Mustard	1.80	4.50	5.63	14.63	174000	1.68
2. Potato	15.00	7.50	4.96	16.96	279150	1.22
3. Lentil	1.20	5.10	5.12	14.72	183600	1.60
4. Field Pea	1.45	3.98	7.41	15.89	172100	1.85
5. Radish	17.0	3.83	6.78	15.11	260000	1.16
6. Cabbage	17.0	5.10	5.48	15.08	262700	1.15
7. French bean	1.50	5.25	6.09	15.84	175600	1.80
8. Carrot	18.0	6.00	6.01	16.51	165300	1.99
9. Tomato	18.0	6.12	6.12	19.62	218300	1.79
10. Chia	-	-	-	-	-	-

Yield of T. aman rice = 4.50 t ha^{-1}, REY = yield of the rabi crop converted to the yield of boro rice. [{Price of crops (BDT/kg): mustard=50, potato=10, lentil=85, field pea= 55, radish = 4.5, cabbage = 8.50, French bean = 70, carrot = 8 and chia = 200, aman rice = 22, and boro rice= 20}. The cost of production for aman rice (BDT/ha) = 48625 and boro rice = 61075]

Activity 2. Productivity improvement through incorporation of different climate smart technologies in T. Aman – Mustard – DDS boro pattern.

(i) Yield and related attributes

Organic amendment treatments had significant effect on grain yield, straw yield, and effective tiller/hill (Table 4) but not on plant height, total tiller/hill, number of grains/panicle, number of spikelet/panicle and weight of 1000-grains. The organic amendment plus recommended fertilizers (RD) gave significantly higher grain yield of rice (cv. BRRI dhan28) than recommended rate of fertilizer. The highest grain yield (5.46 t/ha) was found from the plot that received all the organic amendments i.e. trichocompost + vermicompost + Mustard oilcake, however this yield is similar to that obtained from trichocompost when applied alone (Table 5). Thus the result clearly showed that yield improvement can be possible by organic amendment with trichocompost or vermicompost @ 3 t/ha.

Table 4: Effect of organic amendment on plant height and tiller production of dry direct seeded boro rice cv. BRRI dhan28

Treatments	Plant height (cm)	Total tillers $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Non effective tillers $hill^{-1}$ (no.)
T_0	107.15	12.67	12.33b	2.33b
T_1	105.00	14.67	13.33ab	2.33b
T_2	105.83	15.67	13.00ab	2.67ab
T_3	105.67	16.67	15.33a	3.67a
T_4	104.58	16.67	15.00ab	3.00ab
T_5	106.17	14.67	14.00ab	2.67ab
CV (%)	1.63	12.10	7.47	15.65
Level of significance	ns	ns	*	*
SED	1.4115	1.4981	0.8433	0.3549
LSD	4.8942	5.1948	2.9240	1.2305

In a column, figures with same letter or without letter do not differ significantly, whereas figures with dissimilar letter differ significantly; *= Significant at 5% level of probability ; ns= non significance [T_0= Control (No organic matter used), T_1=Trico-compost (TC) @ 3 t ha^{-1} used, T_2= Vermicompost @ ha^{-1}, T_3=Mustard oil cake @ 0.5 ha^{-1}, T_4= Trichocompost+Mustard oil cake , T_5=Vermicompost+Mustard oil cake]

Table 5. Effect of organic amendment on yield and related attributes of BRRIdhan28

Treatments	Grains Panicle^{-1} (no.)	Sterile spikelet panicle^{-1} (no.)	Weight of 1000 grains (g)	Grain Yield ha^{-1} (ton)	Straw yield ha^{-1} (ton)
T_0	68.30	23.00	20.19	4.25b	4.68b
T_1	72.77	26.00	19.89	5.95a	5.41a
T_2	85.33	26.33	20.08	5.57a	5.07ab
T_3	77.80	24.33	19.15	5.25ab	5.37a
T_4	73.13	26.67	20.06	5.61a	5.38a
T_5	73.07	25.00	20.75	5.48ab	5.46a
CV (%)	8.94	11.93	4.69	8.33	4.41
Level of significance	ns	ns	ns	*	*
SE	5.4771	2.4570	0.7671	0.3643	0.1884
LSD	18.992	8.5198	2.6600	1.2630	0.6531

Soil physical and chemical properties

The organic amendment did not have any significant effect on different physical and organic characteristics of soil (Table 6). The soil pH ranged between 5.8 and 6.3 after harvest of crop. Field capacity and bulk density of soil was not different due to organic amendment. However, the application of organic materials to the soil would increase the organic matter content of soil although not found in this trial as soil physical and chemical characters generally take longer time to improve.

Table 6. Effect of organic amendment on soil physical and chemical characteristics

Treatments	PH	Organic matter (%)	Phosphorus meq/100g	Potassium meq/100g	Bulk density (gm/cm^3)	Field capacity (%)
T_0	5.8	1.04	22.39	0.16	1.42	32.58
T_1	6.0	1.01	24.97	0.16	1.43	31.20
T_2	6.1	0.84	16.23	0.17	1.33	31.98
T_3	6.2	1.08	22.43	0.16	1.36	31.85
T_4	6.3	1.06	17.66	0.16	1.35	31.54
T_5	6.2	0.91	10.93	0.15	1.32	33.81
CV (%)	3.68	18.14	33.04	15.46	6.26	9.52
Level of significance	ns	ns	ns	ns	ns	ns
SE	0.18	0.14	5.15	0.02	0.07	2.50
LSD	0.41	0.32	11.48	0.04	0.15	5.57

In a column, figures with same letter or without letter do not differ significantly, whereas figures with dissimilar letter differ significantly; *= Significant at 5% level of probability; [T_0= Control (No organic matter used), T_1=Trico-compost (TC) @ 3 t ha^{-1} used, T_2= Vermicompost@ ha^{-1}, T_3=Mustard oilcake@ 0.5 ha^{-1}, T_4= Trichocompost+Mustard oil cake, T_5=Vermicompost+Mustard oil cake.]

Activity 3. Adoption of dry direct seeded boro rice based cropping pattern in drought prone areas of Bangladesh

The following activities were done under this programme

(i) Establishment of block demonstration of the T. aman rice – mustard – DDS boro rice cropping pattern at farmers' field in the two locations.

(ii) Organizing training of the SAAO and farmers

(iii) Organizing field day, field visit, meeting, networking and mass media communication for awareness building

(iv) Conducting survey and focus group discussion (FGD) before and after intervention to determine the farmers' perception and awareness on the dry direct seeded boro rice based cropping pattern.

(i) Establishment of block demonstration

Demonstration of Transplant Aman Rice in T. aman Rice – Mustard – DDS boro rice cropping pattern

The overall performance of aman rice at both the location was satisfactory. The yield of BRRI dhan57 and BRRI dhan72 were 4.5 and 5.0 t/ha respectively in Rajshahi and Dinajpur sites. In the proposal we planned to introduce Binadhan-7 in both the locations but farmers at both the locations did not accept BINA dhan 7.

Photo 3. Aman rice cv. BRRI dhan72 at Sundarban, Dinajpur in 2017

Photo 4. Aman rice cv. BRRI dhan57 at Khidra Kashipur, Rajshahi in 2017

Table 7. Yield of T. Aman rice at Rajshahi and Dinajpur sites in 2017

Variety	Rajshahi	Dinajpur
BRRI dhan57	4.5	-
BRRI dhan72	-	5.0

Demonstration of mustard in T. aman rice – Mustard – DDS boro rice pattern

The yields of mustard in both the locations were satisfactory although the sowing was delayed due to rain in last week of October 2017. Generally farmers grow Tori7 variety which is very low yielder but growing of BARI sharish 14 can increase the yield to some extent. In the present trial the yield of mustard at Rajshahi and Dinajpur sites were 1.88 and 1.99 t ha^{-1} respectively.

Photo 5. Field after sowing of mustard with VMP

Photo 6. Mustard field at Durgapur, Rajshahi

Table 8. Yield of mustard at Rajshahi and Dinajpur in 2017-2018

Farmers	Rajshahi	Dinajpur
Farmer1	1.90	2.00
Farmer 2	1.53	1.82
Farmer 3	1.97	1.95
Farmer 4	2.10	2.20
Mean	1.88	1.99

Photo 7. Mustard plot at Sundarban, Dinajpur

Demonstration of Dry direct seeded boro rice in T. aman rice – Mustard – DDS boro rice pattern

Participating farmers at both the sites were not interested in cultivating rice by dry direct seeding method as they became unmotivated and lost their reliance on the technology. In Rajshahi, among the 48 farmers only six devoted their land to this new practice but they were not interested in this process. On the other hand, among the 14 farmers 6 quit from our practice and the remaining 8 farmers participated in the process. We shared the matter with the Upazilla Agricultural Officer and in both the locations the upazilla agricultural officers visited the sites and found that the crop

growth is highly satisfactory and there is no reason of avoiding this technology. The crop was harvested during last week of June in both the sites.

Table 9. Information about the demonstration during boro season (dry direct seeded rice)

Particulars/information	Rajshahi	Dinajpur	Remarks
Demonstration area (acres)	2	8	One acre under PTR
Participating farmers	6	12	
Boro rice variety	BRRI dhan28	BRRI dhan58	
Sowing method	Sowing with VMP	Sowing with VMP	
Date of sowing	5-6 March	23-26 Feb 2018	
Date of harvesting	24-26 June 2018	19-23 June 2018	
Yield	5.2	7.5	
Field duration	108	116	
No of irrigation applied	5	3	14-17 PTR-CI

Photo 9. Sowing of rice by VMP at Dinajpur

Photo 10. Field view of boro rice at seedling stage in Dianjpur

Photo 11. Field view of boro rice at seedling stage in Dianjpur

Photo 12. Field view of boro rice at reproductive stage in Dianjpur

Photo 13. Field view of boro rice at seedling stage at Rajshahi

Photo 14. Field view of boro rice at harvesting stage in Rajshahi

Pre-and post-invention survey and FGD

Questionnaire survey

Data presented in Table 10 and Figure 1 indicate that there were eight variables studied and their pre-and post- intervention values were obtained. No significant difference was observed in personal income between pre-and post-intervention period because within a year there was no potential scope to increase income level of the farmer. Again, cultural knowledge, extension contact, training exposure, environmental awareness, attitude towards DDS rice and adoption of DDS rice were found to have higher mean value at post intervention than pre-intervention and the t-values were highly significant, as the project activities helped the farmers to increase the merit of the variables. However, Cosmo politeness of the farmers did not show any significant difference between pre- and post-intervention of the project.

Table 10. Comparative performance of the respondents under different variables the over time

Name of the variables	Pre-intervention	Post-intervention	Level of signif.
1. Personal income	75.8	76.2	ns
2. Agricultural knowledge	15.3	25.8	**
3. Cosmopoliteness	6.2	8.2	Ns
4. Extension contact	12.5	18.2	**
5. Training exposure	1.8	3.2	**
6. Environmental awareness	27.8	35.3	**
7. Attitude towards DDS rice	16.5	31.2	**
8. Adoption of DDS rice	12.5	27.7	**

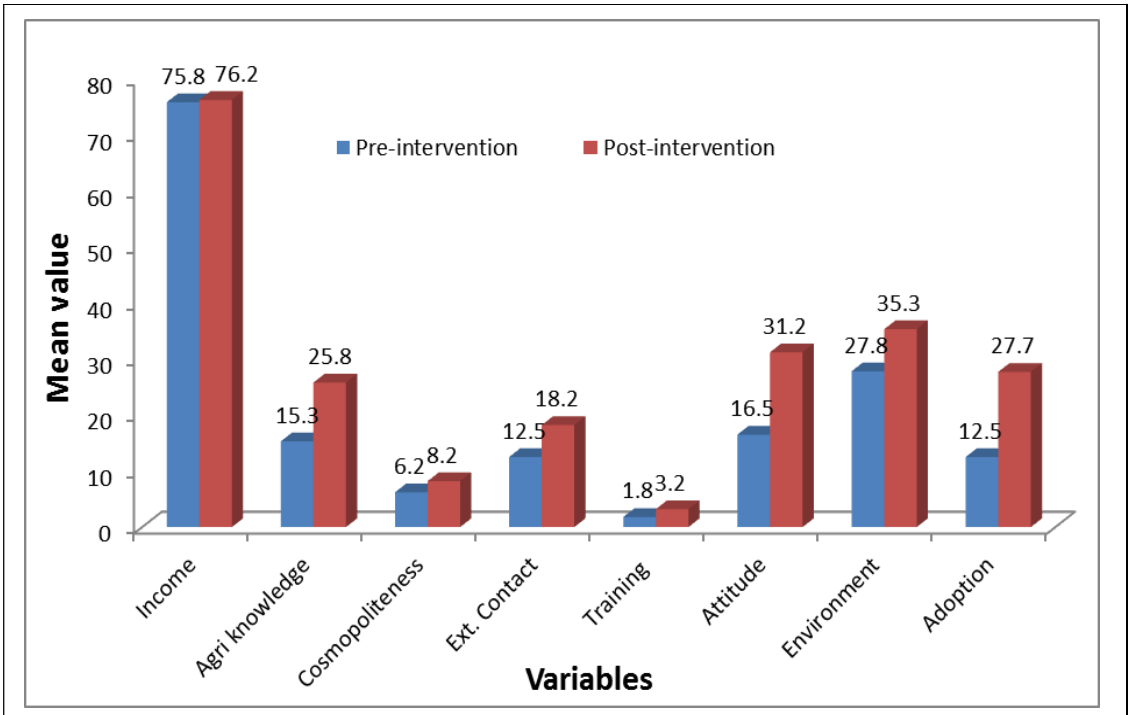


Fig. 1. Comparative performance of the respondents under different variables the over time

Focus Group Discussion

Following information regarding dry direct seeded rice based cropping pattern was gathered through focus group discussion. The FGD was done after the intervention:

(a) Benefits of dry direct seeded boro rice based cropping pattern

1. Dry direct seeded rice yield is higher than puddle transplanted rice.
2. Dry direct seeding saved about 60-70% irrigation than puddle transplanted rice.
3. Many rabi crops such as mustard, potato, cabbage, carrot, tomato etc. can be grown in between aman and boro rice.
4. Dry direct seeding used less labour for crop establishment
5. Weed did not become any difficult problem to the dry direct seeded rice.

(b) Constraints of dry direct seeded boro rice based cropping pattern

1. Irrigation water management is difficult as deep tube well owners are not interested in any water saving practice.
2. Insect attack causes severe yield loss as the boro rice is sown too late.

3. Weed especially mutha appeared as a major weed in dry direct seeded rice.

4. Good quality VMP machine is not available and farmers are not trained on the DDS technology.

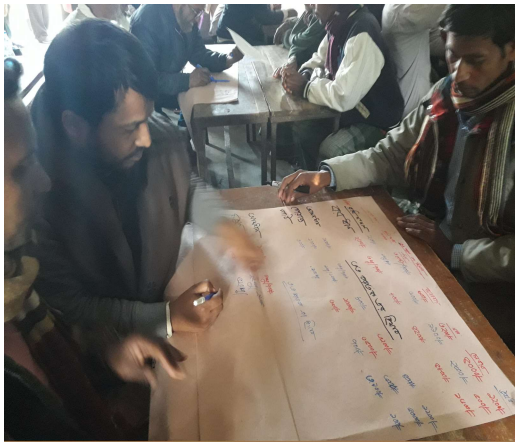
(c) Suggestions for improvement of adoption of the technology

1. Good quality VMP machine needs to be made available to the service providers.

2. Farmer's need based irrigation system to be developed instead of fixed rate system.

3. Weed management system for easy and economic control needs to be developed.

4. Community based block demonstration needed to motivate farmers towards the technology.

	
Photo 15. FGD conducted at Dinajpur	**Photo 16.** FGD conducted at Rajshahi

Training of SAAO and Farmers

A day-long training on dry direct seeded boro rice based cropping system was given to the Sub-Assistant Agriculture Officers and Farmers of the project area to give them better understanding on the dry direct seeded boro rice based cropping system and also increase their knowledge on dry direct seeded technology. Upazilla Agriculture Officer and relevant officers of the Upazilla Agriculture office were present in the training programme. At the end of the training the participants were interested to the system but they raised the question about the performance or precision of the VMP machine in seeding of rice.

Photo 17. Pictorial view of training at Rajshahi

Photo 18. Pictorial view of training at Dinajpur

12. Research highlight/findings:

- Different rabi crops such as mustard, potato, field pea, french bean, tomato and lentil can be grown in between aman and dry direct seeded Boro rice
- Organic amendment by tricho-compost, vermicompost or mustard oil cake along with recommended fertilizers improved yield of dry direct seeded boro by 15% over the plots applied with the recommended fertilizers alone.
- Boro rice cultivation with dry direct seeding technology saves 66% irrigation water compared to puddle transplanted one.
- Dry direct seeding by VMP saved more than 80% labour cost for planting compared to manual transplanting.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
a) Office equipment	-	-	-	-	
b) Lab & field equipment	-	-	-	-	
(c) Other capital items	2	150000	2	149600	

2. Establishment/renovation facilities: Not applicable

Description of facilities	Newly established		Up-graded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/workshop/conference organized:

Description	Number of participants			Duration (days/weeks/months)	Remarks
	Male	Female	Total		
(a) Training	39	1	40	Daylong (2 batches)	
(b) Workshop					
(c) Field day	76	4	80	One day	

C. Financial and physical progress

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	451720	451720	434945	16775	96.29	
B. Field research/lab expenses and supplies	976100	963375	975815	-12440	99.97	
C. Operating expenses	395000	161000	172115	-11115	43.57	Air travel not allowed
D. Vehicle hire and fuel, oil & maintenance	150000	303735	283238	20497	188.77	Travel cost increased
E. Training/workshop/seminar etc.	130000	121000	105000	16000	80.77	
F. Publications and printing	125000	148750	65000	83750	52.00	
G. Miscellaneous	122180	61353	86050	-24697	70.42	
H. Capital expenses	150000	150000	149600	400	99.73	
Total	2500000	2360933	2271763	**89170**	90.87	

D. Achievements of Sub-project by objectives

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
To select suitable T. Aman – Rabi – DDS Boro cropping pattern(s) through farmer's participatory approach.	A screening trial involving 10 rabi crops to select best T. aman rice – rabi crop – DDS boro cropping patter	T. aman – rabi crops -DDS boro pattern could be adopted with suitable crop out of 9 tested ones	Many rabi crops can easily be grown in between T. aman and boro rice.
To evaluate the effect of different climate smart	An experiment was conducted to evaluate the effect of different	Organic amendment along with recommended	Organic amendment increases boro

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
technologies on the agronomic efficiency and productivity of T. Aman – Mustard – DDS Boro pattern.	organic amendments such as tricho-compost, vermin-compost and mustard oilcake on the performance of DDS rice	fertilizers could increase rice yield by 15% under dry direct seeded system.	rice yield compared with recommended fertilizer alone.
To improve awareness of the farmers to the DDS boro rice based cropping patterns towards adoption of the technology package.	(i) Establishment of demonstration (ii) Survey and FGD before and after intervention (iii) Training of SAAO and Farmers (iv) Organizing field day and mass media communication	T. aman rice – Mustard – DDS boro rice increases crop productivity with saving of 60% irrigation water and 80% labor cost	Awareness developed in the farmers of the locality

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

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.		Booklet -1 Folder -1	1. Dry direct seeded boro and aus rice based cropping patterns for growing more with less water (booklet) ২. শুকনো পদ্ধতিতে রোরো ও আউশ ধান চাষ: একটি সেচ সাশ্রয়ী আধুনিক প্রযুক্তি (ফোল্ডার)
Journal publication	2		
Information development			
Other publications, if any			

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

i. Generation of technology (Commodity & Non-commodity)

1. Dry direct seeded boro rice based cropping pattern for drought prone areas of Bangladesh

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

1. Rabi crops can be cultivated in between T. aman rice and dry direct seeded boro rice that would help intensification and diversification of crops to improve farmer's income.
2. Sowing of rice in dry direct seeding (DDS) method with VMP (versatile multi-crop planter) saves 80% cost for crop establishment compared to conventional manual seedling transplanting system.
3. Boro rice cultivation using DDS method saves 60% irrigation water and more saving can be possible by organic amendment with tricho-compost or vermin-compost.

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

T. Aman rice – Mustard – DDS boro rice pattern improves productivity and crop diversity

iv. Policy Support

1. "Pay as you use" instead of fixed rate water sharing system should be introduced.
2. Rice seeder with optimal distant dibbling facility should be made available
3. Training program on the new technology should be undertaken for the target area

G. Information regarding Desk and Field Monitoring

i) **Desk Monitoring**:

Two visits were made by the team (17/2/2018 and 7/3/2018)
The teams suggested us various aspects of the project work which helped us a lot towards successful implementation of the project.

ii) Field Monitoring (time& No. of visit, Team visit and output):

H. Lesson Learned/Challenges (if any)

i) Cropping intensity and diversity can be increased by adopting dry direct seeded boro rice based cropping pattern.
ii). Dry direct seeded rice based cropping pattern gives higher productivity and farm income with 50% less irrigation water compared with puddle transplanted rice system.
ii) Seeding by VMP (versatile multicrop planter) saves more than 80% labour cost for rice planting compared with manual transplanting.

iii) The fixed rate water sharing irrigation system is the major barrier to adoption of dry direct seeded boro rice culture.

iv) Sowing of boro rice during February and March helps avoiding hailstorm during the reproductive phase and do not create any problem for harvesting and processing.

v). The crop sown in February and March reaches reproductive and ripening phase at a time when there remains no other crops in the field are subjected to severe insect pest attack.

vi). Different rabi crops such as mustard, potato, field pea, French bean, tomato and lentil can be grown in between T. aman and dry direct seeded boro rice.

vii). Organic amendment by tricho-compost, vermi-compost or mustard oil cake improves yield performance of dry direct seeded boro rice yield.

viii). Dry direct seeded boro rice based cropping pattern increases system productivity and cropping intensity.

I. Challenges (if any)

1. Existing fixed rate irrigation water sharing system is the major barrier to the adoption of the dry direct seeded rice production technology.

2. Dry direct seeded boro rice is subject to serious insect pest attack at the reproductive stage as none of the crops generally remain in the field due to lack of involvement of whole community in a block.

3. Farmers negative attitude towards dry direct seeded rice culture due to their poor knowledge and awareness on the technology. Therefore, farmers' motivation towards the new technology is a great challenge.

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