“Action Research” for introducing/ promoting climate adaptive and resilient crops at Tazumuddin, Bhola

Bangladesh Agricultural University

Mymensingh

Final Report on

"Action Research" for introducing/ promoting climate adaptive and resilient crops at Tazumuddin, Bhola

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Executive Summary

The southern coastal zone of Bangladesh, covering 27 per cent of the area and 21 per cent of the population, is one of the most food insecure areas of the country. Most of the people living in the coastal area depend on agriculture with very low productivity. The farmers in the area are dominantly marginal farmers usually cultivating one crop in a year. During the monsoon season the farmers primarily grow low-yielding and late-maturing transplant *aman* rice varieties and most of the lands remain fallow during the dry period of the year. Thus, the levels of cropping intensity, crop diversity and crop yield in the area are much lower than the other parts of the country. As a result, the area is disadvantaged by poverty, food insecurity and limited livelihood opportunities, which is reflected by nearly 65% of the population in this area living below the poverty line compared to the country's average of 40%. Under the current climate change context sustainable agricultural productivity in the coastal area of Bangladesh is under a big challenge due to increasing salinity, drought and submergence. The constraints of low agricultural productivity in the coastal area include prolonged submergence/ water logging during and after the monsoon (*kharif*-II season) and increasing soil salinity and lack of fresh irrigation water during the dry season (both *rabi* and *kharif*-I seasons). Moreover, the area is also highly vulnerable to various environmental hazards like cyclone affecting the agricultural productivity. Climate-induced hazards, especially cyclones and sea level rise cause salinity intrusion in soil, which adversely affects crop production in coastal Bangladesh. Under this situation, appropriate selection of crop species and varieties suitable for the area, crop intensification, efficient use and optimal management of resources like fresh water and improved agronomic practices are some of the options for maximizing the agricultural productivity in the coastal area of the country. This 'action research' project aimed to sustainably improve crop productivity in Tazummudin Upazilla of Bhola district by selecting appropriate crop species/ varieties and adopting improved agronomic practices for the efficient and optimum resource management for all three cropping seasons (*kharif*-I, *kharif*-II and *rabi*). To meet the aim the objectives of the work were designed as: i) to identify the best suit crops for the local area and ways to improve the production of successful crops trialed at demonstration plots, ii) to conduct action research on field conditions with crop trials and suitable soil treatments, iii) to introduce/develop climate adaptive and resilient agricultural crops for all three cropping seasons

and iv) to train up the local level Govt. officials, local leaders and farmers on adaptive crop cultivation and management practices.

The research area of the project was Tazumuddin Upazilla of Bhola district, which is under "Integrated Sustainable Development Project for the Climate Vulnerable Ultra Poor Communities of Southern Bangladesh" (ISD Climb UP) of Islamic Relief, Bangladesh. Two research sites were selected in Tazumuddin Upazilla: one at Shambhupur Village under Shambhupur Union representing medium lowland and one at Uttar Chanchra village under Chanchra Union representing medium highland. A land size of 40 decimals in each of the sites was leased out for a year. Preliminary information on existing cropping patterns and cultivation practices in the study areas were collected through desk review, consultation with Upazilla Agriculture Officer, Tazumuddin, site visits and Focus Group Discussions with the farmers in Chanchra and Shambhupur union. Major cropping patterns of Tazumuddin were identified as- Tansplant *aman* rice – mungbean/ groundnut/potato/chilli/ *boro* rice – fallow. Considering the agro-ecosystem of Tazumuddin Upazilla, which is mostly affected by salinity and drought during dry season and submergence during monsoon season, a number of climate adaptive crops were taken into consideration for their adoption in the study area during the three cropping seasons- *rabi*, *kharif* I and *kharif* II.

During *rabi* season 2016-17, sunflower (2 varieties: BARI sunflower-2 and Armani Gold), maize (var. Sunshine), soybean (var. BARI soybean-6), barley (var. BARI barley-5), bitter gourd (var. Tia), brinjal (var. Sheuli), tomato (var. Unnoyon) and *boro* rice (vars. BRRI dhan28 and BRRI dhan29) were grown in addition to the farmers' grown crops chilli, mungbean, potato and groundnut. During *kharif* I season maize, sesame, soybean, jute, and *Dhaincha* (as green manure crop) were grown. In addition, *aus* rice was grown in the medium lowland of Shambhupur site under rain-fed condition and aroid was grown as water logging tolerant crop in the Shambhupur site. Five varieties of transplant *aman* rice namely Binadhan-7, BR-11, BRRI dhan49, Bhojan, and Shawrna were cultivated in the medium highland of Chanchra. Binadhan-7, BR11 and BRRI dhan49 were transplanted on 21 July 2017 as an intervention and Bhojan, BR 11 and Shawrna were transplanted on 13 August 2017 as per farmers' practice in the area. In the medium lowland of Shambhupur, six varieties namely Binadhan-7, BR 11, BRRI dhan49, Bhojan, BR 23 and BRRI dhan52 were transplanted. Again, Binadhan-7, BR11 and BRRI dhan49 were transplanted

on 21 July 2017 as an intervention and Bhojan, BR11, BR23 and BRRI dhan52 were transplanted on 3 August as per farmers' practice.

All the crops were grown in a 12 m^2 plot (4m x 3m) plot as laid out in randomized complete block design with three replications. Crops were cultivated as per the standard management practices. The crops were harvested at maturity. After threshing and cleaning plot-wise crop yields (for both products and by-products) were recorded. In case of multiple harvests, the yield of each harvest was recorded and the aggregate yield was calculated after the final one. For costing analysis crop yields (product and by-products) were considered. The price of the each of the commodities was recorded as per their harvesting date and market price of the commodity on that particular date. In case of multiple harvests, quantity of each harvest and market price on that particular day were recorded.

Soil samples from 0-15 cm depth were collected from five different locations of each of the experimental fields before starting the experiments. The soil samples from each site were mixed together and a pooled sample was collected. The soil samples were used to determine EC (dSm^{-1}), spoil pH and contents of organic matter, nitrogen, phosphorus, potassium and sulphur in the Laboratory of Soil Science Department of Bangladesh Agricultural University, Mymensingh. Soil samples were also collected month-wise in a similar way to determine soil EC and also after every cropping season to determine soil pH and contents of organic matter, nitrogen, phosphorus, potassium and sulphur. After the completion of the field research, a two-day long training program was arranged in the two research locations (one day for each location) for the farmers, local leaders and DAE people for conducting the training on the cultivation technology of the crops intervened in the area through the project. A result sharing workshop was arranged in the Conference Room of DC Office of Bhola district with the policy makers, scientists, Extension people, media people, local leaders and farmers on 17 July 2018.

A number of *rabi* crops like tomato, sunflower, maize, barley, soybean, and wheat appeared as very promising crop adapted to the existing environment including salinity and drought situation with high benefit cost ratio as compared to the farmers' grown crops. In Chanchra, the highest BCR of 4.60 was found from the cultivation of tomato. Substantially higher BCR was also obtained from the cultivation of maize (1.99) and sunflower (1.96) as compared to farmers' grown crop. Among the crops intervened and successfully grown, soybean and barley also gave higher

BCR than the farmers' grown crops, although the BCR was just above 1. On the other hand, except potato other farmers' crops like groundnut, mungbean and chilli produced BCR less than 1 meaning that all of the crops incurred loss for their cultivation. Cultivation of potato incurred profit but still lower than the profit obtained from barley and soybean. A similar trend of BCR was also obtained in the experiment done in Shambhupur producing the highest BCR of 4.87 from tomato followed by maize (1.73) and soybean (1.50). Within the two locations, crop profitability in general was higher in Chanchra as compared to Shambhupur except tomato. This is also worth reporting that all of farmers' crops incurred loss in Shambhupur, though the loss in potato was lower than groundnut, chilli and mungbean. The crops grown in the study during *rabi* season made a substantial impact on the attitude of the local farmers, who did not know that these crops can be cultivated there with such an excellent performance. From the study it has been proven that most of our suggested crops, in particular tomato, sunflower, maize, barley and wheat showed high adaptability to the local salinity and drought dominated environment and can be successfully grown in the area during dry *rabi* season, which will improve crop productivity, cropping intensity and crop diversity in the area and eventually improve the economic condition of the farmers in the area.

Among the *kharif* I crops, *aus* rice (cv. BRRI dhan48), jute (cv. BJC-2197 and CVL-1), *kharif* maize (NK-40), *dhaincha* and aroid were grown successfully. In Shambhupur, yield of *aus* rice was 3.83 t ha^{-1}, which is higher than the national average. Green biomass yield of jute cv. BJC-2197 was 96 t ha^{-1} in Shambhupur site. The yields of CVL-1 were 88 t ha^{-1} and 92 t ha^{-1} in Shambhupur and Chanchra, respectively. Maize and sesame grew very well in Chanchra but due to heavy rainfall and subsequent water logging condition these crops died in Shambhupur site (medium lowland). However, maize and sesame survived in Chanchra site (medium highland) and gave reasonable yields of 9.5 t ha^{-1} and 1.4 t ha^{-1}, respectively. *Dhaincha* could successfully be grown and incorporated in Chanchra site with the green biomass yield of 15 t ha^{-1}. In both the locations, jute incurred high profit with BCR more than 1.5. In Chanchra, *kharif* maize cultivation was also profitable giving BCR of 1.27. However, *aus* rice cultivation in Shambhupur was nearly just marginal with BCR of 0.99.

Among the transplant *aman* rice varieties grown in both the locations, BRRI dhan49 as transplanted on 21 July produced the highest grain yields of 5.67 t ha^{-1} and 6.90 tha^{-1} with the

field duration of 133 days and 134 days in Chanchra and Shambhupur, respectively. The second best *aman* rice variety as appeared in study is BR 11 which produced the grain yields of 5.33 t ha^{-1} and 5.90 t ha^{-1} in Chanchra and Shambhupur, respectively, though this variety took longer duration than BRRI dhan49. Among the farmers' varieties, Shawrno dhan gave the highest yield in Chanchra (5.10 t ha^{-1}) and Bhujan in Shambhupur (5.50 t ha^{-1}). Among the varieties intervened, Binadhan-7 produced the lowest yield of 5.0 t ha^{-1}, but the variety also took the shortest field duration of only 120 days as against more than 130 days in case of varieties BR 11 and BRRI dhan49. Interestingly BR 11 produced 1.17 t ha^{-1} higher grain yield when transplanted on 21 July (intervention) as compared to transplanting on 13August (farmers' practice) in Chanchra. The same variety also produced 0.64 t ha^{-1} higher grain yield in Shambhupur with transplanting on 21 July as compared to transplanting on 3 August. Considering both field duration and yield BRRI dhan49 appeared as the best one producing the highest grain yield and giving the highest BCRs of 1.77 and 1.45 in Shambhupur and Chanchra, respectively.

The results of the study indicate that transplant *aman* rice can be harvested in late October or early November without compromising with the yield and economic profitability if suitable *aman* rice varieties are selected and transplanted at the beginning of the season. For example, Binadhan-7, BRRI dhan49 and BR11 were harvested on 22 October, 2 November and 5 November, respectively when they were transplanted on 21 July. In that case, *rabi* crops can be sown/planted in time (early November) and they can be harvested by March with good yield and thus the risk of crop failure due to cyclone/'*Kalbaishakhi*' and/or early shower, which usually occurs in April/May, can be avoided. Tomato, sunflower, maize, soybean, barley and wheat performed very well in both Chanchra and Shambhupur locations, even though they were sown/ planted later than the optimum time. The performance of the crops in the area could possibly be improved further if they can be sown/ planted in time (by mid-November). If the *rabi* crops can be sown by mid-November, some of the crops like tomato, sunflower, barley and wheat can be harvested by mid-March and then there will have enough time to grow *kharif* I crops like sesame, tosha jute and *kharif* maize, particularly in the highland and medium highland. In

addition, *aus* rice, deshi jute and aroid could be the rain-fed crops to be grown in the medium lowland of the area.

The study clearly reveals that three crops can easily be cultivated in the research area during three cropping seasons in a year. By selecting short duration high yielding transplant *aman* rice varieties (such as Binadhan-7, BRRI dhan49 and BR11) and by transplanting them at the beginning of the season (second to third week of July) farmers can get higher BCR as compared to their existing varieties and also they can harvest the crops some 2 to 4 weeks earlier than their varieties. This will help the farmers cultivate *rabi* crops in time. Tomato, sunflower, maize, barley, wheat and soybean appeared as the best crops for the area during *rabi* season. If the *rabi* crops can be planted in first week of November, they can be harvested by 3rd week of March (except maize) and then the land could be used for cultivation of rain-fed *kharif* I crops like sesame, *kharif* maize and jute.

Tomato produced the highest profit of Tk. 326938 per hectare followed by maize Tk. 111296 and sunflower Tk. 110837 during *rabi* season. Among the *kharif* I crops intervened, tosha jute gave the maximum profit of Tk. 121954 per hectare followed by *kharif* maize Tk. 30597. BRRI dhan49 as transplanted on 21 July appeared as the best transplant *aman* rice variety offering the highest profit of Tk. 59840 per hectare. On the other hand, the most profitable crops of the farmers' practice as appeared from the study is potato in *rabi* season with profit of Tk. 8304 and transplant *aman* rice cv. Bhojan with profit of Tk. 31840 per hectare. Thus, five most profitable cropping patterns from the current intervention can be suggested for the study areas as – i) Tomato – Tosha jute – Transplant *aman* rice cv. BRRI dhan49, ii) Tomato – *kharif* maize – Transplant *aman* rice cv. BRRI dhan49, iii) Maize – Tosha jute – Transplant *aman* rice cv. BRRI dhan49, iv) Sunflower – Tosha jute – Transplant *aman* rice cv. BRRI dhan49 and v) Sunflower – *kharif* maize – Transplant *aman* rice cv. BRRI dhan49 with the surplus profit of Tk. 468588, 374213, 252946, 252484 and 161112, respectively over the farmers' best cropping pattern potato – fallow – Transplant *aman* rice cv. Bhojan.

As year-round calendar *rabi* crops like tomato, sunflower, maize, barley, wheat and soybean, *kharif* I crops like jute, sesame, *kharif* maize and *dhaincha*, and *kharif* II crops like transplant *aman* rice cvs. Binadhan-7, BRRI dhan49 and BR11 are suggested for highland and medium

highland of the research area. On the other hand, for medium lowland same *rabi* crops as in medium highland are suggested. However, in *kharif* I season *aus* rice, deshi jute and aroid are suggested as they can tolerate water logging condition. During *kharif* II season transplant *aman* rice vars. Binadhan-7, BRRI dhan49 and BR11 are suggested. BRRI dhan52 can be cultivated if the land is prone to high submergence.

For the scaling up of the research findings initiatives need to be taken for motivating the farmers in the area so that they replace their existing *rabi* crops (mungbean, chilli, potato and groundnut) with tomato/ sunflower/ maize/ barley/ soybean/ wheat. Farmers are to be encouraged to cultivate their land during *kharif* I season by selecting jute/ *kharif* maize/ sesame/ *aus* rice as rain-fed crops. Farmers are also to be motivated to cultivate high-yielding *aman* rice varieties like BRRI dhan49/ BR11/ Binadhan-7/ in time. Farmers are to be given proper training about the climate adaptive crop species and varieties and improved management practices, particularly the management practices for ameliorating salinity and drought effects in crops. Quality seeds of the suggested crops are to be made available to the farmers. DAE personnel are to be involved for giving training and necessary input supports for expansion of the suggested crops in the study area. Marketing for the new crops such as maize, barley, soybean etc. in the area is to be strengthened so that the farmers get fair price of their product. Linkages can be developed between farmers and industries in that connection.

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Chapter 1: Introduction

1.1 Background of the study

The southern coastal zone of Bangladesh, covering 27 per cent of the area and 21 per cent of the population, is one of the most food insecure areas of the country (FAO, 2013). Most of the people living in the coastal area depend on agriculture with very low productivity. The farmers in the area are dominantly marginal farmers usually cultivating one crop in a year (Rashid *et al*., 2014; Sarangi *et al*., 2015). During the monsoon season the farmers primarily grow low-yielding and late-maturing transplant *aman* rice varieties and most of the lands ranging from 700000 to 800000 ha remain fallow during the dry period of the year (Mainuddin *et al*., 2014; Schulthess *et al*., 2015). Thus, the levels of cropping intensity, crop diversity and crop yield in the area are much lower than the other parts of the country. As a result, the area is disadvantaged by poverty, food insecurity and limited livelihood opportunities, which is reflected by nearly 65% of the population in this area living below the poverty line compared to the country's average of 40%.

Under the current climate change context agricultural productivity in the coastal area of Bangladesh is under a big challenge due to increasing salinity, drought and submergence. The constraints of low agricultural productivity in the coastal area include prolonged submergence/ water logging during and after the monsoon (*Kharif*-II season) and increasing soil salinity and lack of fresh irrigation water during the dry season (both *Kharif*-I and *Rabi* seasons). Almost 65% of the coastal zone of Bangladesh is affected by various levels (low to high) of salinity during dry season (SRDI, 2010). Moreover, the area is also highly vulnerable to various environmental hazards like cyclone affecting the agricultural productivity. Under this situation, appropriate selection of crop species and varieties suitable for the area, crop intensification, efficient use and optimal management of resources like fresh water and improved agronomic practices are some of the options for maximizing the agricultural productivity in the coastal area of the country.

Islamic Relief Worldwide is an international humanitarian and development organization, who works for the world's most vulnerable people for minimizing their poverty and sufferings. Islamic Relief Worldwide has been operating in Bangladesh since 1991, when Bangladeshi people met the devastation of mighty cyclone. Currently, Islamic Relief, Bangladesh (IRB) is

running different projects in 22 districts in Bangladesh. As one of the core programmes, **Livelihood and Community Development (L&CD) Programme** has started implementing its activities since 1995 and implementing "Integrated Sustainable Development Project for the Climate Vulnerable Ultra Poor Communities of Southern Bangladesh" (ISD Climb UP) addressing the poverty and climate vulnerability of Tazumuddin Upazila (sub-district) under Bhola district in Bangladesh. The project area has one of the highest incidences of poverty in Bangladesh as well as very low in water & sanitation, health, education and hygiene indicators. As of other parts of the southern coastal area of Bangladesh, the project areas are ecologically vulnerable to cyclones, tidal surges, salinity and loss of land for frequent river erosion. Introducing/promoting climate adaptive and resilient agricultural crops round the year by using indigenous/appropriate technologies at Tazumuddin Upazilla is one of the activities of the project.

1.2 Cropping seasons in Bangladesh

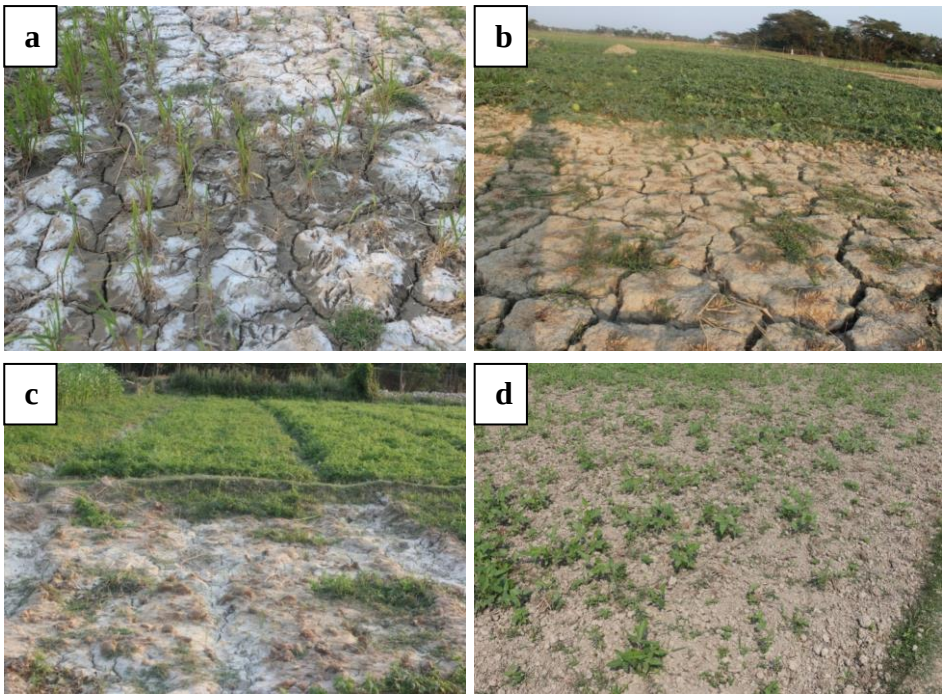
Based on the prevailing climatic conditions there are three cropping seasons in Bangladesh, namely *kharif*-I, *kharif*-II and *rabi*. *Kharif*-I season starts at mid-March and ends after June. *Kharif*-II seasosn spans from July to mid-October while *rabi* season begins from November and continues up to mid-March. During *kharif*-I season the weather remains mostly dry with less rainfall accompanied with high temperature. Furthermore, weather during this part of the year often experiences sudden strong wind and tornado, which is commonly known as "*Kal Baishakhi*" and cyclone mostly in the southern belt of the country. *Kharif*-II season corresponds to the rainy season of Bangladesh. This season is characterized by high temperature, rainfall and high humidity. As a result, moisture supply from rainfall plus soil storage is enough to support crop production during this season. Very often *kharif*-II crops are affected by floods in areas where there are no appropriate flood control measures. *Rabi* season in Bangladesh is characterized by dry and bright sunny weather and a bit hot weather warm at the beginning and end, but mostly cool during December-February. Since the season is more or less rain less, crop production is heavily dependent on irrigation. The major crops grown during these three cropping seasons are given in Table 1.1.

Table 1.1 Major crops grown in Bangladesh during different cropping seasons

Kharif-I (16 March to 30 June)	*Kharif*-II (1 July to 15 October)	*Rabi* (16 October to 15 March)
Aus rice, jute, maize, sesame, groundnut, sorghum, cheena, kaon, blackgram, and summer mungbean.	Transplant *aman* rice, aroids, lady's finger, red amaranths, amaranths, Indian Spinach, sweet gourd, ash gourd, bitter gourd, snake gourd, teasle gourd, brinjal and chilli.	*Boro* rice, wheat, maize, barley, potato, sweet potato, mustard, sesame, groundnut, sunflower, linseed, chickpea, lentil, grass pea, cowpea, cabbage, cauliflower, brinjal, tomato, carrot, turnip, radish, spinach, lettuce, bottle gourd, country bean, garden pea, chilli, onion, garlic, coriander, sweet cumin, black cumin, fenugreek; sunnhemp, tobacco and watermelon

1.3 Status of crop productivity in the salinity affected coastal area of Bangladesh

Southern regions of Bangladesh including Bhola district are salinity prone area with scarcity of good quality irrigation water. Although salinity is a year-round problem in the coastal belt of Bangladesh, the intensity of the stress becomes acute during the dry period (January to May) of the year and as such the production of *boro* rice and other *rabi* and *kharif*-I crops are mostly affected in the area due to salinity stress (Photograph 1.1 a, c). Because of less rainfall and scarcity of fresh irrigation water in the southern coastal area crops during *rabi* and *kharif*-I seasons are also affected by drought (Photograph 1.1 b, c). On the other hand, due to plenty of rainfall during *kharif*-II season accompanied by inappropriate drainage and due to broken dam the crops are affected by submergence/ water-logging in this season. Poor crop management by the farmers (Photograph 1.1 d) either due to ignorance about the modern technologies or due to socio-economic barriers like lack of capitals, labourers etc. may also lead to lower yield of crops in the salinity affected area of the country.



Photograph **1.1** Crop fields affected by salinity (a; *boro* rice), drought (b; water melon), both salinity and drought (c; bitter gourd) and with poor management (d; mung bean) (Photographs were taken from the farmers field in Borguna district in April 2016)

The dominant cropping patterns being practiced in the salinity affected coastal area is Fallow – T. *aman* rice – Fallow or Fallow – T. *aman* rice – *Boro* rice. The dominant patterns indicate the lower cropping intensity in the coastal area as shown in Fig. 1.1. The cropping intensities in three costal districts Potuakhali, Khulna and Barisal are only 146%, 148% and 187% as against national average of 194% and the highest cropping intensity in Kusthia district of 257% (Fig. 1.1). Moreover, because of poor management and inappropriate variety selection rice yield in the coastal districts are also much lower than the national average (Fig. 1.2).

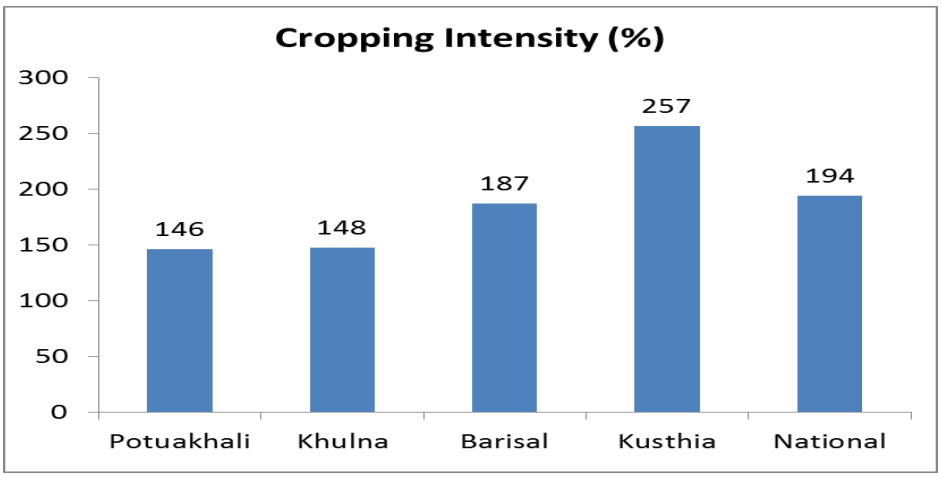


Fig. 1.1 Cropping intensity (%) in major coastal districts of Bangladesh (BBS, 2017)

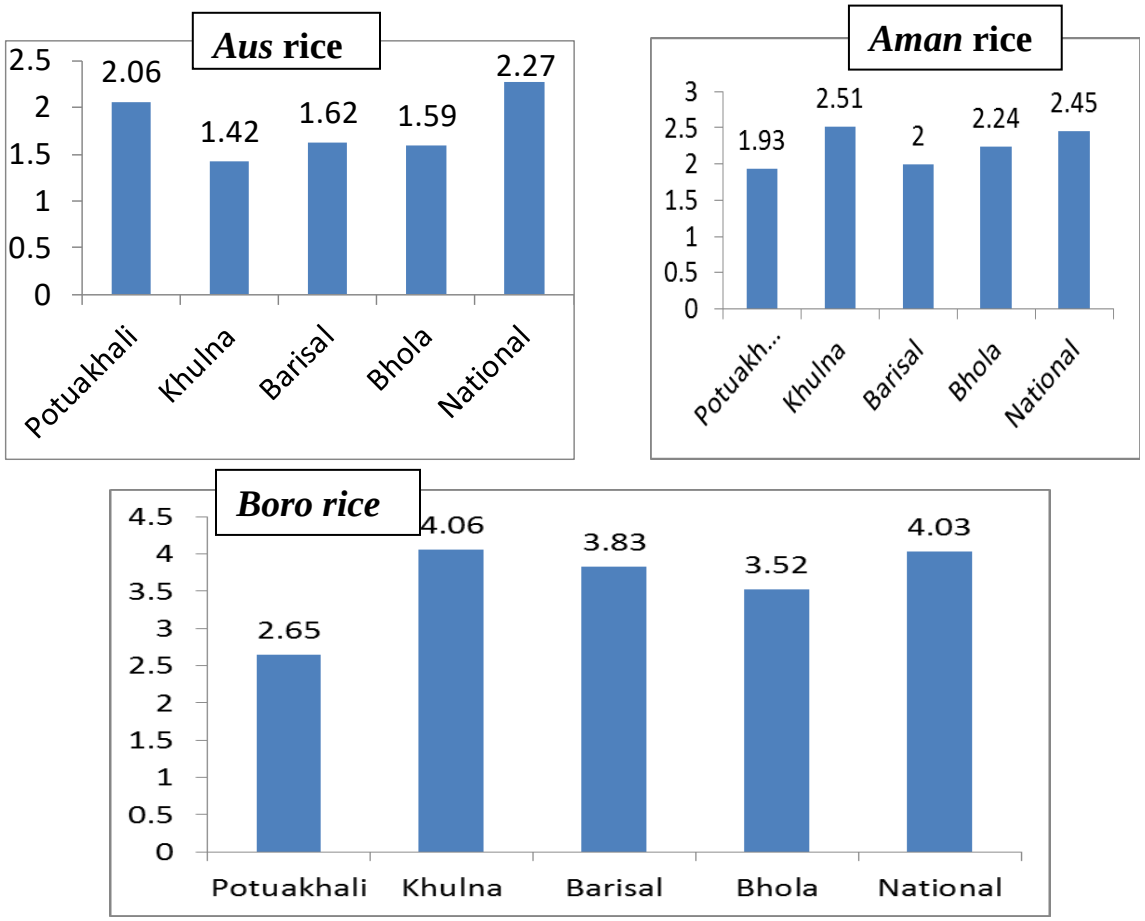


Fig. 1.2 Yield (t ha^{-1}) of *aus*, *aman* and *boro* rice in some salinity affected districts of Bangladesh (BBS, 2017)

1.4. Objectives of the study

The project aimed to sustainably improve crop productivity in Tazummudin Upazilla of Bhola district by selecting appropriate crop species/ varieties and adopting improved agronomic practices for the efficient and optimum resource management for all three cropping seasons (*kharif*-I, *kharif*-II and *rabi*). To meet the aim the objectives of the work were designed as:

i. To identify the best suit crops for the local area and ways to improve the production of successful crops trialed at demonstration plots.

ii. To conduct action research on field conditions with crop trials and suitable soil treatments.

iii. To introduce/develop climate adaptive and resilient agricultural crops for all three cropping seasons.

iv. To train up the local level Govt. officials, local leaders and farmers on adaptive crop cultivation and management practices.

Chapter 2: Methodology

2.1 Study Area

Tazumuddin Upazila of Bhola District was selected for the study. **Tazumuddin Upazila** is bounded by Daulatkhan upazila on the north, Lalmohon and Manpura upazilas and Meghna river on the south, Hatiya and Ramgati upazilas and Meghna river on the east and Burhanuddin upazila on the west. The Upazilla belongs to AEZ 18: Young Meghna Estuarine Floodplain.

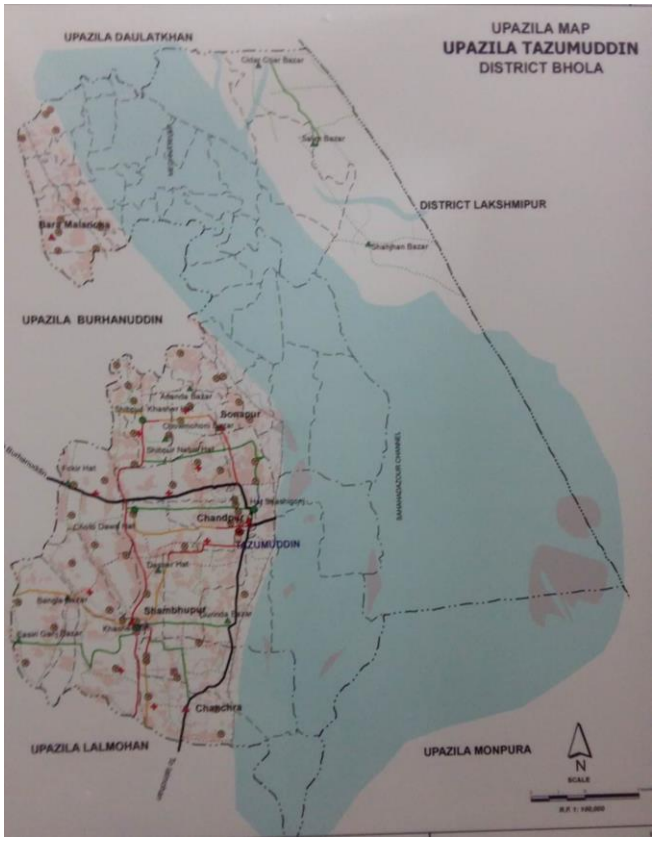


Fig. 2.1 Map of Tazumuddin Upazilla, Bhola (source: Upazilla Agriculture Office, Tazumuddin, Bhola)

The Upazila is having 5 Unions namely Chanchra, Chandpur, Bara Malancha, Shambhupur and Sonapur with an area of area of 512.92 sq km. Total cultivated land in the Upazila is 11876 ha of which 9.43% is highland, 30.64% is medium highland, 45.89% medium lowland and 14.03% is lowland. Thus, the cultivated land in the Upazila is dominated by medium lowland to medium highland. To select the research locations we, the whole team visited the Upazilla during 24-26

October 2016. The team had several meetings with the Officials of Local IR'B at Tazumuddin followed by the filed visits in the study areas. Finally in collaboration with the IR'B local office, two research sites were selected: one at Shambhupur Village under Shambhupur Union representing medium lowland and one at Uttar Chanchra village under Chanchra Union representing medium highland. A land size of 40 decimals in each of the sites was leased out for a year.

2.2 Major cropping patters being practiced in the study area

Preliminary information on existing cropping patterns and cultivation practices in the study area of Tazumuddin Upazilla were collected through desk review and telephone conversation with Mr. Sazzad Hossain Talukder, Upazilla Agriculture Officer, Tazumuddin. To get the real scenario of agriculture in the study area the research team visited Tazumuddin during 22-24 October and made two Focus Group Discussions with the farmers in Chanchra and Shambhupur union. The team also talked to the employees of IRB working in Tazumuddin and UAO of Tazumuddin Upazilla. From the review study and practical visit, the major cropping patterns of Tazumuddin were identified as-

1) Tansplant *aman* rice – mungbean – fallow
2) Tansplant *aman* rice – groundnut – fallow
3) Tansplant *aman* rice – potato – fallow
4) Tansplant *aman* rice – *boro* rice – fallow
5) Tansplant *aman* rice – chilli – fallow

2.3 Adoption of the cropping patterns in the study area

Considering the agro-ecosystem of Tazumuddin Upazilla, which is mostly affected by salinity and drought during dry season and submergence during monsoon season, the following crops were taken into consideration for their adoption in the study area:

Kharif-I	*Kharif*-II	*Rabi*
Maize/ Sesame/ Soybean/ Jute/ *Aus* rice / Summer mungbean/ Dhaincha (as green manure crop)	Transplant *aman* rice	Sunflower/ Maize/ Wheat/ Barley/ *Boro* rice

2.3.1 *Rabi* season (Mid-October to Mid-March)

During *rabi* season 2016-17, the following crops/ varieties were cultivated in each of the locations: sunflower (2 varieties: BARI sunflower-2 and Armani Gold), maize (var. Sunshine), soybean (var. BARI soybean-6), barley (BARI barley-5), wheat (var. BARI gom-25) bitter gourd (var. Tia), brinjal (var. Sheuli), tomato (var. Unnoyon), *boro* rice (vars. BRRI dhan28 and BRRI dhan29), chilli (local), mungbean (local), potato (local) and groundnut (local). Each of the crops/ varieties was cultivated in a plot of 12 m^2 (3m x 4m). Randomized complete block design with 3 replications was used in the study.

2.3.2 *Kharif* I season (Mid-March to June)

As per the work plan and activity schedule of the research project, the following crops were grown in both the research sites during *kharif* I season: maize, sesame, soybean, jute, and *dhaincha* (as green manure crop). *Aus* rice was grown in the medium lowland of Shambhupur site under rain-fed condition. In addition, aroid was grown as water logging tolerant crop in the Shambhupur site, as the area is medium low land and prone to submergence. Each of the crops/ varieties was cultivated in a plot of 12 m^2 (3m x 4m). Randomized complete block design with 3 replications was used in the study.

2.3.3 *Kharif* II season (July to Mid-October)

During *kharif* II season transplant *aman* rice was grown in both the locations. Five varieties namely Binadhan-7, BR-11, BRRI dhan49, Bhojan, and Shawrno dhan were cultivated in the medium highland of Chanchra. Binadhan-7, BR11 and BRRI dhan49 were transplanted on 21 July 2017 and as per farmers' practice in the area Bhojan, BR 11 and Shawrna were transplanted on 13 August 2017. In the medium lowland of Shambhupur six varieties namely Binadhan-7, BR 11, BRRI dhan49, Bhojan, BR 23 and BRRI dhan52 were transplanted. Again, Binadhan-7, BR11 and BRRI dhan49 were transplanted on 21 July 2017 and Bhojan, BR11, BR23 and BRRI dhan52 were transplanted on 3 August as per farmers' practice. Each of the varieties was cultivated in a plot of 12 m^2 (3m x 4m). Randomized complete block design with 3 replications was used in the study.

2.4 Cultivation of the crops

All the crops were cultivated as per the standard management practices. Fertilizers were used as per the recommendation given by the Fertilizer Recommendation Guide (BARC, 2012). Sowing/planting/transplanting dates of each of the crops are shown in the following Table:

Table 2.1 Sowing/planting/transplanting and harvesting/final harvesting dates of the crops grown in Chanchra and Shambhupur

Season	Crop	Sowing/transplanting date		Harvesting date	
		Chanchra	Shambhupur	Chanchra	Shambhupur
Rabi	Sunflower cv. BARI Sunflower 2	10 Dec	10 Dec	21 Mar	26 Mar
	Sunflower cv. Armani Gold	10 Dec	10 Dec	21 Mar	26 Mar
	Maize cv. Sunshine	10 Dec	10 Dec	20 Apr	2 May
	Soybean cv. BARI Soybean-6	9 Dec	10 Dec	30 Mar	11 Apr
	Barley cv. BARI barley-5	10 Dec	10 Dec	15 Mar	16 Mar
	Wheat cv. Barigom-25	10 Dec	10 Dec	18 Mar	20 Mar
	Tomato cv. Unnoyon	7 Dec	7 Dec	18 Mar	21 Mar
	Bitter gourd cv. Tia	10 Dec	10 Dec	-	-
	Brinjal cv. Sheuli	9 Dec	10 Dec	-	-
	Boro rice cv. BRRI dhan28	10 Jan	11 Jan	-	-
	Boro rice cv. BRRI dhan29	10 Jan	11 Jan	-	-
	Chilli (local)	11 Dec	15 Dec	24 Apr	28 Apr
	Mungbean (local)	10 Dec	8 Dec	24 Mar	12 Apr
	Potato (local)	11 Dec	8 Dec	8 Mar	11 Mar
	Groundnut (local)	9 Dec	8 Dec	22 Apr	28 Apr
Kharif I					
	Maize	3 Apr	-	14 Jul	-
	Sesame	28 Mar	-	30 Jun	-
	Soybean	28 Mar	-	10 Jul	-
	Jute cv. BJC 2197 and CVL-1	28 mar	27 Mar	2 Aug	31 Jul
	Dhaincha (as green manure crop)	25 May	-	10 Jul	-
	Aus rice	-	9 June	-	20 Aug
	Aroid	4 Apr	-	16 Aug	-
Kharif II					
	Transplant *aman* rice cv. Binadhan-7	21 Jul	21 Jul	19 Oct	21 Oct
	Transplant *aman* rice cv. BR11	21 Jul	21 Jul	5 Nov	6 Nov
	Transplant *aman* rice cv. BRRI dhan49	21 Jul	21 Jul	1 Nov	2 Nov
	Transplant *aman* rice cv. BR23		3 Aug		12 Nov
	Transplant *aman* rice cv. BRRI dhan52		3 Aug		26Nov
	Transplant *aman* rice cv. Bhojan	13 Aug	3 Aug	7 Nov	7 Nov
	BR 11	13 Aug	3 Aug	21 Nov	13 Nov
	Showrna	13 Aug	-	26 Nov	-

2.5 Harvesting and estimation of yield

All the crops were harvested on maturity. After threshing and cleaning plot-wise crop yield (for both products and by-products) were recorded. In case of multiple harvests, the yield of each harvest was recorded and the aggregate yield was calculated after the final one.

2.6 Measurement of soil salinity

Soil samples from 0-15 cm depth were collected from five different locations of each of the experimental fields in every month. The soil samples from each site were dried in room temperature, cleaned and mixed thoroughly. The soil samples were then sent to the Laboratory of the Soil Science Department, Bangladesh Agricultural University for the measurement of EC (dSm^{-1}).

2.7 Measurement of soil fertility parameters

Soil samples from 0-15 cm depth were collected from five different locations of each of the experimental fields at the beginning of the study. The soil samples from each site were mixed together and a pooled sample was collected. Soil samples in a similar way were also collected from each of the crop fields at the end of each cropping season. The soil samples were then dried, cleaned and sent to the Laboratory of the Soil Science Department, Bangladesh Agricultural University for the measurement of organic matter, soil pH and nutrient status (N, P, K and S).

2.8 Statistical Analysis

The recorded data were tabulated and the "Analysis of Variance" was done using computer package MSTATC program. The means were evaluated with Duncan's Multiple Range Test (Gomez and Gomez, 1984)

2.9 Costing Analysis

Cost of cultivation of each of the crops was calculated as per the standard procedure. Non-material input costs were calculated based on the actual costs for machineries and wages for labourers in the area. Input costs were taken as per the inputs used and their market price. Land lease value was added to the total cost. For income crop yields (product and by-products) were considered. The price of the each of the commodities was recorded as per their harvesting date

and market price of the commodity on that particular date. In case of multiple harvests, quantity of each harvest and market price on that particular date were recorded. Cost Benefit ratio for all crops was calculated.

2.10 Conduction of training for the local level Govt. officials, local leaders and farmers on adaptive crop cultivation and management practices

A two-day long training program was arranged in the two research locations (one day for each location) for the farmers, local leaders and DAE people. Upazilla Agriculture Officer of Tazumuddin Mr. Md. Sazzad Hossian was present in the Training Workshop as Chief Guest and the Chairman of the Union Parishad was there as Special Guest. The team members were the resource persons for conducting the training on the cultivation technology of the crops intervened in the area through the project. A training manual was developed and distributed among the participants.

2.11 Conduction of result sharing workshop

A result sharing workshop was arranged in the Conference Room of DC Office of Bhola district with the policy makers, scientists, eextension people, media people, local leaders and farmers on 17 July 2018. The workshop was presided over by Mr. Md. Masud Alam Siddique, DC of Bhola District, the Official Head of the District. Mr. Prashanta Kumar, Deputy Director of Department of Agriculture Extension, Bhola was present in the workshop as special guest. A keynote presentation was given by the team leader Professor Dr. Md. Abdul Kader highlighting the achievements of the research works in relation to increased crop productivity and profitability on the introduced crops as compared to the farmers' practice. Afterwards, all the participants took part in the discussion meeting and suggested to take the initiative to expand the research findings among the farmers in Bhola district.

Chapter 3: Results and Discussion

3.1 *Rabi* Crops

3.1.1 Crop performance and yield

Crop cultivation in the research site of Tazumuddin Upazila is affected by a various magnitude of environmental hazards like salinity and drought during dry *Rabi* season. Considering the incidence of salinity and drought, the research work designed for *Rabi* season 2016-17 included the following salinity and drought adaptive crops/ varieties: sunflower (2 varieties: BARI sunflower-2 and Armani Gold), maize (variety Sunshine), soybean (var. BARI soybean-6), barley (BARI barley-5), wheat (var. BARI gom-25), bitter gourd (var. Tia), brinjal (var. Sheuli), tomato (var. Unnoyon) and *boro* rice (vars. BRRI dhan47 and BRRI dhan28). Four existing crops which are dominantly being cultivated by the farmers in the area viz. chilli (local), mungbean (local), potato (local) and groundnut (local) were also included in the study for comparison. The yield and profitability of the crops are given below:

3.1.1.1 Sunflower

As a salinity and drought tolerant crop, sunflower is considered as an emerging oilseed crop for the coastal area of Bangladesh. To increase cropping intensity and crop diversity in the coastal area of Bangladesh BRAC and ACI Bangladesh Ltd. have been working for the last several years to adopt sunflower and the crop is getting huge popularity among the coastal farmers because of its high yield, extensive adaptability and good market value. A very good performance of the crop was found in the study which is evident in Photograph 3.1. The yields of sunflower as obtained were 2.26 t ha^{-1} and 1.69 t ha^{-1} in Chanchra and Shambhupur, respectively for BARI sunflower-2 and 2.42 t ha^{-1} and 1.83 t ha^{-1} in Chanchra and Shambhupur, respectively for Armani Gold (Table 3.1). The lower yield in Shambhupur was probably because of heavy rainfall during last week of March and first week of April in the area which caused water stagnation in the medium lowland but not in medium highland.

Table 3.1 Yield of *rabi* crops as grown in the farmers' field of Shambhupur and Chanchra sites during 2016-17

Crops	(Yield t ha^{-1})*	
	Shambhupur	Chanchra
Sunflower cv. BARI Sunflower 2	1.69 (0.127)	2.26 (0.034)
Sunflower cv. Armani Gold	1.83 (0.033)	2.42 (0.124)
Maize cv. Sunshine	12.66 (0.697)	14.89 (0.421)
Soybean cv. BARI Soybean-6	2.91(0.083)	2.00 (0.019)
Barley cv. BARI barley-5	4.43 (0.042)	4.30 (0.081)
Wheat cv. Barigom-25	3.17 (0.051)	3.13 (0.094)
Tomato cv. Unnoyon	41.15 (4.040)	39.95 (1.576)
Bitter gourd cv. Tia	8.33 (0.601)	-
Brinjal cv. Sheuli	15.16 (0.957)	-
Boro rice cv. BRRI dhan28	-	-
Boro rice cv. BRRI dhan29	-	-
Chilli (local)	5.67 (0.0127)	15.33 (0.333)
Mungbean (local)	1.17 (0.017)	1.48 (0.033)
Potato (local)	23.83 (1.528)	24.00 (1.424)
Groundnut (local)	4.00 (0.231)	6.0 (0.674)

*Mean value of 3 replications; ** SE value in parentheses

Photograph 3.1 A very good performance of sunflower in the experimental field of Chanchra (top) and Shambhupur (below)

3.1.1.2 Maize

Maize is known as a drought tolerant crop which shows a significant tolerance to salinity as well. Because of rising poultry and fishery industries in the country, the demand for maize as poultry and fish feed is increasing day by day. Considering the high demand for maize grain, it is suggested that salinity and drought affected coastal area of the country could be promising maize growing zone both for *Rabi* and *Kharif* 1 seasons. A very vigorous growth and yield of maize in both the locations (Photograph 3.2) was obtained. The yield of maize was obtained 14.89 t ha^{-1} in Chanchra and 12.66 t ha^{-1} in Shambhupur (Table 3.1).

Photograph 3.2 Performance of maize in the experimental field of Chanchra (top) and Shambhupur

3.1.1.3 Barley

Barley is one of the important salinity tolerant crops. The crop also grows well under water scarcity condition. Therefore, there is a great prospect of growing barley in the salinity affected coastal area of Bangladesh during dry *Rabi* season. A very good yield of barley was harvested in in the study in both the locations with 4.30 t ha^{-1} in Chanchra and 4.43 t ha^{-1} in Shambhupur (Table 3.1). The field view of the crop is shown in Photograph 3.3.

Photograph 3.3 Performance of barley in the experimental field of Chanchra (top) and Shambhupur

3.1.1.4 Soybean

Soybean has successfully been grown in the salinity affected coastal districts, particularly in Noakhali for the last few years. A very good growth of the crop in both the locations (Photograph 3.4) was also obtained in the study. Soybean yield of 2.00 t ha^{-1} in Chanchra and 2.91 t ha^{-1} in Shambhupur was recorded in the study (Table 3.1).

Photograph 3.4 Performance of soybean in the experimental field of Chanchra (top) and Shambhupur

3.1.1.5 Tomato

Very excellent growth of tomato was found in the experimental field in both the locations (Photograph 3.5). Tomato yields as obtained in the study were 39.95 t ha^{-1} in Chanchra and 41.15 t ha^{-1} in Shambhupur (Table 3.1).

Photograph 3.5 Performance of tomato in the experimental field of Chanchra (top) and Shambhupur

3.1.1.6 Wheat

Wheat also performed very well in terms of growth and yield in the experimental fields in both the locations. The harvested wheat yields were 3.13 t ha^{-1} in Chanchra and 3.17 t ha^{-1} in Shambhupur (Table 3.1).

The field view of the crop is shown in Photograph 3.6.

Photograph 3.6 Performance of wheat in the experimental field of Chanchra (top) and Shambhupur

3.1.1.7 Brinjal

Brinjal grew well in Shambhupur but not in Chanchra. The yield was 15.16 t ha^{-1} in Shambhupur (Table 3.1).

Photograph 3.7 Performance of brinjal in the experimental field of Shambhupur

3.1.1.8 Bitter gourd

Bitter gourd did not grow well Chanchra but performed moderately in Shambhupur. The yield as obtained in Shambhupur was 8.33 t ha^{-1} (Table 3.1).

Photograph 3.8 Performance of bitter gourd in the experimental field of Shambhupur

3.1.1.9 *Boro* rice

The cultivation of *Boro* rice (vrs. BRRI dhan47 and BRRI dhan28) was hampered due to serious crisis of irrigation water and finally the cultivation of *boro* rice was abandoned.

Photograph 3.9 Performance of *boro* rice in the experimental field of Shambhupur

3.1.1.10 Cultivation of existing crop

Four existing crops which are dominantly being cultivated by the farmers in the locality viz. mungbean, potato, groundnut and chilli were also grown in the experiments in both the locations. The yield of chilli was 15.33 tha^{-1} in Chanchra and 5.67 tha^{-1} in Shambhupur (Table 3.1). However, the crop was affected by "*Kalbaishakhi"* and subsequent rainfall causing water stagnation during 19 to 24 April 2017 in both the locations. We harvested potato yield of 24.00 t ha^{-1} in Chanchra and 23.83 t ha^{-1} in Shambhupur, groundnut yield of 6.00 t ha^{-1} in Chanchra and 4.00 t ha^{-1} in Shambhupur and mungbean yield of 1.48 t ha^{-1} in Chanchra and 1.17 t ha^{-1} in Shambhupur .

Photograph 3.10 Performance of mungbean, potato, groundnut and chilli as grown with farmers' practice in the experimental field of Shambhupur

3.1.2 Profitability of *Rabi* Crop

As shown in Table 3.2, in Chanchra location, the highest BCR of 4.60 was found from the cultivation of Tomato. Substantially higher BCR was also obtained from the cultivation of maize (1.99) and sunflower (1.96). Among the crops intervened and successfully grown, soybean and barly also gave higher BCR than the farmers' practice, although the BCR was just above 1. On the other hand, except potato cultivation of all other farmer crops like groundnut, mungbean and chilli produced BCR less than 1 meaning that all of the crops incurred loss for their cultivation. Cultivation of Potato incurred profit but still lower than the profit obtained from barley and soybean. A similar trend of BCR was also obtained in the experiment done in Shambhupur (Table 3.3) producing the highest BCR of 4.87 from Tomato followed by maize (1.73) and soybean (1.50). Within the two locations, crop profitability in general was higher in Chanchra as compared to Shambhupur except tomato. This is also worth reporting that all of farmers' crops incurred loss in Shambhupur, though the loss in potato was lower than groundnut, chilli and mungbean.

Table 3.2 Yield and profitability of *rabi* crops per hectare grown in the farmer's field of Chanchra, Tazumuddin, Bhola

Rabi Crops	Duration	Yield (t)	Income Tk.	Costing Tk.	Profit or loss, Tk.	BCR
Introduced crops (salinity and drought adaptive)						
Sunflower	101	2.26	226000	115163	110837	1.96
Soybean	111	2.00	80000	76208.4	3791	1.05
Maize	131	1.49	223200	111903.1	111296	1.99
Barley	95	4.30	86000	81610.75	4389	1.05
Tomato	101	3.90	389500	84561.7	304938	4.60
Farmers crop						
Potato	87	24.00	259200	250896	8304	1.03
Mungbean	104	1.48	85800	114009	-28209	0.75
Groundnut	134	6.00	96000	136349	-40349	0.70
Chilli	134	7.66	150000	167626	-17626	0.89

Table 3.3 Yield and profitability of *rabi* crops grown in the farmer's field of Shambhupur, Tazumuddin

Rabi Crops	Duration	Yield ($t\ ha^{-1}$)	Total Income, Tk.	Total Cost, Tk.	Profit/ loss, Tk.	BCR
Introduced (salinity/ drought adaptive) crops						
Sunflower	106	1.70	170000	121289	48711	1.40
Soybean	122	2.92	116800	76208	40591	1.53
Maize	143	12.66	189900	111903	77996	1.70
Barley	96	4.43	88600	81610	6989	1.09
Tomato	104	41.15	411500	84561	326938	4.87
Farmers crop						
Potato	93	23.83	240000	250896	-10896	0.96
Mungbean	125	1.16	96300	114009	-17709	0.85
Groundnut	141	4.00	96000	136349	-40349.7	0.70
Chilli	134	5.70	126350	167626	-41276.8	0.75

3.2 *Kharif* I Crops

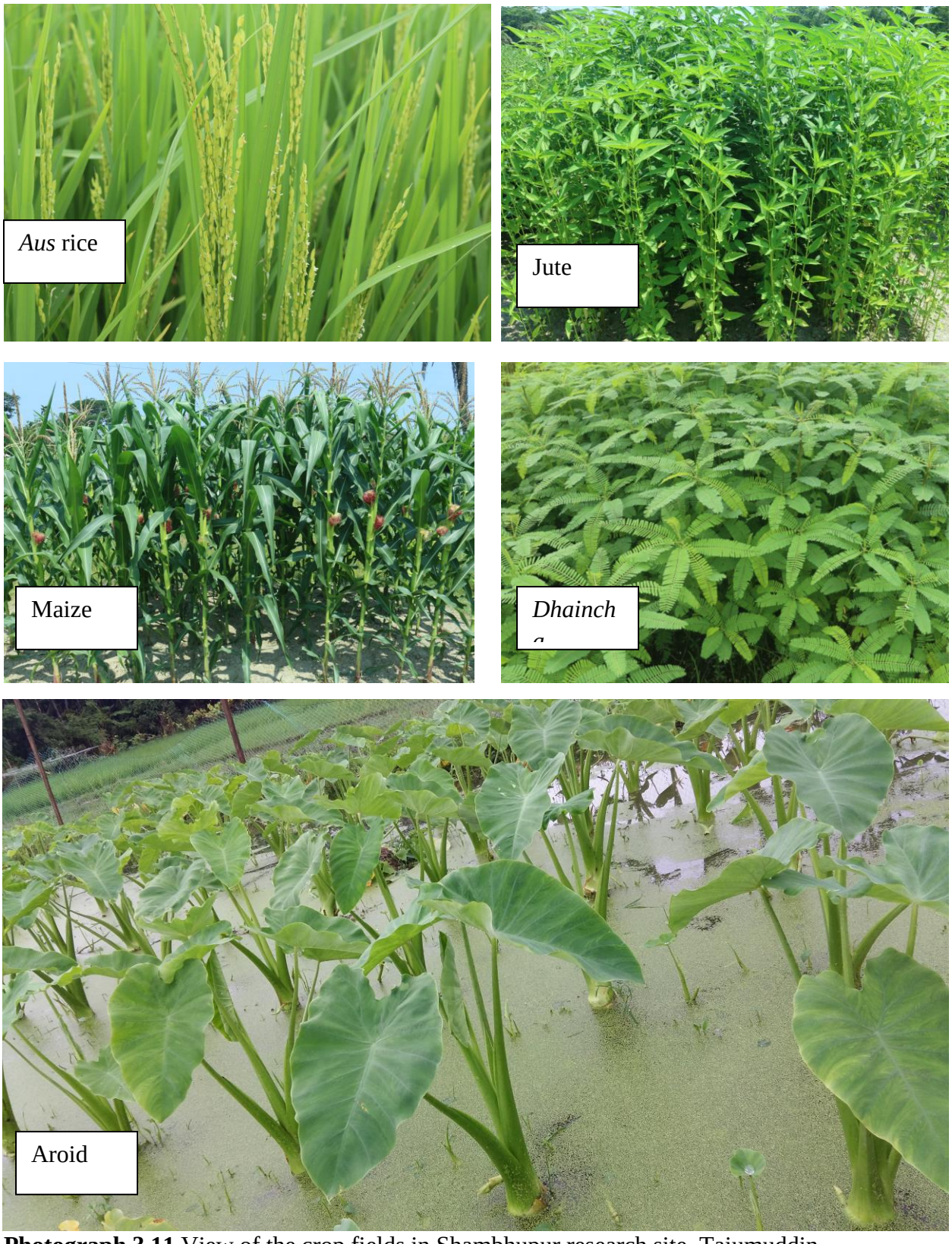
3.2.1 Crop performance and yield

All the crops were grown under rain-fed condition. Among the crops, *aus* rice (cv. BRRI dhan48), tosha jute (cv. BJC-2197) deshi jute (CVL-1), *kharif* maize (NK-40), *dhaincha* and aroid were grown successfully (Photograph 3.11). Table 3.4 shows the yield of the crops grown in both the research sites of Shambhupur and Chanchra. In Shambhupur, yield of *aus* rice was 3.83 t ha^{-1}. Green biomass yield of jute cv. BJC-2197 was t ha^{-1} in Shambhupur site and that of CVL-1 were 88 t ha^{-1} and 92 t ha^{-1} in Shambhupur and Chanchra site, respectively. Maize and sesame grew very well in Chanchra (Photograph 3.12) but due to heavy rainfall and subsequent water logging condition (Photograph 3.13) these crops died in Shambhupur site (medium lowland). Table 3.5 shows that in fourth week of April more than 400 mm rain occurred in the research sites causing a severe water logging condition in the area, particularly in Shambhupur sites. As a result sesame, maize and soybean plants died at seedling stage. On June 22 the research sites experienced heavy shower of 215 mm rainfall followed by another 35 mm rainfall in the following week. To aggravate the situation the area received a huge amount of 315 mm rainfall during the 1st week of July (Table 3.5). However, maize and sesame survived in Chanchra site (medium highland) and gave reasonable yield of 9.5 t ha^{-1} and 1.4 t ha^{-1}, respectively. *Dhaincha* could successfully be grown and incorporated in Chanchra site with the green biomass yield of 15 t ha^{-1}.

Table 3.4 Yield of the crops (t/ha) grown in two research sites under Tazumuddin Upazilla, Bhola during *kharif* I season 2017

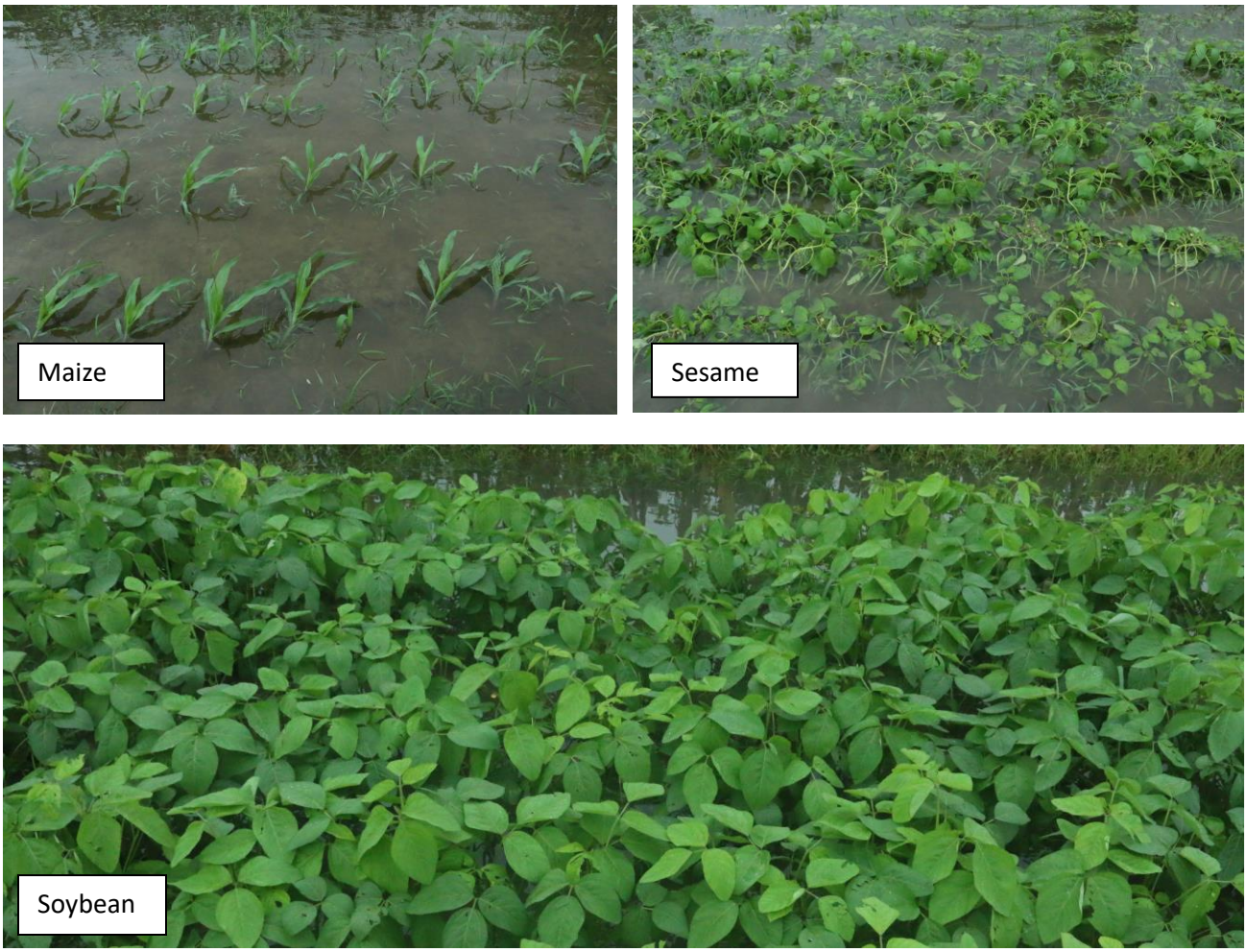
Research Site	Yield (t/ha)*						
	Jute		Maize	*Aus* rice	Soybean	Sesame	African Dhaincha
	cv. BJC-2197	cv. CVL-1	cv. NK-40	cv. BRRI dhan48	BARI Soybean-6	BARI Til-4	
Shambhupur	96.0 (2.30)	88.0 (4.18)	-	3.83 (0.76)	-	-	-
Chanchra	-	92.0 (2.67)	9.50 (6.93)	-	-	1.40 (0.06)	15.0 (0.30)

*Mean value of 3 replications; ** SE value in parentheses



Photograph 3.11 View of the crop fields in Shambhupur research site, Tajumuddin

Photgraph 3.12 View of crop fields of sesame and soybean at flowering stage



Photograph 3.13 View of the crop fields of maize, sesame and soybean in Shambhupur research site. Due to heavy rainfall in April the fields were waterlogged and the plants died

Table 3.5 Daily Rainfall (mm) in Tajumudding Upazilla during the flowering and maturity time of *kharif* I crops (mid-June to mid-July)- source: Upazilla Agriculture Office, Tazumuddin, Bhola

April 2017	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Rainfall (mm)	0	0	0	0	70	64	92.5	78	59	40	0	0	0	0	0
June 2017	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Rainfall (mm)	0	0	0	0	0	0	215	0	0	3	10	4	6	5	7
July 2017	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Rainfall (mm)	28	48	26	72	104	56	0	0	28	32	48	0	27	102	104

3.2.2 Profitability of *Kharif* I crops

Among the *kharif* I crops tried in both the research locations, maize and jute could successfully be grown in medium highland of Chanchra and jute and *aus* rice in medium lowland of Shambhupur. In both the locations, jute incurred very high profit with BCR more than 1.5 (Table 3.6). In Chanchra *kharif* maize cultivation was also profitable giving BCR of 1.27. However, *aus* rice cultivation in Shambhupur incurred a little loss with BCR of 0.99.

Table 3.6 Yield and profitability of *kharif I* crops grown in the farmer's field of Chanchra, and Shambhupur, Tazumuddin, Bhola

Crop	**Field duration**	**Yield (t ha^{-1})**	**Total Income, Tk.**	**Total Cost, Tk.**	**Net Profit, Tk.**	**BCR**
Chanchra						
Maize cv. NK-40	102	9.50	142500	111903	30597	1.27
Tosha Jute cv. BJC-2197	127	5.00	225000	148046	76954	1.52
Deshi Jute cv. CVL-1	127	5.75	258750	148046	110704	1.75
Shambhupur						
Tosha Jute cv. BJC-2197	126	6.00	270000	148046	121954	1.82
Deshi Jute cv. CVL-1	126	5.50	247500	148046	99454	1.67
Aus rice cv. BRRI dhan48	107	4.17	67713	68164	-451	0.99

3.3 *Kharif* II Crops

3.3.1 Crop performance and yield

Optimum time for transplanting of *aman* rice is 15 July - 15 August. Farmers in the study areas generally transplant *aman* rice a little late not until the first week of August, though their fields are available from the beginning of the season. Intervention was made with different transplant *aman* rice varieties considering their yield and duration and they were transplanted at the beginning of *aman* season. Short duration *aman* rice variety Binadhan-7 and currently most popular *aman* rice varieties BRRI dhan49 and BR 11 were included in the study and 30-day old seedlings of the varieties were transplanted on 21 July 2017 in both the locations. In addition, Bhujon, BR11 and Shawrno dhan were cultivated as farmers' practice and transplanted on 13 August in Chanchra (medium highland) and 2 August in Shambhupur. As the field in Shambhupur is medium lowland, submergence tolerant rice variety BRRI dhan52 was also included in the location. Yield and yield contributing characters of the varieties as obtained from the study are presented in Table 3.7 and Table 3.8. BRRI dhan49 as transplanted on 21 July produced the best yield and yield contributing characters. The highest grain yields of 5.67 t ha^{-1} and 6.90 t ha^{-1} were recorded from BRRI dhan49 with the field duration of 133 days and 134 days from Chnchra and Shambhupur, respectively. The second best *aman* rice variety as appeared in study is BR 11 which produced the grain yields of 5.33 t ha^{-1} and 5.90 t ha^{-1} in Chanchra and Shambhupur, respectively, though this variety took longer duration than BRRI dhan49. Among the farmers practice, Shawrno dhan gave the highest yield in Chanchra (5.10 t ha^{-1}) and Bhujon in Shambhupur (5.50 t ha^{-1}). All the varieties performed better in Shambhupur than Chanchra. Among the crops intervened, Binadhan-7 produced the lowest yield of 5.0 t ha^{-1}, but the variety also took the shortest field duration of only 120 days as against more than 130 days in case of varieties BR 11 and BRRI dhan49. Among the farmers crop, in Chanchra Shawrno dhan produced the highest grain yield of 5.10 t ha^{-1} and took the highest field duration of 150 days and Bhujon yielded the lowest one (4.07 t ha^{-1}) with 131 days field duration. However, Bhujon gave the best yield (5.50 t ha^{-1}) among the farmers crop in Shambhupur with the field duration of 132 days. This is very interesting to note that BR 11 produced 1.17 t ha^{-1} higher grain yield when transplanted on 21 July (intervention) as compared to transplanted on 13August (farmers practice) in Chanchra. The same variety also produced 0.64 t ha^{-1} higher grain

yield in Shambhupur with transplanting on 21 July as compared to transplanting on 3 August. The yield reduction in all transplant *aman* rice varieties in both locations is quite reasonable with the fact that the yield of transplant *aman* rice declines with the delayed transplanting of every day since middle of July. So, considering both field duration and yield BRRI dhan49 appeared as the best one producing the highest grains yields in both the locations.

Table 3.7 Yield and yield contributing characters of different varieties of transplant *aman* rice grown in the farmer's field of Chanchra, Tazumuddin, Bhola

Transplant *aman* rice varieties	No. of total tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000-grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Crop duration (days)
Intervention								
Binadhan-7	9.83	23.28	106.5	25.43	21.86	5.00	6.75	120
BR 11	13.26	22.03	82.09	24.94	30.00	5.33	7.19	137
BRRI dhan49	18.133	22.4	107.32	10.38	24.00	5.67	7.64	133
Farmers crop								
Bhojan	13.33	22.87	79.24	23.94	30.00	4.07	5.47	131
BR 11	9.4	22.07	79.58	23.18	30.00	4.16	5.60	145
Shawrno dhan	10	21.17	77.02	15.54	20.00	5.10	6.70	150

*All the data are mean value of 3 replications

Table 3.8 Yield and yield contributing characters of different varieties of transplant *aman* rice grown in the farmer's field of Shambhupur, Tazumuddin, Bhola

Transplant *aman* rice varieties	Total tillers hill^{-1} (No.)	Panicle length (cm)	No. of grains panicle^{-1}	Sterile spikelets panicle^{-1}	1000-grain wt. (g)	Grain yield (t ha-^{1})	Straw yield (t ha-1)	Crop duration (days)
Intervention								
Binadhan-7	9.83	23.28	106.5	25.43	21.86	5.00	6.75	120
BR 11	12.73	22.75	107.82	12.85	32.00	5.90	7.69	138
BRRI dhan49	21.47	23.26	118.88	17.55	23.70	6.90	7.99	134
Farmers' crop								
Bhojan	12.33	21.75	85.14	9.19	30.00	5.50	6.36	132
BR 11	9.6	23.12	61.02	23.88	30.00	5.26	6.09	138
BR 23	9.33	23.22	58.54	24.79	30.00	5.21	6.02	137
BRRI dhan52	11.8	22.52	46.41	18.89	28.00	4.00	4.94	151

*All the data are mean value of 3 replications

3.3.2 Profitability of *kharif* II crops

Profitability of all the transplant *aman* rice varieties as grown in both the research locations were calculated and presented in Table 3.9 and Table 3.10. From the results, it is very clear that transplanting of *aman* rice irrespective of variety produced higher profitability and BCR with transplanting at the beginning of the season as compared to transplanting late. Like the grain yield, BRRI dhan49 gave the highest BCR of 1.45 in Chanchra followed by BCR 1.36 with BR 11 transplanted on 21 July. However, the same variety gave BCR of only 1.06 when transplanted on 13 August. Interestingly, Binadhan-7 also gave the BCR value of 1.28 with field duration only 120 days whereas Shawrno dhan produced nearly similar BCR (1.31) with the field duration of 150 days. The results clearly indicate that farmers can get similar profit of their best variety Shawrno dhan by replacing it with Binadhan-7 and also can save 30 days in their year round crop calendar. The situation was more or less similar as in Chanchra, though overall profitability for all the varieties was higher as compared to Shambhupur. The highest BCR (1.77) was obtained from the variety BRRI dhan49 followed by 1.51 from BR 11. Among the farmers crop, Bhujon produced the highest BCR of 1.41 followed by BR 11 (1.35) and BR 23 (1.33). Cultivation of BRRI dhan52 gave just marginal profit with BCR of 1.02.

Table 3.9 Profitability of Transplant *aman* rice grown in the farmers' field of Chanchra, Tazumuddin Upazilla, Bhola

Crop	Variety	Duration	Yield (t ha^{-1})	Total income, Tk.	Total cost, Tk.	Profit/ Tk.	BCR
Transplant *aman* rice	**Intervention**						
	Binadhan-7	120	5000	100000	78159	21840	1.28
	BR 11	137	5330	106600	78159	28440	1.36
	BRRI dhan49	133	5670	113400	78159	35240	1.45
	Farmers crop						
	Bhojan	131	4070	81400	78159	3240	1.04
	BR 11	145	4160	83200	78159	5040	1.06
	Shawrno dhan	150	5100	102000	78159	23840	1.31

Table 3.10 Profitability of Transplant *aman* rice grown in the farmers' field of Shambhupur, Tazumuddin Upazilla, Bhola

Crop	Variety	Duration	Yield (t ha^{-1})	Total income, Tk.	Total cost, Tk.	Profit/ Tk.	BCR
Transplant *aman* rice	**Intervention**						
	Binadhan-7	120	5000	100000	78159.6	21840	1.28
	BR 11	138	5900	118000	78159.6	39840	1.51
	BRRI dhan49	134	6900	138000	78159.6	59840	1.77
	Farmers crop						
	Bhojan	132	5500	110000	78159.6	31840	1.41
	BR 11	138	5260	105200	78159.6	27040	1.35
	BR 23	137	5210	104200	78159.6	26040	1.33
	BRRI dhan52	151	4000	80000	78159.6	1840	1.02

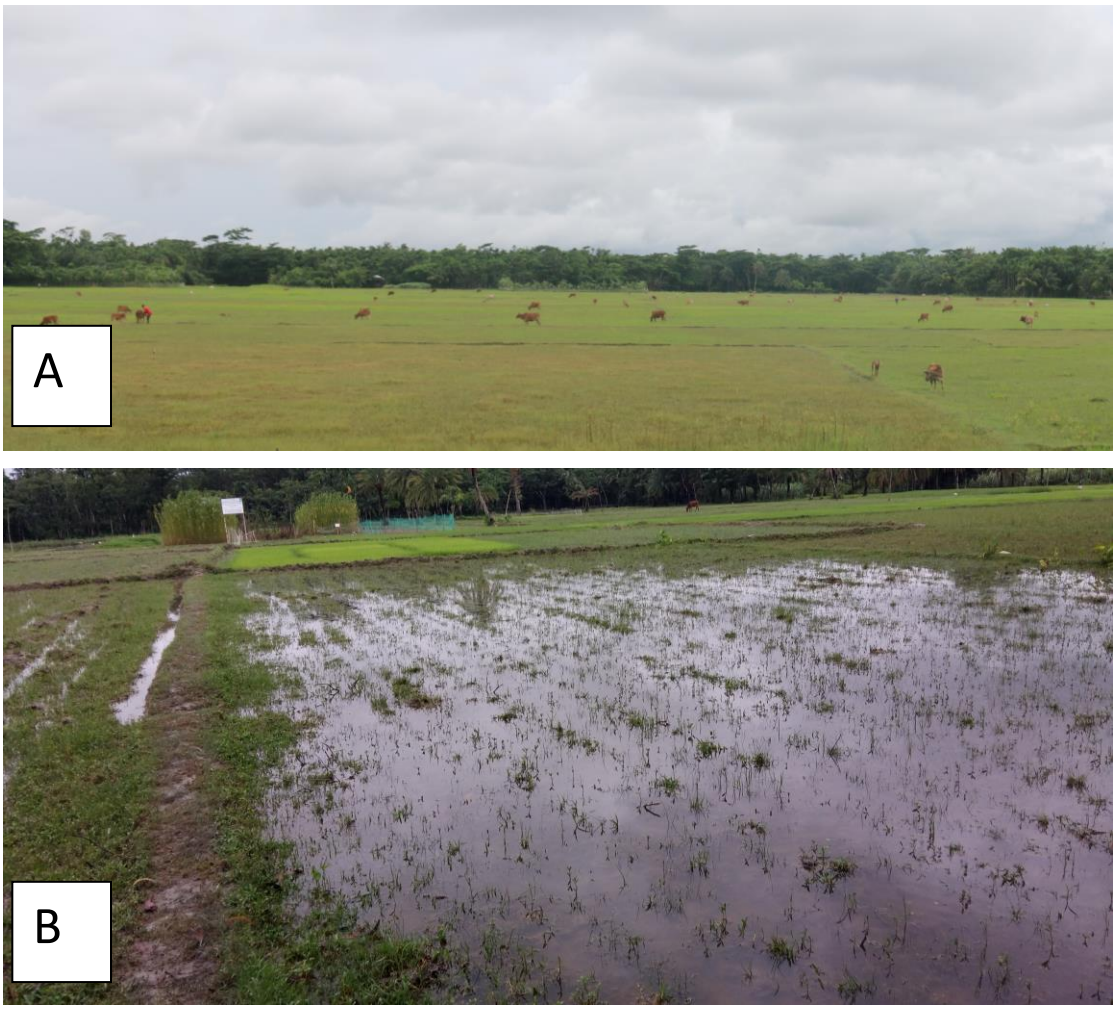
Chapter 4: Key findings, challenges and learning

4.1 *Rabi* crops

A number of *rabi* crops like sunflower, maize, barley, soybean, wheat and tomato appeared as very promising crop adapted to the existing environment including salinity and drought situation. However, *boro* rice could not be grown in the area because of unavailability of irrigation water. But *boro* rice may grow well in the area provided that sufficient irrigation facilities with fresh water are available. Brinjal and bitter gourd did not perform well in the study. The crops grown in the study during *rabi* season made a substantial impact on the attitude of the local farmers, who did not know that these crops can be cultivated there with such an excellent performance. During our field visit we talked to the farmers who owned the fields and also to the neighboring farmers. They were all found very impressed with many of the crops cultivated in our field, particularly sunflower, maize, tomato and barley (a video clip made during the study is enclosed herewith as attached). We also invited local electronic and print media people to visit our fields. News on our study highlighting our new innovations was published in local newspaper (Appendix 1). From the study it has been proven that most of our suggested crops, in particular sunflower, maize, barley, tomato and wheat showed high adaptability to the local salinity and drought dominated environment and can be successfully grown in the area during dry *rabi* season, which will improve crop productivity, cropping intensity and crop diversity in the area and eventually improve the economic condition of the farmers in the area.

4.2 *Kharif* I crops

The research site gets affected by salinity and drought during the beginning of *kharif* I season and submergence during the later part of the season. Therefore, most of the fields remain fallow in the area during *kharif* I season (Photograph 4.1), which can also be reflected from the fact that out of 179757 ha of net cropped area in Bhola district, 42510 ha are single cropped area and 74089 ha are double cropped area (BBS, 2017). In Tazumuddin Upazilla, out of 11876 ha of cultivated land 1025 ha are single cropped and 5010 ha are double cropped area (Upazilla Nirdesika, Tazumuddin, Bhola, 2016). Therefore, intervention was given in the study to introduce a number of *kharif* I crops viz. jute, *aus* rice, *kharif* maize, soybean, *dhaincha* (as green manure crop) and aroid in the area.



Photograph 4.1 Picture showing the **fallow lands** (farmers' field) in the research site of Chanchra (A) and Shambhupur (B) during the *kharif* I season of 2017

The research sites have adverse climatic condition for the production of crops. The major challenges prevailing in the area include:

i) Drought stress
ii) Salinity stress
iii) Lack of irrigation facilities with fresh water
iv) Erratic rainfall during the cropping season; long dry period with sudden huge rainfall causing waterlogging condition.
v) Lack of motivation and technological support for the farmers to grow crops under rainfed condition.

The cultivable fields in the research area remain virtually fallow because of adverse climatic situation. Due to dry weather the area is mostly affected by drought and salinity during *kharif* I season. There is no sufficient irrigation facility to grow crops in the prevailing dry weather condition. Therefore, the farmers in the area do not grow any crop during *kharif* I season in most of the cases. Among the crops intervened in the study jute grew very well in both the research sites and gave satisfactory yield. The yield performance of maize was very good in the medium highland of Chanchra area, but they did not survive in the medium lowland of Shambhupur area. However, in the medium lowland of Shambhupur area *Aus* rice and aroid appeared as the promising crops during *kharif* I season. *Dhaincha* cultivation was very successful in the medium highland of Chanchra area.

Jute, *kharif* maize, sesame, *aus* rice, aroid and *dhaincha* could be grown in the research sites of Tazumuddin Upazilla. Jute appeared as very suitable crop both for medium highland and medium lowland. *Kharif* maize, sesame and *dhaincha* are suitable for the medium highland whereas *aus* rice and aroid are suitable for the medium lowland. From the study it can be concluded that to increase the cropping intensity and crop productivity in Tazumudding Upazilla *khairif* maize, jute and *dhaincha* can be grown in medium highland and *aus* rice, jute and aroid can be grown in medium lowland. Although sesame was damaged by rainfall in June, early sowing (in February) may give a substantial yield in the medium highland of the area.

4.3 *Kharif* II crops

The study area is in general low-lying and if heavy rainfall occurs during July transplanting of *aman* rice may be delayed as the field gets water logged more than the height of the transplanted seedlings. This may insist the farmers to use local transplant *aman* rice varieties with taller seedling during transplanting and also go for late transplanting to avoid the heavy monsoon. Farmers in the area also use the high yielding varieties of transplant *aman* rice such as BR 11, BR 23 and BRRI dhan52 but with late transplanting as they do it for their local varieties. However, during this study we saw that seedlings of high yielding transplant *aman* rice varieties such as BRRI dhan49 and BR11 could successfully be transplanted and grown with early transplanting as we did it on 21 July. All of the varieties we used with early transplanting gave the better yield and higher profitability than the varieties with late transplanting. Even when we use the same variety such as BR 11 with early transplanting and late transplanting, it produced

higher yield in early transplanting than the late one. Binadhan-7 also appeared as a promising variety producing reasonably higher yield as compared to the farmers' crop with only 120 days field duration. However, early transplanting of Binadhan-7 may expose the flowering stage of the crop to torrential rain during late September which may cause serious spikelet sterility in the variety.

4.4 Changes of soil pH, organic matter and major nutrients

Soil fertility parameters like soil pH, organic matter, nitrogen, potassium, phosphorus and sulphur in the experimental fields of the study areas are presented in Table 4.1. The table indicates no major changes of soil fertility parameters in both the locations with the intervention of the crops. Overall, soil fertility parameters were superior in Shambhupur site as compared to Chanchra site. At the beginning soil pH in Shambhupur was almost neutral which remained same at the end of the study. Soil pH in Chanchra site was, however, acidic (pH 5.4) and remained similar throughout the study period. The soil of Shmbhupur site was rich in soil organic matter (2.4%) at the beginning which also remained same at the end of the study. Soil pH in Chanchra site (2.0) was also higher than the national average (less than 1.5 in most of the soils). In terms of major nutrients N, P, K and S, soils of Shmbhupur site was better than Chanchra site. Particularly potassium and sulphur were lower in Chanchra site.

Table 4.1 Soil fertility parameters in the experimental fields before and after the intervention

Soil properties	At the beginning		After *Rabi* crop		After *Kharif* I crop		After *Kharif* II crop	
	Shambhupur	Chanchra	Shambhupur	Chanchra	Shambhupur	Chanchra	Shambhupur	Chanchra
Soil pH	6.9	5.4	6.8	5.7	6.9	5.8	6.9	5.6
Soil organic matter	2.4	2.0	2.5	1.9	2.3	1.8	2.4	1.9
Total Nitrogen (%)	0.145	0.095	0.155	0.112	0.143	0.098	0.142	0.101
Phosphorus (ppm)	35.67	26.93	39.24	27.12	37.21	27.11	36.76	25.43
Potassium (meq/100g)	1.29	0.24	1.27	0.28	1.34	0.26	1.31	0.31
Sulphur (ppm)	89.24	28.77	92.11	34.21	87.31	32.11	88.12	31.46

4.5 Occurrence of salinity stress in the study area

The lowest soil salinity was found in both the research locations during August and September (Fig. 4.1). Since then salinity started to increase gradually with time and got the peak in March. Afterwards salinity declined gradually up to August. The highest salinity was found in Shambhupur during March. Comparatively higher salinity in Shambhupur than Chanchra was recorded during November to May, but lower salinity from June to October. Increased salinity from November to March is understandably due to dry weather. Since the research area experience heavy rainfall during April and onwards, salinity also declined reasonably since April and got the lowest during the monsoon season (July-August). The salinity data indicate that the research areas are not badly affected by salinity as it was always less than the critical level 4.0 dSm^{-1} except in Shambhupur during March. However, the salinity of upper soil in the area could be much higher than the value we got, as we took the soil sample from 0-15 cm depth and mixed together for measuring the salinity level.

4.6 Occurrence of drought stress in the study area

Total rainfall in the study area during the year (November 2016 to October 2917) was recorded 3340 mm, which is much higher than the national average of 2500 – 3000 mm (Fig. 4.2). However, nearly 80% of the total rainfall occurred during June to October. Very little rainfall occurred during November and the period from December to March was almost rainless. Since the area does not have enough irrigation facilities, no rain for almost four months in the area posed drought stress affecting agricultural productivity in the area. On the other hand, more than 13% of the total rainfall (453.5 mm) occurred surprisingly in April, which caused sudden waterlogged condition and damaged some of the *Kharif* I crops which are vulnerable to water logging condition. So, the rainfall patters in the area clearly indicates that the area is prone to flood and submergence during monsoon season (June to October) and drought during dry season (December to May). Heavy early shower in April is also detrimental for the cultivation of *Kharif* I crops in the area.

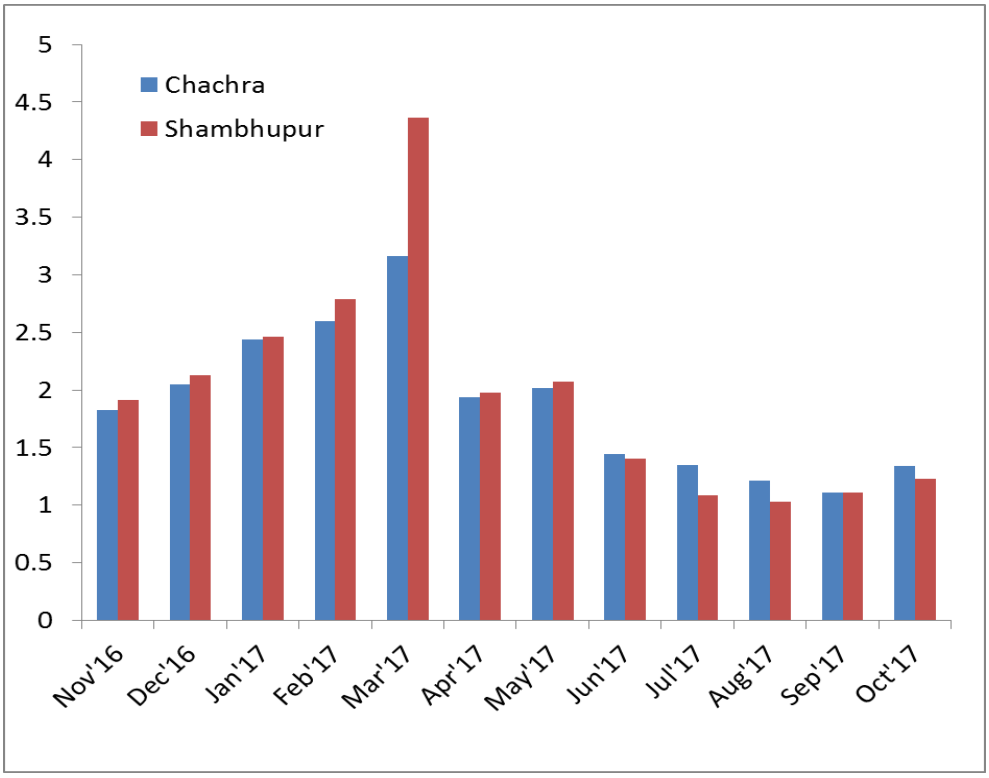


Fig. 4.1 Occurrence of year round soil salinity (EC in dSm^{-1}) in the experimental fields of the study area

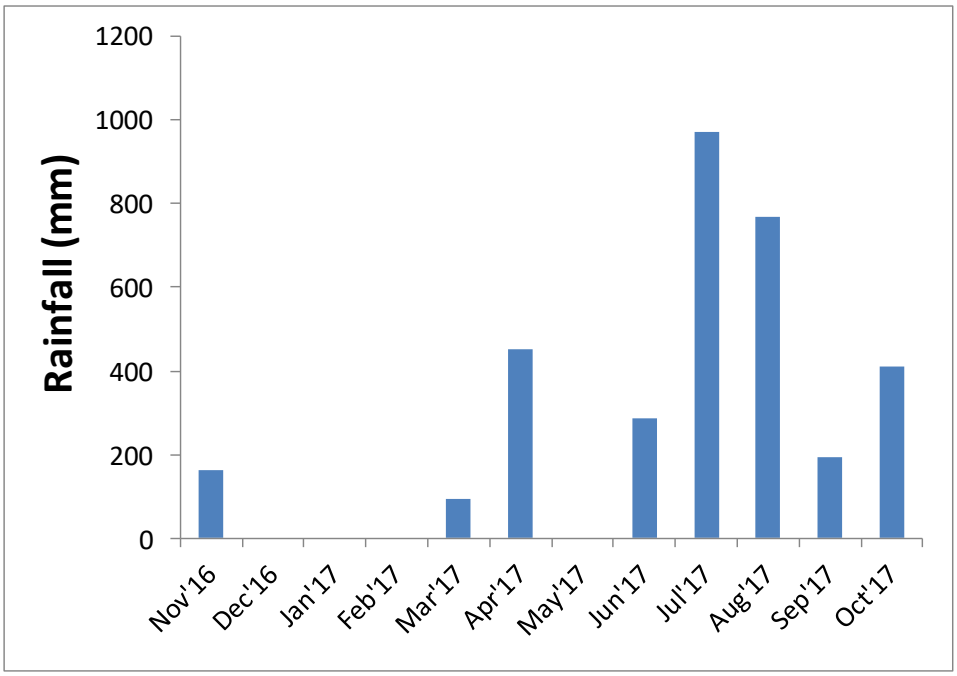


Fig. 4.2 Occurrence of year round rainfall (mm) in the study area

Chapter 5: Year-round Crop Calendar for the Study Areas

The study area is dominated by either single cropped and/or double cropped area having late transplanting *aman* rice (1st to 2nd week of August) as the main crop during *Kharif* II season. Farmers also use long duration *aman* rice varieties such as Bhujon, Shawrno dhan, BR 11, BR 23 and BRRI dhan52. Since long duration *aman* rice varieties are transplanted in August, the crop is harvested not until the end of November and as a result the lands do not get ready for *rabi* crops until 1st week of December. For example, with the farmers' cultivation of *aman* rice our land was not ready until 7 December 2016 to start our *rabi* crops. So, the farmers opt to cultivate *rabi* crops with low yield and profitability like potato, groundnut, mungbean, chilli etc. Moreover, the harvesting time of the crops sown in December becomes risky if early shower occurs in April, as did in April 2017 (Table 4.1). Most of the lands remain fallow during *kharif* I season (April to June). In the study it was shown that transplant *aman* rice can be harvested in late October or early November if suitable *aman* varieties are selected without compromising with the yield and economic profitability. For example, Binadhan-7, BRRI dhan49 and BR11 were harvested on 22 October, 2 November and 5 November, respectively when they were transplanted on 21 July. In that case, *rabi* crops can be sown/planted in time (early November) and they can be harvested by March with good yield and thus the risk of crop failure due to cyclone/'*Kalbaishakhi*' and/or early shower, which usually occurs in April/May, can be avoided. We started to grown Rabi crops in the study areas from the first week of December, as the lands were not ready because of late maturing transplant *aman* rice cultivation in the preceding season. In addition to the common crops grown by the farmers in the area (potato, mungbean, groundnut and chilli), nine crops viz., sunflower, maize, barley, wheat, soybean, tomato, bitter gourd, brinjal and *boro* rice were cultivated. Bitter gourd and brinjal did not perform well in both the areas. This could be because of late planting of the crops. *Boro* rice cultivation could not be continued because of crisis of irrigation water. On the other hand, sunflower, maize, soybean, barley, wheat and tomato performed very well in both Chanchra and Shambhupur locations, even though they were sown/planted late than the optimum time. The performance of the crops in the area could possibly be improved further if they can be sown/planted in time (by mid-November). If the *rabi* crops can be sown by mid-November, some of the crops like tomato, sunflower, barley and wheat can be harvested by mid-March and then there will have enough time to grow *kharif* I

crops like sesame and *kharif* maize. In our experiments, *aus* rice, jute and aroid could successfully be grown in medium lowland of Shambhupur during *kharif* I season. On the other hand, jute, *kharif* maize and dhaincha grew well in the medium highland of Chahchra area during the same season. Sesame also grew well in the medium highland of Chanchra area, though the crop was affected by rainfall in the early June and did not produce seeds. If sesame can, however, be sown earlier (by early March), the crop could be successfully grown in the area. Considering the yield and profitability of the crops intervened in the study areas, tomato produced the highest profit of Tk. 326938 per hectare followed by maize Tk. 111296 and sunflower Tk. 110837 during *rabi* season (Table 5.1). Among the *kharif* I crops intervened, tosha jute gave the maximum profit of Tk. 121954 per hectare followed by *kharif* maize Tk. 30597. BRRI dhan49 as transplanted on 21 July appeared as the best transplant *aman* rice variety offering the highest profit of Tk. 59840 per hectare. On the other hand, the most profitable crops of the farmers' practice as appeared from the study is potato in *rabi* season with profit of Tk. 8304 and Transplant *aman* rice cv. Bhujan with profit of Tk. 31840 per hectare. Thus, five most profitable cropping patterns from the current intervention can be suggested for the study areas as – i) Tomato – Tosha jute – Transplant *aman* rice cv. BRRI dhan49, ii) Tomato – *kharif* maize – Transplant *aman* rice cv. BRRI dhan49, iii) Maize – Tosha jute – Transplant *aman* rice cv. BRRI dhan49, iv) Sunflower – Tosha jute – Transplant *aman* rice cv. BRRI dhan49 and v) Sunflower – *kharif* maize – Transplant *aman* rice cv. BRRI dhan49 with the profit of Tk. 468588, 374213, 252946, 252484 and 161112, respectively over the farmers' best cropping pattern potato – fallow – Transplant *aman* rice cv. Bhojan.

Table 5.1 Profitability of some of the best cropping patterns intervened in the study areas as compared to farmers' best pattern

Cropping pattern			Profit Tk./ ha^{-1}				Profitability over farmers' pattern
Rabi	*Kharif* I	*Kharif* II	*Rabi*	*Kharif* I	*Kharif* II	Total	
Best Interventions							
Tomato	Tosha Jute	Transplant *aman* rice cv. BRRI dhan49	326938	121954	59840	508732	468588
Tomato	*Kharif* maize	Transplant *aman* rice cv. BRRI dhan49	326938	30597	59840	417357	374213
Maize	Tosha Jute	Transplant *aman* rice cv. BRRI dhan49	111296	121954	59840	293090	252946
Sunflower	Tosha Jute	Transplant *aman* rice cv. BRRI dhan49	110837	121954	59840	292628	252484
Sunflower	*Kharif* maize	Transplant *aman* rice cv. BRRI dhan49	110837	30597	59840	201256	161112
Farmers' best pattern							
Potato	-	Transplant *aman* rice cv. Bhojan	8304	-	31840	40144	-

However, considering the performance of the experimental crops and the existing agro-climatic condition in both the study locations, we suggest the following year-round crop calendar:

Medium Highland of Chanchra

Rabi crops: Tomato, sunflower, maize, barley, wheat and soybean

Kharif I crops: Jute, sesame, *kharif* maize and dhaincha

Kharif II crops: Transplant *aman* rice cv. Binadhan-7, BRRI dhan 49 and BR11

After the cultivation of all of the aforesaid *rabi* crops sesame, *kharif* maize and jute can be cultivated during *kharif* I season. However, in case of maize cultivation during *rabi* season, jute is to be the first choice crop for *kharif* I season and sesame should not be cultivated after *rabi* maize.

Medium lowland of Shambhupur

Rabi crops: Tomato, sunflower, maize, barley, wheat and soybean

Kharif I crops: Jute, *aus* rice and aroid

Kharif II crops: Transplant *aman* rice cv. Binadhan-7, BRRI dhan49 and BR11. BRRI dhan52 can be cultivated if the land is prone to high submergence.

After the cultivation of all of the aforesaid *rabi* crops except maize, jute should be the preferred crop in *kharif* I season. In case of maize in *rabi* season, *aus* rice is to be grown in *kharif* I season.

Fig. 5.1 Suggested year-round crop calendar for the study areas of Chanchra based on the findings of the study, which could be applicable for medium highland of the Tazumuddin Upazilla

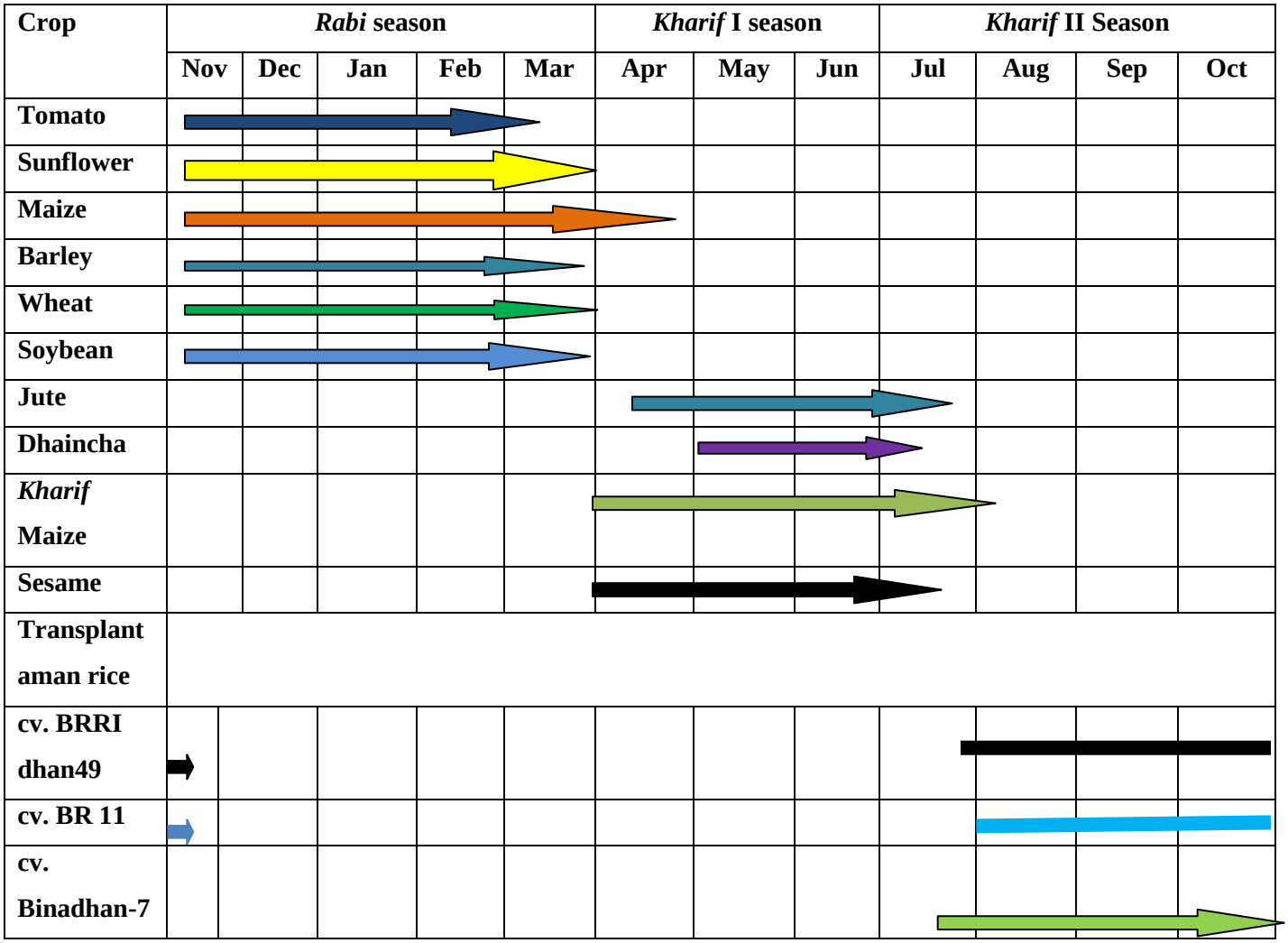
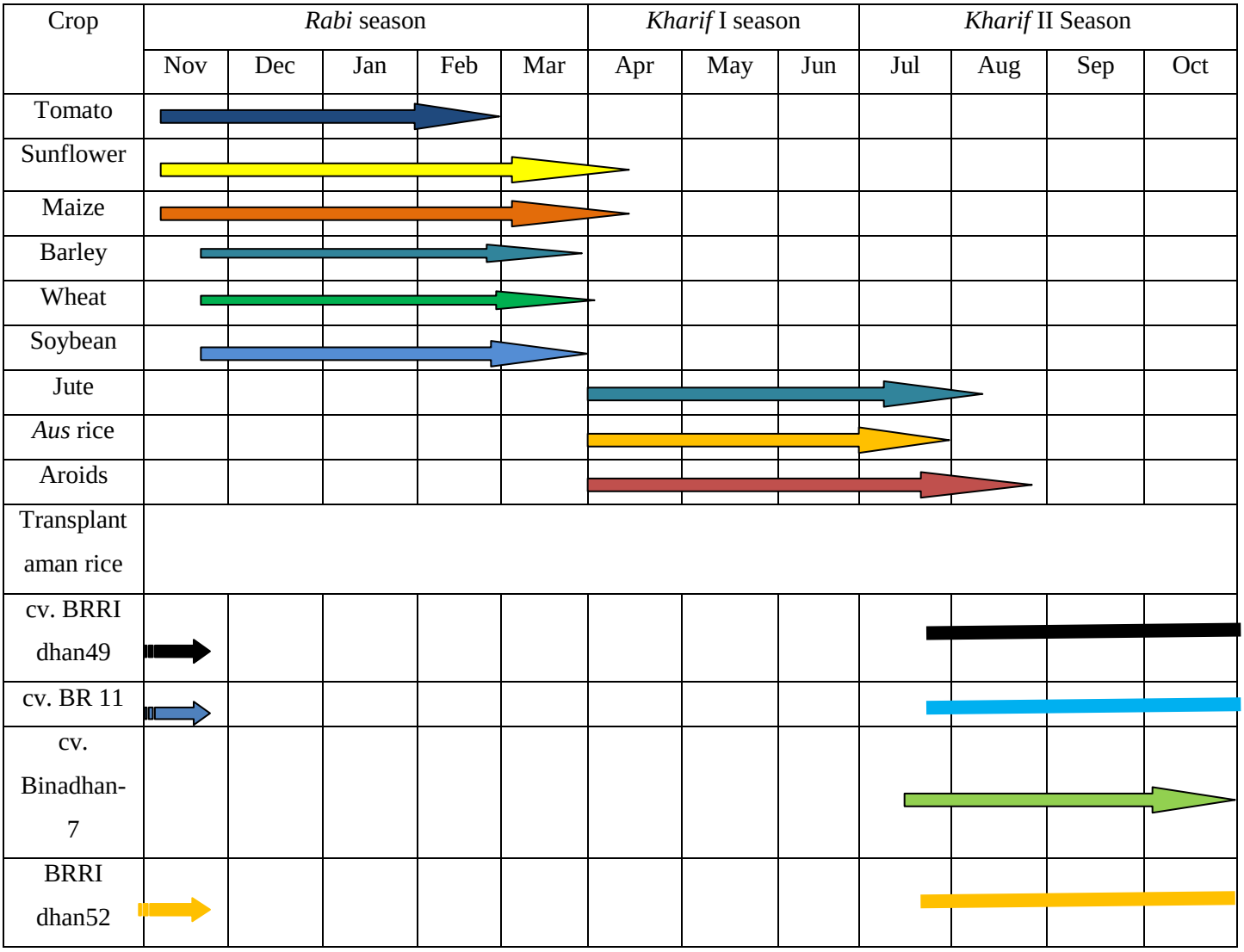


Fig. 5.2 Suggested year-round crop calendar for the study areas of Shambhupur based on the findings of the study, which could be applicable for medium lowland of the Tazumuddin Upazilla



Chapter 6: Summary and Conclusion

Tazumuddin Upazilla is a salinity prone area with scarcity of good quality irrigation water, which also leads to drought during *rabi* and *kharif* I season. This action research project was undertaken with the aim of sustainably improving crop productivity in Tazummudin Upazilla of Bhola district by selecting appropriate crop species/ varieties and adopting improved agronomic practices for the efficient and optimum resource management for all three cropping seasons (*kharif*-I, *kharif*-II and *rabi*). Two research locations- one in medium highland of Chanchra Union and one in medium lowland of Shambhupur Union were selected for the interventions of selected crops in all three cropping seasons. Considering the incidence of salinity and drought, the research work designed for *rabi* season 2016-17 included the following salinity and drought adaptive crops: Sunflower (2 varieties: BARI sunflower-2 and Armani Gold), Maize (var. Sunshine), Soybean (var. BARI soybean-6), Barley (BARI barley-5), Wheat (var. BARI gom-25), Bitter gourd (var. Tia), Brinjal (var. Sheuli), Tomato (var. Unnoyon) and *Boro* rice (vars. BRRI dhan28 and BRRI dhan29). Four existing crops which are dominantly being cultivated by the farmers in the area viz. chilli (local), mungbean (local), potato (local) and groundnut (local) were also included in the study for comparison. Tomato, sunflower, maize, barley, soybean and wheat appeared as very promising crop adapted to the existing environment including salinity and drought situation. In Chanchra location, the highest BCR of 4.60 was found from the cultivation of Tomato. Substantially higher BCR was also obtained from the cultivation of maize (1.99) and sunflower (1.96). Among the crops intervened and successfully grown, soybean and barley also gave higher BCR than the farmers' practice, although the BCR was just above 1. On the other hand, except potato cultivation of all other farmer crops like groundnut, mungbean and chilli produced BCR less than 1 meaning that all of the crops incurred loss for their cultivation. Cultivation of potato incurred profit but still lower than the profit obtained from barley and soybean. A similar trend of BCR was also obtained in the experiment done in Shambhupur producing the highest BCR of 4.87 from Tomato followed by maize (1.73) and soybean (1.50). Within the two locations, crop profitability in general was higher in Chanchra as compared to Shambhupur except tomato. This is also worth reporting that all of farmers' crops incurred loss in Shambhupur, though the loss in potato was lower than groundnut, chilli and mungbean. The crops grown in the study during *rabi* season made a substantial impact on the attitude of the local

farmers, who did not know that these crops can be cultivated there with such an excellent performance. However, among the crops brinjal and bitter gourd did not perform well in both the locations possibly because of their late sowing/ planting. *Boro* rice cultivation was not possible due to crisis of irrigation water. From the study it has been proven that sunflower, maize, barley, tomato, soybean and wheat showed high adaptability to the local salinity and drought dominated environment and can be successfully grown in the area during dry *rabi* season.

Following crops were grown in both the research sites during *kharif* I season: maize, sesame, soybean, jute, and *dhaincha* (as green manure crop). *Aus* rice was grown in the medium lowland of Shambhupur site under rain-fed condition. In addition, aroid was grown as water logging tolerant crop in the Shambhupur site, as the area is medium low land and prone to submergence. Among the crops, *aus* rice (cv. BRRI dhan48), jute (cv. BJC-2197 and CVL-1), *kharif* maize (NK-40), *dhaincha* and aroid were grown successfully. Maize and sesame grew very well in Chanchra but due to heavy rainfall and subsequent water logging condition these crops died in Shambhupur site (medium lowland). However, maize and sesame survived in Chanchra site (medium highland) and gave reasonable yield of 9.5 t/ha and 1.4 t/ha, respectively. *Dhaincha* could successfully be grown and incorporated in Chanchra site with the green biomass yield of 15 t ha^{-1}.

Among the *kharif* I crops, maize and jute could successfully be grown in medium highland of Chanchra, and jute and *aus* rice in medium lowland of Shambhupur. In both the locations, jute incurred very high profit with BCR more than 1.5. In Chanchra, kharif maize cultivation was also profitable giving BCR of 1.27. However, *aus* rice cultivation in Shambhupur incurred a little loss with BCR of 0.99.

Farmers in the study areas generally transplant *aman* rice a little late not until the first week of August, though their fields are available from the beginning of the season. Intervention was made with different transplant *aman* rice varieties considering their yield and duration and they were transplanted at the beginning of *aman* season. Short duration *aman* rice variety Binadhan-7 and currently most popular *aman* rice varieties BRRI dhan49 and BR 11 were included in the study and 30-day old seedlings of the varieties were transplanted on 21 July 2017 in both the locations. In addition, Bhujon, BR11 and Shawrno dhan were cultivated as farmers' practice and

transplanted on 13 August in Chanchra and 2 August in Shambhupur. As the field in Shambhupur was medium lowland, submergence tolerant rice variety BRRI dhan52 was also included in the location. Among the varieties used BRRI dhan49 as transplanted on 21 July produced the highest grain yield. The highest grain yields of 5.67 t ha^{-1} and 6.90 tha^{-1} were recorded from BRRI dhan49 with the field duration of 133 days and 134 days from Chanchra and Shambhupur, respectively. The second best *aman* rice variety as appeared in study is BR 11 which produced the grain yields of 5.33 t ha^{-1} and 5.90 t ha^{-1} in Chanchra and Shambhupur, respectively, though this variety took longer duration than BRRI dhan49. Among the farmers practice, Shawrno dhan gave the highest yield in Chanchra (5.10 t ha^{-1}) and Bhujon in Shambhupur (5.50 t ha^{-1}). All the varieties performed better in Shambhupur than Chanchra. Among the crops intervened, Binadhan-7 produced the lowest yield of 5.0 t ha^{-1}, but the variety also took the shortest field duration of only 120 days as against more than 130 days in case of varieties BR 11 and BRRI dhan49. Among the farmers crop, in Chanchra Shawrno dhan produced the highest grain yield of 5.10 t ha^{-1} and took the highest field duration of 150 days and Bhujon yielded the lowest one (4.07 t ha^{-1}) with 131 days field duration. However, Bhujon gave the best yield (5.50 t ha^{-1}) among the farmers crop in Shambhupur with the field duration of 132 days. This is very interesting to note that BR 11 produced 1.17 t ha^{-1} higher grain yield when transplanted on 21 July (intervention) as compared to transplanted on 13August (farmers practice) in Chanchra. The same variety also produced 0.64 t ha^{-1} higher grain yield in Shambhupur with transplanting on 21 July as compared to transplanting on 3 August. The yield reduction in all transplant aman rice varieties in both locations is quite reasonable with the fact that the yield of transplant *aman* rice declines with the delayed transplanting of every day since middle of July. So, considering both field duration and yield BRRI dhan49 appeared as the best one producing the highest grains yields in both the locations. Irrespective of variety, transplant *aman* rice produced higher profitability and BCR with transplanting at the beginning of the season as compared to transplanting late. Like the grain yield, BRRI dhan49 gave the highest BCR of 1.45 in Chanchra followed by BCR 1.36 with BR 11 transplanted on 21 July. However, the same variety gave BCR of only 1.06 when transplanted on 13 August. Interestingly, Binadhan-7 also gave the BCR value of 1.28 with field duration only 120 days whereas Shawrno dhan produced nearly similar BCR (1.31) with the field duration of 150 days. The results clearly

indicate that farmers can get similar profit of their best variety Sharnadhan by replacing it with Binadhan-7 and also can save 30 days in their year-round crop calendar. The situation was more or less similar as in Chanchra, though overall profitability for all the varieties was higher as compared to Chanchra. The highest BCR (1.77) was obtained from the variety BRRI dhan49 followed by 1.51 from BR 11. Among the farmers crop, Bhujon produced the highest BCR of 1.41 followed by BR 11 (1.35) and BR 23 (1.33).

The study clearly reveals that three crops can easily be cultivated in the research area during three cropping seasons in a year. By selecting short/medium duration high yielding transplant *aman* rice varieties (such as Binadhan-7, BRRI dhan49 and BR11 and by transplanting them at the beginning of the season (3rd/ 4th week of July) farmers can get higher BCR as compared to their existing varieties and also they can harvest the crops some 2 to 4 weeks earlier than their varieties. This will help the farmers cultivate *rabi* crops in time. Tomato, sunflower, maize, barley, wheat and soybean appeared as the best crops for the area during *rabi* season. If the *rabi* crops can be planted in first week of November, they can be harvested by 3rd week of March (except maize) and then the land could be used for cultivation of rain-fed *kharif* crops like sesame, *kharif* maize and jute. The land with maize cultivation in *rabi* season could be utilized for the cultivation of jute and/or *aus* rice. Thus a farmer could get a maximum profit of Tk. 508732 per ha of land with the suggested crops Tomato – tosha jute – transplant *aman* rice cv. BRRI dhan49 or Tk. 417357 with Tomato – tosha jute – Transplant aman rice cv. BRRI dhan49 as against their maximum benefit of Tk. 40144 with the existing crops potato –fallow – transplant *aman* rice cv. Bhojan. Inclusion of maize and sunflower (instead of tomato) in the cropping patterns would also give the profit more than two lakhs taka.

Chapter 7: Recommendations

Considering the findings of the research study and the remarks came out of the result sharing workshop from the policy makers, extension people, media people, NGO representatives, local leaders and farmers, the following recommendations are made:

1. Farmers are advised to replace their existing *rabi* crops (mungbean, chilli, potato and groundnut) with tomato/ sunflower/ maize/ barley/ soybean/ wheat.
2. Instead of keeping land fallow, farmers should cultivate their land during *kharif* I season selecting jute/ *kharif* maize/ sesame/ *aus* rice. For medium highland jute, *kharif* maize and sesame are suitable crops. On the other hand, *deshi* jute, *aus* rice and aroid are suitable crops for medium lowland.
3. In case of sesame cultivation, the crop is to be sown by March (preferably 3rd week of March).
4. Farmers should cultivate transplant *aman* rice at the beginning of the season (3rd week of July) and they should select high yielding short/medium duration varieties like BRRI dhan49/ BR11 Binadhan-7/.
5. Among the transplant *aman* rice varieties farmers are currently cultivating in the area, Bhojan appeared as a good one, though it took longer duration than the other varieties. Importantly, the variety should be transplanted at the beginning of the season so that its long duration does not delay the cultivation of succeeding *rabi* crops.
6. Farmers are to be motivated to practice improved agronomic management practices for increased crop yield.
7. They are to be given proper training about the climate adaptive crop species and varieties and improved management practices, particularly the management practices for ameliorating salinity and drought effects in crops.
8. To scale up the cultivation of the new crops quality seeds of the crop species are to be made available to the farmers with affordable price (supply of quality seeds free of cost at least for two seasons would be very encouraging for the farmers).
9. DAE people are to be involved for giving training and necessary input supports for expansion of the suggested crops in the study area.

10. Marketing for the new crops such as sunflower, maize, barley, soybean in the area is to be strengthened so that the farmers get fair price of their product. Use of the new crops locally is also to be encouraged. For example, oil can be extracted from sunflower using local *ghani* which is already used for extracting oil from mustard.
11. Linkages can be developed between farmers and industries such as PRAN Bangladesh Ltd., ACI Bangladesh Ltd. etc. to explore the area of using the new products such as barley (an important raw material for many confectionaries), soybean, sunflower (for oil industry), etc.

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