

Project ID 768

## Competitive Research Grant

# Sub-Project Completion Report

on

## Utilization of Fallow Land using Underutilized Crops in Coastal Saline Area of Noakhali

### Project Duration

25 May 2016 to 31 September 2018

On-Farm Research Division  
Bangladesh Agricultural Research Institute  
Noakhali-3800

Submitted to

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

September 2018



**Competitive Research Grant (CRG)**

# **Sub-Project Completion Report**

**on**

## **Utilization of Fallow Land using Underutilized Crops in Coastal Saline Area of Noakhali**

**Project Duration**

**25 May 2016 to 31 September 2018**

**On-Farm Research Division  
Bangladesh Agricultural Research Institute  
Noakhali-3800**



**Submitted to**

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



**September 2018**

**Citation:**

**Faisal, A. H. M. A., M. M. U. Chowdhury and M. M. Hossain. 2019. Utilization of Fallow Land using Underutilized Crops in Coastal Saline Area of Noakhali.** A report of Competitive Research Grant Sub-Project under National Agricultural Technology Program-Phase II Project (NATP-2), Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka, Bangladesh.

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

Edited and Published by:

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

***Acknowledgement***

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

Published in: September 2018

Printed by:

## Acronyms

AEZ = Agro Ecological Zone  
AO=Agriculture Officer  
ATER = Area Time Equivalent Ratio  
B=Boron  
BARC=Bangladesh Agricultural Research Council  
BARI=Bangladesh Agricultural Research Institute  
BCSIR = Bangladesh Council of Scientific and Industrial Research  
BINA=Bangladesh Institute of Nuclear Agriculture  
BMD = Bangladesh Meteorological Division  
BWDB = Bangladesh Water Development Board  
CC = Component Crop  
CDSP = Char Development and Settlement Project  
CDSP IV = Char Development and Settlement Project Phase IV  
CGAIR = Consortium of International Agricultural Research Centers  
CO-PI = Co-Principal Investigator  
CSO = Chief Scientific Officer  
DAE=Department of Agricultural Extension  
DAS = Days after Sowing  
°C = Degree Centigrade  
DUS=Deep Unnayan Sangstha  
E = East  
EC<sub>e</sub> = Electric Conductivity  
F = Fallow  
FR = Feed Rate  
FRG = Fertilizer Recommendation Guide  
FSRD = Farming System Research and Development  
g = Gram  
HL = high land  
HYV = High Yielding Variety  
ICARDA = International Center for Agricultural Research in the Dry Areas  
ICRISAT= International Crops Research Institute for the Semi-Arid Tropics  
IIMR= Indian Institute of Millets Research  
IPM = Integrated Pest Management  
IPNS = Integrated Plant Nutrition System  
K=Potash  
Km = Kilometer  
LER = Land Equivalent Ratio  
MAI = Monetary Advantage Index  
MC = Main Crop  
MEY = Main Crop Equivalent Yield  
MF = Multigrain Flour  
MHL = medium high land  
MLL = medium low land  
m m = Millimeter  
MoP = Muriate of Potash

MS = Mild Steel  
MSSRF = MS Swaminathan Research Foundation  
N = North  
N m = Newton Meter  
N= Nitrogen  
NGOs = Non-Government Organization  
OFRD = On-Farm Research Division  
ORC = Oilseeds Research Center  
ORP= Oxidation-Reduction Potential  
P = Phosphorus  
PBD = Plant Breeding Division  
PFB= Prism Foundation Bangladesh  
PGRC = Plant Genetic Resources Center  
PI = Principal Investigator  
PRA = Participatory Rural Appraisal  
PSO = Principal Scientific Officer  
PVS = Participatory Variety Selection  
R. Grass pea = Relay Grass pea  
RCBD = Randomized Complete Block Design  
rpm = Rotation per Minute  
RPVS = Researcher-led Participatory Variety Section  
S = Sulphur  
SA = Scientific Assistant  
SAAO = Sub Assistant Agricultural Officer  
Sec or S = Second  
SO = Scientific Officer  
SRDI = Soil Resources Development Institute  
SSUS= Sagarika Samaj Unnayan Sangstha  
t ha<sup>-1</sup>= Ton per hectare  
T. Aman = Transplanted Aman rice  
TDS = Total Dissolved Solids  
Temp. = Temperature  
TSP = Triple Super Phosphate  
UAO = Upazila Agriculture Officer  
USA = United State of America  
VC = Vermicompost  
VLL = very low land  
WAPDA = Water and Power Development Authority  
WP = Wettable Powder  
Zn = Zinc

## Table of Contents

SI No.	Subject	Page No.
	Cover Page	i
	Citation	ii
	Acronyms	iii
	Table of Contents	v
	List of Picture	vii
	List of Table	viii
	List of Graph	ix
	List of Map	ix
	Executive Summary	x
<b>A.</b>	<b>Sub-project Description</b>	
1.	Title of the CRG sub-project	1
2.	Implementation Organization	1
3.	Name and Full address with phone, cell and E-mail of PI/Co-PI	1
4.	Sub-project budget (TK.)	1
	4.1. Total	1
	4.2. Revised	1
5.	Duration of the Sub-project	1
	5.1. Start date (based on LoA signed)	1
	5.2. End date	1
6.	Justification of undertaking the Sub-project	1
7.	Sub-project goal	3
8.	Sub-project objectives	3
9.	Implementation locations	3
10.	Methodology in brief	3
	10.1. Selection of the Target Sites for Project Intervention	3
	10.2. Characterization the Target Sites (Baseline Survey)	3
	10.3. Diversity Kit Development	5
	10.4. Co-operating farmers selection for Research-led Participatory Variety Selection Trials	6
	10.5. Organizing “Diversity Fair”	7
	10.6. Conduction of Researcher-led Participatory Variety Selection trials	7
	10.7. Development of post-harvest machineries	16
	10.7.1. Dehuller/Dehusking machine for Millets	16
	10.7.2. Threshing Machine for multicrops (Barley, Sorghum and Safflower)	20
	10.8. Recipe of different kinds food and multigrain flour quality test	22
	10.9. Gene- Seed bank establishment	24
11.	Results and discussion	25
	11.1. Base line Survey	25
	11.1.1. Physical Parameters	25
	11.1.2. Biological Characteristics	31
	11.1.3. Socio-economic characteristics	33

		11.1.4.	Problem Identification and Prioritization	36
		11.2.	Diversity Kit and Diversity fair	37
		11.3.	Researcher led Participatory Varietal Selection (RPVS) Trials	38
		11.3.1.	Participatory Variety Selection in Barley	38
		11.3.2.	Participatory Variety Selection in Foxtail millet	41
		11.3.3.	Participatory Variety Selection in Proso millet	45
		11.3.4.	Participatory Variety Selection in Sorghum	46
		11.3.5.	Participatory Variety Selection in Safflower	49
		11.3.6.	Participatory Variety Selection in Linseed	52
		11.4.	Cropping Systems of Some Crop species with underutilized crops	55
		11.4.1.	Mixed, inter and boarder cropping system of oil and pulse crops with Linseed	55
		11.4.2.	Intercropping systems of some crop species with Sorghum	58
		11.4.3.	Intercropping systems of some crop species with safflower	60
		11.4	Postharvest machineries	63
		11.5.1.	Dehuller machine	63
		11.5.2.	Multicrops thresher	67
		11.6	Recipe of underutilized crops	67
		11.7	Chemical analysis of the tested Multigrain flour (MF)	68
		10.8	Seed-Gene bank	69
	12.		Research highlight/findings	70
	13.		References	70
	<b>B.</b>		<b>Implementation Position</b>	77
	1.		Procurement	77
	2.		Establishment/renovation facilities	77
	3.		Training/Study tour/Seminar/Workshop/Conference Organized	77
	<b>C.</b>		<b>Financial and Physical Progress</b>	78
	<b>D.</b>		<b>Achievement of Sub-project by objectives</b>	79
	<b>E.</b>		<b>Materials Development/Publication made under the Sub-project</b>	80
	<b>F.</b>		<b>Technology/Knowledge generation/Policy Support</b>	80
	<b>G.</b>		<b>Information regarding Desk and Field Monitoring</b>	81
	<b>I.</b>		<b>Lesson Learned/Challenges</b>	81
	<b>J.</b>		<b>Challenges</b>	82

## List of Picture

Sl. No.	Subject	Page No.
Picture 10.3.1.	Steps of Diversity kit development for organizing Diversity Fair	6
Picture 10.4.1.	Informal field visit by PI, Co-PI and Scientific Assistant at the Targeted Villages	7
Picture 10.6.1.	Participatory Crop production improvement training program at targeted sites among co-operating farmers during <i>Rabi</i> season of 2017-18	7
Picture 10.6.2.	Establishment of RPVS trails at different sites in Noakhali during <i>Rabi</i> season	9
Picture 10.6.3.	Agronomic data collection from different RPVS trials	11
Picture 10.6.4.	Problems occurred during RPVS trails due to rain	13
Picture 10.6.5.	Farm walks along with monitoring and evaluation done by diverse stakeholders at different RPVS trials during the <i>Rabi</i> season of 2017-18	14
Picture 10.6.6.	Beauty contest in Participatory variety selection trails at different locations	16
Picture 10.7.1.1.	Functional components of the dehuller (a = feeding chute, b = dehulling cylinder and rotor, c= blower, d = motor, e = V-belt pulley power transmission, f = unloading pedal, g = torque transducer, and h = torque and rotary speed measurement system).	18
Picture 10.7.2.1.	Functional components of the multicrops thresher (a = feeding chute, b = threshing cylinder, c = Fan blower, d = motor, e = V-belt pulley power transmission to flywheel, f = flywheel, g = grain outlet, and h = chaff outlet, i = transport wheel, j = electric switch, k = reciprocating chamber, l = main shaft and m = grain collector).	21
Picture 10.8.1.	Underutilized Crops and oil crop (soybean) used in Multigrain Flour preparation	22
Picture 10.8.2.	Flow chart for the preparation of multigrain composite mixture	23
Picture 11.1.1.	PRA activities at Kellar Char, Char Jabbar and Tomoruddi villages in Noakhali during 2017	25
Picture 11.1.2.1.	Crop Calendar of Kellar Char village, Companigonj in Noakhali during 2016-17	32
Picture 11.1.2.2.	Crop Calendar of Tomoruddi village, Hatiya in Noakhali during 2016-17	32
Picture 11.1.2.3.	Crop Calendar of Char Jabbar village, Subarnachar in Noakhali during 2016-17	32
Picture 11.1.3.1.	Venn Diagram on organizations working at (a) Kellar Char village (b) Tomoruddi village (c) Char Jabbar village Kellar Char in Noakhali	35
Picture 11.1.4.1.	Problem identification and voting by farmers during PRA session	36
Picture 11.2.1.	Diversity kit and Diversity fair organized among the farmers	37
Picture 11.3.1.1.	Participatory Variety Selection Trials (PVS) in Barley at Different Sites of Noakhali District during <i>Rabi</i> Season of 2017-18	40
Picture 11.3.1.2.	Evaluation of Barley genotypes by farmers and concerned stakeholders during Beauty Contest at different locations during <i>Rabi</i> season of 2017-18	41
Picture 11.3.2.1.	Evaluation of Foxtail millet varieties/Advanced lines/Cultivars/Gerplasms by farmers and concerned stakeholders during Beauty Contest at different locations during <i>Rabi</i> season of 2017-18	43
Picture 11.3.2.2.	Pictorial view of Participatory Variety Selection Trials (PVS) in Foxtail millet at different sites of Noakhali District during <i>Rabi</i> Season of 2017-18	44
Picture 11.3.3.2.	Participatory Variety Selection Trials (PVS) in Proso millet at Different Sites of Noakhali District during <i>Rabi</i> Season of 2017-18	46
Picture 11.3.4.1.	Participatory Variety Selection Trials (PVS) in Sorghum at Different Sites of Noakhali District during <i>Rabi</i> Season of 2017-18	48
Picture 11.3.5.1.	Participatory Variety Selection Trials (PVS) in Safflower at Different Sites of Noakhali District during <i>Rabi</i> Season of 2017-18	51
Picture 11.6.1.1.	Pictorial view of PVS Trials in Linseed at different sites of Noakhali during <i>Rabi</i> season	53
Picture 11.3.6. 2	Different sowing methods practiced in Linseed during PVS trials at Keller Char site in Noakhali district during <i>Rabi</i> Season of 2017-18	54
Picture 11.4.1.1.	Pictorial view of different cropping systems (where, (a) to (c) refers to mixed cropping; (d) to (j) represented to intercropping and (k) to (m) represents boarder cropping system) of oil and pulse crops with linseed in coastal saline fallow lands of different upazilla under Noakhali district during <i>Rabi</i> season of 2017	57
Picture 11.4.2.1.	Pictorial view of intercropping system (where (a) to (c) represent replacement design and (d) to (f) represent additive design) of some crop species with sorghum in coastal saline fallow lands of different upazilla under Noakhali district during <i>Rabi</i> season of 2017-18	59
Picture 11.4.3.1.	Pictorial view of intercropping system (where (a) to (c) represent replacement design and (d) to (f) represent additive design) of some crop species with sorghum in coastal saline fallow lands of different upazilla under Noakhali district during <i>Rabi</i> season of 2017-18	62
Picture 11.6.1.	A bird view of recipes made from underutilized crops	67
Picture 11.7.1.	The whole system of community seed-gene bank	69

### List of Table

SL. No.	Subject	Page No.
<b>Table 10.6.1.</b>	Crop management practices in the RPVS Trials at the selected sites under different upazila in Noakhali district during <i>Rabi</i> season of 2017-18	<b>10</b>
<b>Table 10.7.1.1.</b>	Factors and level values considered on dehulling millet	<b>17</b>
<b>Table 11.1.1.1.</b>	Transect of Kellar Char village, Companigonj, Noakhali, 2017	<b>27</b>
<b>Table 11.1.1.2.</b>	Transect of Char Jabbar, Subarnachar, Noakhali, 2017	<b>27</b>
<b>Table 11.1.1.3.</b>	Transect of Tomoruddi village, Hatiya, Noakhali, 2017	<b>28</b>
<b>Table 11.1.1.3.1.</b>	Household characteristics and farm size of all sample villages in Noakhali, 2017	<b>33</b>
<b>Table 11.1.1.3.2.</b>	Family size and effective family member of respondent farm family of the study villages	<b>34</b>
<b>Table 11.1.1.3.3.</b>	Information of different crops cultivated by the farmers at the sampled villages	<b>34</b>
<b>Table 11.1.4.1.</b>	Matrix of problems ranking by the sampled farmers during PRA exercise	<b>36</b>
<b>Table 11.2.1.</b>	Overview of UC genotypes included in developing “Diversity Kit” as well as for RPVS trials	<b>37</b>
<b>Table 11.3.1.1.</b>	Days to maturity, yield and farmers’ rankings of barley varieties/lines at three sites in previous year fallow medium high lands of Noakhali district during <i>Rabi</i> season of 2017-18	<b>39</b>
<b>Table 11.3.2.1.</b>	Days to maturity, yield and farmers’ rankings of Foxtail millet Varieties/Lines/ Cultivars/Germplasms at three sites in previous year fallow medium high lands of Noakhali district during <i>Rabi</i> season of 2017-18	<b>43</b>
<b>Table 11.3.3.1.</b>	Days to maturity, Yield and farmers’ preferences of Proso Millet variety/cultivars at different sites of Noakhali during <i>Rabi</i> season of 2017-18	<b>46</b>
<b>Table 11.3.4.1.</b>	Days to maturity, Yield and farmers’ preferences of Sorghum variety/advanced lines/ germplasms at different sites of Noakhali during <i>Rabi</i> season of 2017-18	<b>49</b>
<b>Table 11.3.5.1.</b>	Days to maturity and yield of Safflower Variety at different sites fallow lands during <i>Rabi</i> season	<b>50</b>
<b>Table 11.6.1.1.</b>	Days to maturity, Yield and farmers’ preferences of Linseed variety/Cultivars at different sites of Noakhali during <i>Rabi</i> season of 2017-18	<b>53</b>
<b>Table 11.6.1.2.</b>	Effect of different sowing methods on the yield, economic return of Linseed (BARI Tishi-1) and farmers’ rankings at fallow lands of Noakhali district during <i>Rabi</i> season of 2017-18	<b>54</b>
<b>Table 11.4.1.1.</b>	Linseed Equivalent yield (LEY), Area time equivalent ratio (ATER), land equivalent ratio (LER), Monetary Advantage Index (MAI) of different cropping system at different locations in fallow lands of Noakhali during <i>Rabi</i> season of 2017-18	<b>56</b>
<b>Table 11.4.2.1.</b>	Sorghum Equivalent yield (SEY), Area time equivalent ratio (ATER), land equivalent ratio (LER), Monetary Advantage Index (MAI) of some crop species with sorghum intercropping system in saline fallow lands of different upazilla under Noakhali district during <i>Rabi</i> season of 2017-18	<b>59</b>
<b>Table 11.4.3.1.</b>	Safflower Equivalent yield (SEY), Area time equivalent ratio (ATER), land equivalent ratio (LER), Monetary Advantage Index (MAI) of some crop species with safflower intercropping system in saline fallow lands of different upazilla under Noakhali district during <i>Rabi</i> season of 2017-18	<b>61</b>
<b>Table 11.5.1.1.</b>	Change of cylinder speed due to feed rate	<b>65</b>
<b>Table 11.5.2.1.</b>	Effect of feed rate on threshing efficiency and unthreshed grains of barley crop	<b>67</b>
<b>Table 11.7.1.</b>	Proximate analysis of multigrain flour	<b>69</b>

### List of Graph

SL. No.	Subject	Page No.
<b>Graph 10.6.1.</b>	Total Rainfall, maximum and minimum temperature of Noakhali during the project intervention period (May, 2017 to September, 2018)	<b>13</b>
<b>Graph 10.7.1.1.</b>	A sample of the torque signal data logged to the computer	<b>19</b>
<b>Graph 11.1.1.1.</b>	Total rainfall and temperature of Noakhali Sadar during February 2015 to April 2016	<b>29</b>
<b>Graph 11.1.1.2.</b>	Comparative status of salinity and rainfall in Noakhali during February, 2015 to April, 2016	<b>30</b>
<b>Graph 11.1.1.3.</b>	Farmers' perception about Rainfall and salinity of the study areas in Noakhali	<b>30</b>
<b>Graph 11.3.1.1.</b>	Soil Salinity levels according to growth stages of Barley at different sites during <i>Rabi</i> Season of 2017	<b>39</b>
<b>Graph 11.3.2.1.</b>	Soil Salinity levels according to growth stages of Foxtail millet varieties/lines at different sites during <i>Rabi</i> Season of 2017-18	<b>42</b>
<b>Graph 11.3.3.1.</b>	Soil Salinity levels according to growth stages of Proso millet Variety/Cultivars at different sites during <i>Rabi</i> Season of 2017-18	<b>45</b>
<b>Graph 11.3.4.1.</b>	Soil Salinity levels according to growth stages of Sorghum Variety/Advanced lines/ Germplasms at different sites during <i>Rabi</i> Season of 2017-18	<b>47</b>
<b>Graph 11.3.5.1.</b>	Soil Salinity levels during growing Season of Safflower at experimental sites in Noakhali during <i>Rabi</i> season of 2017-18	<b>50</b>
<b>Graph 11.6.1.1.</b>	Soil Salinity levels according to growth stages of Linseed Variety/ Cultivars at different sites during <i>Rabi</i> Season of 2017-18	<b>52</b>
<b>Graph 11.5.1.1.</b>	Variation of dehulling efficiency due to feed rate and dehulling time	<b>64</b>
<b>Graph 11.5.1.2.</b>	Variation of total milling recovery due to feed rate and dehulling time	<b>64</b>
<b>Graph 11.5.1.3.</b>	Variation of head grain recovery due to feed rate and dehulling time	<b>64</b>
<b>Graph 11.5.1.4.</b>	Variation of throughput capacity due to feed rate and dehulling time	<b>64</b>
<b>Graph 11.5.1.5.</b>	Variation of torque due to feed rate and dehulling time	<b>65</b>
<b>Graph 11.5.1.6.</b>	Variation of power requirement due to feed rate and dehulling time.	<b>66</b>
<b>Graph 11.5.1.7.</b>	Variation of peak power requirement due to feed rate and dehulling	<b>66</b>
<b>Graph 11.5.1.8.</b>	Variation of energy requirement due to feed rate and dehulling time.	<b>66</b>
<b>Graph 11.5.1.9.</b>	Variation of specific energy requirement due to feed rate and dehulling time	<b>66</b>

### List of Map

SL. No.	Subject	Page No.
<b>Map 11.1.1.1.</b>	Physical and Enterprise Map of the study villages in Noakhali, 2017	<b>26</b>

## Executive Summary

There are a good number of underutilized crops grown in Bangladesh. The state of diversity of underutilized crops has hardly been monitored for germplasms collection, evaluation and dissemination. Many of these are important for cash income, food security and nutrition of the rural people, especially the poorer sections of the population. Due to intensive agriculture with modern varieties, the diversity of underutilized species is decreasing fast. On the other hand, a vast coastal saline land remains fallow after harvesting of T. Aman rice. Moreover, climate are changing. The fallow lands should be cultivated for foods supply of increasing population. Under such state the project titled “Utilization of Fallow Land using Underutilized Crops in Coastal Saline Area of Noakhali” was instigated.

During first three months of the project, a baseline survey through Participatory Rural Appraisal exercises were conducted in three Upazila namely-Companigonj (Kellar Char village), Subarnachar (Char Jabbar village) and Hatiya (Tomoruddi village) for getting information on land and soil types, crops, cropping pattern, problems of agricultural productivity and socio-economic conditions of the locality. After the six months of the project started, the project team have made progress in collecting germplasms from the different National research organizations and different parts of the country. Total fifteen (15) varieties included one (01) exotic variety, eight (08) advanced lines, twenty (20) germplasms and nine (09) cultivars of targeted crops (Barley, Foxtail millet, Proso millet, Sorghum, Linseed and Safflower) were collected. Afterwards, a “Diversity kit” have being developing. In addition, several informal field visits were done by the PI, CO-PI and Scientific Assistant at the targeted villages for selecting lands and farmers. Initially, 26 farmers were selected as all the lands are not available during the optimum sowing time of specific crops. Finally 18 farmers were selected depends on the lands conditions and crops suitability. The farmers were selected for Participatory Varietal Selection trials which is main activity of the project. Afterwards, “Diversity Fair” was organized among the co-operative farmers and training was conducted on the cultivation methods of underutilized crops. RPVS trials set up started from last week of November, 2017 and continued up to 12 January, 2018. Agronomic practices, growth stage wise salinity data, data on yield and farmers presences were collected and used for final result preparation. The results showed that among six (06) underutilized crops four (04) crops namely-Proso millet, Safflower, Sorghum and Linseed found more suitable for cultivation in moderate to strong (6.1 to 12 dSm<sup>-1</sup>) saline areas. Barley was suitable for moderate (6.1to 8 dSm<sup>-1</sup>) saline areas whereas Foxtail millet was found suitable for slightly (4 to 6 dSm<sup>-1</sup>) saline areas. Out of twenty seven (27) cropping systems twelve (12) systems (mixed cropping system-02, intercropping system-08 and border cropping system-02) found promising for coastal area. As per project proposal, two post-harvest machineries- one for millets dehulling and one multicrops threshing Machine were developed through reverse engineering systems. Additionally, twenty four (24) types of food preparation recipe were documented and distributed among the farmers for utilization of underutilized crops. Moreover, multigrain flour by mixing of four types (04) of millet (Foxtail millet, Proso millet, Barley, Sorghum) and two types of oil seed crops (Flax seed and soybean) were prepared which was rich in protein, fiber and energy. Finally, 02 field level gene bank (one in FSRD site, Subarnachar and other in Agricultural Officer’s office, Sagarika Samaj Unnayan Sangstha) were established for further utilization of underutilized crops.

The project was implemented over a period of 25 May. 2017 to 31, September. 2018. To achieve effective result of the project a sustainable and strategic plan should be developed for future implications.

## CRG Sub-Project Completion Report (PCR)

### A. Sub-project Description

1. Title of the CRG sub-project: Utilization of Fallow Land using Underutilized Crops in Coastal Saline Area of Noakhali
2. Implementing organization: On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), Noakhali-3800
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):  
  
Principal Investigator: A.H. Md. Amir Faisal, Scientific Officer, On-Farm Research Division, BARI, Maijdee Bazar, Noakhali-3800, Mobile no.: 01711032777, e-mail: faisalofrd@yahoo.com  
  
Co-principal Investigator: Dr. Mohiuddin Chowdhury, Principal Scientific Officer, On-Farm Research Division, Bangladesh Agricultural Research Institute, Maijdee Bazar, Noakhali-3800, Mobile no.: 01827865860, e-mail: psoofrdbari@gmail.com
4. Sub-project budget (Tk):
  - 4.1 Total: 15 Lac
  - 4.2 Revised (if any): N/A
5. Duration of the sub-project:
  - 5.1 Start date (based on LoA signed): 25 May, 2017
  - 5.2 End date: 30 September 2018
6. Justification of undertaking the sub-project:

The Bengal Delta, largest delta in the world (Gupta, 2007) which drains almost all of the sediment from Himalayas, through the three main river systems: the Ganges, Brahmaputra, and Meghna. These system carry more than 1 billion tons of sediment every year (Goodbred and Kuehl, 2000) into the Bay of Bengal through southern part of Bangladesh where more than 70% of the sediment load is silt; with an additional 10% sand (Coleman, 1969; cited in Allison *et al.*, 2003) and part of this deposit in shallow waters off the coast. The sedimentation, at the long end, results in the formation of new land, coastal *Char land*. However, according to CDSP IV (2012), each year there is a net accretion of around 20 sq. Km where approximately 26,000 people lose their land in the estuary due to riverbank erosion and many of them moves to newly accreted lands. The newly low lying lands are highly saline as compared to older lands which is unfavorable for agricultural use. Although, some areas are protected by a system of embankments and sluices which creates a new environment for agricultural production and assume that soil salinity will be decreased over time. Unfortunately, the severity of salinity problem has increased over the years as more land affected by salinity and expected to increase in future due to sea level rise. SRDI showed that the salinity area has increased to 1.05 million ha from 0.83 million ha in 1975 (Asiatic Society of Bangladesh, 2003). In the char areas of Noakhali region, soil salinity increases progressively through capillary movement and reaches peak in around Mid-March to April, at the beginning of the pre-monsoon season ( $8.5$  to  $14.0$   $dS\ m^{-1}$ ) which diminishes with the onset of monsoon ( $1.5$  to  $4.2$   $dS\ m^{-1}$ ) and allow farmers to grow T. Aman. Moreover, the salinity stress is most pronounced in the top 10 cm of soil where large spatial variations exists though, both in the top and sub soil layers, and even within the same plot of land. Dry season Aus rice can only be grown on plots of land that have the suitable land level and soil salinity. However, During *Rabi* season the land mostly remains fallow in the upazila namely Sadar, Subarnachar, Companigonj and Hatiya due to salinity, scarcity of quality

irrigation water and irrigation facilities, poor knowledge about agronomic management of salt affected land and inadequate salt tolerant varieties etc. In contrast to salinity, some pocket areas in the Companigonj and Subarnachar upazilla go through water logged during the period July to August when the peak period for HYV Aman transplantation approaches. Most recently the Cyclone 'Nada' damaged the standing Aman rice. Due to constriction and chocking of rivers and rivulets (*Khals*) especially *Noakhali Khal* together with unplanned infrastructure, local level drainage as well as natural drainage system collapsed. The predominant cropping pattern is Fallow-T.Aman-Fallow (25% of the total cultivable lands), although double cropping (Fallow-T. Aman-*Rabi* crops) is practiced in some areas, triple cropping (T. /D. Aus -T. Aman-*Rabi* crops) is rare. Consequently, about 82,005 ha lands remain uncropped or fallow (Mainuddin *et. al.*, 2013) and many agricultural workers are unemployed during the dry season. On the other hand, winter is relatively short in the coastal char areas where timely sowing/planting of *Rabi* crops is essential by utilizing the residual soil moisture at the end of monsoon season but this is restricted by the late harvest of Aman rice. Despite all these constraints, the area has much potential and opportunities to broaden farmers' cropping options without increasing their risks by selecting agro-ecologically suitable crops. In general, a soil may be too saline for one crop but it may be quite suitable and productive for another crop (BARI, 2006). On-Farm Research Division, BARI, Noakhali tested several crops along with their varieties found some promising crops (Barley, Foxtail millets, Proso millets known as minor cereals and Linseed known as minor oilseed crops) in slightly saline (4.1-8 dSm<sup>-1</sup>) and moderately saline (8.1-12 dSm<sup>-1</sup>) soil, although some problems associated with harvesting and post-harvesting operations (Amin *et. al.*, 2011). It is notable that, many of the plant species that are cultivated where they play a crucial role in the food security, nutrition, and income generation of the rural poor but are neglected and underutilized in other parts. The term 'underutilized' has raised more discussions among scientific personnel around the world in the changing climate scenario. In the study, the term underutilized crops indicating that are in cultivation already but still may be underutilized locally, nationally or globally. Six underutilized crops such as Barley, Foxtail millet, Proso millet, Sorghum, Safflower and Linseed were selected for researcher-led participatory varietal selection (RPVS) trails. Then again, previous research conducted by OFRD, BARI found that farmers were complaining to grow such crops in this area due to difficulties in threshing, winnowing. Simultaneously, a number of challenges which impeded the dissemination of above mentioned underutilized crops including improper or lack of harvesting methods, suitable varieties for processing (hull less), lack of appropriate processing technologies, and insufficient promotion of processed products. Remarkably, underutilized crops have a potential (Proso millet- rich in *iron* micronutrient, Linseed- oil content *omega (ω)-3 fatty acid* and *α-linolenic acid*, Barley rice in *β-glucan* etc.) that needs to be exploited for the prevention of several types of diseases. Furthermore, Bangladesh may explore the export potentiality of barley to Saudi Arabia, China and Japan by growing barley in the vast saline area with proper management practices. Last but not least, in a country facing limited natural resources and climate change underutilized crops are issues relevant to tackle hunger, poverty and malnutrition. Under such sceneries, the project aimed to increase crop production by means of crop diversification along with good agronomic practices in slightly and moderately fallow saline area through participatory approaches, development of small-scale post-harvest machineries and different kinds of food invention from the mentioned crops.

7. Sub-project goal:

Adjustment the risks of saline prone fallow land through sustainable use and conservation of underutilized crops, particularly in the context of farm productivity and profitability of small and marginal farmers living on newly accreted coastal chars.

8. Sub-project objective (s):

- To increase crop diversification and cropping intensity by introducing and cultivation of newly developed high yielding varieties of underutilized crops (Barley, Foxtail millets, Proso millet, Sorghum, Safflower and Linseed) as well as collection and evaluation of local planting materials available in other areas.
- To concentrate on developing a suitable management system for untested saline fallow lands in coastal char area which not yet go through this practice.
- To develop suitable post-harvest machineries for using household level and prepare different kinds of food products, assess their quality and make it familiar with consumer level through active participation of farmers.

9. Implementing location (s): Subarnachar, Companigonj and Hatiya upazilla under Noakhali district

10. Methodology in brief:

The following steps were the general prerequisites for continuing targeted research activities on underutilized crops cultivation by utilizing fallow lands in the coastal saline areas of Noakhali district.

**10.1. Selection of the Target Sites for Project Intervention**

Site selection has been often the most impactful stage of the project development and implementation. For such project type of project implementation, secondary information on agro-ecological setting of farming communities affected by different levels of salinity were collected from Department of Agricultural Extension (DAE), "Upazila Nirdeshika" developed by Soil Resources Development Institute along with personal communication, previous site details of OFRD, BARI, Noakhali. In addition, several informal field visits were done by the PI, Co-PI and Scientific Assistant for need assessments of the selected upazila in terms of fallow lands status and underutilized crops cultivation potentiality and constraints. Then, three (03) Upazila viz. Subarnachar, Companigonj and Hatiya were selected.

**10.2. Characterization of the Target Sites through Baseline Survey**

Subsequently, the targeted villages for baseline survey were selected by the help of Sub Assistant Agricultural Officer (SAAO) of the respected block along with Agricultural Officer (AO) from three NGOs (Sagarika Samaj Unnayan Sangstha, Deep Unnayan Sangstha, and Prism Foundation Bangladesh) which confirmed by means of walk through the area and discussion with progressive farmers as key informants. The main objective of the survey, as used in the Participatory Variety Selection (PVS) process narrated in the detailed project proposal, was to characterize the fallow lands conditions for utilization and the driving forces behind the current cropping systems along with the flow of technologies in the target communities. Later, Local SAAO, DAE assisted in selecting the farmers (36 farmers from each location) and organized Participatory Rural Appraisal (PRA) at each village of the respected Upazila. Finally, PRA exercises were conducted at three targeted Villages namely: Kellar Char (Companigonj), Char Jabbar (Subarnachar) and Tomoruddi village (Hatiya) where all the logical steps of PRA relevant to baseline survey was used as tools. The PRA exercises were implemented on three different dates (5<sup>th</sup> June, 7<sup>th</sup> June and 20<sup>th</sup> July. 2017) for three different locations.

Through continued informal field visits, the PI and project staff was successful to build a strong rapport with villagers which in terms to understand the local culture, traditions, community norms and values. The following steps were followed in conducting the PRA:

**a) Orientation of the Resource Personnel**

Before starting the PRA, a briefing session was organized at OFRD, BARI, Noakhali with resource personnel (PI, Co-PI, SO, SA, SAAO) to discuss methodological aspects and tasks to be done during conducting PRA. After briefing, check list of activities, materials and sources of data/ information was prepared based on the objectives of the study.

**b) Rapport Building**

On the day of PRA exercise, the team members and all the invited farmers were assembled at a homestead premise of one participating farmer at each village. The team members introduced themselves in a casual way to the participating farmers which was followed by the introduction of participating farmers. Before starting PRA activity, a brief discussion was held among the participants about the objectives of the PRA and activities to be performed during each session. Through conversation, the PRA team was successful in building a strong rapport with villagers and an environment of natural confidence was created. As a result, spontaneous cooperation and responses were available from the villagers up to the end of the gathering and organizing data during PRA.

**c) Group Formation**

The resource personnel and participating farmers were divided into four groups (09 farmers in each group) to facilitate activities for successful completion of tasks. Each of the groups was assigned to perform set of tasks.

**d) The Village Transect**

The PRA sub-group consisted of resource personnel and participating farmers walked across the village roads and observed topographic variations, existing land use with the identity and explain the cause and effect of relationship between topography, soil, natural vegetation cultivation and other production activities with human settlement patterns. On the basis of physical observations, future scopes of improvements were identified.

**e) Mapping**

The groups assigned for transect traveled village areas through all pucca and kutcha roads and recorded all information which was later integrated in preparing maps of different kinds. Physical map showing topography, infrastructure, crop fields (saline and non-saline along fallow during *Rabi* season) canals and water bodies was sketched out by farmers on brown paper sheet after returning to the place of meeting.

**f) Venn diagram**

Venn diagram (circular diagram) indicated the farmers' perception relating to importance of various organizations/ groups/ institutions working/involvement at the village to provide different support services to the village people. At the beginning farmers sketched a big circle on a brown paper sheet and then drawn several small circles inside the big one to show the presence of various organizations rendering services to the villagers. Different sizes of circles were used for representing degree of

involvement in providing services. Then the name of different organization was placed inside of different circles depending on their relative importance.

#### **g) Seasonal Calendar**

Seasonal calendars identified the cause and effect relationship between climate, production activities, economical activities and other significant seasonally varying factors over the whole year of a particular area. A straight horizontal line on a brown paper sheet was drawn and divided into 12 small cells each indicate a month starting from January to December.

#### **h) Production practices**

Production flow chart gave the understanding about what farmers do and how they managed their different enterprises. It indicated the agro-economic productivity of different enterprises being practiced by farmers. It also shown the level of management adopted by a farm for a particular enterprise and the scope of further improvement. Problems and issues were identified to address for further research and development process. All the information provided by farmers were recorded and synthesized in the context of project objectives.

#### **i) Problem Identification and Prioritization**

At first problems of different agricultural enterprises and problems in general being faced by farmers were listed down by asking them. Prioritizations of problems were done to find out the points to give attention with priority for appraising possible strategies of solutions. This was done by voting procedure. Each farmer was asked to prioritize the problem by putting country bean seeds besides the problem such as most important problem one country bean seed and so on. Aggregated values were ranked hierarchically and thus problems were prioritized.

#### **j) Triangulation**

All the information collected through different steps mentioned above were presented in front of the participants on the last session of PRA for validation and authentications. Corrections or modifications were made according to farmers' comments and/ or suggestions.

### **10.3. Diversity Kit Development**

Afterwards, for the establishing of RPVS trials six (06) underutilized crops such as Barley, Foxtail millets, Proso millet, Sorghum, Safflower and Linseed were selected as per project proposal. In the proposal, at least five new breeding lines together with released varieties of each targeted crop need to be evaluated in PVS trials which had to be collected from national and international organizations. In this regard, several e-mail were sending to ICARDA and CGIAR. On the other hand, for collecting mentioned target crops varieties from national research organization office letters were distributed to Plant Breeding Division (PBD), Oilseeds Research Center (ORC) and Plant Genetic Resources Center (PGRC), BARI through appropriate authority. In case of local land races/cultivars, PI and Scientific Assistant travel extensively throughout the region. Moreover, for collecting local cultivars from other parts of the country personal communication was carried out by the PI with DAE, other OFRD stations of BARI. Records of the collected Germplasms were kept as per conservation rules set by PGRC, BARI. Finally, "Diversity kit" were developed through collected target crops varieties/lines/cultivars. The diversity kit is a set of small quantities of seed of target crops varieties that is made available to the farmers for informal research and development. The basic idea of the diversity kit is to deploy the diversity, giving

priority to neglected, underutilized, rare and unique crop varieties and species, increasing community access to seed and knowledge, and promoting biodiversity conservation through use. It also contains information about selected complementary species.



**Picture 10.3.1. :** Steps of Diversity kit development for organizing Diversity Fair

#### 10.4. Co-operating farmers selection for Researcher-led Participatory Variety Selection Trials

In addition, several informal field visits were done by the PI, Co-PI and Scientific Assistant at the targeted villages for rapport building which in turns led to farmers positive attitude towards research activities. After frequent visit in the targeted villages and discussion with elderly person, SAO and NGOs representative, the fields and farmers were selected for RPVS trials. The selection criteria of lands were determined-

- a) **Land types** - saline or non-saline, remain fallow or will be cultivated
- b) **Causes of the lands kept fallow** - salinity or others causes (lack of labour, lack of input, lack of quality irrigation water and irrigation facilities, lack of capital etc.)
- c) **Salinity level of the fields** -based on co-operating farmers and neighboring farmers perception

Initially, twenty six (26) farmers land taken consideration for RPVS to avoid risks as harvesting of T. Aman and particular underutilized crops optimum sowing date might not matched. After selecting the lands, it was an urgent need to motivate farmers for active participation in the research activities. At this stage, “Diversity Fair” was organized at each village. Finally, eighteen (18) farmers were selected after sowing completed. Soil salinity of the selected lands during sowing varied from 0.87 to 1.92 dS m<sup>-1</sup> (in case of last sowing at Subarnachar). The soil salinity measurements indicated that all the lands were moderate to highly saline in nature which was later confirmed by SRDI personnel based on their salinity monitoring reports.



**Picture 10.4.1.** : Informal field visit by PI, Co-PI and Scientific Assistant at the Targeted Villages

### 10.5. Organizing “Diversity Fair”

After selecting target farmers, “Diversity Fair” was organized at all three (03) locations among thirty (30) co-operating and neighboring farmers in each location to create awareness on several issue such as underutilized crops provide economic benefits, underutilized crops need low cost for cultivation, some underutilized crops can tolerate salinity and drought, underutilized crops have less disease and insect infestation etc. Local cultivars and improved varieties/ lines of target underutilized crops were included for motivating the community for managing seeds in the changing climatic conditions.

### 10.6. Conduction of Researcher led Participatory Variety Selection trials

Before conducting RPVS trials, one training at each location was conducted which focused on the following issues:

- (i) Benefit of quality seeds, including traditional varieties
- (ii) Promotion of row planting instead of the traditional broadcasting with high seed rate
- (iii) Structured intercropping of target crops and traditional crops instead of their broadcasting as multispecies seed mix
- (iv) Promotion of use of Vermicompost and fertilize as Integrated Plant Nutrition System (IPNS)
- (v) Promotion of Integrated Pest Management (IPM) approaches and
- (vi) Thinning/transplanting and promoting weeding and with top dress.



**Picture 10.6.1.** : Participatory crop production improvement training program at RPVS trials sites among co-operative farmers during *Rabi* season of 2017-18

The steps were followed in general for the entire RPVS trials.

- a) Selection of treatments:** The numbers of the treatments depended on the amount of particular crops varieties/ lines/cultivar seeds (Table 10.6.1.).

**b) Experimental design:** The randomized complete block design (RCBD) was used. The basic unit of replication was a participating farmer at different sites which means each trial was conducted as dispersed replication (03 replications for each trial).

**c) Plot size:** The plot size was 4 meters wide by 5 meters long (4 m × 5 m), a total of 20 sq. m for each treatment in each RPVS trial.

**d) Field operations:** The lands of trials plots (18) were prepared by two to three times ploughing (depends on the crops) through Sifang power tiller as when the lands turn into optimum conditions for crops establishment. Fertilizers were applied according to FRG, 2012 and sowing and intercultural operations were done according to KRISHI PROJUkti HATBOI, 5th Edition. All the fertilizers were applied during final land preparation. In all the trials, Vermicompost (VC) @ 1.25 t ha<sup>-1</sup> were applied as an organic source in IPNS system. Before sowing the seeds, Provax 200 WP (@ 2 g per Kg seeds) was used as seed treatment materials. Crop management practices for eighteen (18) RPVS were illustrated in the Table 10.6.1. Plant protection measures particularly IPM (use of botanical pesticide “Bioneem Plus” for controlling piercing and sucking insects in safflower, mungbean and cowpea, yellow sticky traps for monitoring and controlling piercing and sucking insect in safflower and safflower intercropped with pulse crops, sex pheromone traps for *Spodoptera litura* controlling in Safflower and safflower intercropped with pulse and oilseed crops) were applied as and when necessary to raise healthy crops especially in safflower and Barley trial fields. Moreover, the selected underutilized crops are less susceptible to diseases infection and insects infestation. On the other hand, Tilt 250 EC (0.05%) were sprayed two times (@ 0.05 ml per liter) at the interval of 10 and 12 days after observing leaf spot and common root rot in Barley crop. In case of different cropping system (inter, mixed and border cropping systems), only recommended doses for main crops were applied whereas sole cropping system of particular main crop was included in the trials with BARI varieties/lines previously identified by OFRD, BARI, Noakhali. Although spatial arrangements played an important role in better crop production, farmers’ preference, tradition practices and available literatures on various cropping systems were taken under consideration for selecting the plant geometry of the particular inter or mixed or border cropping systems. In the experiments under project dimension intercropping were carried out either in additive (no sacrifice of main crops) or replacement series (main crop row is reduced for each intercrop row) following the suggestion of Iqbal *et. al.*, (2017). In case of mixed cropping system, seeds of both the crops broadcasted with the ratio of 100% (main crop) and 30% (component crops). In case of border cropping system, oil crops (mustard, safflower and sunflower) were grown as a border crop (one row) around the periphery of linseed field (15 cm apart from main crops). In case of replacement series intercropping with different row proportion such as 2:1 means after two row of main crops were alternated by one row of component crops. Similar planting geometry were followed in 1:1, 2:2, 2:4, 3:1 and 4:2 replacement series of intercropping systems. In case of additive series intercropping of sorghum, spacing available in between two paired row of sorghum crop (spacing for safflower : 60 cm, cowpea and mungbean : 65 cm) additional row of the crops (safflower, grass pea and cowpea-10 cm apart from sorghum row) were planted by narrowing the inter row spacing (safflower: 20 cm, Cowpea: 15 cm, Mungbean: 15 cm) but the intra row spacing (safflower: 10 to 12 cm, cowpea and mungbean: 7 cm) were same as sole cropping.



**Picture 10.6.2.** : Establishment of RPVS trails at different sites in Noakhali during *Rabi* season

**a) Data collection and Evaluation**

- **Agronomic data:** The dates of all operations (sowing, fertilizer dose, weeding, harvesting) and soil salinity data during growth stages of the mentioned entities were recorded (Table 10.6.1.). The salinity was measured by EZODO PCT-407 pH/ORP/Conductivity/TDS/Salt/Temp. Meter (GONDO Electronic Co. Ltd.), Made by Taiwan. To get the actual reading, each time representative soil samples according to treatment from each replication were measured in the FSRD office using 1:3 soil and distilled water extract method. The area of the plots and yield obtained from each plot were measured separately after harvesting in a participatory way.

**Table 10.6.1.:** Crop management practices in the RPVS Trials at the selected sites under different upazila in Noakhali district during *Rabi* season of 2017-2018

Village Name	Trials description	Sowing Date	Harvesting Date
Tomoruddi	<b>Participatory varietal selection in Barley</b>	25/ 11/17	02 to 07/3/18
Kellar Char	<b>Treatments:</b> BARI Barley-1, BARI Barley-2, BARI Barley-3, BARI Barley-4, BARI Barley-5, BARI Barley-6, BARI Barley-7, BHL-15, BHL-17, BHL-19, BHL-25, BHL-26, BHL-27 <b>Sowing method:</b> Line sowing (20 cm, continuous), <b>Seed rate (Kg ha<sup>-1</sup>):</b> 100 <b>Fertilizer dose (N-P-K-S-Zn-B Kgha<sup>-1</sup> + VC t ha<sup>-1</sup>):</b> 54-24-38-0-1-0-1.25	05/12/17 14/12/17 (resowing)	11 to 19/3/18
Char Jabbar		11/01/18	12 to 19/4/18
Tomoruddi	<b>Participatory Varietal selection in Linseed</b> <b>Treatments :</b> BARI Tishi-1, Local from Noakhali, Patuakhali, Zokigonj and Bandarban <b>Sowing methods for Linseed</b> -Line sowing (20 cm and continuous ), Bed planting (bed -1 m X 2 m, broadcasted), Broadcasting, <b>Seed rate (Kg ha<sup>-1</sup>):</b> Line sowing-7 , Bed Planting-6, Broadcasting -10	24/11/17	07 to 13/3/18
Kellar Char	<b>Cropping System (CP) Linseed with pulses and oil crops</b> <b>Intercropping system (Replacement design)</b> - Linseed + Sunflower (3:1), 2:1 row ratio- Linseed+ Barley Linseed+ Cowpea, Linseed+ Safflower Linseed + Sunflower <b>Mixed cropping System-</b> Linseed (100%) with 30% of Mustard/ Grass pea/cowpea/Safflower	04/12/17 14/12/17 (resowing)	26 to 28/3/18
Char Jabbar	<b>Border cropping System-</b> Linseed surrounding by Safflower, Linseed surrounding by Mustard, Linseed surrounding by Sunflower <b>Fertilizer dose (N-P-K-S-Zn-B Kg ha<sup>-1</sup> + VC t ha<sup>-1</sup>):</b> 34-16-11-0-0-0-1.25	20/12/17	23 to 30/3/18
Tomoruddi	<b>Participatory Varietal selection in Safflower</b> <b>Treatments:</b> BARI Saff-1	24/11/17	23 to 25/3/18
Kellar Char	<b>Sowing methods:</b> Line sowing ( 30 X 12 cm), <b>Seed rate (Kg ha<sup>-1</sup>):</b> 12 <b>Fertilizer dose (N-P-K-S-Zn-B Kg ha<sup>-1</sup> + VC t ha<sup>-1</sup>):</b> 38-20-11-0-0-0-1.25 <b>Intercropping System with Safflower (Replacement design):</b> Safflower + Foxtail millet (2:4), Safflower + Sorghum (1:1), Safflower + Grass pea (2:2), Safflower + Mungbean (2:2), Safflower + Cowpea (2:2), Safflower + Soybean (2:2), Safflower + Mustard (2:2), Safflower + Linseed (2:2), Safflower + Sunflower (2:2)	04/12/17 15/12/17 (resowing)	13 to 15/4/18
Char Jabbar		20/12/17	10 to 12/4/18
Tomoruddi	<b>Participatory Varietal Selection in Sorghum</b> <b>Treatments :</b> exotic variety-Green Grand-1 (Forage), ISC-19153, BD-710, BD-732, BD-755, BD-740, BD-4659	26/11/17	14 to 17/3/18
Kellar Char	<b>Sowing methods:</b> Line sowing ( 60 X 15 cm with 2 to 3 cm depth) <b>Seed rate (kg ha<sup>-1</sup>):</b> 10 <b>Fertilizer dose (N-P-K-S-Zn-B Kg ha<sup>-1</sup> + VC t ha<sup>-1</sup>):</b> 94-56-37-0-0-0-1.25 <b>Intercropping System with Safflower</b>	03/12/17 13/12/17 (resowing)	02 to 04/4/18
Char Jabbar	<b>Replacement design:</b> Sorghum + Foxtail millet (2:4 ), Sorghum + Proso millet (2:4), Sorghum + Sunflower (4:2) <b>Additive design :</b> Sorghum + Safflower (2:2 ), Sorghum + Grass pea (2:3 ), Sorghum + Cowpea (2:3 )	23/12/17	05 to 8/4/18
Tomoruddi	<b>Participatory varietal selection in Foxtail</b> <b>Treatments:</b> BARI Kaon-1, BARI Kaon-2, BARI Kaon-3, ISC-375, ISC-376, BD-927, BD-928, BD-930, BD-931, BD-932, BD-934, BD-944, BD-945, BD-948, BD-959, BD-984, BD-1057, BD-1059, BD-1074, BD-1077, Local from Bandarban and Noakhali <b>Sowing method:</b> Line sowing ( 20 cm, continuous and uprooted after 25 to 30 DAS and maintained plant to plant 6-8 cm)	23/11/17	03 to 06/3/18
Kellar Char		02/12/17 14/12/17 (resowing )	22 to 31/3/18
Char Jabbar	<b>Seed rate (Kg ha<sup>-1</sup>):</b> 12 <b>Fertilizer dose (N-P-K-S-Zn-B Kgha<sup>-1</sup> + VC t ha<sup>-1</sup>):</b> 54-28-29-0-1-0-1.25	11/01/18	16 to 26/4/18
Tomoruddi	<b>Participatory varietal selection in Proso millet</b>	22/11/2017	12 to 15/2/18
Kellar Char	<b>Treatments:</b> BARI Cheena-1, Cheena (kalo), Cheena (Lal), Cheena (Sada)	02/12/17	05 to 07/3/18
Char Jabbar	<b>Sowing method:</b> Broadcasting, <b>Seed rate (Kg ha<sup>-1</sup>):</b> 22 <b>Fertilizer dose (N-P-K-S-Zn-B Kgha<sup>-1</sup> + VC t ha<sup>-1</sup>):</b> 54-24-32-0-1-0-1.25	23/12/17	27 to 31/3/18



**Picture 10.6.3. :** Agronomic data collection from different RPVS trials

- **Competitive analysis of intercropping systems**

Competitive relationships were calculated as follows:

**Main Crop Equivalent Yield (MEY):** It was computed as yield of individual crop multiplied by market price of that crop divided by market price of Garlic (Verma and Modgal, 1983).

$$\text{Main Crop Equivalent Yield (t ha}^{-1}\text{)} = \frac{\text{Yield of individual crop} \times \text{Market price of that crop}}{\text{Market price of Main Crop}}$$

**Land Equivalent Ratio (LER):** LER were calculated according to Mead and Willey (1980) as

$$\text{Land Equivalent Ratio (LER)} = \frac{Y_{MI}}{Y_{MS}} + \frac{Y_{CI}}{Y_{CS}}$$

Where,  $Y_{MS}$  = yield of Main crop (MC) as sole crop and  $Y_{MI}$  = yield of Main crop as intercrop

$Y_{CS}$  = yield of Component crop (CP) as sole crop,  $Y_{CI}$  = yield of CC as intercrop

**Area Time Equivalent Ratio (ATER) :**ATER provides more realistic comparison of the yield advantage of intercropping over monocropping in terms of time taken by component crops in the intercropping systems than LER. It was calculated by using the following relevant equation (Hiebsch and McCollum, 1987).

$$\text{Area Time Equivalent Ratio (ATER)} = \frac{L_M \times T_M + L_C \times T_C}{T}$$

Where,  $L_M$  = Partial LER of Main Crop (MC) in intercrop and  $T_M$  = Duration (in days) of MC

$$\text{Partial LER of Main crop in intercrop (L}_M\text{)} = \frac{Y_{MI}}{Y_{MS}}$$

Where,  $L_C$  = Partial LER of Component Crop in intercrop and  $T_C$  = Duration (in days) of CC

$$\text{Partial LER of Component Crop in intercrop (L}_C\text{)} = \frac{Y_{CI}}{Y_{CS}}$$

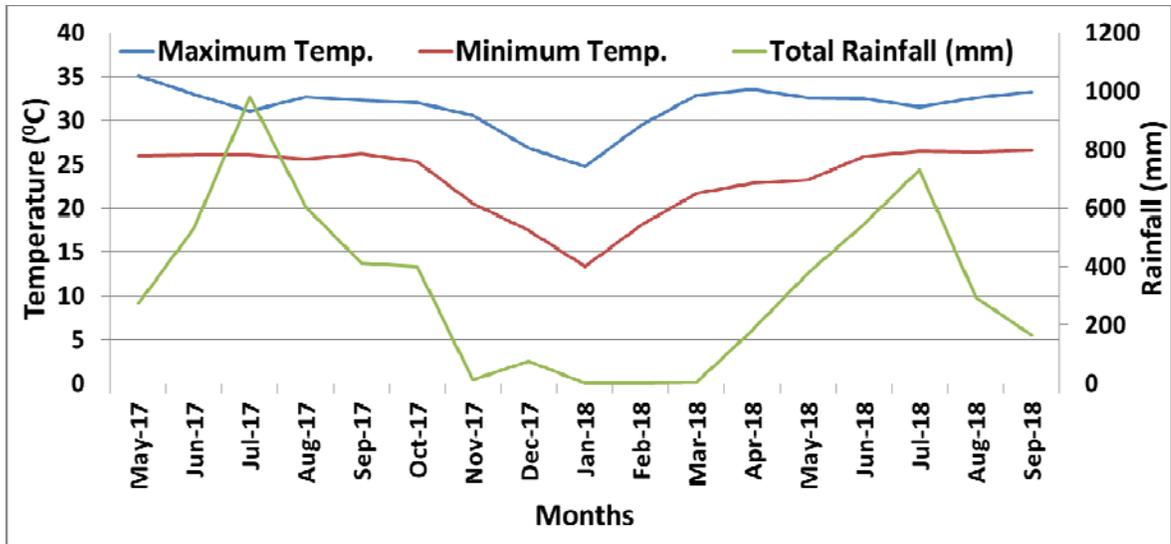
T = Total duration of the intercropping system (in days)

**Monetary Advantage Index (MAI):** The Monetary Advantage Index (MAI) which gives an indication of the economic advantage of the intercropping system was calculated as follows (Willey, 1985 and Ghosh, 2004):

$$\text{Monetary Advantage Index (MAI)} = [\text{Value of combined intercropped yield} \times \left(\frac{\text{LER} - 1}{\text{LER}}\right)]$$

Economic values of component crops were estimated based on the average prevailing prices during 2017-18 cropping season from nearby main two (02) local market of the respected area. The prices of the main crops and component crops were written below the table of the particular intercropping system. Moreover, prices of the fertilizers were- urea Tk. 13 Kg<sup>-1</sup>, TSP Tk. 22 Kg<sup>-1</sup>, MoP Tk. 15 Kg<sup>-1</sup> and gypsum Tk. 12 Kg<sup>-1</sup>. Other variables like land preparation, weeding, insecticide and harvesting costs were included.

- **Information about trial conditions and problems:** Information about location, soil conditions (too much water due to rain or severe water stress conditions), topography, and pest and disease outbreaks were recorded as when necessary in interpreting the results of the trial. Such as, heavy rainfall occurred during 8 to 10 December, 2017 after sowing Barley, linseed, sorghum, safflower and foxtail millet a Keller char village, Subarnachar upazila, Noakhali.



**Graph 10.6.1. :** Total rainfall, Maximum and Minimum temperature of Noakhali during the project intervention period (May, 2017 to September, 2018)

Source: Bangladesh Meteorological Division (BMD), Noakhali



Later on crops growing stage, heavy rainfall occurred during the mid-March which cause waterlogged condition in sorghum at Char Jabbar site. However, grain sorghum are extremely resistant to drought and can withstand waterlogging condition better than other cereal crops. In addition, sorghum varieties have been known to thrive well on marginal lands than other cereal crops Saballos (2008) stated that

**Picture 10.6.4. :** Problems occurred during RPVS trails due to rain

**b) Evaluation**

• **Farm walks:** In the farm walk the participating farmers visit each other’s plots. Moreover, Director Research, BARI, Gazipur; Chief Scientific Officer, PSO and SO from OFRD, BARI, Gazipur; PSO, P&E Division, Gazipur as well as monitoring team from Crop Division, BARC, Farmgate, Dhaka evaluated the RPVS trials while queried to the farmers on underutilized crops preferences and causes of the preferences etc. In addition, SA, OFRD and SAAO, DAE of respected block visited the experimental side along with farmers to evaluate the preferences of UCs. Finally, the PI of the project noted the points which latter on reflected in the result section. Farm walks allowed each cultivar to be assessed by a group of farmers on its performance across all of the replications. Comparative data were collected on all of the varieties in a trial by PI of the project.



**Picture 10.6.5.:** Farm walks along with monitoring and evaluation done by diverse stakeholders at different RPVS trials during the *Rabi* season of 2017-18

- Preference data:** Preference data in relation to attributes like maturity duration, grain yield, grain size, colour, appearance, and disease resistance etc. in farmers own way was collected during “Beauty Contest”. In each beauty contest, 25 farmers (male and female) along with SAAO, DAE; SA from BARI; NGOs personnel were allowed to “vote” for their preferred entity (ies) during a selected day (depends on the crops maturity period) by depositing paper ballots in a bag or envelope in front of the plot. In generally, each participant was provided three (v) ballots for best

variety and three (X) ballots for worst variety whereas each group of ballots were supplied more than three (03) when the number of entities exceeded six (06). A total of six (06) “Beauty Contest” were conducted on the targeted (six) underutilized crops trials fields. After votes were tallied, the farmers were asked to final scoring of the plots or varieties as why they preferred the variety (ies) / line (s) / germplasms (s) / cultivar (s) that received the most votes and the other received fewer votes. In this case, relative attributes were taken consideration like stay green for sorghum lines, grain colour for foxtail millet more saline tolerant crop etc. Farmers were supported by PI and Scientific assistant in recording the data during final ranking by collecting the yield data.



Picture 10.6.6. : Beauty contest in Participatory variety selection trails at different locations

- **Confirmation of the result:** Finally, data on average plot yield of the respected crops varieties/lines/Germplasms/cultivar in response to different levels of soil salinity and beauty contest results across all location were assessed to determine the final variety selection by the PI.

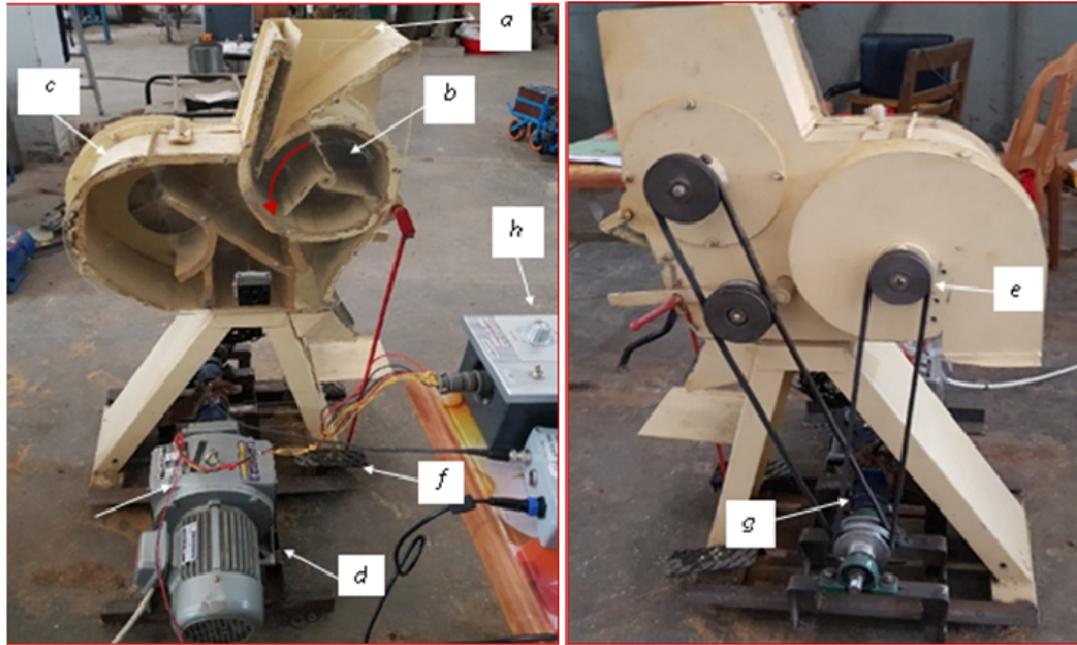
## 10.7. Development of post-harvest machineries

During the RPVS trials implementation period, post-harvest machineries for household level were developed with the help of Farm machinery and Postharvest Process Engineering Division (FMPE), BARI, Gazipur. Under the fund of the project two (02) Dehuller/Dehusking machines and one (01) Threshing machine (replaceable drum) were developed by reverse engineering methods.

### 10.7.1. Dehuller/Dehusking machine for Millets

Once harvested, millets have to undergo a series of post-harvest operations like threshing, drying, storage, etc., (FAO, 2001) before further processing for human consumption. It is important to remove the outer husk as it contains anti-nutritional and organoleptically unacceptable compounds (Basse & Mbengue, 1993), which make the grains undesirable for consumption. The separation of the inedible outer husk and bran is the most tedious process in millet processing because of its smaller grain size compared to many other cereals (Saleh *et. al.*, 2013; Taylor and Duodu, 2015; Verma *et. al.*, 2014). This step is carried out in the traditional way using mortar and pestle in the rural areas. Hence, there is a great need for developing processing machineries affordable, at the village scale, which could ease millet processing, eventually leading to the production of high quality millet food products at the commercial scale that could be distributed for the consumption of urban populations (Saleh *et. al.*, 2013). The basic design and operation of a millet dehusker is –

- a) The feeding chute is located at the upper part of the cylinder. It has a sliding gate that remains closed due to gravity, made up of metal plate strip (18 gauges) to close or open the discharge opening of feed hopper as well as controlling the grains rate.
- b) A dehuller unit consist of a cylinder with 3-blade impeller type rotor (abrasive materials blade at the head of the beater) with a concave clearance of 10 mm (as suggested by Kaankuka, 2015) was installed within the casing. At the tip of the blades, reinforced rubber sheet strips were bolted that mainly do the task of dehulling. The middle front part of the concave is being corrugated. During rotation of the rotor, the grains repeatedly impact with the impeller and get rubbed by the concave and gradually get dehulled. The shaft of the rotor is mounted on two bearing supports and being operated by an electric motor via V-pulleys (A section) and belts. The casing is made of MS and plastic sheets and seals the cylinder (and the blower). The bottom part of the casing (concave) is split into two halves that can be opened or closed via a spring loaded pedal. This split allows unloading of the dehulled grains to the outlet chute via the cleaning chamber.
- c) Blower: The blower is fabricated of MS sheets, shaft and plastic sheets and fitted with ball bearings and V-belts and pulleys. It is located slightly below the cylinder. The blower rotates, suck air out of the cylinder and creates a vacuum inside the machine. Once the pedal is pressed, the cylinder concave splits and the dehulled grains (mixed with husks) fall out of the cylinder to the outlet chute. During falling, the blower sucks the husks (lighter than grains) of the falling dehulled grains out of the machine. The grains (rice), due to their heavier weights, keep falling down until get deposited on a tray/bowl placed below the delivery chute. Once unloading is complete, the pedal is released to close the cylinder concave splits and start another batch of dehulling.
- d) Prime mover: The dehuller is powered by an electric motor (3  $\Phi$ , 750 W, 1400 rpm, 380 V, 50 Hz, Bati Ghar, Nawabpur, Dhaka, Bangladesh) that transmits power to the dehulling cylinder and blower via V belts-pulleys. The chassis of the motor was extended in order to facilitate installation of measurement instruments.



**Picture 10.7.1.1.:** Functional components of the dehusser (*a* = feeding chute, *b* = dehusking cylinder and rotor, *c* = blower, *d* = motor, *e* = V-belt pulley power transmission, *f* = unloading pedal, *g* = torque transducer, and *h* = torque and rotary speed measurement system).

**Instrumentation and torque data logging**

Power from the motor shaft to the dehusser was transmitted via a torque transducer (Model T8 ECO, 200 N m, 6000 rpm, Interface Inc., Scottsdale, Arizona 85260, USA) and two pairs of flexible couplings (Picture 10.7.1.1.). The transducer was connected to a laptop computer and torque data (N m) were logged to an Excel sheet as a .csv file. The data were acquired at 10 Hz (10 torque readings per second) during the dehusking period (90 s or 120 s as per the test plan). The motor was connected via an inverter to regulate and measure motor speed.

**Testing and performance data collection and processing**

*Kaon* grains collected from the PVS trials and sun dried to a moisture content of 9% for testing. Before test runs, mock tests were conducted and a no load rotor (dehusking cylinder) speed of around 1200 rpm was selected that produced clean rice. It was also found that a dehusking time of 90-120 s (single pass only) were useful to obtain clean ready to cook rice. Following the mock tests, the following tests were conducted with the factors and treatment levels stated below (replicated three times).

**Table 10.7.1.1.:** Factors and level values considered on dehusking millet

<b>Factors</b>	<b>Treatment levels</b>
A: Dehusking time (s)	90 and 120
B: Feed rate (g batch <sup>-1</sup> )	125, 167, 208, 250

The dehusser was run idle (empty) for about a minute before each test run to stabilize the dehusser and instruments. Following that a measured quantity of grains ( $Q_f$ ) was feed in to the feeding chute and dehusling started. Once the desired dehusling time (90 s or 120 s) was over, the dehulled grains were unloaded. During unloading, the grains fell though the cleaning chamber and finally clean rice was

deposited to a bowl placed below the delivery chute. The unloading time for each test run was recorded. No load speed of the dehulling cylinder rotor was maintained at 1200 rpm. During loading (dehulling) the motor speed reduced (depending on the load) which was measured using a tachometer and recorded for each test run. Torque data were recorded on a laptop computer for the dehulling period using a data acquisition software (INF-USB-VS, Version 2.12, Interface Inc., Scottsdale, Arizona 85260, USA). After completion of all the test runs, the collected rice samples were weighed ( $W_m$ ). Unhulled grains remaining in the rice samples were separated and weighed ( $W_u$ ). The rice (pure rice) was then passed through a 0.7 mm sieve to get weights of the head/whole ( $\geq 0.7$  mm) grains ( $W_w$ ) and broken ( $<0.7$  mm) grains  $W_b$ . From the above measurements, the performance parameters of the dehuller were calculated as below (Kannkuka, 2015).

**Dehulling efficiency ( $\eta_d$ ):** It measures the percentages grains fed remained unhulled (present in the rice). It was calculated using following equation.

$$\eta_d (\%) = \left( 1 - \frac{W_u}{Q_f} \right) \times 100$$

Where,  $\eta_d$  = Dehulling efficiency (%)

$W_u$  = Weight (g) of unhulled grains remaining in the rice (collected at the outlet) and

$Q_f$  = Total weight (g) of grains fed into the dehuller

**Total milling recovery (R):** It is a measure of percentage of rice obtained from grains fed. It was calculated as follows-

$$R (\%) = \left( \frac{W_m}{Q_f} \right) \times 100$$

Where,  $R$  = Total milling recovery (%)

$W_m$  = Weight (g) of rice (collected at the outlet chute)

$Q_f$  = Quantity of foxtail millet fed into the thresher (g)

**Head grain recovery (H):** It is a measure of the percentage of the whole grains in the rice. It was calculated by the following equation.

$$H (\%) = \left( \frac{W_w}{W_w + W_b} \right) \times 100$$

Where,  $H$  = Head grain recovery (%)

$W_w$  = Weight (g) of whole grains in the rice (collected at the delivery chute)

$W_b$  = Weight (g) of broken grains present in the same rice

**Throughput capacity (C):** It is measure of quantity of grains processed by the dehuller per unit time. The following equation was used to calculate Throughput Capacity ( $\text{Kg h}^{-1}$ ).

$$C (\text{Kg h}^{-1}) = \left( \frac{Q_f}{t} \right) \times 3.6$$

Where,  $C$  = Throughput capacity ( $\text{kg h}^{-1}$ )

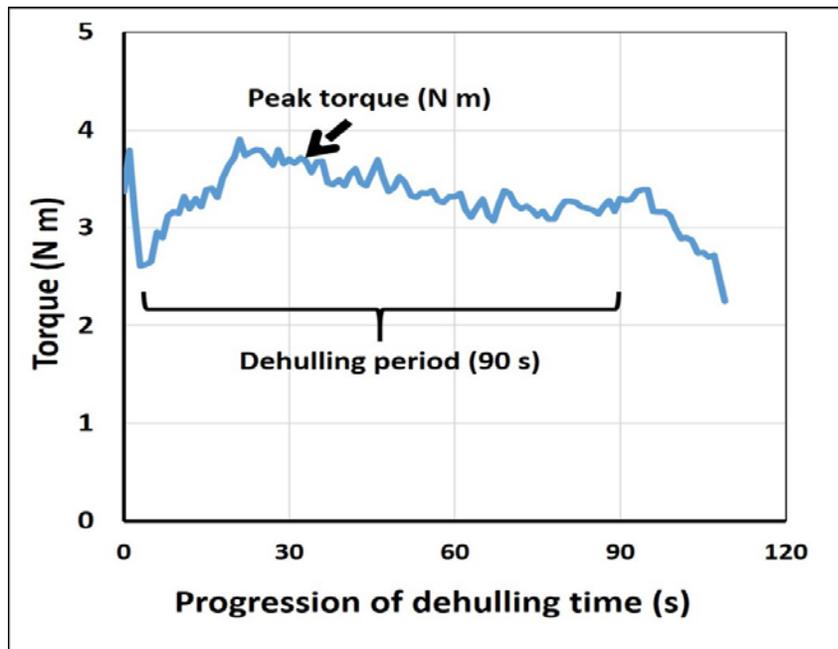
$Q_f$  = Total weight (g) of grains fed into the dehuller and

$t$  = Dehulling time (s)

**Torque, power, energy and specific energy consumption:** An example of the torque signal data logged were presented in Graph 10.7.1.1. From the torque data, average torque was calculated. The peak torque was taken as the highest value of torque data recorded during the dehulling period (Graph 10.7.1. 1.). The average and the peak power requirements were calculated using the following equation.

$$P (W) = 2\pi \times \left(\frac{n}{60}\right) \times T$$

Where,  $P$  = Power (average or peak) requirement (W)  
 $n$  = Rotary speed (rpm) and  
 $T$  = Average or peak torque (N m)



**Graph 10.7.1. 1.:** A sample of the torque signal data logged to the computer

The parameter specific energy requirement, commonly used by researchers to measure the effectiveness of the machines in terms of energy requirement per unit volume of output, was calculated using the following equation.

$$E_s (KJ g^{-1}) = \left(\frac{P \times t}{Q_f}\right) \times \left(\frac{1}{1000}\right)$$

Where,  $E_s$  = Specific energy requirement ( $kJ g^{-1}$ )  
 $P$  = Power (average or peak) requirement (W)  
 $T$  = Average or peak torque (N m) and  
 $Q_f$  = Total weight (g) of grains fed into the dehuller

### 10.7.2. Threshing Machine for multicrops (Barley, Sorghum and Safflower)

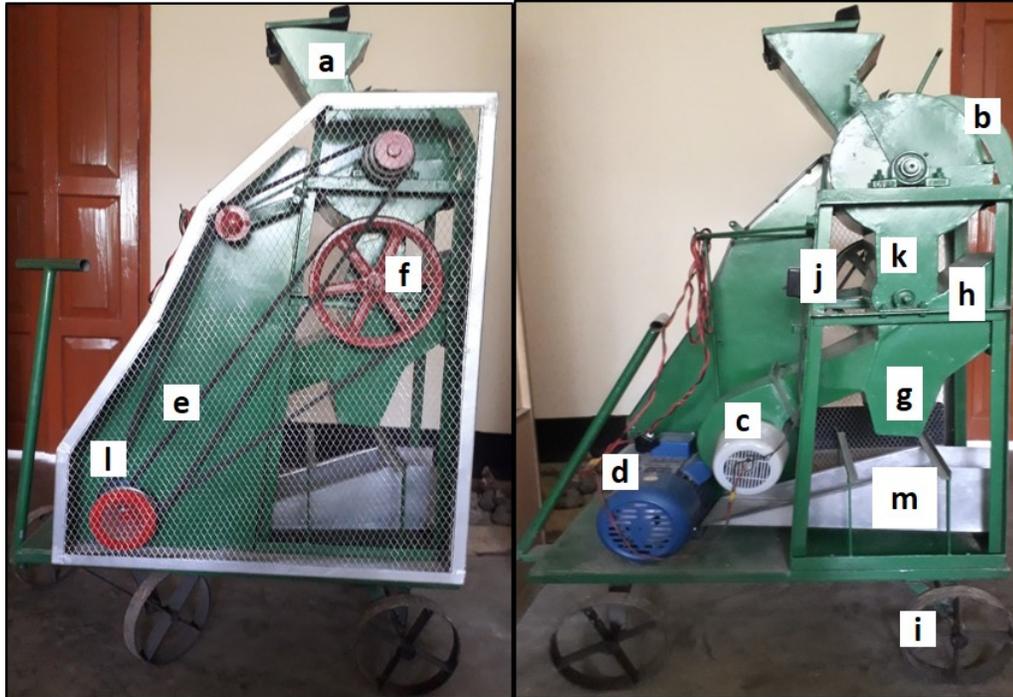
The thresher was redesigned for threshing of barley/ Safflower/Sorghum for edible grain purpose which was used for wheat threshing by the Plant Breeding Division, BARI, Gazipur. In order to meet the threshing requirements needed different parameters (machine, crop and varietal) such as cylinder speed for various crop, various feed rate, modification and size of bar or pegs for specific crop, distribution of bar/peg/spike over cylinder periphery, grain moisture content and blower speed etc. were not possible to determine in proper scientific manner. The leading causes behind schedule were time constraints of the project and the availability of the harvested crops as manufacturing cycle time was longer than estimated. In addition, some modification were made for threshing multi-crop such as replaceable bar (square/round/triangular) types for different crops with interchangeable drum, cast iron wheels were provided for portable and easily transported to the needed area with 2 to 3 persons comfortably. Finally, decision was made to continual modification of the thresher by Farm Machineries and Post-harvest Process Engineering Division, BARI, Gazipur as research program although the project was ended.

Notwithstanding the mentioned situations, multicrops thresher consists of the following four major components:

**a) Feeding unit:** The operation of delivering the harvested crop (panicle/inflorescence with stem/pod of the crops) into threshing unit is known as feeding unit. In the thresher, 'hold-on-type' feeding unit is used where the heads of the harvested crops were being only pushed into the cylinder and straw was manually or mechanically held. It is located directly above the threshing drum and is welded to the upper housing of the main frame. A flapper was fitted in the feeding chute to capture the dust which may create health problems of the operator.

**b) Threshing unit and mechanism:** The threshing unit consists of threshing cylinder (replaceable), concave (used for small millets) and cylinder cover. The inner side of semi-circular cylinder cover were welded with helically shaped pegs which was parallel to axis to act as rubbing base for threshing of the crop. When the machine is to be used for threshing crops, other than barley, the rectangular shaped pegs are to be covered by a ribbed casing having semicircular side plates, fixed with ribbed casing and concave to prevent flow of material in to the throwing chamber. The semi-circular shape open grate concave made from round-bars where the clearance between the drum and concave was adjustable by sliding the drum shaft bearings vertically and by spacers in the bearing mountings which displaced it horizontally. The threshing cylinder drum was made out of the cast iron where five (05) pegs of square iron pieces in six (06) paired rows form along the length of the drum were welded in staggered arrangement. The main shaft on which threshing cylinder attached had been supported at two ends by heavy pedal bearings. While being threshed, the material undergoes a spiral motion between the threshing drum and concave with the help of louvers where the pegs hit the crop and the impact causes detachment of grains from the straw. One radial centrifugal fan blower flipped out of the concave on the radial arm of the flywheel which was driven from main shaft with the help of V belt.

**c) Separating and winnowing unit:** After threshing, grain and chaff fall into reciprocating chamber. Chaff straws were enable to pass the holes where the air blast from the radial centrifugal fan blower levitated the mat of material and blown away out of the thresher through chaff outlet. The grains are further cleaned from small straw pieces and debris by air coming horizontally from small fan mounted just above the main shaft. Clean grain was collected through collector box.



**Picture 10.7. 2.1.:** Functional components of the multicrops thresher (*a* = feeding chute, *b* = threshing cylinder, *c* = Fan blower, *d* = motor, *e* = V-belt pulley power transmission to flywheel, *f* = flywheel, *g* = grain outlet, and *h* = chaff outlet, *i* = transport wheel, *j* = electric switch, *k* = reciprocating chamber, *l* = main shaft and *m* = grain collector).

#### Testing and performance data collection and processing

The modified machine was installed on level surface and barley crop materials were taken for evaluation. Three different feed rates were consider as treatment such as  $FR_1 = 180 \text{ Kg h}^{-1}$ ,  $FR_2 = 240 \text{ Kg h}^{-1}$  and  $FR_3 = 300 \text{ Kg h}^{-1}$ . Cylinder speed (700 rpm) and concave clearance (7 mm) were fixed at 13% moisture content. The thresher was powered by an electric motor (3  $\Phi$ , 1000 W, 2000 rpm, 380 V, 50 Hz, Bati Ghar, Nawabpur, Dhaka, Bangladesh) that transmits power to the cylinder, cutters and blower via flywheel, V belts and pulleys. Different weighted barley bundles were fed into threshing unit and the threshed materials was collected at the outlet which was cleaned and weighed. The portion of the material containing unthreshed grain was separated from straw and weighed after hand threshing and cleaning in order to determine the threshing efficiency in terms of percentage of the total grain recovered. The following parameters were calculated-

**Feed rate ( $\text{kg h}^{-1}$ ):** it was calculated according to Ukatua (2006).

$$FR (\text{Kgh}^{-1}) = \frac{Q_f}{T}$$

Where, **FR** = Feed Rate ( $\text{kg h}^{-1}$ )

**$Q_f$**  = Quantity of crop material fed into the thresher (Kg) and

**T** = Feed time (h)

**Threshing efficiency (%)**: it was determined by applying following equation (Mahmoud *et. al.*, 2007).

$$TE (\%) = \left( \frac{T_G - Un_G}{T_G} \right) \times 100$$

Where, **TE** = Threshing efficiency (%)

**Un<sub>G</sub>** = Weight of unthreshed grains in the sample (g) and

**T<sub>G</sub>** = Weight of total grains in the sample (g)

**Unthreshed Grain Losses (%)**: Un-threshed grain is an important factor to estimate the machine efficiency. It was determined by taking three samples of threshed grains, Weight of each sample was measured. Unthreshed grains were separated and the samples were weighed again. Un-threshed grain losses percentage was calculated as following (Mishram and Desta, 1990):

$$UGL (\%) = \left( \frac{Un_G}{T_G} \right) \times 100$$

Where, **UGL** = Un-threshed grain losses (%)

**Un<sub>G</sub>** = Weight of unthreshed grains in the sample (g) and

**T<sub>G</sub>** = Weight of total grains in the sample (g)

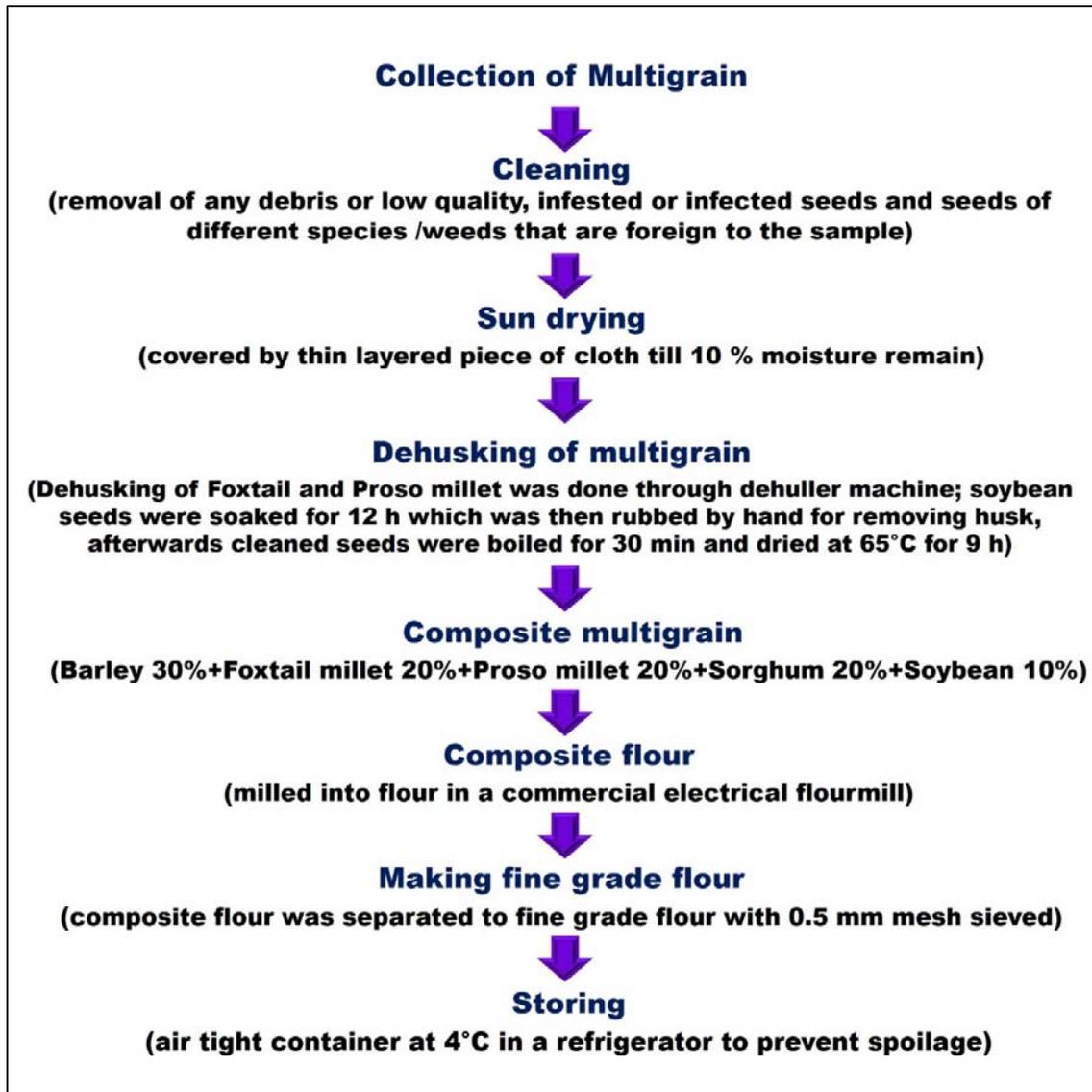
#### 10.8. Recipe of different kind food and multigrain flour quality test

Different kinds of food recipes were collected from “MILLET RECIPES – A Healthy Choice” developed by ICAR- Indian Institute of Millets Research, Rajendranagar, Hyderabad and Smart Food Millet Recipes by International Crops Research Institute for the Semi-Arid Tropics, Telangana, India and other reliable sources from internet as most of the underutilized target crops were millets such as foxtail millet, proso millet, sorghum and barley. The detailed preparatory Methods of multigrain flour was provided in this section.



**Picture 10.8.1.** : Underutilized Crops and oil crop (soybean) used in Multigrain Flour preparation

Two types of millet (BARI Kaon-2, BARI Cheena-1), BARI Barley-7, Sorghum advance line (ISC-19153) and two types of oilseed crops (BARI Tishi-1, BARI Soybean-5) were collected from the trail fields. After collecting all the materials the following procedure were maintained for making multigrain flour.



**Picture 10.8.2.:** Flow Chart for the preparation of multigrain composite mixture

After following the above mentioned procedure, Wheat flour were procured from the local market and mixed with the composite flour with 50:50 ratio. Finally, 1% Flaxseed (Grinding to fine smooth powder and sieved by 0.25 mm) was incorporated in the mixture.

For chemical analysis, the sample was submitted to the Bangladesh Council for Scientific and Industrial Research (BCSIR).

### **10.9. Gene- Seed bank establishment**

Community based village seed-gene bank was established with the attempt of following the MSSRF (2001) advocated approach where they considered it as community managed village Gene- Seed- Grain approach. It stranded to be a small scale seed conservation for short time basis, access and availability of diverse type of seeds and planting materials to the target farmers group or surrounding farmers group within the villages or outside the villages. Due to short time frame, communication risks from main land to Hatiya as main transport Sea-Truck was out of service and finally the political unrest during formation of gene bank, it was not possible to established gene bank at Hatiya upazilla. However, before establishing the seed-gene bank continuous motivation and awareness was carried out among the participating farmers at FSRD site, Subarnachar and co-operating farmers at the middle point of Companigonj and Hatiya upazila under the umbrella of Sagarika Samaj Unnayan Sangstha, Kasher hat, Noakhali. In each area, one register was created to write down the characteristics of the entities along with the picture and weight of the respected crops entities. The seed were collected by the help of participating farmers and project staff. Afterwards, drying, winnowing and cleaning were done for storage of the particular entities. The seeds were put into the glassware with maintaining proper moisture level and labeled with the name. For management of the seed-gene bank, a committee was formed in each location and headed by the SA and Agricultural Officer (Sagarika Samaj Unnayan Sangstha) of the particular area.

## 11. Results and discussion:

### 11.1. Base line Survey

Three Participatory Rural Appraisal (PRA) exercises were carried out at Kellar Char, Char Jabbar and Tomoruddi villages situated in three different Upazila (Companigonj, Subarnachar and Hatiya) of Noakhali district (Picture 11.1.1.1.). All the Upazila belongs to AEZ 18f (Young Meghna Estuarine Floodplains). Kellar Char and Tomoruddi villages are unprotected coastal chars, vulnerable to regular flooding with saline water thus land become moderately to highly saline. Only one rice crop is being possible in the Aman season when heavy rains temporarily decreased the salinity from the topsoil. In the winter (*Rabi*) season, an additional crop is possible at some places. The agriculture benchmark survey revealed that the overall cropping intensity in is 150.66 %, which indicated very low compared to the national average of 181%. Moreover, food crop yield have generally been lower (1.5 - 2.0 t ha<sup>-1</sup>) compared to favorable ecosystem. The levels of soil salinity be supposed to gradually decline over the years when the area will be protected. Embankment (locally called “Berry Bandh”) has been constructed during mid-80s by Water and Power Development Authority (WAPDA) to protect char areas where Char Jabbar village located.



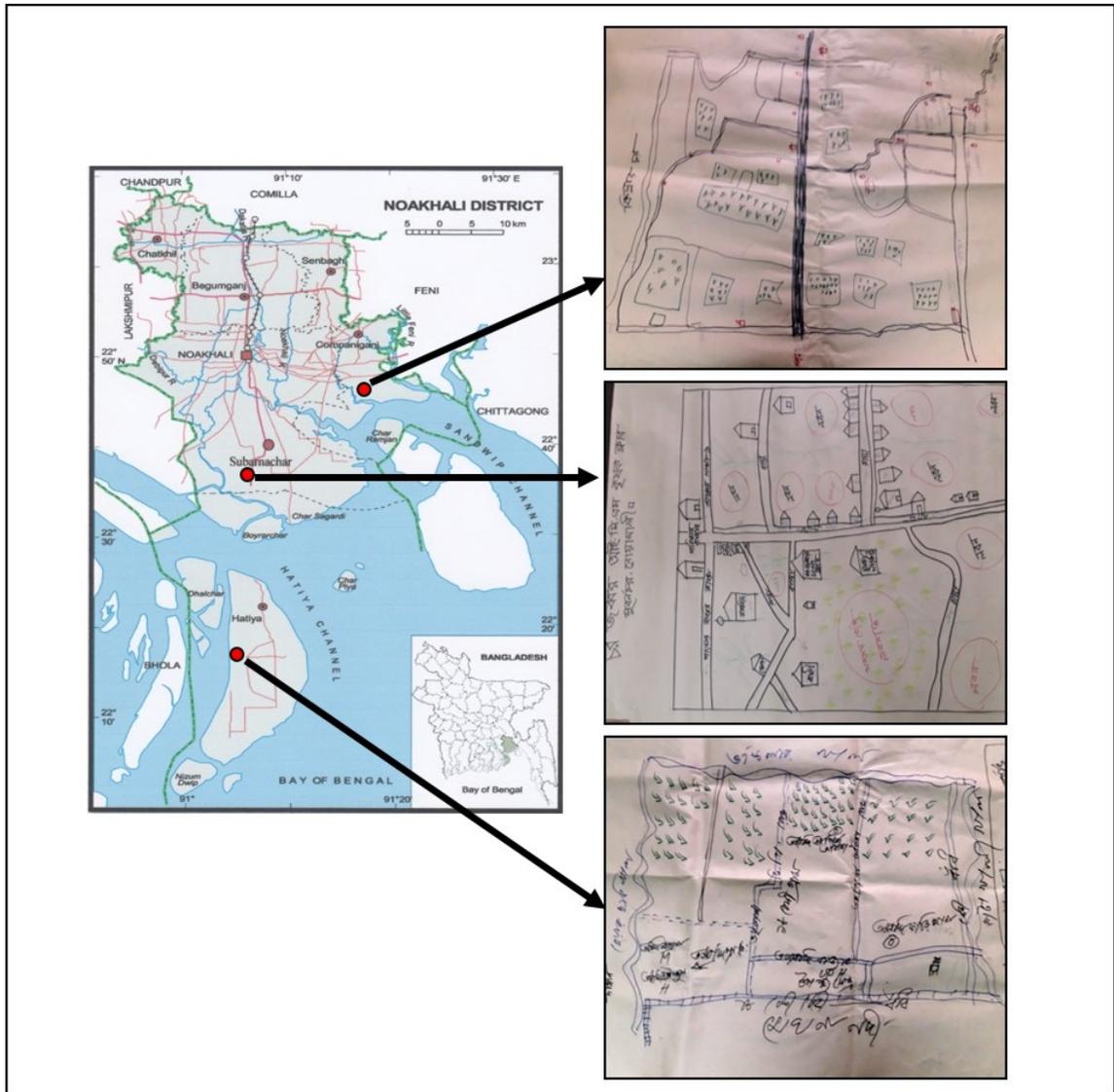
**Picture 11.1.1.:** PRA activities at Kellar Char, Char Jabbar and Tomoruddi villages in Noakhali during 2017

The PRA activities were carried out by preparing maps and collecting information/data of three villages for prioritization of the problems as under:

#### 11.1.1. Physical Parameters

##### a) Location

The PRA site at Kellar Char is located about 32 Km south-east side of Majidee Court, Noakhali at 22°41' 24.9 ''N Latitude and 91°14' 9.6 '' E Longitude. Tomoruddi village is located about 45 km southern side from Majidee Court and there is a channel in-between Subarnachar and Hatiya Upazilla (22°29' 51.12'' N Latitude and 91°07' 39.39'' E Longitude). Char Jabbar village (22°40' 06.0'' N Latitude and 91°04' 53.8'' E Longitude) under Subarnachar upazila located at 31 Km south-western from Majidee Court. The site represents the vast saline and waterlogged (*Kharif II*) areas belongs to AEZ 18f (Young Meghna Estuarine Floodplains).



**Map 11.1.1.1.:** Physical and Enterprise Map of the study villages in Noakhali, 2017

**b) Land and soil types**

The villages has been characterized by different types of lands for example- high land (HL), medium high land (MHL), medium low land (MLL) and very low land (VLL). MHL are the dominant land type of Kellar Char and Char Jabbar villages while MHL type occupied 55% at Tomoruddi village. There is being existence of medium low land and VLL besides the canals at Tomoruddi village whereas MLL and VLL exist at Char Jabbar village. Big to small canals connected to sea via river are existed at Kellar Char and Tomoruddi villages where a natural phenomenon is intrusion of tidal saline water. Soils are mostly silty clay loam, silty clay and clay loam at Kellar Char and Tomoruddi villages. At Char Jabbar village, soils are Clay loam, Sandy Clay and Sandy loam.

**Table 11.1.1.1.:** Transect of Kellar Char village, Companigonj, Noakhali, 2017

<b>Land Type</b> <b>Land use</b>	<b>High land (5%)</b>	<b>Medium high land (90%)</b>	<b>Medium low land (4%)</b>	<b>Canal (1%)</b>
Soil	Silty clay to clay loam	Silty clay to clay loam	Silty clay	-
Crops	Vegetable	Rice, Grass pea, Linseed	Rice, Grass pea, Linseed	-
Cropping pattern	Homestead: Brinjal, Sweet gourd, Bottle gourd, Country bean	Fallow-Fallow- T. Aman R. Grass pea-Fallow-T. Aman Linseed-Fallow- T. Aman	Fallow-Fallow- T. Aman R. Grass pea-Fallow-T. Aman Linseed-Fallow- T. Aman	-
Livestock	Cattle, Sheep, buffalo, Chicken, Duck pigeon	-	-	-
Fisheries	Pond Fisheries	-	-	Capture Fisheries
Vegetation	Coconut, Betel nut and Other Woody trees	-	-	-
Constraints	Soil moisture stress, kutcha house, roads become muddy during rainy season	Natural hazards, Salinity, Drought, Embankment, Water logging, High insects infestation and diseases infections, Low yield of crops, Sharing crops absent	Natural hazards, , Salinity, Embankment, Drought, Water logging, High insects infestation and diseases infections, Low yield of crops, Proper Sharing crops absent	Natural hazards, Embankment, Tidal saline water intrusion

**Table 11.1.1.2.:** Transect of Char Jabbar, Subarnachar, Noakhali, 2017

<b>Land Type</b> <b>Land use</b>	<b>High land (13%)</b>	<b>Medium high land (80%)</b>	<b>Medium low land (6%)</b>	<b>Very lowland (1%)</b>
Soil	Sandy Clay, Sandy loam	Clay loam, Sandy Clay, Sandy loam	Clay loam, Sandy Clay, Sandy loam	Clay loam, Sandy Clay
Crops	Vegetable	Rice, Soybean, Watermelon, Cowpea, Mungbean	Rice, Grass pea	Rice
Cropping pattern	Homestead: Brinjal, Radish, Tomato, Sweet gourd, Bottle gourd, Country bean, spinach	Soybean-Fallow- T. Aman Watermelon-Fallow- T. Aman Pulse-Fallow-T. Aman Fallow-Fallow- T. Aman	R. Grass pea-Fallow-T. Aman Fallow-Fallow- T. Aman	Boro-Fallow-Fallow
Livestock	Cattle, Goat, Poultry, Duck	-	-	-
Fisheries	Pond Fisheries	-	-	-
Vegetation	Coconut, Betel nut, Papaya and Other Woody and fruit trees (Local Banana)	-	-	-
Constraints	Soil moisture stress, Unplanned tree plantation, Low yield Vegetables variety	Natural hazards, Water Logging, drainage, Salinity, lack of quality irrigation water, High insects infestation and diseases infections, crops low yield	Natural hazards, Water Logging, drainage, Salinity, lack of quality irrigation water, High insects infestation and diseases infections, crops low yield	Water logging, drainage congestion

**Table 11.1.1.3.: Transect of Tomoruiddi village, Hatiya, Noakhali, 2017**

Land Type Land use	High land (2%)	Medium high land (55%)	Medium low land (35%)	Very lowland (5%)	Canal (2%)
Soil	Silty clay, Clay loam	Silty clay, Clay loam, Silty clay loam	Silty clay, Clay loam, Silty clay loam	Clay, silty Clay loam	Clay, silty Clay loam
Crops	Vegetable	Rice, Grass pea, Linseed	Rice, Grass pea	Rice	
Cropping pattern	Homestead: Brinjal, Radish, Sweet gourd, Bottle gourd, Country bean etc.	Fallow-Fallow- T. Aman Linseed-Fallow-T. Aman R. Gras pea-Fallow-T. Aman	Fallow-Fallow- T. Aman R. Grass pea-Fallow-T. Aman	F-F- T. Aman	-
Livestock	Cow, buffalo, Chicken, Duck and pigeon	-	-	-	
Fisheries	Pond Fisheries	-	-	-	Capture Fisheries
Vegetation	Coconut, Date palm, Palm, Other Woody and fruit trees	-	-	-	
Constraints	Displacement of farm families due river bank erosion	Natural hazards, Erosion, tidal saline water intrusion makes land saline, Silting up of drainage canals as a result water logging, lack of HYV variety	Natural hazards, Erosion, tidal saline water intrusion makes land saline, Silting up of drainage canals as a result water logging etc.	Water logging, drainage congestion etc.	

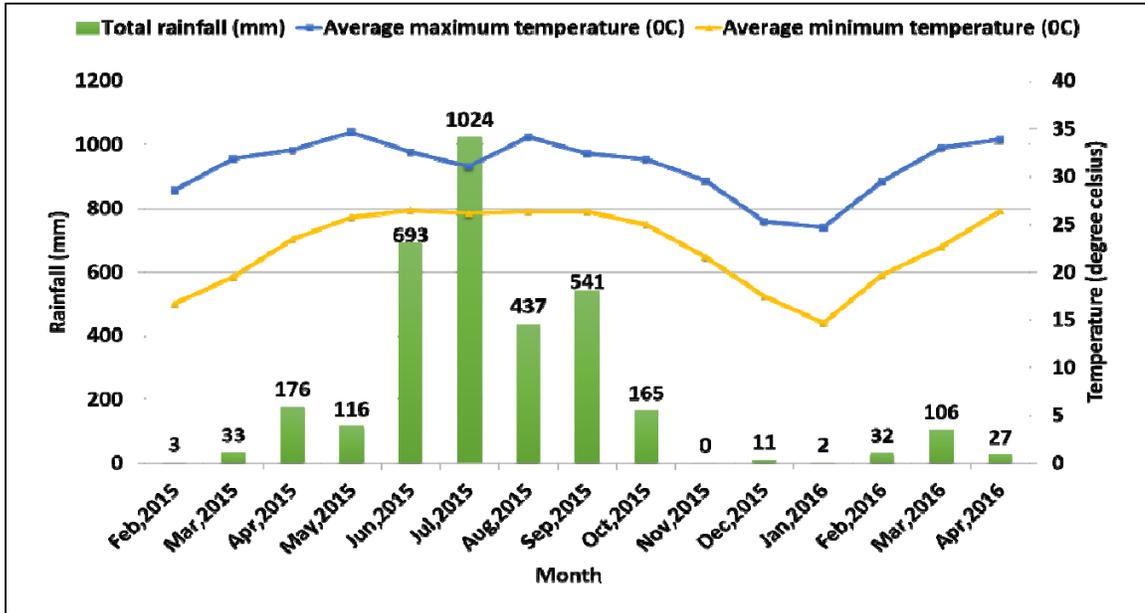
#### c) Land use

Transects of three villages (Table 11.1.1.1 to Table 11.1.1.3.) indicated different the land use system during the PRA exercises. The high land is being used for homestead purpose. In the homestead area, farmers has been cultivated vegetables haphazardly for home consumption. Moreover, livestock are being reared; fruit, timber and non-timber trees existed in the homesteads, roadsides and MHL. Most of the household has pond and the sizes varied for the purposes of fish culture or domestic utilization. At all villages, medium high lands are being utilized for T. Aman rice cultivation. Relay grass pea is a common cultivation culture in MHL and MLL. Farmers noticed that crops cultivation during *Rabi* season became limited due to late harvest of T. Aman, lack of quality irrigation water and irrigation facility and soil salinity. In addition, farmers of Char Jabbar village has been cultivated soybean, watermelon, mungbean and cowpea in MHL.

#### d) Climate

There is no weather station at mentioned three Upazila. Data on rainfall and temperature recorded at nearby station of Noakhali Sadar by Bangladesh Metrological Department (BMD), Noakhali which was not available. In Annual report of OFRD, BARI, Noakhali (2015-16) provided a graph on rainfall and temperature (maximum and minimum temperature) which was included to get a snapshot about weather of this area (Graph 11.1.1.1.). Additionally, climatically the region represents a very wet region with annual rainfall ranged from 2500 mm to 3000 mm. The highest temperature measured in April to May (33.75<sup>0</sup>c) and the lowest in December to January (13.11<sup>0</sup>c). After October the temperature

chronologically decreased up to January and again started to increase in February. The highest rate of rainfall was in May to September and the lowest in November to February compare than the months of June and July. Little or no rainfall occurred in November to January. The area experienced a short duration of cool winter period. The natural hazards of the area are frequent cyclones and storm surges with exceptionally high tides.

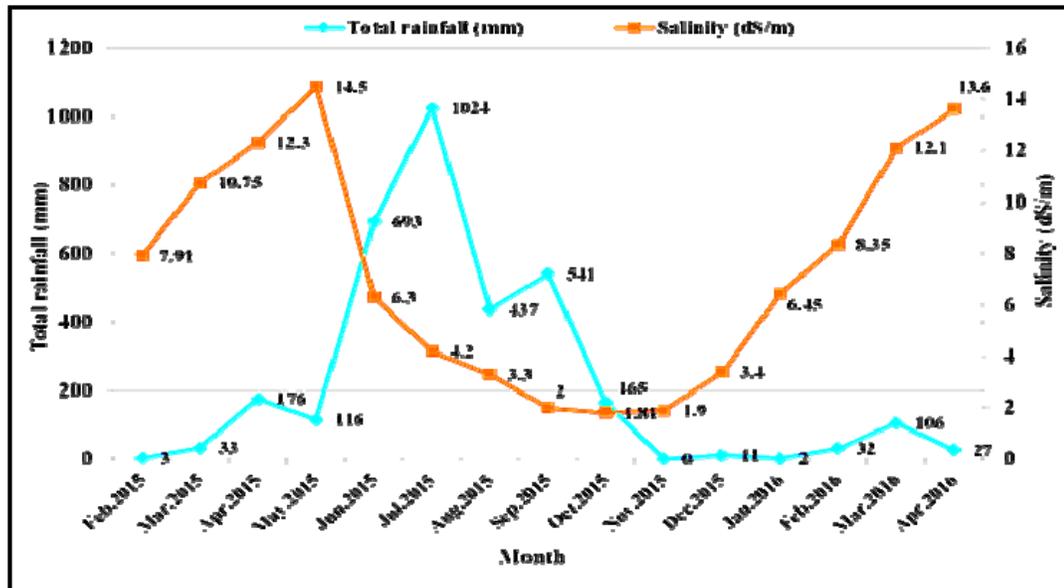


Graph 11.1.1.1.: Total rainfall and temperature of Noakhali Sadar during February 2015 to April 2016

Source: Annual Report by OFRD, BARI, Noakhali (2015-16)

### e) Hydrology and salinity

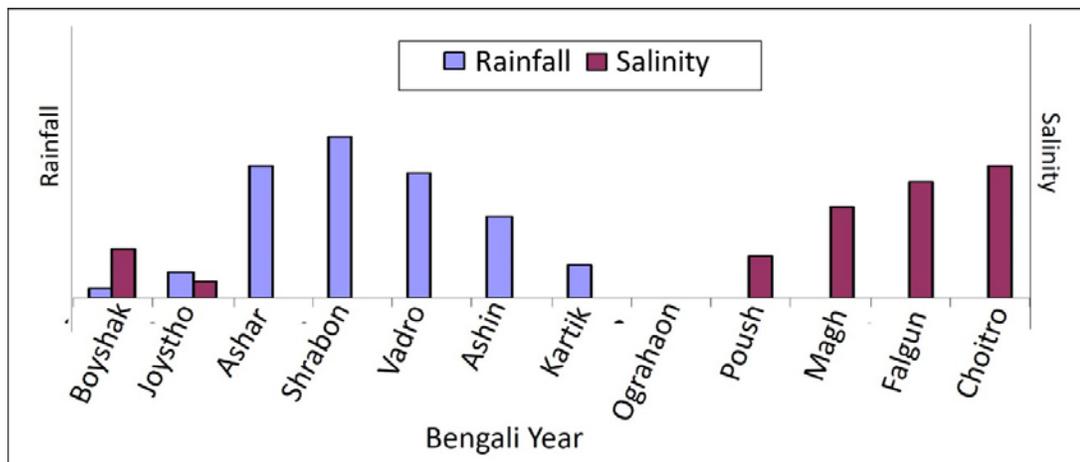
Char Jabbar village subjected to free from normal flooding due to the construction of embankments by WAPDA during land reclamation in mid-80s, thus protected from saline water intrusion. Some parts of the village became waterlogged during *Kharif II* season due to constriction and choking of rivulets (*Khals*) together with unplanned infrastructure and natural drainage system collapsed. On the other hand, Kellar Char and Tomoruiddi villages remained an unprotected areas where saline water intrusion is a natural phenomenon. The water of *Meghna* River remained non-saline during the rainy season from July to December and gradually became saline during the dry season. At Char Jabbar village, soil salinity observed in some sporadic areas which became at picks level from March to April and demolished by the onset of the rainy season. At Char Jabbar village, soil salinity observed in some sporadic areas which became at picks level from March to April and demolished by the onset of the rainy season. At Kellar Char and Tomoruiddi village, level of soil salinity in the field ranged from 1.37 to 3.05 dS/m after harvesting of T. Aman. The following graph was collected from the Annual Report of OFRD, BARI, Noakhali (2015-16) for understanding the salinity and rainfall comparative study.



**Graph 11.1.1.2.:** Comparative status of soil salinity levels and rainfall conditions in Noakhali district during February, 2015 to April, 2016

Source: Annual Report by OFRD, BARI, Noakhali (2015-16)

From the perception of farmers, the salinity effect started from the month of Poush and it is severd in the month of Falgun to Chiutro. When rainfall started at the month of Boyshak then the salinity started to decrease and no salinity stress found in the month of Ashar to Kartic.



**Graph 11.1.1.3.:** Farmers' perception about rainfall and salinity of the study areas in Noakhali

### **11.1.2. Biological Characteristics**

Biological characteristics concerned with natural vegetation, crops and cropping patterns, diseases, insects and pest of different enterprises being practiced by farmers.

#### **a) Crops and cropping patterns**

Crops and cropping patterns being practiced by farmers at Char Jabbar are different from Kellar Char and Tomoruiddi villages excepting T. Aman. The main crop is T. Aman in the mentioned villages. Non-rice crops such as watermelon, soybean, cowpea, mungbean, etc. are grown at Char Jabbar village. Farmers used pond water and canals for irrigation in watermelon fields. Farmers of Kellar Char and Tomoruiddi villages desired to cultivate diversified crops, mostly cultivated grass pea and linseed after harvesting of T. Aman. At Kellar Char and Tomoruiddi villages, Fallow- Fallow-T. Aman is the dominant cropping pattern (75%) whereas Soybean-Fallow-T. Aman is the dominant cropping pattern at Char Jabbar village followed by Watermelon-Fallow-T. Aman. The cropping intensity (CI) of the Kellar Char and Tomoruiddi villages are 138% and 127%, respectively. The cropping intensity of Char Jabbar village was higher (187%) compared to other two sites due to diversified *Rabi* crops are grown.

#### **b) Livestock**

Cattle, chicken, duck are being reared by all the villagers as mentioned above. Sheep and Buffalo are reared at Kellar char. Buffalo also reared by the Tomoruiddi villagers.

#### **c) Plantation and vegetables**

Vegetables are mainly grown around the periphery of the homesteads at all villages. Generally, country bean with local varieties was cultivated at homesteads or roadsides by the villagers of the sites.

#### **d) Pests and diseases**

Different types of insects such as stem borer, leaf roller, brown plant hopper, rice bug and gall midge infested in T. Aman rice. In case of diseases, leaf blast and leaf blight infestation were mentioned by the farmers as common diseases in T. Aman rice. However, farmers of Char Jabbar villages experienced root rot and bacterial wilt infestation in watermelon crop.

#### **e) Crop calendar**

The main cropping pattern of the Kellar Char and Tomoruiddi villages is Fallow-Fallow-T. Aman (local variety -Rajashail, Kajalshail, Sadamota, etc.), covering on an average more than 90% of the T. Aman area. BRRI dhan40, BRRI dhan52, Sharna, Hori are being cultivated by Char Jabbar farmers. Cropping patterns based crop calendars were presented as follow (Picture 11.1.2.1. to Picture 11.1.2.3.).

crops	Months												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
T. Aman													
Relay Grass pea													
Linseed													

Picture 11.1.2.1.: Crop Calendar of Kellar Char village, Companigonj in Noakhali during 2016-17

crops	Months												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
T. Aman													
Relay Grass pea													
Linseed													

Picture 11.1.2.2.: Crop Calendar of Tomoruddi village, Hatiya in Noakhali during 2016-17

crops	Months												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
T. Aman													
Boro rice													
Soybean													
Watermelon													
Relay Grass pea													
Cowpea													
Mungbean													

Picture 11.1.2.3.: Crop Calendar of Char Jabbar village, Subarnachar in Noakhali during 2016-17

### 11.1.3. Socio-economic characteristics

#### a) Household and Their Characters

Details of household characteristics and farm size of all sample farmers in the study areas were presented in the tabular form (Table 11.1.3.1.). It was evident from Table that percent of small farmers were high in all three locations whereas number of medium farmers were higher at Char Jabbar village compared to other two villages sample farmers. On the other hand, percent of marginal farmers were high at Kellar Char and Tomoruddi village which were 36.11 and 27.50%, respectively. Most of the farmers reported that lands became saline during *Rabi* season which coupled with household characteristics transformed the peoples as “unfavorable natural resources holder poor farmers”. Likewise, unusual natures of land tenure system was prevailed in the study sites. Among the farmers most of them were leaseholders or tenant farmers. Even landless farmers cultivated most of the land by means of rented/leased/caretaker locally known as “Bhaga”/“Borgha”.

**Table 11.1.3.1.:** Household characteristics and farm size of all sample villages in Noakhali, 2017

Farm size	% of total Sampled farmers			Characteristics of different group of people
	Kellar Char (N=36)	Char Jabbar (N=40)	Tomoruddi (N=40)	
Large	5.56 (2)	12.50 (5)	7.50 (3)	More than 500 decimals land, Average land holding is 692 dec
				Education level is comparatively high (literacy rate is about 100%)
				Asset ownership: have power tiller, water pump, Motor bike, Bi-cycle, Mobile phone, Pucca house to semi pucca house etc.
				Most of them have small business (agricultural input, commodities, etc.)
Medium	19.44 (7)	27.50 (11)	15 (6)	251-500 decimals (less than 15% operated other peoples land)
				Average land holding is about 347 dec
				Education level is lower than large farmer (Literacy rate is about 85%)
				Asset ownership: Some of the farmer have Bicycle, TV, mobile phone, Spray machine, Kutcha house with tin sheet roof (more than 70%) and a few of them have semi Pucca house
Small	27.78 (10)	37.50 (15)	40 (16)	100-250 decimal (about 80% operated landlords land), Average landholding is about 134 dec
				Literacy rate is about 45%
				Asset ownership: Some of them have Bicycle (30%), Kutcha house with straw roof (about 60%) but Kutcha house with tin sheet roof (about 40%)
				Seasonal migration observed in few of the sample farmers (less than 30%), few of the family members worked as agricultural and non-agricultural labor
Marginal	36.11 (13)	17.50 (7)	27.50 (11)	Less than 100 decimal (About 85% operated landlords land who lives outside the village mainly in the city), average landholding is about 79 dec
				Literacy rate is about 40%
				Asset ownership: A few of them have mobile phone and bicycle, all most all of them have Kutcha house
				Rate of seasonal migration is high as compared to small group of farmers, other family members worked as day labor in nearby areas as agricultural and non-agricultural labor
Landless /Laborer	11.11 (4)	5 (2)	10 (4)	No agricultural land except homestead area, average landholding is 6.4dec, some of them operated landlords land (more than 60%)
				No assets at all (few of them have mobile phone), Most of them are illiterate
				Migration of effective male family members are highest

Note: Figures in parenthesis indicate number of farmers attend in PRA session

#### b) Family Size

The average family size of the responded farmers of Kellar Char was 7.5 person while 6.3 person at Char Jabbar and 7.2 person at Tomoruddi village. Female family members were higher than the male

members in all the villages (Table 11.1.3.2.). Among the responded family members, the effective family members were 59, 56 and 67 % at Kellar Char, Char Jabbar and Tomoruddi villages, respectively.

**Table 11.1.3.2.:** Family size and effective family member of respondent farm family of the study villages

Location	Family size (no.)			Effective family member (no.)
	Male	Female	Total	
Kellar Char (N= 36)	3.5	4	7.5	2.0
Char Jabbar (N= 40)	2.9	3.4	6.3	1.5
Tomoruddi (N= 40)	3.3	3.9	7.2	1.65

### c) Dirking and Irrigation Water Sources

The sampled areas are non-irrigated areas where farmers used ponds and canals water during Rabi season as supplementary irrigation. However, a little surface water were remained from the month of January to March. Only twenty percent (20 %) ponds retained water during the month of December to March for supplementary irrigation in limited areas. There was no use of deep and shallow tube-well in the area of Kellar Char and Tomoruddi villages since the lifted water remains saline. The main sources of drinking water of the study villages were tube wells. Most of the farmers from Kellar Char and Tomoruddi reported that they have to collect drinking water from others people tube wells. Sometimes women or children have to walk more than 1 or 2 Km for collecting drinking water during dry season.

### d) Input-Output Relationship

For crops production input-materials were not available in the area. Farm inputs like seeds, fertilizers, pesticides etc. were bought from seed and fertilizer dealers. Sometimes they stored their seed for their own use. About 62 to70 % of the local production was sold in the local market and in “Dadon” (borrows money with high rate of interest from Mohajon) system. Conversely, only 30 to 38 % was used for home consumption. Farmers were usually sold their livestock and poultry products during the local “Hat’ day or to neighbors and also to “Faria”.

### e) Information on major crops cultivated by the farmers

Farmers of Kellar Char and Tomoruddi villages cultivated local T. Aman varieties as they believed that these varieties are being more tolerant to salinity as compared to HYV varieties. Moreover, farmers were not aware about modern salt tolerant rice varieties.

**Table 11.1.3.3.:** Information of different crops cultivated by the farmers at the sampled villages

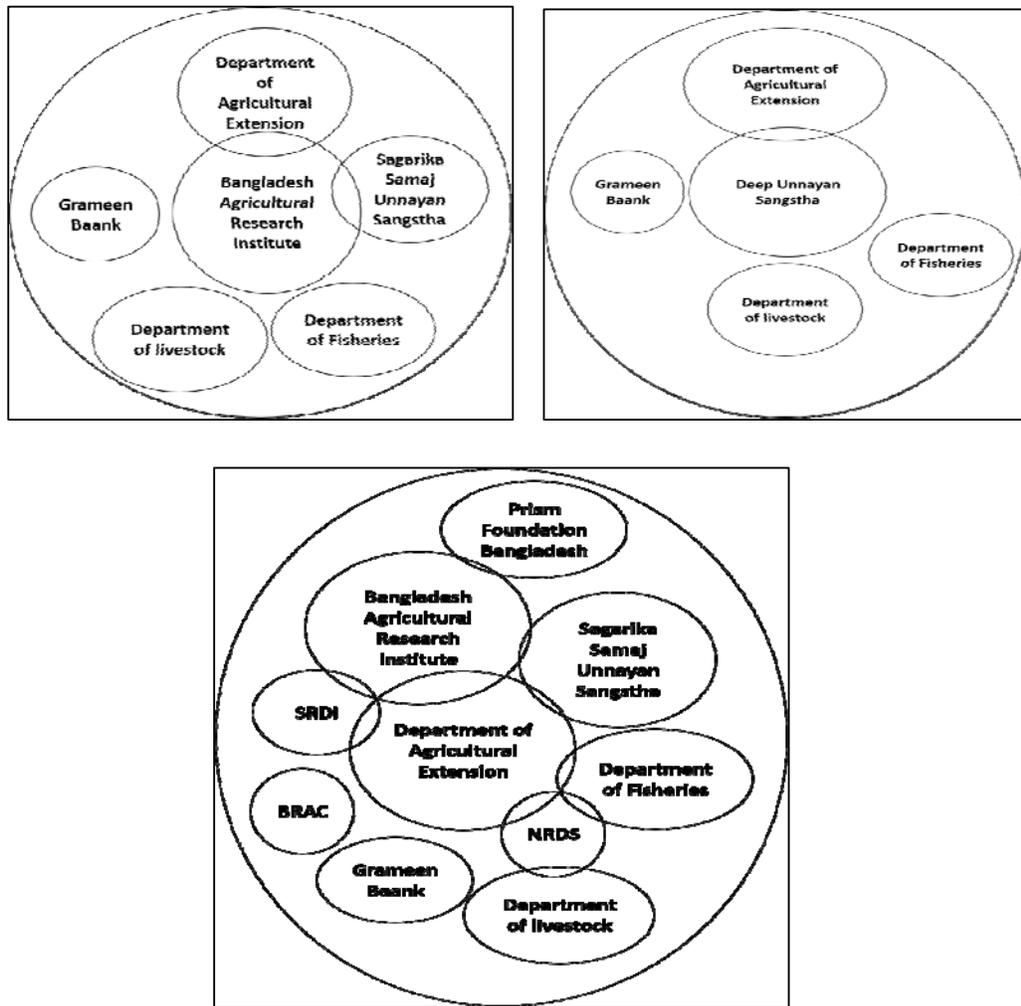
Crops	Kellar Char			Char Jabbar			Tomoruddi		
	Variety	Yield (t ha <sup>-1</sup> )	Price (Tk. t <sup>-1</sup> )	Variety	Yield (t ha <sup>-1</sup> )	Price (Tk. t <sup>-1</sup> )	Variety	Yield (t ha <sup>-1</sup> )	Price (Tk. t <sup>-1</sup> )
T. Aman	Rajashail, Kajalshail, Sadamota	1.97	39,400	BRRI dhan40, BRRI dhan52, Sharna, Hori	2.54	55,880	Rajashail, Kajalshail, Sadamota	1.53	30,600
Grass pea	Local	0.63	15,750	Local	0.69	17,250	Local	0.72	18,000
Cowpea	-	-	-	Local	0.92	32,200	-	-	-
Mungbean	-	-	-	Sona mung	0.74	40,700	-	-	-
				BARI Mung-5	0.97	43,650			
Soybean	-	-	-	Shohag	1.46	36,500	-	-	-
				BARI Soybean-5	1.82	45,500			
Watermelon	-	-	-	Glory, Jumbo	22	1,32,000	-	-	-
Linseed	Local	0.76	30,400	-	-	-	Local	0.79	31,600

[Price (Tk/kg): T. Aman (local) = 20, T. Aman (HYV) = 22, Grass pea = 25, Cowpea = 35, Mungbean (sona mung) = 55, Mungbean (BARI Mung-5) = 45, Soybean (all varieties) = 25, Linseed = 40, watermelon = 6]

On the other hand, farmers of Char Jabbar cultivated HYV varieties due to information shared by the DAE and other agricultural organizations operated in their locality. Farmers of all villages were motivated to cultivate diversified salt tolerant crops if the seed and inputs were offered.

**f) Venn diagram**

The role of different organizations in the Socio-economic development of the sampled villages was also reflected in the Venn diagram. The size of the circle indicated degree of involvement in the study area i.e. the bigger the circle, the superior operation involvement, while the overlaps indicated working relationships between/among institutions. The Bangladesh Agricultural Research Institute (BARI) played a vital role in agricultural development of Kellar Char and Char Jabbar (Picture 11.1.3.1.). The organizations engaged in the socio-economic development at the sampled areas were DAE, BARI, SRDI, DL, DF, BRAC, Sagarika Samaj Unnayan Sangstha (SSUS), Deep Unnayan Sangstha (DUS), and Prism Foundation Bangladesh (PBF) etc.



**Picture 11.1.3.1.:** Venn diagram on organizations involvement at (a) Kellar Char village (b) Tomoruddi village (c) Char Jabbar village in Noakhali district during 2016-17

#### 11.1.4. Problem Identification and Prioritization

During PRA exercise, the team were attempted to understand and identify problems/constraints faced by farmers in the farm production systems. Farmers of the three villages mentioned almost similar type of constraints related to the improvement of farm productivity and income. In general, farmers mentioned as many as 18 constraints (Table 11.1.4.1.). Farmers of Kellar char and Tomoruiddi village mentioned river bank erosion, intrusion of saline water and soil salinity were the main problems for agricultural production whereas farmers of Char Jabbar village mentioned erratic rainfall, water logging during *Kharif II* season and lack of quality irrigation water as main. They also mentioned that sometimes too much rain which created water logging conditions and sometimes little or no rainfall created



drought conditions during T. Aman cultivation season. Moreover, early rainfall during crop harvesting period (*Rabi* crops) were now a days common phenomena of the locality. Though soil salinity ranked differently among the villagers yet it was an important issue for dry season cropping at Kellar Char and Tomoruiddi villages. Farmers' opined that since there is embankment no saline water intrusion occurred as a result salinity will be decreased over time.

Picture 11.1.4.1.: Problem identification and voting by farmers

Table 11.1.4.1.: Matrix of problems ranking by the sampled farmers during PRA exercise

Problems	Rank		
	Kellar Char	Char Jabbar	Tomoruiddi
Intrusion of saline water	3	-	2
Lack of quality irrigation water	4	3	6
Lack saline tolerant crops and varieties	9	12	7
Lack of capital	8	8	9
Improved crop variety	10	11	13
Lack of modern technology and technical knowledge	7	6	8
Insect & diseases	-	7	12
Communication	6	-	10
Market price and marketing	11	10	14
Water logging during <i>Kharif II</i>	-	2	-
Soil Salinity	1	5	3
Availability of quality Fertilizer	-	12	11
Unavailability of proper insecticide	-	13	15
Labor scarcity and High labor wages	-	4	16
Absence of Embankment	5	-	5
Lack of agricultural machinery	-	9	-
Erratic rainfall	10	1	4
River bank erosion	2	-	1

## 11.2. Diversity Kit and Diversity fair

Diversity kits include small quantities of seeds or saplings of different kinds made available to farmers to complement the available resources (Sthapit *et. al.*, 2006). The basic idea of the diversity kit is to deploy the diversity, giving priority to neglected, underutilized, rare and unique crop varieties and species, increasing community access to seed and knowledge, and promoting biodiversity conservation through use (Shrestha *et. al.*, 2013). In this regard, Varieties and lines of targeted underutilized crops were collected from different organization for evaluating their performance along with the local land races to develop Diversity kit (Table 11.2.1). A total of fifteen (15) varieties included exotic variety, eight (08) advanced line, twenty (20) Germplasms and nine (09) cultivars of six (06) underutilized crops were collected from different Research Organizations and farmers (Table 11.2.1.). After selecting target farmers, “Diversity Fair” was organized at all three (03) locations among thirty (30) co-operating and neighboring farmers in each location to create awareness on several issue such as- underutilized crops provide economic benefits, underutilized crops need low cost for cultivation, some underutilized crops can tolerate salinity and drought, underutilized crops have less disease and insect infestation etc.. Local



varieties and improved varieties/ lines of target underutilized crops were included for motivating the community for managing seeds in the changing climatic conditions.

**Picture 11.2.1:** Diversity kit and Diversity fair organized among the farmers

**Table 11.2.1.:** Overview of UC genotypes included in developing “Diversity Kit” as well as for RPVS trials

Name of the Crops		Entities (Varieties/Lines/Germplasms/ Cultivars)	Sources
Barley	Varieties (07)	BARI Barley-1, BARI Barley-2, BARI Barley-3, BARI Barley-4, BARI Barley-5, BARI Barley-6, BARI Barley-7	PBD, BARI, Gazipur
	Advanced Lines (05)	BHL-15, BHL-19, BHL-25, BHL-26, BHL-27	
	Cultivar (01)	Bandarban Local	OFRD, Bandarban
Foxtail millet	Varieties (03)	BARI Kaon-1 (Titas), BARI Kaon-2, BARI Kaon-3	PBD, BARI, Gazipur
	Advanced Lines (02)	ISC-375, ISC-376	
	Germplasms (15)	BD-927, BD-928, BD-930, BD-931, BD-932, BD-934, BD-944, BD-945, BD-948, BD-959, BD-984, BD-1057, BD-1059, BD-1074, BD-1077	PGRC, BARI, Gazipur
	Cultivars (02)	Noakhali Local and Bandarban Local	OFRD, Noakhali & Bandarban
Proso millet	Varieties (01)	BARI Cheena-1 (Tushar)	PBD, BARI, Gazipur
	Cultivars (03)	Cheena (Kalo), Cheena (Sada), Cheena (Lal)	OFRD, BARI, Bandarban
Sorghum	Varieties (01)	Green Grand-1 (Exotic)	BLRI, Savar
	Advanced Lines (01)	IS-19153	PBD, BARI, Gazipur
	Germplasms (05)	BD-710, BD-732, BD-738, BD-740, BD-4659	PGRC, BARI, Gazipur
Safflower	Variety (01)	BARI Saf-1	ORC, BARI, Gazipur
Linseed	Variety (01)	BARI Tishi-1 (Nila)	OFRD, BARI, Noakhali
	Cultivars (03)	Local cultivars from Noakhali, Patuakhali, Zokigonj	OFRD, BARI, Patuakhali OFRD, BARI, Sylhet

### **11.3. Researcher led Participatory Varietal Selection (RPVS) Trials**

In the study, researcher led or managed PVS trials on underutilized crops were conducted where selected farmers were given seeds of underutilized crops to test in their own fields. In such case, farmers were supported by the researcher on various issues such as agronomic management, use of IPNS and IPM approaches, yield data collection and causes of tested materials preference identifications. Researchers have used seeds that have already been released and might also be 'pre-release' material at an advanced stage of testing or kept as germplasms or locally cultivating varieties not only from the target areas but also from other areas of the countries. The following section were described the results obtained from RPVS trails conducted at cooperative farmers' fields during the *Rabi* season of 2017-18.

#### **11.3.1. Participatory Variety Selection in Barley crop**

Barley (*Hordeum vulgare* L.) is the fourth most important cereal crop after wheat, rice and maize. It is believed to be the first cereal crop that was domesticated by humans nearly 10,500 years ago in the Middle East. It is one of the most salt tolerant major crops and is highly adaptable to varied growing conditions and consequently planted in a wide range of areas including the marginal lands (Shahid and Jaradat, 2013). Considering the climate change and properties of Barley crop, a total of seven (07) varieties and five (05) advanced lines and one (01) cultivar (not germinated) were tested in the participatory varietal trials. The growth stages of Barley crops were given below:

**Growth Stage I (GSI): Emergence Stage (10-12 DAS)**

**Growth Stage II (GSII): Tillering Stage (25 to 30 DAS)**

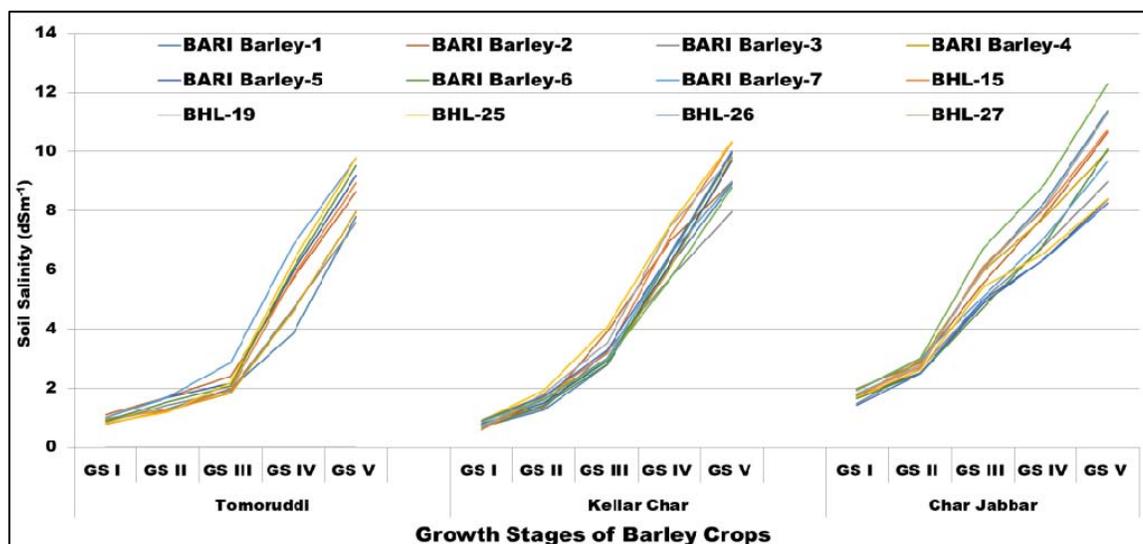
**Growth Stage III (GSIII): Stem Extension Stage (40 to 45 DAS)**

**Growth Stage IV (GSIV): Heading Stage (60 to 70 DAS)**

**Growth Stage V (GSV): Ripening Stage (90-105 DAS)**

#### **Soil Salinity Level at experimental fields of barley crop**

Barley is among the most tolerant crop plants under salinity stress, however, under the higher levels of salinity, its growth and yield production decreases (Jamshidi and Javanmard, 2017). However, the soil salinity levels were varied due to nature of soil salinity progression within different locations or even in the same locations within few meters. Soil salinity was low at Tomoruddi and Keller Char sites during Emergence Stage (10 to 12 days after sowing) because of rainfall (72 mm) occurred during 6 to 10 December, 2017. At Tomoruddi site, salinity ranged from 0.78 to 1.1 dS m<sup>-1</sup> whereas it was 0.63 to 0.92 dS m<sup>-1</sup> at Keller char site. However, commencing from January, EC started to increase and reached the peak (7.6 to 9.79 dS m<sup>-1</sup> at Tomoruddi; 7.97 to 10.34 dS m<sup>-1</sup> at Keller Char) at the time of harvesting. At Char Jabbar village, soil salinity levels were ranged from 1.43 to 1.98 dS m<sup>-1</sup> during emergence stage which was almost twofold compared to other two sites soil salinity level at same time. According to earlier research on effect of salinity on germination of different cops showed that increasing salinity decreased percent germination in wheat, barley and triticale (Alka *et. al.*, 1981; Iqbal *et. al.*, 1998). Moreover, during heading stage soil salinity was above 6 dS m<sup>-1</sup> in all varieties and lines at Kellar Char and Char Jabar sites whereas it was below 6 dS m<sup>-1</sup> in BARI Barley- 6 and below 6.5 dS m<sup>-1</sup> in BARI Barley-7 and other advanced line plots. However, the salinity levels were ranged from 8.39 to 12.31 dS m<sup>-1</sup> at Char Jabbar during harvesting stage.



**Graph 11.3.1.1.:** Soil Salinity levels according to growth stages of Barley at different sites during *Rabi* Season of 2017-18

**Yield and Farmers Preference:** Among the tested varieties, BARI Barley-6 produced superior yield under saline conditions compared to other varieties/lines. It may be fitted into the cropping pattern such as Fallow-Fallow-T. Aman. Furthermore, the results revealed that the mean grain yield among tested varieties ranged from 0.83 (BARI Barley-3) to 1.21 t ha<sup>-1</sup> (BARI Barley-6). Among the lines, BHL-15 produced higher yield (1.09 t ha<sup>-1</sup>) which required longer time (99 days) to mature in comparison to the varieties with similar yield like as BARI Barley-4 (1.10 t ha<sup>-1</sup>) which required 95 days to mature. According to the yield potential (KRISHI PROJUKTI HATBOI, 5th Edition), BARI Barley-4 and BARI Barley-6 can produce 1.75 to 2.0 t ha<sup>-1</sup> and 2 to 2.20 t ha<sup>-1</sup> in saline area, respectively.

**Table 11.3.1.1.:** Days to maturity, yield and farmers' rankings of barley varieties/lines at three sites in previous year fallow medium high lands of Noakhali district during *Rabi* season of 2017-18

Varieties/Lines	Days to maturity	Grain yield (t ha <sup>-1</sup> )	Farmers Preference	Final Ranking
BARI Barley-1	95	1.05	2 (GY, EM)	5
BARI Barley-2	94	0.87	9 (MS)	11
BARI Barley-3	91	0.89	11 (MS)	10
BARI Barley-4	95	1.10	6 (GY, EM, ST, LD)	2
BARI Barley-5	92	0.83	12 (MS)	12
BARI Barley-6	97	1.21	1 (MT, GY, ST, LR, LD)	1
BARI Barley-7	95	1.03	3 (GY, EM, LR, HL)	6
BHL-15	99	1.09	7 (GY, MT, ST, HL)	3
BHL-19	95	1.01	8 (GY, HL)	8
BHL-25	101	1.02	4 (GY, ST, HL)	7
BHL-26	96	0.99	10 (GY, HL)	9
BHL-27	99	1.06	5 (GY, HL, MT)	4

Note: MT= More Tillering, GY = Grain Yield, EM = Early Maturity, ST = Salinity tolerance, LR = Lodging Resistant, LD = Less Diseases, HL= Hurl less, MS = More Susceptible

Besides yield, all the varieties matured early in comparison to normal conditions (110 to 115 days) which was an indication of salt stress on the crop. It is notable that higher yields were accompanied by higher number of effective days required for grain filling. Based on direct matrix ranking evaluation,

farmers identified BARI Barley-6 as the best due to a number of criteria such as more tillering, grain yield, salinity tolerance, lodging resistant and less diseases.



**Picture 11.3.1.1.:** Participatory Variety Selection Trials (PVS) in Barley at different sites of Noakhali district during *Rabi* Season of 2017-18



**Picture 11.3.1.2.:** Evaluation of Barley genotypes by farmers and concerned stakeholders during Beauty Contest at different locations during *Rabi* season of 2017-18

### 11.3.2. Participatory Variety Selection in Foxtail millet

Foxtail millet (*Setaria italica*) is thought to be native to Southern Asia and is considered one of the oldest cultivated millets (Oelke *et. al.*, 1990). It can grow in sandy to loamy soils with pH from 5.5-7. It has a high level of tolerance to salinity (Krishnamurthy *et. al.*, 2014). The seedheads of foxtail millet are dense and bristly (Cash *et. al.*, 2002) and the oval, convex seed grain can be a variety of colors. Although, Foxtail millet is being a widely grown as Rainfed cereal crop in the greater Noakhali districts, either mixed crop with soybean and groundnut or as sole crop (in limited cases). The growth stages of Foxtail millet can be broadly divided into three growth stages:

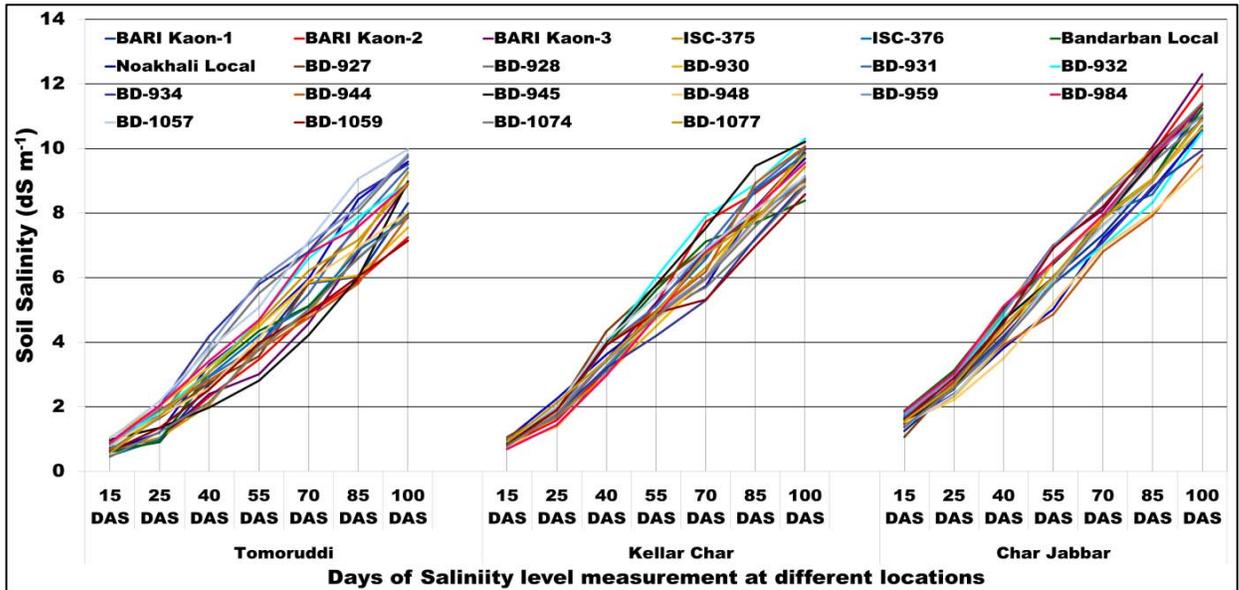
**Growth Stage I (GSI): Sowing to Panicle Differentiation (up to 35 DAS)**

**Growth Stage II (GSII): Panicle Initiation to Floral induction (35-65 DAS)**

**Growth Stage III (GSIII): Flowering to Grain maturity (65 -100 DAS)**

**Soil Salinity Level at experimental fields of Foxtail millet crop:** The soil salinity levels were different for different varieties or lines observed at different locations or even in same locations within few meter. However, soil salinity was low at Tomoruddi and Kellar Char village sites during Emergence Stage (up to 35 DAS) because there was rainfall (72 mm) during 6 to 10 December, 2017. At Tomoruddi, salinity ranged 0.48 to 1.04 dS m<sup>-1</sup> whereas it was 0.72 to 1.01 dS m<sup>-1</sup> at Kellar Char. However, commencing from January, EC started to increase and reached the peak (7.15 to 9.98 dS m<sup>-1</sup> at Tomoruddi; 8.39 to 10.31 dS m<sup>-1</sup> at Kellar Char) at grain maturity stage (100 DAS). Due to early sowing at Tomoruddi sites, soil salinity levels were low (below 6 dS m<sup>-1</sup>) from GSI (panicle differentiation) to GSII (Panicle Initiation to Floral induction) stage which enabled majority of the tested varieties/lines/Germplasm to avoid

adverse effect soil salinity. In case of soil salinity at Kellar Char site, it was below 4 dS m<sup>-1</sup> during GSI whereas it was above 6 dS m<sup>-1</sup> during late GSII stage at most of the tested varieties/lines/Germplasms and ultimately hampered panicle initiation and floral induction. However, soil salinity levels were ranged from 1.25 to 1.88 dS m<sup>-1</sup> during emergence stage as sowing was delayed nearly 35 to 40 days (11 January, 2018) at Char Jabbar village compared to other two villages. During mid to late GSII stage, soil salinity started to increase above 6 dS m<sup>-1</sup> in most of the tested varieties/lines/Germplasms plots. Furthermore, during grain maturity stage the salinity levels were ranged from 9.45 to 12.3 dS m<sup>-1</sup>.



**Graph 11.3.2.1.:** Soil Salinity levels according to growth stages of Foxtail millet varieties/lines at different sites during *Rabi* Season of 2017-18

**Yield and Farmers Preference:** Results obtained from the study have been presented in Table 11.3.2.1. The yield of Kaon varieties had differences between lines and germplasms. The density of sowing was 60 plants m<sup>-2</sup>. The highest mean yield was observed from BARI Kaon-2 (1.32 t ha<sup>-1</sup>) and the lowest yield was observed from BD-927 (0.76 t ha<sup>-1</sup>). In the coastal area, BARI Kaon-3 (1.17 t ha<sup>-1</sup>) has showed the suitability because early “Kal Boishaki” damaged panicle of BARI Kaon-2. Form farmers’ perception, Noakhali Local cultivars achieved 12<sup>th</sup> position but later on it ranked 20<sup>th</sup> position due to grain yield (0.82 t ha<sup>-1</sup>). Farmers’ from all location preferred BARI Kaon-2 because of its long panicle length, golden colour and more tolerance to salinity compared to other genotypes. The yields of all genotype were low in comparison to their yield potentiality due to adverse effect of salinity during late vegetative (GSI) and mid to late reproductive stage (GSII). Moreover, the soil types were silty clay loam in nature which prevents root growth.

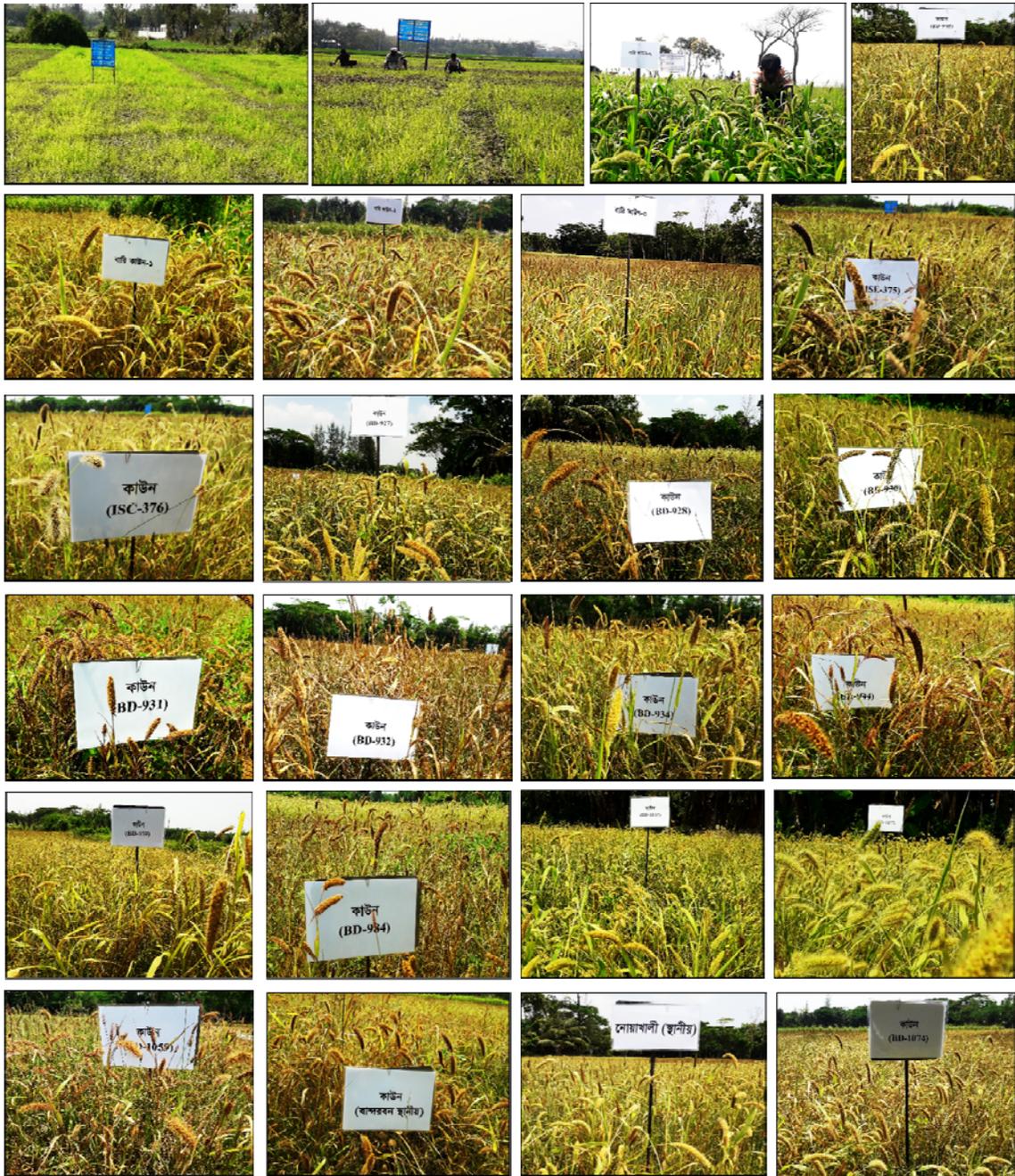
**Table 11.3.2.1.:** Days to maturity, yield and farmers' rankings of Foxtail millet Varieties/Lines/Cultivars/Germplasms at three sites in previous year fallow medium high lands of Noakhali district during *Rabi* season of 2017-18

Varieties/Lines/Germplasms	Days to maturity	Grain yield (t ha <sup>-1</sup> )	Farmers' Preference	Final Ranking
BARI Kaon-1	105	1.09	6 (GY, ST)	4
BARI Kaon -2	108	1.32	1(PL, GY, ST)	1
BARI Kaon-3	102	1.17	3 (D, GY,ST, GC)	2
ISC-375	99	1.08	9 (D, GY, GC)	5
ISC-376	101	1.11	7 (D, GY, GC)	3
Bandarban Local	95	0.76	19 (MS)	21
Noakhali Local	109	0.82	12 (MT)	20
BD-927	107	0.76	22 (MS)	22
BD-928	104	0.95	14 (GY)	13
BD-930	106	0.92	10 (GY)	15
BD-931	114	0.97	8 (GY)	11
BD-932	109	0.91	15 (GY)	16
BD-934	107	0.98	11 (GY)	10
BD-944	106	0.84	21 (MS)	19
BD-945	116	0.88	16 (GY)	18
BD-948	113	0.92	17 (GY)	14
BD-959	103	0.89	13 (GY)	17
BD-984	114	1.01	18 (MS)	7
BD-1057	108	1.02	2 (D, GY,ST)	6
BD-1059	106	0.97	20 (MS)	12
BD-1074	112	1.01	4 (D, GY)	8
BD-1077	114	1.00	5 (D, GY)	9

Note: PL=Panicle Length, GY=Grain Yield, D=Dwarfness, ST=Salinity tolerance, GC= Grain Colour, MS = More Susceptible



**Picture 11.3.2.1.:** Evaluation of Foxtail millet varieties/Advanced lines/Cultivars/Gerplasms by farmers and concerned stakeholders during Beauty Contest at different locations during *Rabi* season of 2017-18



**Picture 11.3.2.2.:** Pictorial view of Participatory Variety Selection Trials (PVS) in Foxtail millet at different sites of Noakhali district during *Rabi* Season of 2017-18

### 11.3.3. Participatory Variety Selection in Proso Millet

Proso millet can be grown on sandy loam, slightly acidic, saline, and low-fertility soils (Riley *et al.*, 1989; Changmei and Dorothy, 2014). Growth and development characteristics of Proso millet have been explained in detail in three phases.

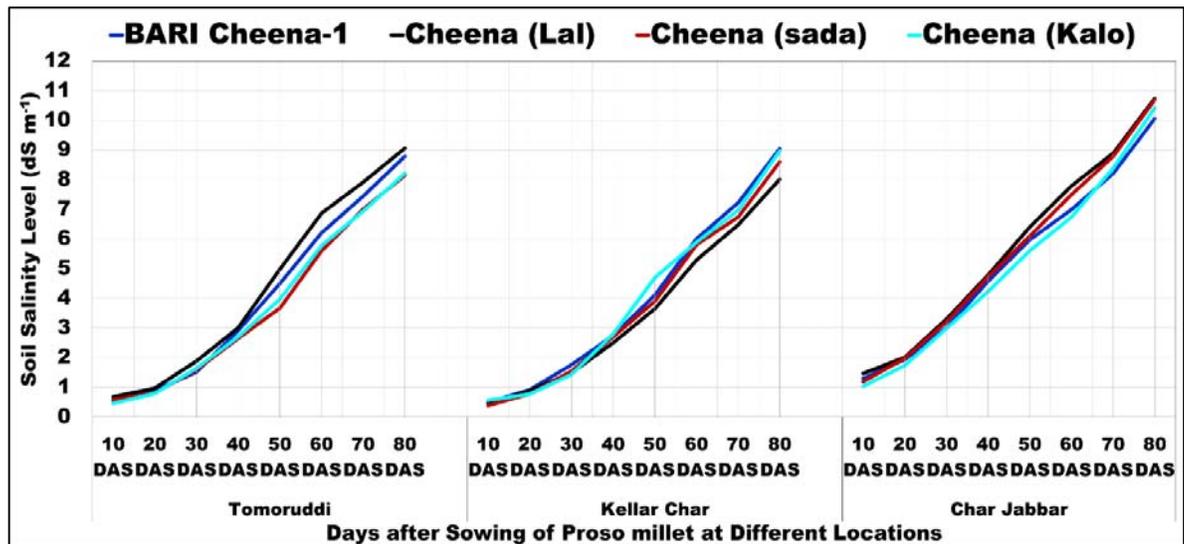
**Growth Stage I (GSI): Vegetative phase (germination to panicle initiation -15 to 25 DAS)**

**Growth Stage II (GSII): Reproduction phase (panicle differentiation to flowering - 26 to 50 DAS)**

**Growth Stage III (GSIII): Ripening phase (physiological maturity-51to 885 DAS)**

All the growth stages are highly dependent on the climatic conditions and area as well as varietal characteristics of the tested materials.

**Soil Salinity Level at experimental fields of Foxtail millet crop:** Soil salinity was low in the experimental sites after 20 days of sowing at Tomoruddi and Kellar Char villages whereas it was near about 2 dS m<sup>-1</sup> at Char Jabbar village due to late sowing compared to other sites. Moreover, during reproductive phase salinity levels ranged from 2.65 to 4.98 dS m<sup>-1</sup> at early sowing sites and it were 4.24 to 6.41 dS m<sup>-1</sup> at char Jabbar site which hampered yields of all tested materials. After reproductive phase, soil salinity levels were below 9 dS m<sup>-1</sup> at Tomoruddi and Kellar char villages where moderate yields were observed compared to the varieties yield potential. On the other hand, soil salinity progressively increased after reproductive phase at Char Jabbar sites and it were 10.01 to 10.75 dS m<sup>-1</sup> (during harvesting time). In this site, shattering of three cultivars were observed and it was high in Cheena (kalo) which may be due to salinity or maturity start from lower side of the panicle to upper side.



**Graph 11.3.3.1.:** Soil Salinity levels according to growth stages of Proso millet Variety/Cultivars at different sites during *Rabi* Season of 2017-18

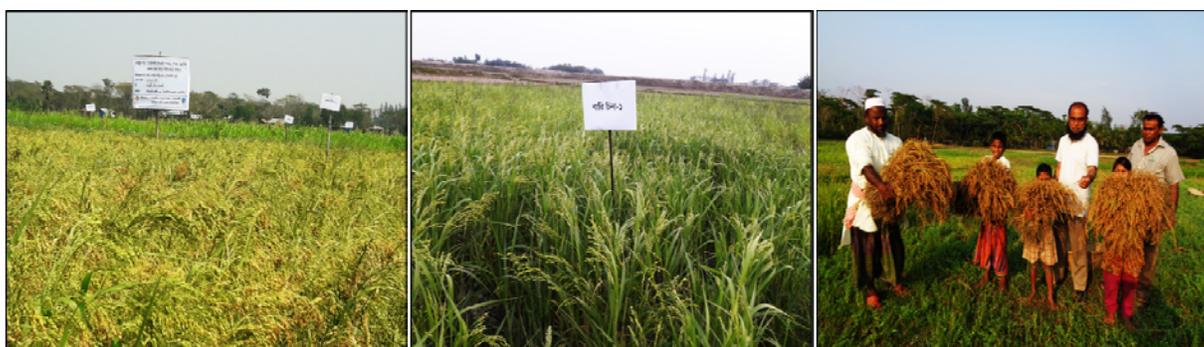
**Yield and Farmers Preference:** The trial result revealed that the highest (1.25 t ha<sup>-1</sup>) yield was found from BARI Cheena-1 and the lowest yield (0.67 t ha<sup>-1</sup>) from Cheena (kalo) which was collected from Bandarban district through OFRD, BARI, Bandarban. The yields of three cultivars were low as compared to BARI Cheena-1 due to may be those varieties are not capable to uptake nutrient from saline soil or less adaptability in low elevation as all the cultivars are collected from hilly areas. In all the locations,

farmers' preferred BARI Cheena-1 due to its higher yield, less shattering and more tolerance to salinity (Table 11.3.3.1.). Farmers were very much happy by observing saline escaping capabilities of Proso millet before the salinity reached peak levels which helped them to cultivate the crops in the saline soils with minimum inputs.

**Table 11.3.3.1.:** Days to maturity, Yield and farmers' preferences of Proso Millet variety/cultivars at different sites of Noakhali during *Rabi* season of 2017-18

Crop	Days to Maturity	Yield (t ha <sup>-1</sup> )	Farmers' Preference	Final Ranking
BARI Cheena-1	83	1.25	1(MT, EM, GY, LS)	1
Cheena (Sada)	82	0.89	3 (EM, LS)	3
Cheena (Lal)	84	0.99	2 (MT,GY)	2
Cheena (Kalo)	82	0.67	4 (GC, EM)	4

Note: MT= More Tolerance, EM= Early Maturity, GY=Grain Yield, GC= Grain Colour, LS= Less Shattering



**Picture 11.3.3.2:** Participatory Variety Selection Trials (PVS) in Proso millet at different sites of Noakhali district during *Rabi* Season of 2017-18

#### 11.3.4. Participatory Variety Selection in Sorghum

Sorghum (*Sorghum bicolor*) is the fifth most important cereal crop of the world belonging to Gramineae family. It is a C<sub>4</sub> plant with higher photosynthetic efficiency and higher abiotic stress tolerance (Nagy *et. al.*, 1995; Reddy *et. al.*, 2009). Sorghum goes through three distinct stages of development after emergence- vegetative, reproductive, and ripening, which may be further sub-divided into physiologically distinct stages:

**Growth Stage I (GS I): Three Leaf Stage (10 to 15 days after emergence)**

**Growth Stage II (GS II): Five Leaf Stage (20 to 25 days after emergence)**

**Growth Stage III (GS III): Growing Point Differentiation (30 to 35 days after emergence)**

**Growth Stage IV (GS IV): Final Leaf Visible in the Whorl (35 to 45 days after emergence)**

**Growth Stage V (GS V): Boot Stage (45 to 55 days after emergence)**

**Growth Stage VI (GS VI): Flowing Stage (55 to 65 DAE)**

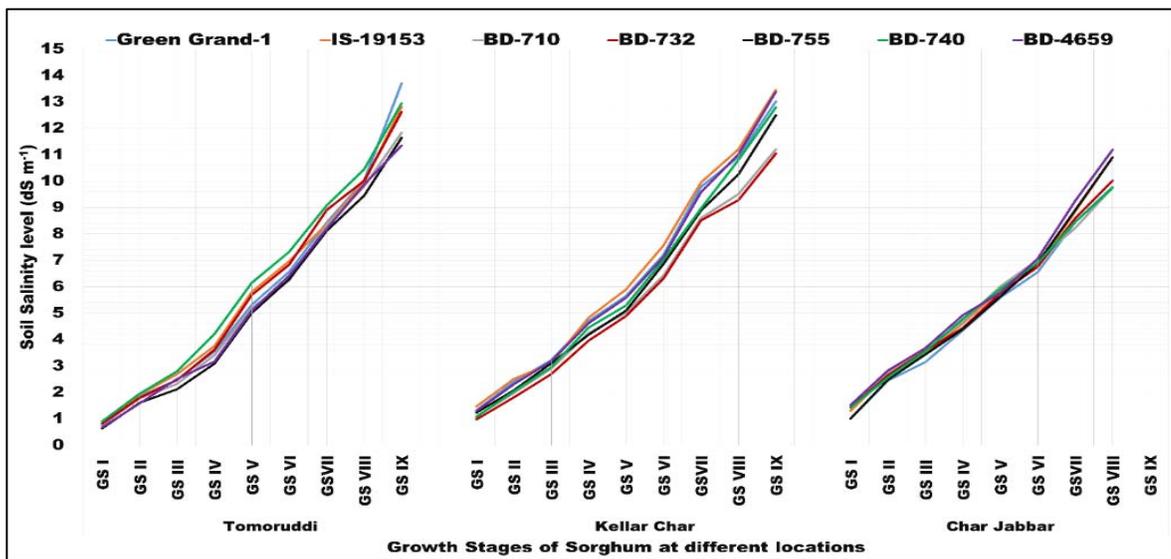
**Growth Stage VII (GS VII): Soft Dough Stage (65 to 80 DAE)**

**Growth Stage VIII (GS VIII): Hard Dough Stage (80 to 95 DAE)**

**Growth Stage IX (GS IX): Physiological Maturity (95 to 125 DAE)**

**Soil Salinity Level at experimental fields of Foxtail millet crop:** Soil salinity of the experimental plots at different locations ranged differently according to the nature of the salt accumulation near root zones through capillary movement. However, salinity levels were below 1 dS m<sup>-1</sup> at Tomoruddi site during GSI

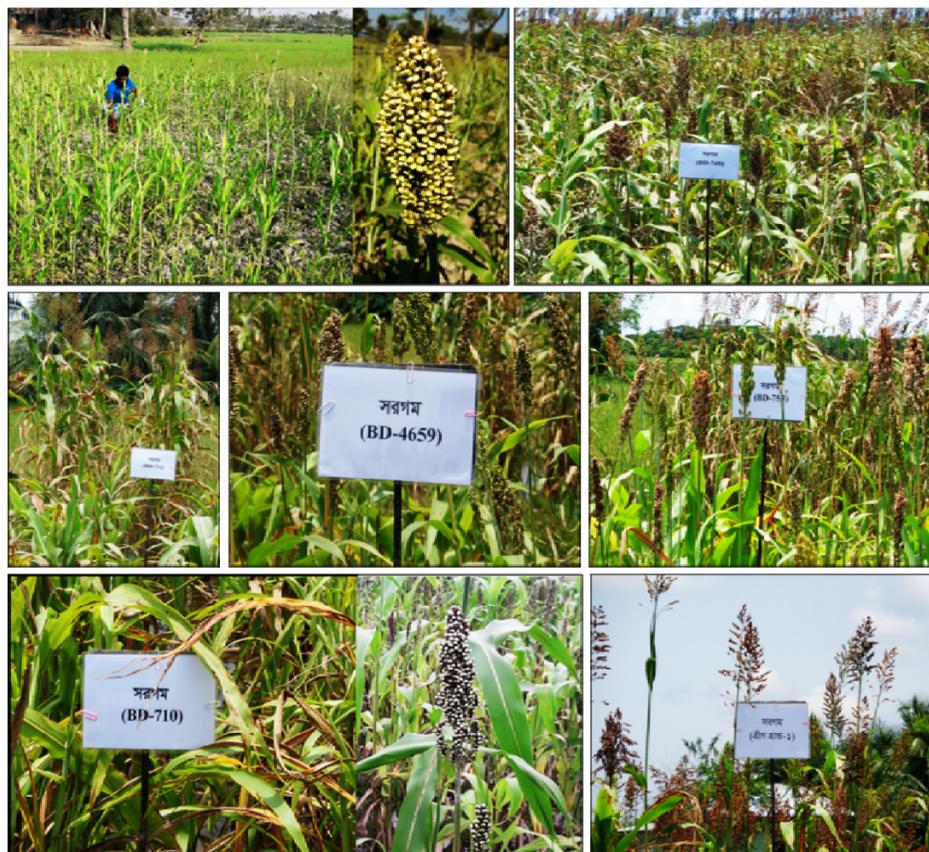
stage whereas it ranged from 0.98 to 1.49 dS m<sup>-1</sup> and 1.01 to 1.52 dS m<sup>-1</sup> at Kellar Char and Char Jabbar sites, respectively. It is notable that Salinity causes more serious damage in the seedling emergence stage than in any other stage in sorghum (Macharia *et. al.*, 1994). In our PVS trial, salinity levels were far below than threshold levels which had no effect on emergence as well seedling establishment. Although, the best way to screen large number of genotypes is planting them in fields with high salinity (with an average EC<sub>e</sub> of 10 dS m<sup>-1</sup> or more) and select for desirable agronomic traits and salinity tolerance (Reddy *et. al.*, 2010). Furthermore, soil salinity remained below 4 dS m<sup>-1</sup> except the plots contained BD-740 entity (4.21 dS m<sup>-1</sup>) during last phase of vegetative (GS IV) stage at Tomoruiddi site. On the hand, salinity levels were above 4 dS m<sup>-1</sup> during the GS IV stage at other two sites. Afterwards, from booting stage to hard dough stage the progression of the salinity levels were almost identical at Kellar Char and Char Jabbar experimental sites. Salinity data were not possible to record at Char Jabbar during maturity stage because of high rainfall occurred and water stagnant was observed in the fields. Nonetheless, the salinity levels in the best performing advanced lines plots were 12.81, 13.45 and 10.81 dS m<sup>-1</sup> at Tomoruiddi, Kellar Char and Char Jabbar sites, respectively. However, salinity levels at that period in case of other varieties were about 12 dS m<sup>-1</sup> except few Germplasms (11.04 dS m<sup>-1</sup> at BD-755 plot and 11.20 dS m<sup>-1</sup> at BD-732 dS m<sup>-1</sup> plot at Kellar Char) and highest level of salinity was observed in ICS-19153 planted plot followed by BD-4659 contained plot (13.38 dS m<sup>-1</sup>). Similarly, Krishnamurthy *et. al.*, (2003) have identified some elite sorghum varieties and improved lines promising for agronomic traits and also exhibited better salinity tolerance under induced salinity (EC<sub>e</sub> 23.4 dS m<sup>-1</sup>) in a series of pot-culture experiments.



**Graph 11.3.4.1.:** Soil Salinity levels according to growth stages of Sorghum Variety/Advanced lines/ Germplasms at different sites during *Rabi* Season of 2017-18

**Yield and Farmers Preference:** An evaluation of a number of germplasms, advanced lines and one cultivars (exotic variety which was cultivated as fodder at Savar) indicated existence of significant genetic variability in sorghum for grain yield under saline soil conditions (Table 11.3.4.1). Although, sorghum is known to be relatively more tolerant to soil salinity than maize (Igartua *et. al.*, 1994, Krishnamurthy *et. al.*, 2007). Among the tested materials, BARI developed advanced line (ISC-19153) gave the highest (1.78 t ha<sup>-1</sup>) yield which was statistically identical with other tested materials.

Furthermore, the BD-710 and BD-4659 germplasms gave satisfactory yield in saline conditions but they were significantly different (Table 11.3.4.1.). In case of field duration, lowest days (117 days) required for physiological maturity observed in BD-740 which yielded lower ( $1.48 \text{ t ha}^{-1}$ ) compared to high yielding tested materials such as ISCS-19153 and BD-4659 (119 days) etc. Yet, one of the high yielding germplasm took more time (125 days) among the tested materials which was preferred by the farmers because of grain yield, saline tolerant, dwarf and grain colour. Farmers preferred the sorghum crop mainly two to three reasons such as saline tolerance, grain yield and good fodder. It was observed by the researchers and farmers at the time of sorghum harvesting a serious fodder crisis was prevailed across all the experimental sites. In this circumstances, sorghum might be a good option for forage production in the saline areas especially the materials Green Grand-1, ISCS-19153, BD-755. According to the farmers of Char Jabbar, BD-4659 germplasm was the more saline tolerant than other tested materials whereas sweet sorghum (ISC-19153) was likely to be more tolerant to salinity (Graph 11.3.4.1.). Furthermore, sorghum yield in normal conditions was more than  $4 \text{ t ha}^{-1}$  which was not produced by none of the tested materials and causes were evident my many researcher in the past. Likewise, salinity causes reduction in germination (Igartua *et. al.*, 1995), growth (Maiti *et. al.*, 1994) and yields of sorghum (Macharia *et. al.*, 1994) and modifies the physiological and biochemical processes of the plant (Dubey, 1994).



**Picture 11.3.4.1.:** Participatory Variety Selection Trials (PVS) in Sorghum at different sites of Noakhali district during *Rabi* Season of 2017-18

**Table 11.3.4.1.:** Days to maturity, Yield and farmers' preferences of Sorghum variety/advanced lines/germplasms at different sites of Noakhali during *Rabi* season of 2017-18

Varieties/Lines / Germplasms	Days to maturity	Grain yield (t ha <sup>-1</sup> )	Farmers' Preference			Final Ranking
			Tomoruddi	Kellar Char	Char Jabbar	
Green Grand-1	122	1.48	4(RG, GF)	6 (ST, GF)	5 (RG,GF, ST)	4
ISC-19153	119	1.78	1(GY,ST, EM)	2(GY, RG, GC,ST)	1(GY, RG, ST,WLT)	1
BD-710	125	1.66	3 (D, GY,ST)	1 (D, GY,ST)	2 (GY,ST, GC)	2
BD-732	118	1.32	7 (MS, GC)	7 (RG,GF)	7 (MS,GC)	7
BD-740	117	1.48	5(D, MT)	4 (MT, RG)	6(MT,RG)	5
BD-755	119	1.43	6 (MS,D)	5 (MS,RG)	4 (MS,WLT,GF)	6
BD-4659	119	1.62	2 (MT,GY)	3 (ST,EM)	3 (MT,EM,GY)	3

GY=Grain Yield, RG=Remain Green, MT=More Saline tolerance, ST=Salinity tolerance, EM=Early maturity, D=Dwarf, GC= Grain Colour, MS = More Susceptible, GF=Good Fodder

### 11.3.5. Participatory Variety Selection Trials in Safflower

Safflower (*Carthamus tinctorius L.*) is an annual, broadleaf oilseed crop of the family Asteraceae that originated in southern Asia (Kohnaward *et al.*, 2012) and adapted chiefly to dry land or irrigated cropping systems (Rohini & Sankara, 2000). It has a well-defined tap root that generally penetrates up to a depth of 2-3 m. This deep-rooting characteristic allows the plant to absorb moisture and nutrients from different volumes of soil (Weiss, 1983). Sunflower and safflower are classified as moderately salt tolerant based on seed yield (Grieve *et al.*, 2012). The growth stages of safflower plants can be divided as follows (Mündel *et al.*, 1992):

**Growth Stage I (GS I): Emergence Stage (15 days after Sowing)**

**Growth Stage II (GS II): Rosette stage (16-35 DAS)**

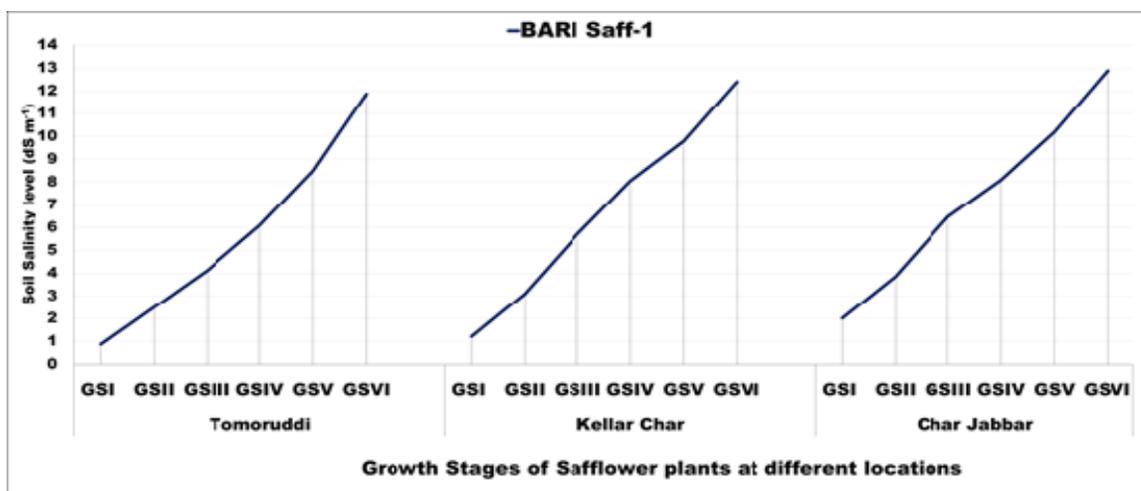
**Growth Stage III (GS III): Stem elongation Stage (36 to 50 DAS)**

**Growth Stage IV (GS IV): Branching Stage (51 to 70 DAS)**

**Growth Stage V (GS V): Flowing Stage (71 to 95 DAS)**

**Growth Stage VI (GS VI): Physiological Maturity (95 to 120 DAS)**

**Soil Salinity Level at experimental fields of Safflower crop:** The salinity levels at different sites along with Safflower growth stages was presented in graphical format (Graph 11.3.5.1.). In general, Salinity tolerance was mainly estimated at plant germination and emergency stages. At Tomoruddi site, soil salinity level was below 1 dS m<sup>-1</sup> whereas it was above 1 dS m<sup>-1</sup> at Kellar Char site. Furthermore, soil salinity was just above 2 dS m<sup>-1</sup> at Char Jabbar site. It is notable that Safflower crop is more sensitive to salinity at germination stage in comparison to late development stages, the plants have small height with reduced stem diameter, and the plants are more succulent with thick and darkened leaves (Weiss, 1971; Beke and Volkmar, 1995; Bassil and Kaffka, 2001). During rosette stage across all locations, salinity ranged from 2.49 to 3.85 dS m<sup>-1</sup>. In case of stem elongation stage, soil salinity at Tomoruddi site was 4.12 dS m<sup>-1</sup> whereas it was 5.69 and 6.46 dS m<sup>-1</sup> at Kellar Char and Char Jabbar sites, respectively. Soil salinity levels were above 8 dS m<sup>-1</sup> at Kellar Char and Char Jabbar sites during branching stage. However, mild salinity stress leads rapidly to growth inhibition of leaves and stems of safflower, whereas roots may continue to elongate (Spollen *et al.*, 1993). During flowering stage, high levels of salinity observed at Kellar char and Char Jabbar sites which were 9.78 and 10.19 dS m<sup>-1</sup>, respectively. Saini and Westgate (1999) narrated that some growth and physiological stages of safflower are salt and drought sensitive, especially at reproductive stage. At the time of harvesting soil salinity was above 11.50 dS m<sup>-1</sup> across all locations and it was highest (12.89 dS m<sup>-1</sup>) at Char Jabbar sites.



**Graph 11.3.5.1.:** Soil Salinity levels during growing Season of Safflower at experimental sites in Noakhali during *Rabi* season of 2017-18

**Yield and Farmers Preference:**

The salt tolerance of different crops needed to be evaluated to test their suitability for marginal environments to offer a more practical solution for effective utilization of salt-affected soils. Some researchers found that safflower can be a potential alternate oil seed crop in saline and drought-prone environment due to the ability to grow under water stress conditions (Yau 2004; Kar *et. al.*, 2007). The objective of the PVS trial was to test whether safflower could be grown successfully and profitably as a Rainfed, winter and oil-seed crop at moderately to strongly saline sites in Noakhali district. The salinity caused significant reduction in seed yields across all the experimental sites. The highest seed yield (1.27 t ha<sup>-1</sup>) was obtained at Tomoruddi site where soil salinity levels were less compared to other locations during vegetative and reproductive stage. Because of rainfall during early growing period in this location, the period and intensity of safflower's exposure to salinity may have been shortened or otherwise lessened. On the other hand, 1.05 and 0.87 t ha<sup>-1</sup> seed yield were found from Kellar Char and Char Jabbar sites, respectively. In artificial salinized plots, Francois and Bernstein (1964) found that at 7, 11 and 14 dS m<sup>-1</sup> relative yield reductions were 10, 25 and 50%, respectively. Other estimates predict a 50% yield decrease on soil with an EC<sub>e</sub> of 9.9 dS m<sup>-1</sup> (Ayers and Westcot, 1976). The decrease in yield and yield components in different safflower genotypes due to salinity, osmotic stress, and water deficiency has also been reported by Kar *et. al.*, (2007).

**Table 11.3.5.1.:** Days to maturity and yield of Safflower Variety at different sites fallow lands during *Rabi* season of 2017-18

Treatments	Locations	Days to Maturity	Yield (t ha <sup>-1</sup> )
BARI Saff -1	Tomoruddi	125	1.17
	Kellar Char	122	1.05
	Char Jabbar	118	0.87



**Picture 11.3.5.1.:** Participatory Variety Selection Trials (PVS) in Safflower at different sites of Noakhali district during *Rabi* Season of 2017-18

### 11.3.6. Participatory Variety Selection in Linseed (Flaxseed)

Flaxseed (*Linum usitatissimum* L.), one of the oldest cultivated crops, continues to be widely grown for oil (excellent source of the omega-3 fatty acid linoleic acid), fiber, and food (Oomah, 2001). The plant has a short, branched taproot which may extend to a depth of more than 1 m with side branches stretching approximately 30 cm. In the coastal saline (Noakhali, Patuakhali) and other char areas (Faridpur, Jamalpur), farmers usually cultivated local linseed variety resulting low yield. Linseed goes through four distinct stages of development:

**Growth Stage I (GS I): Emergence Stage (5 to 10 days after Sowing)**

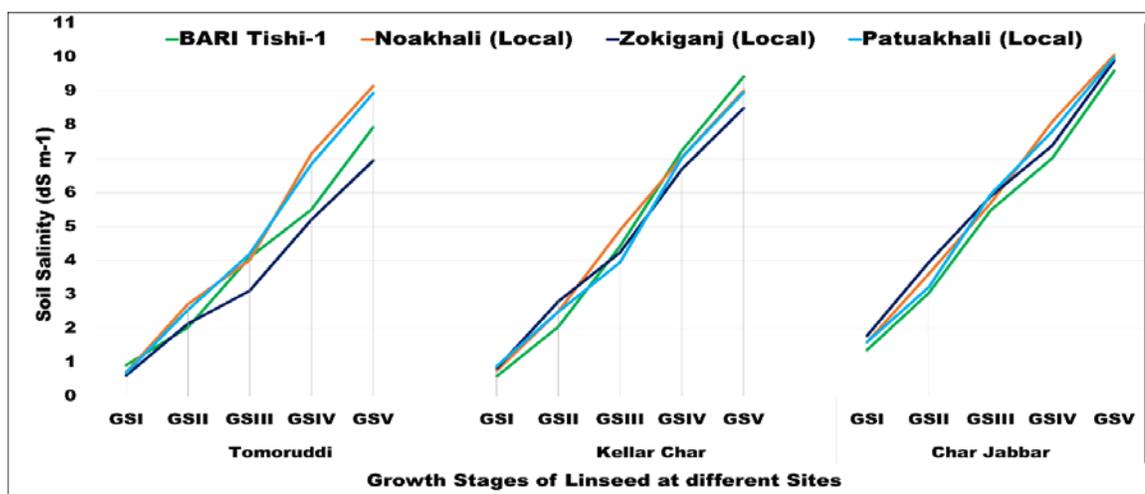
**Growth Stage II (GS II): Vegetative Stage (11 to 50 days after emergence)**

**Growth Stage III (GS III): Flowering Stage (51 to 65 days after emergence)**

**Growth Stage IV (GS IV): Seed Formation Stage (66 to 85 days after emergence)**

**Growth Stage V (GS V): Physiological Maturity (86 to 115 days after emergence)**

**Soil Salinity Level at experimental fields of Foxtail millet crop:** Soil salinity gradually increased up to maturity stage of the crop (Graph 11.6.1.1.) at different sites. During vegetative stage at Tomoruddi site, Soil salinity was below 3 dS m<sup>-1</sup> which had no adverse effect on the growth of flaxseed. Similar trend was observed at Keller Char village. On the other hand, soil salinity ranged from 3.05 to 5.95 dS m<sup>-1</sup> during vegetative to early flowering stage at Char Jabbar village which exerted adverse effect on the branching and flowering of all genotypes. It is notable that linseed yielding is determined by the ability of plants to accumulate the yield of dry matter during the vegetative period (Aufhammer *et. al.*, 2000, Hassan and Leitch, 2000). Furthermore, during flowering stage salinity levels were 5.48 to 5.95 dS m<sup>-1</sup> at Char Jabbar which were 7.02 to 8.09 dS m<sup>-1</sup> during initial seed formation stage. At Tomoruddi, site during flowering to initial seed formation stage soil salinity levels ranged from 3.11 to 7.15 dS m<sup>-1</sup> whereas it was 3.95 to 7.25 dS m<sup>-1</sup> at Keller char experimental site. During maturity stage at Tomoruddi and Keller Char sites, soil salinity ranged from 6.94 (Zokigonj) to 9.14 (Noakhali local) dS m<sup>-1</sup>, 8.49 (Zokigonj) to 9.42 (BARI Tishi-1) dS m<sup>-1</sup>, respectively. At Char Jabbar site, salinity during maturity stage ranged from 9.59 (BARI Tishi-1) to 10.06 (Noakhali local) dS m<sup>-1</sup>.



**Graph 11.6.1.1.:** Soil Salinity levels according to growth stages of Linseed Variety/Cultivars at different sites during *Rabi* Season of 2017-18

**Yield and Farmers Preference:** Among the tested materials, BARI Tishi-1 gave highest yield ( $0.92 \text{ t ha}^{-1}$ ) under saline conditions which was statistically significant to other cultivars. It may be fitted into the Fallow-Fallow-T. Aman cropping pattern. Furthermore, the results revealed that BARI Tishi-1 required less time (104 days) to mature in comparison to the cultivars. However, Noakhali (Local) cultivar produced 2<sup>nd</sup> highest yield ( $0.78 \text{ t ha}^{-1}$ ) which was statistically insignificant to other cultivars. Among the cultivars, Noakhali (Local) days to maturity was the highest (110 days) whereas Zokigonj (Local) and Patuakhali (Local) days to maturity were 108 and 107 days, respectively.



**Picture 11.6.1.1.:** Pictorial view of PVS Trials in Linseed at different sites of Noakhali during *Rabi* Season

**Table 11.6.1.1.:** Days to maturity, Yield and farmers' preferences of Linseed variety/Cultivars at different sites of Noakhali during *Rabi* season of 2017-18

Variety/Cultivars	Days to Maturity	Seed Yield ( $\text{t ha}^{-1}$ )	Farmers Preference			Final Ranking
			Tomoruddi	Keller Char	Char Jabbar	
BARI Tishi -1	104	0.92	1(GY, MB, EM)	1 (GY, GS,GC)	1 (ST, GY, GC)	1
Noakhali (Local)	110	0.78	3 (LY, LB, LM)	2 (GY, GC)	2 (ST, MY)	2
Zokiganj (Local)	108	0.74	4 (LY, LB, LM)	3 (MY)	4(MSS, LY)	4
Patuakhali (Local)	107	0.76	2 (MY,MB, MM)	4 (LY)	3 (MS, MY)	3

\*MB=More Branches, LB=Less Branches, GY=Grain Yield, LY=Low Yield, MY=Medium Yield, GS=Grain Size, GC=Grain Colour, EM=Early Maturity, MM=Medium Maturity, LM=Late Maturity, ST=Saline Tolerant, MS= Moderate Saline Tolerant, LS=Low tolerance to salinity, MSS= More Susceptible to soil salinity

The top priority of farmers' selection criteria varied from site to site. Hence, grain yield was ranked as the first selection criteria by Tomoruddi and Keller Char farmers. Similarly, saline tolerance level was the top ranking criteria by Char Jabbar farmers. In the ranking of best varieties, most farmers' across all the locations selected BARI Tishi-1 variety as first choice (Table 11.6.1.1.). According to the farmers of Tomoruddi site, the variety produced more branches during vegetative stage lead to multi-branches

with more flower buds which eventually gave higher yield. On the other hand, grain size and colour as well as yield performance of BARI Tishi-1 was superior compared to other cultivars opined by the farmers of Keller char. At Char Jabbar, BARI Tishi-1 was more saline tolerant capability followed by Noakhali local. After group discussion and data analysis, BARI Tishi-1 found best among the tested materials followed by Noakhali local and Patuakhali local where Zokigonj local observed as less productive cultivars at saline areas.

**Table 11.6.1.2.:** Effect of different sowing methods on the yield, economic return of Linseed (BARI Tishi-1) at fallow lands of Noakhali district during *Rabi* season of 2017-18

Planting System	Seed Yield (t ha <sup>-1</sup> )	GR (TK. ha <sup>-1</sup> )	TVC (TK. ha <sup>-1</sup> )	GM (TK. ha <sup>-1</sup> )	BCR	Farmers Preference	Final Ranking
Line Sowing	0.96	48000	16350	31650	1.94	1(MB,GY,EIO)	1
Bed Planting	0.81	40500	14750	25750	1.75	3 (EIO)	2
Broadcasting	0.74	37000	12950	24650	1.90	2(LLR)	3

\*MB=More Branching, GY=Grain Yield, EIO=Easy for Intercultural Operation, LLR=Less Labor Required, GR=Gross Return, TVC=Total Variable Cost, GM=Gross Margin, Linseed= Tk. 50 per Kg



**Picture 11.3.6.2.:** Different sowing methods practiced in Linseed during PVS trials at Keller Char sites in Noakhali district during *Rabi* Season of 2017-18

Despite variety, farmers usually broadcasted linseed after final land preparation without recommended doses of fertilizers or even without fertilizers. The data revealed that among sowing methods, the seed yield of linseed was significantly higher under line sowing as compared to other treatments (Table 11.6.1.2.). This treatment (line sowing) might be attributed to better performance of plant growth parameters (plant height, primary and secondary branches) through optimum utilization of resources which had directly linked with yield. According to Delesa and Choferie (2015), six (06) percent seed yield advantage could be obtained by using row planting method as compared to broadcasting.

Economics of linseed production in terms of gross return and gross margin were calculated for different sowing methods and the outcome were presented (Table 11.6.1.2.). The data revealed that the maximum gross return (Tk. 48000 ha<sup>-1</sup>) and gross margin (Tk. 31650 ha<sup>-1</sup>) were obtained under line sowing followed by bed planting system on mean basis. However, the return per Taka invested was maximum (1.94) under line sowing method followed by broadcasting method (1.90). According to the participating farmers, line sowing method permitted the plants to produce maximum branching as distance were maintained which also allowed to continue intercultural operations such as application of fertilizer during flowering stage, weeding etc. Farmers also opined that though it took more labour but the yield and economic return was satisfactory compared to other two sowing methods.

#### **11.4. Cropping Systems of Some Crop species with underutilized crops**

The ideas of resource partitioning (niche partitioning and niche differentiation) and facilitation mechanisms of intercropping systems were applied in the design of intercropped systems of the project. The purpose of this participatory trials on intercropping systems was to demonstrate that underutilized crops could be cultivated in the same land with other underutilized crops (cereals, legumes and oil crops) as intercropping system and to find out most efficient cropping/intercropping systems for maximizing system productivity as well as crop diversification in the saline fallow lands.

##### **11.4.1. Mixed, inter and boarder cropping system of oil and pulse crops with Linseed**

In view of the above headlines, mixed, inter and boarder cropping system of different pulse and oil crops with linseed in Rabi season were studied to sustain the productivity of available fallow land resources in the experimental sites under Noakhali district.

##### **Linseed Equivalent Yield (LEY)**

In the cropping system, sole stand of all the component crops and main crops showed higher values for their respective yield (Table 11.4.1.1.). This is may be due to the fact that less inter space competition, between main crop (linseed) and the component crops for resources such as space, nutrients, solar radiation and limited disturbance of habitat and increase the plant population. Despite sole stand of component crops, the yield of all the crops in the mixed cropping system showed a decreasing trend due plant density of the particular crops according to the treatments. In case of mixed cropping system, the highest ( $0.97 \text{ t ha}^{-1}$ ) total productivity in terms of linseed equivalent yield (LEY) was recorded with Linseed (100%) + Safflower (30%) cropping system and lowest ( $0.78 \text{ t ha}^{-1}$ ) observed with Linseed (100%) + Cowpea (30%). The difference in LEY was mainly as a consequence of yield and price of individual component crops which could be attributed to poor development of plants and shedding effect on an each other, resulted poor utilization of resources such as moisture, space, nutrients and solar radiation. On the other hand, the tested intercropping system linseed + Safflower (2:1) intercropping system produced more than one metric ton yield compared to other intercropping systems. In case of boarder cropping system, the yield of linseed was higher than the mixed and intercropping system. The differences in the yield of linseed due to different plant population in the treatment combination of mixed and intercropping system whereas only unutilized boarder of the respected lands were used for growing additional component crops.

##### **Land Equivalent Ratio (LER)**

Total land productivity in terms of LER, yield of main crops (Linseed) and component crops were influenced by the different cropping system (Table 11.4.1.1.). It was observed that the means of almost all cropping treatments were greater than one ( $\text{LER} > 1$ ). This confirms the advantage of these types of cropping system practices to get more production from the same area of land as compared with the same unit of area in which sole crop is applied. But two cropping system such as linseed cowpea mixed cropping system and linseed + sunflower intercropping system were lower than 1 which implies that the sole cropping pattern provides a greater yield advantages.

##### **Area Time Equivalent Ratio (ATER)**

In case of all cropping systems, the ATER values were lesser than LER values (Table 11.4.1.1) indicating the over estimation of resource utilization perhaps due to the wide variations in the maturity periods of

the crops of which component crops stayed longer on the land. ATER is free from problems of over estimation of resource utilization contrary to LER. In contrast, ATER values showed that only five (05) cropping systems had yield advantages and the ranged was 1 to 8 percent. In the LER values, ten (10) cropping systems had the yield advantages over sole cropping system.

**Table 11.4.1.1.:** Linseed Equivalent yield (LEY), Area time equivalent ratio (ATER), land equivalent ratio (LER), Monetary Advantage Index (MAI) of different cropping system at different locations in fallow lands of Noakhali during *Rabi* season of 2017-18

Cropping System		Yield (t ha <sup>-1</sup> )		LEY (t ha <sup>-1</sup> )	LER	ATER	MAI
		Linseed	Component crops				
Sole	Linseed	0.90	-	0.90	1		
	Mustard	-	0.76	0.61	1		
	Grass pea	-	0.86	0.60	1		
	Safflower	-	1.17	1.05	1		
	Sunflower	-	1.31	1.05	1		
	Cowpea	-	0.83	0.83	1		
	Barley	-	1.29	0.93	1		
Mixed	Linseed (100%) + Mustard (30%)	0.69	0.27	0.92	1.13	1.07	5130
	Linseed (100%) + Grass pea (30%)	0.70	0.29	0.91	1.12	1.04	4837
	Linseed (100%) + Safflower (30%)	0.71	0.28	0.97	1.03	0.94	2960
	Linseed (100%) + Cowpea (30%)	0.69	0.10	0.78	0.88	0.80	-5247
Intercropping (Replacement)	Linseed + Sunflower (2:1)	0.69	0.37	0.98	1.04	0.94	1928
	Linseed + Sunflower (3:1)	0.77	0.17	0.91	0.99	0.88	-625
	Linseed + Barley (2:1)	0.76	0.28	0.93	1.06	1.04	1634
	Linseed + Cowpea (2:1)	0.69	0.22	0.91	1.02	0.94	1050
	Linseed + Safflower (2:1)	0.66	0.39	1.02	1.07	0.99	3248
Border	Linseed surrounding by Safflower	0.85	0.20	1.03	1.11	1.01	5080
	Linseed surrounding by Mustard	0.85	0.13	0.95	1.11	1.08	4747
	Linseed surrounding by Sunflower	0.83	0.13	0.93	1.01	0.90	517

Price (Tk. Kg<sup>-1</sup>): Linseed=50, Mustard=40, Grass pea=35, Safflower=45, Sunflower=40, Cowpea=50

#### Monetary Advantage Index (EMAI)

Monetary advantage index (MAI) values of ten (10) cropping systems were positive (Table 11.4.1.1.) values which showed a definite yield advantages compared to sole cropping system. MAI values of two plant combinations indicated that the disadvantage of the system as the MAI values were in negative form. However, linseed + mustard mixed cropping system showed a maximum (5130) yield advantage compared with the respective sole cropping systems tested in this study followed by linseed + grass pea combination (4837). In case of intercropping systems, the maximum MAI value obtained from in 2:1 row with linseed + Safflower (3248) system which confirms the result of LER but not ATER's index. It is mentionable that MAI values are an indicator of the economic feasibility of intercropping systems as compared to sole cropping (Aasim *et. al.*, 2008; Willey and Rao, 1980). Moreover, intercropping of safflower with chickpea, coriander and linseed in 2:1 row ratio increased net returns substantially compared to their respective sole crops in Andhra Pradesh, India (Hegde and Koli, 1997). On the other hand, the MAI values of two boarder cropping systems such as linseed surrounded by safflower (5080) and mustard (4747) were maximum compared to other one which confirm the results of LER's and

ATER's indices. Similarly, Ghosh *et. al.*, (2004) found that when the LER were higher there is also significant economic benefit expressed with higher MAI.



**Picture 11.4.1.1.:** Pictorial view of different cropping systems (where, (a) to (c) refers to mixed cropping; (d) to (j) represented to intercropping and (k) to (m) represents boarder cropping system) of oil and pulse crops with linseed in coastal saline fallow lands of different upazilla under Noakhali district during *Rabi* season of 2017-18

#### **11.4.2. Intercropping systems of some crop species with Sorghum**

Intercropping system of cereals with legume and cereal with cereal are commonly practiced by the smallholder farmers in many parts of the world ((Steiner, 1982; Stoop, 1987; Ghosh *et. al.*, 2009). The following intercropping systems were broaden the knowledge of intercropping system of underutilized crops in the saline conditions.

##### **Sorghum Equivalent Yield (SEY)**

Seed yield of main crops and other component crops were recorded higher when grown as sole compared to intercropping system (Table 11.4.2.1). Among intercropping systems, the highest sorghum equivalent yield (SEY) was obtained in intercropping of sorghum with cowpea in 2:3 row ratio where three rows of cowpea were added in a pair of two rows of Sorghum as additive series. It is notable that Sorghum + cowpea intercropping gave significantly more green fodder, dry matter yield and sorghum equivalent yield than sorghum + pigeon pea and sorghum + *Cenchrus setigerus* intercropping systems (Arya *et. al.*, 2000). Moreover, the yield of cowpea intercropped with sorghum was reported higher by many researcher (Zougmore *et. al.*, 2000; Singh and Ahuja, 1990; El Naim *et. al.*, 2013). The higher yield of all the tested crops in sole cropping systems might be due to no competition with other crops resulted in better growth, yield attributes and yield. Further, perusal of data in Table 11.4.2.1 revealed that among different intercropping ratios, the second higher SEY was exhibited in 2:2 ratio of sorghum and safflower intercropping. The higher SEY of all the additive series intercropping systems was on account of higher plant population due to accommodation of more number of rows in between interspaces of sorghum as compared to replacement series of intercropping systems. However, sorghum with proso millet intercropping system gave satisfactory SEY compared to other replacement series of intercropping and close to sorghum with grass pea additive design intercropping system. This might be due to low market price of grass pea compared to proso millet. On the other hand, replacement of sorghum by other crops (Foxtail millet, Proso millet and sunflower) caused a decrease in sorghum yield which was not compensated by the yields of component crops (Table 11.4.2.1.). Furthermore, Intercropping of cereals with legumes also increases the productivity per unit of land area due to the atmospheric nitrogen biological fixation (BNF) that takes place in the root nodules of legumes (Pal and Sheshu, 2001).

##### **Land Equivalent Ratio (LER)**

Land equivalent ratios (LER) of all additive design intercropping systems were higher than 1.00 (Table 11.4.2.1.), indicating better land use efficiency in terms of yield over sole cropping system. In case of replacement design intercropping systems, intercropping advantages were generally less for the sorghum + Foxtail millet and sorghum + sunflower systems, and it proved serious competition between sorghum and component crops. Complementary, proso millet intercropped with sorghum provided LER more than 1, it transpired that this combination had also promising advantages in terms production over sole cropping. Nevertheless, the highest LER was observed in sorghum + cowpea (1.19), followed by sorghum + grass pea (1.17) and sorghum + safflower (1.05) additive design intercropping system. Moreover, Iqbal *et. al.*, (2019) found that the LER was highest in sorghum+ cowpea (1.55) intercropping system when analyzing competitive indices in cereal and legume mixtures in South Asian environment.

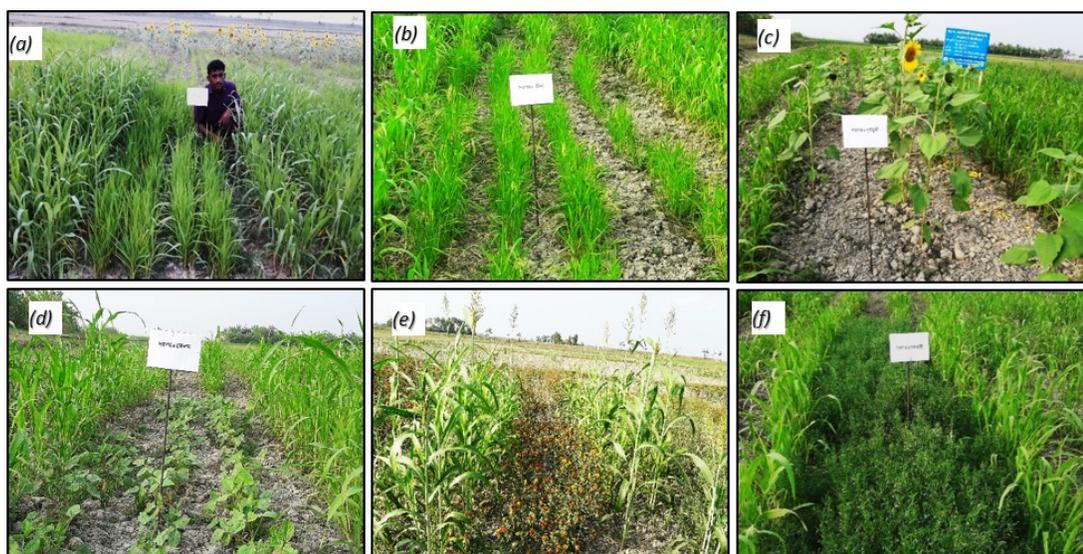
### Area Time Equivalent Ratio (ATER)

In case of all additive design intercropping systems, the ATER values were more than 1 (Table 11.4.2.1) which indicated an advantage of these intercropping systems for exploiting the resources of the environment compared to sole and other replacement design intercropping systems. In this study, the values of ATER showed an advantage ranged from 4 % to 17 %. In addition, the ATER value of sorghum + proso millet was close to 1 which exposed a risk-reducing alternative to sole cropping system. Iqbal *et. al.*, (2019) reported that the highest area-time equivalent ratio for sorghum-cowpea binary mixture indicated the maximum advantage for this binary mixture compared to other binary mixtures.

**Table 11.4.2.1.:** Sorghum Equivalent yield (SEY), Area time equivalent ratio (ATER), land equivalent ratio (LER), Monetary Advantage Index (MAI) of some crop species with sorghum intercropping system in saline fallow lands of different upazilla under Noakhali district during *Rabi* season of 2017-18

Cropping System		Yield (t ha <sup>-1</sup> )		SEY (t ha <sup>-1</sup> )	LER	ATER	MAI
		Sorghum	Component crops				
Sole	Sorghum	1.52	-	1.52	1		
	Foxtail millet	-	1.22	1.22	1		
	Proso millet	-	1.18	1.18	1		
	Grass pea	-	0.82	0.72	1		
	Cowpea	-	0.87	1.09	1		
	Safflower	-	1.19	1.34	1		
	Sunflower	-	1.29	1.29	1		
Intercropping (Replacement)	Sorghum + Foxtail millet (2:4)	0.96	0.32	1.28	0.91	0.86	-6079
	Sorghum + Proso millet (2:4)	0.98	0.43	1.42	1.02	0.95	879
	Sorghum + Sunflower (4:2)	0.92	0.31	1.23	0.88	0.85	-8801
Intercropping (Additive)	Sorghum + Safflower (2:2)	1.11	0.38	1.54	1.05	1.04	2906
	Sorghum + Grass pea (2:3)	1.13	0.35	1.44	1.17	1.15	8358
	Sorghum + Cowpea (2:3)	1.16	0.37	1.62	1.19	1.17	10290

Price (Tk. Kg<sup>-1</sup>): Sorghum=40, Foxtail millet=40, Proso millet= 40, Grass pea=35, Cowpea=50, Safflower=45, Sunflower=40



**Picture 11.4.2.1.:** Pictorial view of intercropping system (where (a) to (c) represent replacement design and (d) to (f) represent additive design) of some crop species with sorghum in coastal saline fallow lands of different upazilla under Noakhali district during *Rabi* season of 2017-18

### **Monetary Advantage Index (EMAI)**

The monetary advantage index (MAI) values were positive in all additive design intercropping systems and one replacement design intercropping system (sorghum+proso millet). The result showed definite yield and economic advantages in sorghum+cowpea, sorghum + grass pea (8358), sorghum+ safflower (2906) and sorghum+ proso millet (879) intercropping patterns over sorghum + foxtail millet (-6079), sorghum + sunflower (-8801) and their sole cropping. The highest MAI (10290) was obtained in the sorghum+cowpea (2:3) planting pattern, which implied that the planting pattern was highly economical and advantageous for the mixtures. Dhima *et. al.*, (2007) reported that if LER and relative crowding coefficient (K) values were higher, then there was an economic benefit expressed with MAI values such as obtained in the present study. On the other hand, using monetary advantage index (MAI), Osman *et. al.*, (2011) reported that intercropping with two rows of cowpea and one row of millet gave significantly higher economic benefit than mixture with one row of each of the crops. Using the same MAI, Oseni (2010) found that intercropping with two rows of sorghum and one row of cowpea gave higher economic return compared to the other planting arrangements and the sole crops. Moreover, higher monetary returns from systems involving intercropping of legumes and non-legumes compared to sole non-legumes were also reported by Krantz *et. al.*, (1976), who attributed it to a better utilization of different resources like labour capital and natural resources'. According to Ajeigbe *et. al.*, (2006). Systems with higher proportion of cowpea to cereals (1Mz:4C, 1S:4C, 2Mz:4C and 2S:4C) had significantly higher returns of the total grains than systems with low cowpea proportions (1:1 and 2:2).

#### **11.4.3. Intercropping systems of some crop species with safflower**

In this participatory trial, nine (09) intercropping system were tested at the farmers' fields in the project areas. Safflower is non-traditional crops at coastal saline char areas of Noakhali. Moreover, one of the more innovative techniques to increase farmer awareness of safflower and also increase production in non-traditional growing regions is intercropping with other crops (Mündel *et. al.*, 1997).

#### **Safflower Equivalent Yield (SEY)**

Compared to the intercropping patterns, sole stands of the respected component crops and main crop were recorded higher (Table 11.4.3.1.) in the study. The Safflower Equivalent Yield (SEY) was higher in safflower + linseed with 2:2 row ratio ( $1.26 \text{ t ha}^{-1}$ ) as compared to sole cropping of safflower ( $1.13 \text{ t ha}^{-1}$ ) followed by the safflower + Sorghum with 1:1 row ratio ( $1.25 \text{ t ha}^{-1}$ ). Moreover, higher SEY was observed in other three intercropping patterns such as Safflower + Cowpea ( $1.16 \text{ t ha}^{-1}$ ), safflower + sunflower ( $1.15 \text{ t ha}^{-1}$ ) and with 2:4 row ratio of safflower + foxtail millet ( $1.15 \text{ t ha}^{-1}$ ). The higher SEY in safflower + linseed (2:2) was due to higher yield obtained by both safflower and linseed and higher market price of linseed and safflower compared to sorghum. Gobade *et. al.*, (2015) reported that higher safflower equivalent yield (SEY) observed in sorghum + safflower (2:1) intercropping system compare to other row proportion. On the other hand, the lowest ( $0.87 \text{ t ha}^{-1}$ ) SEY was recorded in safflower + soybean with 2:2 row ratio followed by safflower + mungbean ( $0.96 \text{ t ha}^{-1}$ ) intercropping combination. This might be due to less plant survival (mungbean and soybean) in saline conditions during experimental periods. Furthermore, SEY of safflower + cowpea and safflower + grass pea cropping combinations were reasonable which was reflected in other competition indices. Last but not least, intercropping of Fabaceae and Asteraceae families' results in increased crop yield, maximized resource consumption and enhanced productivity of cultivation system (Singh *et. al.*, 2010).

### Land Equivalent Ratio (LER)

The value of LER appeared greater than 1.00 in seven (07) intercropping systems tested in the participatory trial (Table 11.4.3.1.), indicated that interspecific facilitation is higher than the interspecific competition resulted greater land use efficiency over sole cropping systems. In addition, the highest LER (1.17) was obtained from safflower + mustard and safflower + linseed cropping system with 2:2 row ratio followed by safflower + sorghum (1.11) with 1:1 row ratio. Remarkably, the LER value was 1.09 in Safflower + grass pea and also when the cowpea was intercropped with safflower at same row ratio (2:2). Jalilian *et. al.*, (2017) reported that 2:2 intercropping pattern of bitter vetch and safflower had greater land equivalent ratio values compared to sole cropping and the other intercropping ratios. The LER value was lowest (0.78) in safflower + soybean intercropping combinations. This might be due to low survival of the component crop in saline condition or interspecific competition was greater than interspecific facilitation in the system. In this context, the higher LER value regardless of the crops for intercropping than sole cropping system was reported by various researchers (Dhima *et. al.*, 2007; Imran *et. al.*, 2011; Chimonyo *et. al.*, 2016). Kazemini and Sadeghi (2012) reported that intercropping of safflower with green bean, improved yield, yield component and biological yield. Intercropping of safflower/potato (Darabad *et. al.*, 2011) and bitter vetch/corn (Javanmard *et. al.*, 2009) showed a clear advantage over sole cropping in terms of biomass and other traits.

**Table 11.4.3.1.:** Safflower Equivalent yield (SEY), Area time equivalent ratio (ATER), land equivalent ratio (LER), Monetary Advantage Index (MAI) of some crop species with safflower intercropping system in saline fallow lands of different upazilla under Noakhali district during *Rabi* season of 2017-18

Cropping System	Yield (t ha <sup>-1</sup> )		SEY (t ha <sup>-1</sup> )	LER	ATER	MAI
	Safflower	Component crops				
Safflower	1.13	-	1.13	1		
Foxtail millet	-	1.25	1.11	1		
Sorghum	-	1.27	1.13	1		
Grass pea	-	0.86	0.67	1		
Cowpea	-	0.87	0.97	1		
Mungbean	-	0.83	1.11	1		
Soybean	-	1.47	0.98	1		
Mustard	-	0.69	0.61	1		
Linseed	-	0.89	0.99	1		
Sunflower	-	1.17	1.04	1		
Safflower + Foxtail millet (2:4)	0.79	0.41	1.15	1.03	1	1371
Safflower + Sorghum (1:1)	0.78	0.53	1.25	1.11	1.10	5469
Safflower + Grass pea (2:2)	0.72	0.39	1.02	1.09	1.08	3828
Safflower + Cowpea (2:2)	0.74	0.38	1.16	1.09	1.09	4391
Safflower + Mungbean (2:2)	0.71	0.19	0.96	0.86	0.80	-7220
Safflower + Soybean (2:2)	0.73	0.21	0.87	0.79	0.78	-10478
Safflower+ Mustard (2:2)	0.76	0.34	1.06	1.17	1.04	6781
Safflower + Linseed (2:2)	0.79	0.42	1.26	1.17	1.12	8259
Safflower + Sunflower (2:2)	0.73	0.47	1.15	1.05	1.04	2353

Price (Tk. Kg<sup>-1</sup>): Safflower=45, Sorghum=40, Foxtail millet=40, Grass pea=35, Cowpea=50, Mungbean= 60, Soybean= 30, Mustard=40, Linseed=50, Sunflower=40

### Area Time Equivalent Ratio (ATER)

In this study, the values of LER showed an advantage ranged from 3% to 17 % while the values of ATER indicated an advantage ranged from 4 % to 12 %. In this study, LER values were greater than those of the ATER, indicating the overestimation of resource utilization by LER. Indeed, Hiebsch and McCollum (1987) stated that it is likely that LER overestimates the advantage of intercropping when component

crops differ in growth duration. When land coverage time by intercrop components is different, ATER provides better estimates than LER (Awal *et. al.*, 2007). Similar results demonstrating better environmental resources utilization in intercropping have also been reported by many researchers around the world (Aasim *et. al.*, 2008, Uddin *et. al.*, 2014; Zafaranih, 2015).



**Picture 11.4.3.1.:** Pictorial view of intercropping system (where (a) to (c) represent replacement design and (d) to (f) represent additive design) of some crop species with sorghum in coastal saline fallow lands of different upazilla under Noakhali district during Rabi season of 2017-18

## **Monetary Advantage Index (EMAI)**

MAI values were positive in seven (07) intercropping systems (Table 11.4.3.1.). The result showed positive yield and economic advantages of the intercropping system over their sole cropping. The highest MAI (8259) was obtained in the safflower + linseed (2:2) cropping system, which implied that this cropping system was highly economical and advantageous for the mixtures. The second higher MAI value were obtained from safflower + mustard cropping system followed by safflower + sorghum (1:1). Though the LER and ATER values of safflower+ grass pea and safflower+ cowpea did not differ too much but MAI value of safflower +cowpea was higher (4391). Many researchers intercropped safflower with other crops in different planting arrangements to find out the economic feasibility of the system. Nikan (1987) in India intercropped safflower with chickpea and obtained a higher return than either mono crop. He also intercropped sorghum and safflower successfully. Intercropping of safflower with chickpea, coriander and linseed in 2:1 row ratio increased net returns substantially compared to their respective sole crops in Andhra Pradesh, India (Hegde and Koli, 1997). Safflower alone and in combination with gram and linseed appeared to be more profitable than the monoculture (Sawant *et. al.*, 1993). Li (1993) intercropped maize and safflower, and found that the intercrop was more profitable than either monoculture. Other crops that have been intercropped successfully with safflower include lentils, amaranthus, mustard and toria (*Brassica rapa* L.) in India and sweet potato, cotton, buckwheat, cabbage and cauliflower in China (Zheng *et. al.*, 1993; Yang and Chen, 1993).

## **11.5. Postharvest machineries**

### **11.5.1. Dehuller machine**

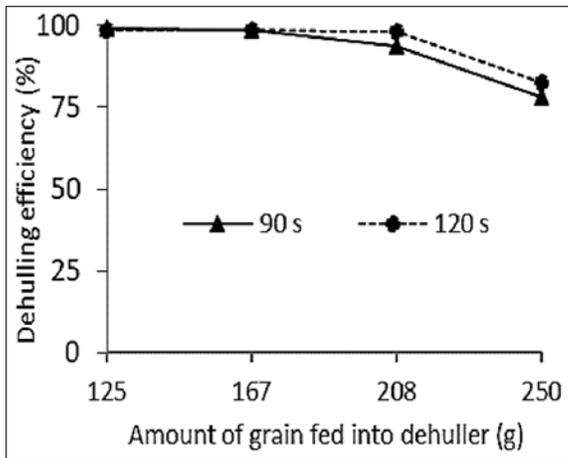
#### **Dehulling efficiency**

The dehulling efficiency varied greatly due to the feed rate and but slightly due to the dehulling time (Graph 11.5.1.1.). At a low feed rate of 167 g or below, the dehulling efficiency was as high as about 99% (highly desirable). At these low feed rates, longer than 90 s feeding time was not effective in increasing the dehulling efficiency any further.

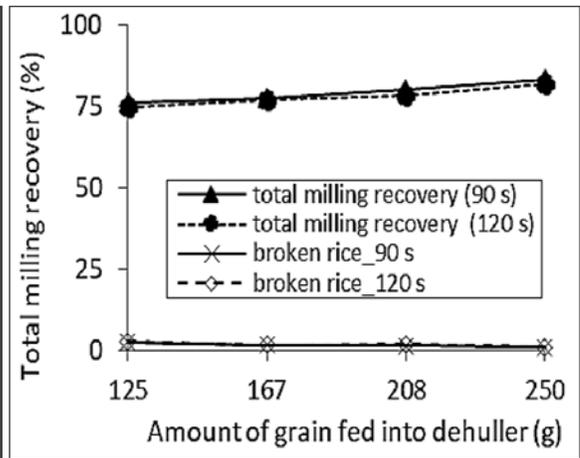
When the feed rate was increased over 167 g, the dehulling efficiency started falling down at an increasing rate (Graph 11.5.1.1.). At these high feed rates, the longer dehulling time was effective in increasing the dehulling efficiencies marginally. Since the rice is used to prepare human foods (e.g. *payesh* or rice pudding), presence of any noteworthy amounts of unhulled grains reduces its quality (e.g. palatability). Therefore, the dehulling efficiencies above 167 g feed rates are not acceptable.

#### **Total milling recovery**

For both the dehulling periods, the total milling recovery linearly increased (by up to 8 %) when the feed rate was increased from 125 g to 250 g (Graph 11.5.1.2.). This indicates that a higher feed rate is useful when a higher milling recovery is desired. At a higher feed rate, grain to grain impacts would have increased (due to cushioning action) compared to grain to metal impacts that would have resulted in lesser degree of milling (producing less rice dust) and lesser breakage (Graph 11.5.1.2.) compared to any lower feed rate.



**Graph 11.5.1.1.: Variation of dehulling efficiency due to feed rate and dehulling time**



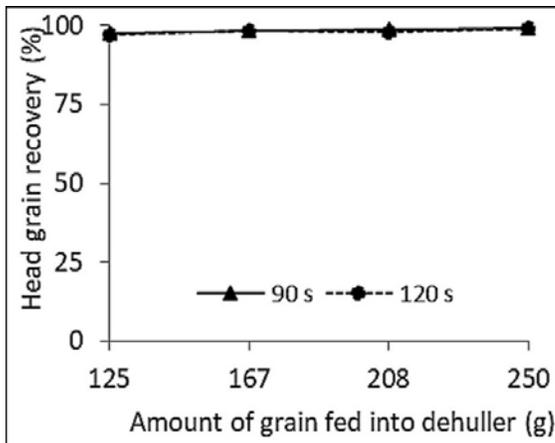
**Graph 11.5.1.2.: Variation of total milling recovery due to feed rate and dehulling time**

### Head grain recovery

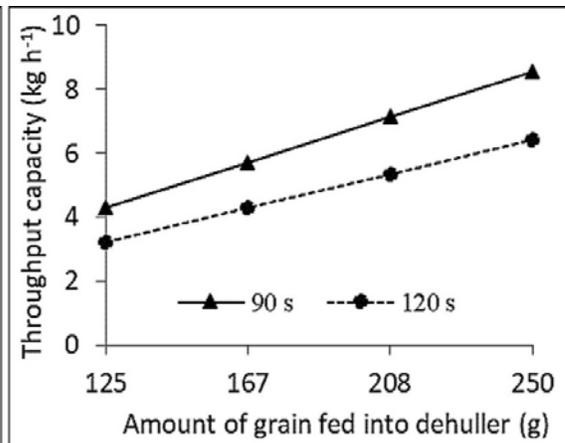
As seen in Fig. 5, the head grain recovery was high (97–99%) for all the feed rates irrespective of the dehulling period. The head grain recovery increased slightly with the increase of the feed rate due to less breakage and lesser degree of dehulling as described earlier. There was no noticeable effect of dehulling time on the head grain recovery.

### Throughput capacity

As seen in Fig. 6, the throughput capacity of the dehuller increased linearly with the fed rate for both the dehulling periods. Due to a short dehulling time and a fixed unloading time (15 s for all the treatments), the throughput capacity was higher for 90 s, compared to 120 s for any of the feed rates. Since a higher throughput capacity is always desirable, 90 s dehulling time would be preferable for a high throughput capacity.



**Graph 11.5.1.3.: Variation of head grain recovery due to feed rate and dehulling time**



**Graph 11.5.1.4.: Variation of throughput capacity due to feed rate and dehulling time**

### Average torque

It was observed that the torque requirement gradually fell during the dehulling period (Graph 10.7.1.1.). The average torque (i.e. torque) requirement gradually increased with the feed rate showing a perfect polynomial relationship for 90 s feeding time, but a perfect linear relationship for 120 s. (Graph 11.5.1.5.).

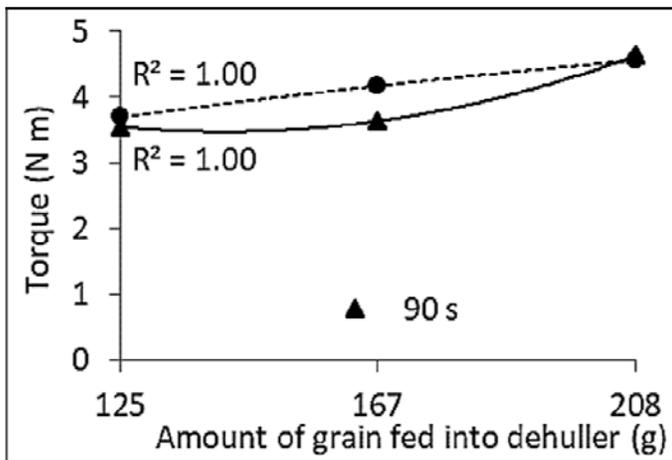
### Power (average) and peak power requirements

As the feed rate increased, the average power requirement increased for both the dehulling periods (Graph 11.5.1.6.). Again, as the feed rate increased, load on the motor increased causing reduction of the motor and cylinder speeds (Table 11.5.1.1.). Therefore, there was a polynomial relationship (degree 2) between the feed rate and the power requirement. For the increase of feed rate from 125 g to 167 g, the power (average) requirement increased for both the dehulling periods (Fig. 8). The power requirement fell slightly over 167 g as the motor and cylinder speeds fell further due to the increased load on the motor. The difference in power requirements between the milling periods narrowed down for the feed rate of 208 g as the corresponding torque requirements and cylinder speeds became almost the same (Graph 11.5.1.6. and Table 11.5.1.1.).

**Table 11.5.1.1.:** Change of cylinder speed due to feed rate

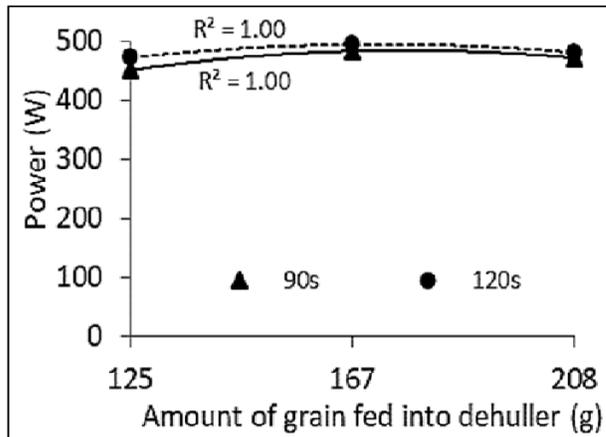
Feed rate (g)	Dehulling time (s)	Cylinder speed (rpm)
125	90	1092
167		1018
208		912
125	120	1097
167		1004
208		925

The peak power requirement followed the same trend as the power requirement as seen in Figs. 8 and 9). The highest peak power was required at 167 g feed rate (483 W and 493 W for the dehulling times of 90 s and 120 s, respectively). Beyond 167 g feed rate, the peak power requirement slightly decreased due to reduction of the cylinder speed (Table 11.5.1.1.) as described earlier. Therefore, the 750 W motor used to operate the dehuller provided a factor of safety of 1.55 (90 s) and 1.52 (120 s). For

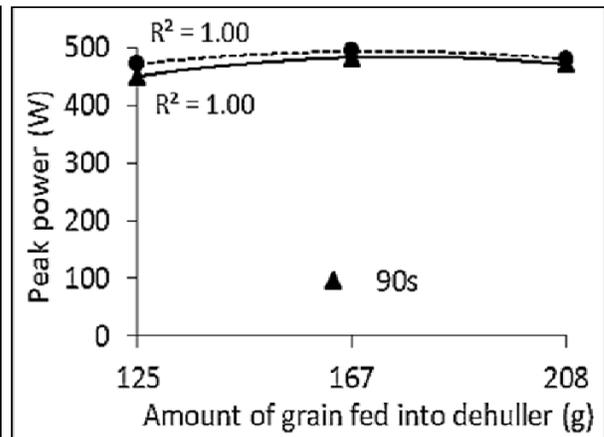


agricultural (field) machines, a factor of safety of 2.0 is recommended as there are lots of variability in the field that can occasionally raise the power requirement. However, this dehuller is a stationary machine and any chance of unexpected rise of power requirement is low. Therefore, the capacity of the current motor (750 W) seems to be sufficient to operate the dehuller at the feed rates.

**Graph 11.5.1.5.:** Variation of torque due to feed rate and dehulling time



**Graph 11.5.1.6.: Variation of power requirement due to feed rate and dehulling**

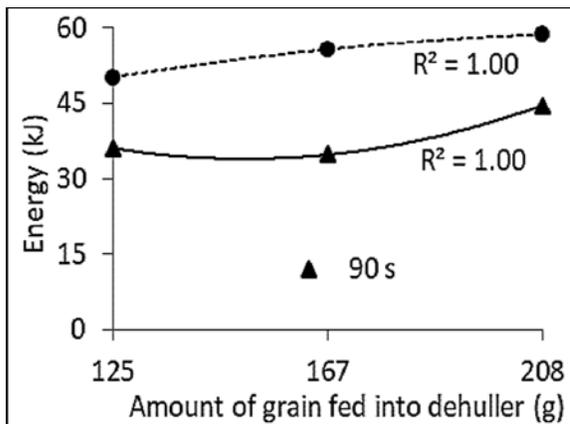


**Graph 11.5.1.7.: Variation of peak power requirement due to feed rate and dehulling**

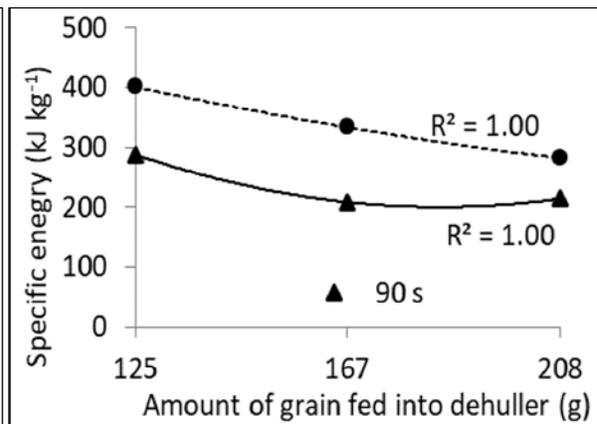
### Energy and specific energy requirements

For both the dehulling periods, energy requirement increased with the feed rate and followed a similar trend as the torque requirement (Graph 11.5.1.5. and Graph 11.5.1.8.). At 167 g feed rate, the power requirement was 20% higher for 120 s dehulling time compared to that for 90 s. However, despite of spending this 20% extra energy there was no considerable gain in dehulling efficiency, total milling recovery or head grain recovery.

As seen in Graph 11.5.1.9., the specific energy requirement decreased at a diminishing rate (i.e., an opposite trend of the power requirement). The specific energy requirement was always lower (28–37%) for the 90 s dehulling period, compared to that for 120 s. It was also observed that for the 90 s dehulling time, the specific energy requirement did not reduce much over 167 g fed rate. It clearly shows that a combination of 90 s milling period and a minimum feed rate of 167 g is useful to keep specific energy requirement low.



**Graph 11.5.1.8.: Variation of energy requirement due to feed rate and dehulling time**



**Graph 11.5.1.9.: Variation of specific energy requirement due to feed rate and dehulling time**

### 11.5.2. Multicrops thresher

#### Threshing capacity of multi-crop thresher on barley crop

The results showed that the greatest threshing efficiency, and minimum un-threshed grains was observed of the thresher at feed rate FR1 (240 kg h<sup>-1</sup>). The table depicted that with the increased in feed rate, there was decreased in the threshing efficiency of the thresher. The lower threshing efficiency at higher feed rate could be due to more mitigating effect of more material that hindered in grain separation.

**Table 11.5.2.1.:** Effect of feed rate on threshing efficiency and Unthreshed grains of Barley crop

Feed Rate	Threshing efficiency (%)	Unthreshed grain losses (%)
FR <sub>1</sub> (180 kg ha <sup>-1</sup> )	86.11	13.89
FR <sub>2</sub> (240 kg ha <sup>-1</sup> )	88.75	11.25
FR <sub>3</sub> (300 kg ha <sup>-1</sup> )	87.66	12.33

### 11.6. Recipe of underutilized crops

A total of twenty four (24) types of food recipes were organized and translated in Bengali which was typed in computer and then colored photocopy the materials. The materials was distributed among the farmers of the respected villages as well as Upazilla level GO and NGOs office personals. Other two crops are oilseed namely- safflower and linseed. Furthermore, linseed was included in multigrain flour as a source of omega-3 and lignin.

#### সরগমের রুটি

**উপকরণ**

- ১। সরগম দানা - ৩ কাপ
- ২। মাসকলাই ডাল - ৩ কাপ
- ৩। লবণ - পরিমাণমত
- ৪। তেল - পরিমাণমত



**প্রস্তুতকরণ**

- ১। সরগম দানা এবং মাসকলাই ডাল ভিজিয়ে নিয়ে ভিজানো সরগম দানা ও মাসকলাই ডাল এক সাথে ভাল করে চূর্ণ করে মিহি তাল কাই তৈরী করে তাকে সামান্য লবণ দিয়ে গাঁজন পকিতার জন্য বেধে দিতে হবে।
- ২। এবার রুটি বানানোর তত্ত্বাধীনে ১ চা চামচ তেল দিয়ে গরম করে তাকে তৈরী করা তাল কাই রুটির মধ্যে করে ছড়িয়ে দিতে হবে। অর্ধ মত্রে হলে পানির বেশকিছু হবে।
- ৩। গরম রুটি হ্যান্ডি দিয়ে খেতে খুব ভাল।

#### চীনার পায়েরস

**উপকরণ**

- ১। পোসো মুক্ত চীনা - ১ কাপ
- ২। ফকলো ফল - প্রয়োজনমত
- ৩। মি - প্রয়োজনমত
- ৪। পানি - প্রয়োজনমত
- ৫। চিনি - প্রয়োজনমত
- ৬। দুধ - প্রয়োজনমত
- ৭। এলাচ গুড়া - প্রয়োজনমত



**প্রস্তুতকরণ**

- ১। পোসো মুক্ত চীনা ৫ মিনিট ধরে গরম পানিতে সিদ্ধ করে নিই।
- ২। এবার ফকলো করে মুখ তুল দিয়ে তাকে সিদ্ধ করা চীনা এবং প্রয়োজনমত চিনি দিয়ে আয়ে আয়ে মাজতে হবে এবং রান্না করতে হবে (১৫ মিনিট ধরে অর্থাৎ ফকলো রান্না না হবে)।
- ৩। এরপর এলাচ গুড়া, ফকলো ফল এবং ফকলো ফল দিয়ে গরম পায়েরস পরিবেশন করুন।

#### কাউন সবজি/চিকেন বিরিয়ানী

**উপকরণ**

- ১। কাউনের রস - ১/২ কাপ
- ২। শিয়াল কুচি - ২ টি
- ৩। পান - ১/২ ছিক সাইজের ১ টি
- ৪। কাউন - ১/২ ছিক সাইজের ১ টি
- ৫। মরিচ - ১ কাপ
- ৬। লবণ - পরিমাণমত
- ৭। এলাচ - ৮ টি
- ৮। পান - ১৫ টি
- ৯। মাকচিনি - ১/২ ছিক সাইজের ১ টি
- ১০। পানি জিরা - ১ টেবিল চামচ
- ১১। আলু ও হলুদ বাটা - ১/২ টেবিল চামচ
- ১২। হলুদ গুড়া - ১ টেবিল চামচ
- ১৩। মরিচের গুড়া - ১ টেবিল চামচ
- ১৪। মরিচা গুড়া - ১ টেবিল চামচ
- ১৫। টমেটো - ১ কাপ
- ১৬। গরম মসুরা গুড়া - ১ টেবিল চামচ
- ১৭। সেতুল রস - ২ টেবিল চামচ
- ১৮। তেজপাতা - ১ টি



**প্রস্তুতকরণ**

- ১। কাউনের রস ৪ কাপ পানিতে পরিমাণমত লবণ, এলাচ, লবঙ্গ, মাকচিনি দিয়ে সিদ্ধ করতে হবে। ৩/৪ কাপ পানির হওয়া পর্যন্ত সিদ্ধ করে পানি কেঁচক লেগেতে হবে।
- ২। সবজিগুলো কেটে সিদ্ধ করে দিতে হবে।
- ৩। সেতুল এলাচ, লবঙ্গ, হালুয়া এলাচ, মাকচিনি, তেজপাতা এবং শাইখিরা গুড়া দিয়ে ত্রয়িপেলে ভেজে দিতে হবে।
- ৪। এবার টমেটো, আলু, হলুদ বাটা, শেঁয়াজ কুচি আলু, পান - কাউন এবং সিদ্ধ সেতুল মসুরা গুড়া দিয়ে হালকা লবণ ছিটা দিয়ে ভেজে দিতে মাকচিনি আঁচলে ২ মিনিট সিদ্ধ করে দিতে হবে।
- ৫। এরপর হলুদ গুড়া, মরিচ গুড়া, মরিচা গুড়া, গরম মসুরা গুড়া জাগো করে মিশিয়ে সিদ্ধ করে দিতে হবে।
- ৬। এবার প্রথমে কাউনের রাসের একটি অংশ দিয়ে তার উপর সিদ্ধ করা সবজির অর্ধেক দিতে হবে।
- ৭। এবার শেঁয়াজ কুচি জাগা উপরে ছিটকে দিয়ে তাকে সেতুল হুপ এবং গরম মসুরা পাউডার দিয়ে ঢেকে দিতে হবে। তাৎপর্য ৫ মিনিট হুপার উপর বেধে দিয়ে গরম গরম পরিবেশন করুন।

বিঃ দ্রঃ কাউন রসে কাউনের তৈরীকরণ সঠিক পরিধারে ঠিকের দিতে হবে।

Picture 11.6.1.: A bird view of recipes made from underutilized crops

### 11.7. Chemical analysis of the tested Multigrain flour (MF)

Wheat is recognized as the second cereal crop in Bangladesh (Hasan *et. al.*, 2008) and 9% of the daily caloric intake derived from wheat (Tama's *et. al.*, 2009). Moreover, every households in urban and pre-urban or even in the village intake wheat flour in preparing 'roti' and many other kinds of food. On the other hand, wheat flour is used to prepare biscuit, cake, puffins, toast, bread, baby formulates, noodles and other confectionary items throughout the country. However, a single grain wheat will not provide healthy nourishment as eaten at least once a day by a majority of the population. For improvement of the nutritive value of the wheat flour to avoid malnutrition and certain disease, an approaches was taken consideration in the study to utilize millets and oil seeds flour mixed with wheat flour. For increasing production areas and popularization of underutilized crops targeted in the project, it is essential to develop nutritious food with low cost and locally available food formulations. Nevertheless, the proximate composition of multigrain flour (MF) presented in the tabular format (Table 11.7.1.), developed under the dimension of the project and analyzed by BCSIR, Dr. Qudrat-E-Khuda Road, Dhaka-1205. According to the result, the moisture content of the MF was 8.50 % whereas in commercial wheat flour it was varied from 9.90% to 12.48% (Saeid *et. al.*, 2015). In the present study, the protein content was found to increase (14.79 %) compare to wheat flour as wheat flour contains 10.32% to 11.58% proteins (Ahmad *et. al.*, 2005). Fat percentage was higher (8.75%) compared to commercial wheat flour as soybean and linseed were included in the multigrain flour. Nevertheless, Reddy (2004) reported that soy flour contained 20-24% of fat, whereas wheat flour contains 0.9-1.1% and most of which are unsaturated in nature. The fiber content of the MF was 7.82%. On the other hand, in commercial wheat flour fiber content was varied from 0.04% to 0.26% (Saeid *et. al.*, 2015) as the fiber content of wheat flour was 0.30% (Ade-Omowaye *et. al.*, 2008). In addition, Horsfall *et. al.*, (2007) observed that the fiber content in wheat flour was 0.82%. The reason behind the caused in increasing fiber contain at multigrain flour might be incorporation of Barley flour. According to Wood (1997), the amounts of dietary fiber ( $\beta$ -glucans and arabinoxylans) are higher in barley, oats and rye compared to wheat (on a dry weight basis, 3-11%, 3-7%, 1-2% and <1%, respectively). According to well-documented studies, it is now accepted that dietary fiber plays a significant role in the prevention of several diseases such as; cardiovascular diseases, diverticulosis, constipation, irritable colon, cancer, and diabetes (Slavin 2005; Chinma and Gernah, 2007; Kamara *et. al.*, 2009; Elleuch *et. al.*, 2011). Moreover, barley and oats are excellent sources of soluble and insoluble dietary fibers, particularly  $\beta$ -glucan, which is reported to lower cholesterol levels (Izydorczyk and Dexte, 2008). Despite fiber contain, the amount of carbohydrate value was lower (58.43%) than wheat flour. According to Meherunnahar *et. al.*, (2018), wheat flour contain 69.64%. Conversely, Singh *et. al.*, (2005) prepared composite flours of foxtail, barnyard and finger millet with wheat flour by adding 10-30% millet flour and observed that addition of milled millet flour to wheat flour increased the concentration of protein, fat and ash but decreased the carbohydrates. Multigrain flour was also rich in iron contain (5.19%). Meherunnahar *et. al.*, (2018) found wheat flour contain 3.39 mg/100g while worked on nutritional and functional Properties of BARI Kaon-2 (Foxtail Millet) with Rice, Wheat and Maize Flour. Additionally, food energy is the amount of caloric value available from food through oxidation. The greatest amount of energy (9 kcal/g) obtained from oxidation of fats while proteins and most carbohydrates have about 4 kcal/g. In the present study, the calorie content of the multigrain flour was 371.63 kcal with the addition of soy flour which contained (Table 2). A similar trend was also reported by Banureka and Mahendran (2009). In a nutshell, multigrain flour made from blended flours of millets, and pulses are rich in nutrients such as protein, vitamins, minerals, and dietary fiber (Kamara *et. al.*, 2009; Indrani *et. al.*, 2011) and meet the

emerging nutritional needs of people in face of preference for modern and healthy food habits for mass feeding and social program (Rao *et. al.*, 2014).

**Table 11.7.1.:** Proximate analysis of multigrain flour

Parameters	Multigrain flour
Moisture (%)	8.50
Ash (%)	1.71
Protein (%)	14.79
Fat (%)	8.75
Fiber (%)	7.82
Iron (mg/100 g)	5.19
Carbohydrate (%)	58.43
Energy (K cal/g)	371.63

### 10.8. Seed-Gene bank

The whole system was illustrated as pictorial format (Picture 10.8.1.). However, the limited resources available for such work make it difficult to implement as well time frame of the project. Furthermore, one field level gene bank was functional and main causes was it situated at FSRD site, BARI, Noakhali, as it was easily monitored and maintained by the PI and other staff of OFRD.



**Picture 10.8.1.:** The whole system of Community Seed-gene bank

## 12. Research highlight/findings (Bullet point – max 10 nos.):

- Among six (06) underutilized crops four (04) crops namely-Proso millet, Safflower, Sorghum and Linseed found more suitable for cultivation in moderate to strong (6.1 to 12 dSm<sup>-1</sup>) saline areas. Barley was suitable for moderate (6.1 to 8 dSm<sup>-1</sup>) saline areas whereas Foxtail millet was found suitable for slightly (4 to 6 dSm<sup>-1</sup>) saline areas.
- Out of twenty seven (27) cropping systems twelve (12) systems found promising for coastal area. Among the cropping systems Linseed (100%)+Mustard(30%) and Linseed (100%)+ Grass pea (30%) are mixed cropping system; Linseed + Safflower (2:1), Sorghum + Grass pea (2:3), Sorghum + Cowpea (2:3), safflower + Linseed (2:2), Safflower + Mustard (2:2), Safflower + Sorghum (1:1), Safflower + Cowpea (2:2), Safflower + Grass pea (2:2) are intercropping systems and Linseed surrounding by safflower, linseed surrounding by mustard are border cropping system found economically viable for scaling up in similar agro-ecological zones.
- Two post-harvest machineries- one for millets dehulling and one multicrops threshing machine were developed through reverse engineering systems.
- Multigrain flour by mixing of two types (02) of millet (Foxtail millet and Proso millet), Barley, Sorghum and two types of oil seed crop (Flax seed and soybean) were prepared which rich in protein, fiber and energy.
- Additionally, twenty four (24) types of food preparation recipe were documented and distributed among the farmers for utilization of underutilized crops.
- Two field level gene bank (one in FSRD site, Subarnachar and other in AO office, Sagarika Samaj Unnayan Sangstha) were established for further utilization of underutilized crops

## 13. References

- Aasim, M., Muhammad, E. U. and Karim, A. 2008. Yield and Competition Indices of Intercropping Cotton (*Gossypium hirsutum* L.) Using Different Planting Patterns. Ankara, Turkey.
- Ade-Omowaye, B. I. O., Akinwande, B. A., Bolarinwa, I. F. and Adebisi, A. O. 2008. Evaluation of Tigernut (*Cyperus esculentus*)-Wheat Composite Flour and Bread, African Journal of Food Science, 2: 87-91.
- Ahmad, I., Ahmad, N., Kausar, T. and Ashraf, M. 2005. Effect of Maltogenic Amylase on the Shelf Life of Bread, Pakistan Journal of Food Science, 15 (3 & 4): 15-19.
- Ajeigbe, H., Oseni, T. and Singh, B. 2006. Effect of Planting Pattern, Crop Variety and Insecticide on the Productivity of Cowpea-Cereal Systems in Northern Guinea Savanna of Nigeria. Journal of Food, Agriculture and Environment. 4 (1): 145-150.
- Alka, P. K., Kumar, A., Masih, S. N. and Shamsheery, A. P. 1981. Tolerance of Some Barely Varieties to Salt Stress at Seedling Stage. Indian Journal of Plant Physiology, 24: 304-311.
- Allison, M. A., Khan, S. R., Goodbred Jr., S. L. and Kuehl, S. A. 2003. Stratigraphic Evolution of the Late Holocene Ganges–Brahmaputra Lower Delta Plain. Sedimentary Geology, 155 (3 & 4): 317-342.
- Amin, M., Bhuiyan, M. S., Faisal, A. H. M. A., Farhad, I. S. M. and Rahman, M. A. 2011. Crop Adaptation in Saline Soils of Noakhali: I. Crop Performance. Bangladesh Agronomy Journal, 14 (1 & 2): 43-52.
- Arya, R. L., Niranjana, K. P., Singh, A. and Singh, J. B. 2000. Effect of Manurial Schedules on Growth and Yield of Different Cropping Systems under Rainfed Alley System. Indian Journal of Agronomy, 45 (4): 687-692.
- Asiatic Society of Bangladesh. 2003. Banglapedia, National Encyclopedia of Bangladesh. Dhaka, Bangladesh.

- Aufhammer, W., Wagner, W., Kaul, H. P. and Kubler E. 2000. Radiation Use by Oil Seed Crops - A Comparison of Winter Rape, Linseed and Sunflower. *Journal of Agronomy and Crop Science*, 184: 277-286.
- Awal, M. A., Pramanik, M. H. R. and Hossen, M. A. 2007. Interspecies Competition, Growth and Yield in Barley-Peanut Intercropping. *Asian Journal of Plant Science*, 6: 577-584.
- Ayers, R. S. and Westcot, D. W. 1976. Water Quality for Agriculture. Irrigation and Drainage Paper No. 29. Food and Agriculture Organization (FAO), Rome, Italy.
- Banureka, V. and Mahendran, T. 2009. Formulation of Wheat-Soybean Biscuits and their Quality Characteristics. *Tropical Agricultural Research and Extension*, 12 (2): 62-66.
- Bassey, M. W. and Mbengue, H. M. 1993. Performance of Abrasive Disk Dehullers. *Journal of Engineering for International Development*, 1 (1):27-35.
- Bassil, E. S. and Kaffka, S. R. 2001. Response of Safflower to Saline Soils and Irrigation: II. Crop Response to Salinity. *Agricultural Water Management*, 54: 81-92.
- Beke, G. J. and Volkmar, K. M.1995. Mineral Composition of Flax (*Linum usitatissimum* L.) and Safflower (*Carthamus tinctorius* L.) on a Saline Soil High in Sulfate Salts. *Canadian Journal of Plant Science*, 75 (2): 399-404.
- Cash, D., Johnson, D. and Wichman, D. 2002. Growing Millet in Montana. Montana State University Extension Service. Retrieved from <http://www.co.yellowstone.mt.gov/extension/ag/pubs/millet.pdf> (accessed on 30<sup>th</sup> July, 2018).
- Changmei S., Dorothy J. 2014. Millet-The Frugal Grain. *International Journal of Scientific Research and Reviews*, 3: 75-90.
- Char Development and Settlement Project Phase IV- At a Glance. 2012. Char Development and Settlement Project IV- Bangladesh Water Development Board (BWDB) Office, Dhaka, Bangladesh. Retrieved from <http://www.cdsp.org.bd/documents> (accessed on 7<sup>th</sup> February, 2017).
- Chimonyo, V. G. P., Modi, A. T. and Mabhaudhi, T. 2016. Water Use and Productivity of a Sorghum-Cowpea-Bottle Gourd Intercrop System. *Agricultural Water Management*, 165:82-96.
- Chinma, C. E. and Gernah, D. I. 2007. Physicochemical and Sensory Properties of Cookies Produced from Cassava/Soybean/Mango Composite flours. *Journal of Food Technology*, 5 (3): 256-260.
- Coleman, J. M. 1969. Brahmaputra River: Channel Processes and Sedimentation. *Sedimentary Geology*, 3 (2 & 3): 129-239. doi: 10.1016/0037-0738(69)90010-4.
- Darabad, R. G., kandi, M. A. S., Barmaki, M., Sharifi, R. S., Hokmalipour, S. and Asadi, S. 2011. Evaluation of Yield and Yield Components in Potato-Safflower Intercropping. *Australian Journal of Basic and Applied Sciences*, 5 (11): 1423-1428.
- Dayakar, R. B., Vishala, A. D., Arlene, C. G. D., and Tonapi, V. A. 2016. Millet Recipes, a Healthy Choice, ICAR-Indian Institute of Millets Research, Rajendranagar, Hyderabad, India.
- Delesa, A. and Choferie, A. 2015. Response of Linseed (*Linum usitatissimum* L.) to Seed Rates and Seeding Methods in South-Eastern Highlands of Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 5 (13): 218-223.
- Dhima, K. V., Lithourgidis, A. A., Vasilakoglou, I. B. and Dordas, C. A. 2007. Competition Indices of Common Vetch and Cereal Intercrops in Two Seeding Ratio. *Field Crop Research*, 100: 249-256.
- Dubey, R. S. 1994. Protein Synthesis by Plants under Stressful Conditions. In: M. Pessaraki (Ed.), *Handbook of plant and crop stress* (2<sup>nd</sup> Edition). Marcel Dekker, Inc., New York, USA. pp. 365-388.

- El Naim, A., Kilali, A., Baballa, E., Hassan, A. and Ahmed, M. 2013. Agronomic Evaluation of Sorghum and Cowpea Intercropped at Different Spatial Arrangements. *Journal of Renewable Agriculture*. 1: 11-15.
- Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C. and Attia, H. 2011. Dietary Fibre and Fibre-Rich By-Products of Food Processing: Characterization, Technological Functionality and Commercial Applications: A Review. *Food Chemistry*, 124 (2): 411-421.
- Food and Agriculture Organization (FAO). 2001. Millet: Post-harvest Operations. Food and Agriculture Organization of United Nations. Rome, Italy. Retrieved from [www.fao.org/3/a-av009e.pdf](http://www.fao.org/3/a-av009e.pdf) (accessed 14<sup>th</sup> October, 2017).
- Francois, L. E. and Bernstein, L. 1964. Salt Tolerance of Safflower. *Agronomy Journal*, 56: 38-40.
- Ghosh, P. K. 2004. Growth, Yield, Competition and Economics of Groundnut/Cereal Fodder Intercropping Systems in the Semi-Arid Tropics of India. *Field Crops Research*, 88: 227-237.
- Ghosh, P. K., Tripathik, A.K., Bandyopadhyay, K. K. and Manna, M. C. 2009. Assessment of Nutrient Competition and Nutrient Requirement in Soybean/Sorghum Intercropping System. *European Journal of Agronomy*, 31 (1): 43-50.
- Gobade, S. M., Patil, C. B. and Gokhale, D. N. 2015. To Quantify Production Potential of Non-Spiny Safflower to Other Rabi Crop and Intercropping System. *National Academy of Agricultural Sciences*, 22 (5): 1087-1089.
- Goodbred Jr., S. L. and Kuehl, S. A. 2000. Enormous Ganges-Brahmaputra Sediment Discharge during Strengthened Early Holocene Monsoon. *Geology*, 28: 1083-1086.
- Grieve, C. M., Grattan, S. R., Mass, E. V. 2012. Plant Salt Tolerance. In: W.W. Wallender and K.K. Tanji (Eds.), *Agricultural Salinity Assessment and Management (2<sup>nd</sup> Edition)*. ASCE Manual and Reports on Engineering Practice No. 71, ASCE, Reston, Virginia, USA. pp. 405-459.
- Gupta, A. 2007. *Large Rivers Geomorphology and Management*. John Wiley & Sons, Ltd., Atrium, Southern Gate, Chichester, England. pp. 1- 689.
- Hasan, M. N., Miah, M. A. M., Islam, M. S., Alam, Q. M. and Hossain, M. I. 2008. Change and Instability in Area and Production of Wheat and Maize in Bangladesh. *Bangladesh Journal of Agricultural Research*, 33: 409-417.
- Hassan F. U. and Leitch, M. H. 2000. Influence of Seeding on Contents and Uptake of N, P and K in Linseed (*Linum usitatissimum* L.). *Journal of Agronomy and Crop Science*, 185: 193-199.
- Hegde, D. M. and Koli, B. D. 1997. Productivity and Economics of Intercropping Systems Involving Safflower under Rainfed Conditions. In: A. Corleto and H. H. Mündel (Eds.), *Proceedings of the 4<sup>th</sup> International Safflower Conference, 2-7<sup>th</sup> June, 1997. Bari, Italy*, pp. 56-57.
- Hiebsch, C. K. and McCollum, R. E. 1987. Area-x-time Equivalency Ratio: A Method for Evaluating the Productivity of Intercrops. *Agronomy Journal*, 79: 15-22.
- Horsfall, D. M., Eboh, L. and Nwaojigwa, S. U. 2007. Chemical Composition, Functional and Baking Properties of Wheat-Plantain Composite Flours. *African Journal of Food, Agriculture, Nutrition and Development*, 7 (1): 1684-5374.
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 2016. *Smart Food Millet Recipes*. ICRISAT, Patancheru, Telangana, India.
- Igartua, E., Gracia, M. P. and Lasa, J. M. 1995. Field Responses of Grain Sorghum to a Salinity Gradient. *Field Crops Research*, 42(1): 15-25.

- Imran, M., Ali, A., Waseem, M., Tahir, M., Ullah, A., Shehzad Mohsin, A. and Ghaffari, H. R. 2011. Bio-economic Assessment of Sunflower-Mungbean Intercropping System at Different Planting Geometry. *International Research Journal of Agricultural Science and Soil Science*, 1: 126-136.
- Indrani, D., Swetha, P., Chandrashekhar, S., Rajiv, J. and Rao, G. V. 2011. Effect of Multigrains on Rheological, Microstructural and Quality Characteristics of North Indian Parotta-an Indian Flat Bread. *LWT- Food Science and Technology*, 44 (3): 719-724.
- Iqbal, M. A., Bethune, B. J., Asif, I., Rana, N. A., Zubair, A., Haroon, Z. K. and Bilal, A. 2017. Agro-botanical Response of Forage Sorghum-Soybean Intercropping Systems under a Typical Spatial-Temporal Pattern. *Pakistan Journal of Botany*, 49: 987-994.
- Iqbal, M. A., Hamid, A., Hussain, I., Siddiqui, M. H., Ahmad, T., Khaliq, A. and Ahmad, Z. 2019. Competitive Indices in Cereal and Legume Mixtures in a South Asian Environment. *Agronomy Journal*. 111: 242-249.
- Iqbal, N., Ashraf, H. Y., Javed, F., Iqbal, Z. and Shah, G. H. 1998. Effect of Salinity on Germination and Seedling Growth of Wheat (*Triticum aestivum* L.). *Pakistan Journal of Biological Sciences*, 1: 226-227.
- Izydorczyk, M. S. and Dexte, J. E. 2008. Barley  $\beta$ -Glucans and Arabinoxylans: Molecular Structure, Physicochemical Properties, and Uses in Food Products- a Review. *Food Research International*, 41 (9): 850-868.
- Jalilian, J., Najafabadi, A. and Zardashti, M. R. 2017. Intercropping Patterns and Different Farming Systems affect the Yield and Yield Components of Safflower and Bitter Vetch, *Journal of Plant Interactions*, 12 (1): 92-99.
- Jamshidi, A. and Javanmard, H. R. 2017. Evaluation of Barley (*Hordeum vulgare* L.) Genotypes for Salinity Tolerance under Field Conditions using the Stress Indices. *Ain Shams Engineering Journal* 9 (4): 2093-2099.
- Javanmard, A., Dabbagh, M. A., Nasab, A., Javanshir, A., Moghaddam, M. and Janmohammandi, H. 2009. Forage Yield and Quality in Intercropping of Maize with Different Legumes as Double-Cropped. *Journal of Food, Agriculture & Environment*, 7: 163-166.
- Kaankuka, T. K. 2015. Comparative Performance Evaluation of an Existing and Modified Acha (Fonio Millet) Dehullers. *Global Journal of Engineering Research*, 14: 9-15.
- Kamara, M. T., Ming, Z. H. and Kexue, Z. 2009. Comparative Study of Chemical Composition and Physicochemical Properties of Two Varieties of Defatted Foxtail Millet Flour (*Setaria italic* L.) Grown in China. *Asian Journal of Biochemistry*, 4: 88-98.
- Kar, G., Kumar, A. and Martha, M. 2007. Water use Efficiency and Crop Coefficients of Dry Season Oilseed Crops. *Agricultural Water Management*, 87: 73-82.
- Kazemini, A. and Sadeghi, H. 2012. Reaction of the Green Bean-Safflower Intercropping Patterns to Different Nitrogen Fertilizer Levels. *Iran Agricultural Research*, 31: 13-22.
- Kohnaward, P., Jalilian, J. and Pirzad, A. 2012. Effect of Foliar Application of Micronutrients on Yield and Yield Components of Safflower under Conventional and Ecological Cropping Systems. *International Research Journal of Applied and Basic Sciences*, 3: 1460-1469.
- Krantz, B. A., Virmani, S. M., Singh, S. and Rao, M. R. 1976. Intercropping for Increased and More Stable Agricultural Production for Semi-Arid Tropics. In: J. H. Monyo, A. D. R. Ker, M. Campbell (Eds.), *Report of Intercropping in Semi-Arid Areas Symposium, 10-12<sup>th</sup> May, 1976*. Faculty of Agriculture, Forestry and Veterinary Science, University of Dar es Salaam, Morogoro, Tanzania and IDRC, Ottawa, Canada.

- Krishnamurthy, L., Reddy, B. V. S. and Serraj, R. 2003. Screening Sorghum Germplasm for Tolerance to Soil Salinity. *International Sorghum and Millets Newsletter*, 44: 90-92.
- Krishnamurthy, L., Serraj, R., Hash, C. T., Abdullah, E., Dakheel, J. and Reddy, B. V. S. 2007. Screening Sorghum Genotypes for Salinity Tolerant and Biomass Production. *Euphytica*, 156: 15-24.
- Krishnamurthy, L., Upadhyaya H. D., Gowda, C. L. L., Kashiwagi, J., Purushothaman, R., Singh, S. and Vadez, V. 2014. Large Variation for Salinity Tolerance in the Core Collection of Foxtail Millet (*Setaria italica* (L.) P. Beauv.) Germplasm. *Crop and Pasture Science*, 65 (4): 353-361.
- Li, H. 1993. An Experiment of Intercropping Maize with Safflower (*Carthamus tinctorius* L.). In: Dajue, L. and Yuanzhou, H. (Eds.), *Proceedings of the Third International Safflower Conference, 14-18<sup>th</sup> June, 1993*. Chinese Academy of Sciences, Beijing, China. pp. 520-526.
- M. S. Swaminathan Research Foundation (MSSRF). 2001. *Community Grain Bank: an Instrument for Local Food Security*. M. S. Swaminathan Research Foundation, Chennai and World Food Programme, New Delhi, India. pp. 1-181.
- Macharia, J. M., Kamau, J., Gituanja, J. N. and Matu, E. W. 1994. Effects of Sodium Salinity on Seed Germination and Seedling Root and Shoot Extension of Four Sorghum [*Sorghum bicolor* (L.) Moench] Cultivars. *International Sorghum and Millets Newsletter*, 35:124-125.
- Mahmoud, M. A. A., El-Sharabasy M. A. M. and Khattab, M.A. K. 2007. Development of Feeding Device in a Turkish Threshing Machine. *Misr Journal of Agricultural Engineering*, 24 (2): 235-258.
- Mainuddin, M., Rawson, H. M., Poulton, P. L., Ali, R., Roth, C., Islam, K. M., Saifuzzaman, M., Rahman, M. M., Quader, M. E., Shah-Newaz, S. M. and Sarker, M. H. 2013. Scoping Study to Assess Constraints and Opportunities for Future Research into Intensification of Cropping Systems in Southern Bangladesh. Australian Centre for International Agricultural Research, Canberra, Australia.
- Maiti, R. K., Rosa, de. Ia. and Laura, A. 1994. Evaluation of Several Sorghum Genotypes for Salinity Tolerance. *International Sorghum and Millets Newsletter*, 35: 121.
- Mead, R. and Willey, R. W. 1980. Yield Advantages in Intercropping and the Land Equivalent Ratio Concept. *Experimental Agriculture*, 16: 217-228.
- Meherunnahar, M., Chowdhury, R. S., Hoque, M. M., Satter, M. A. and Islam, M. F. 2018. Comparison of Nutritional and Functional Properties of BK2 Foxtail Millet with Rice, Wheat and Maize Flour. *Progressive Agriculture*, 29 (2): 186-194.
- Mishram, T. N. and K. Desta. 1990. Development and Performance Evaluation of a Sorghum Thresher. *Journal of Agricultural Mechanization in Asia, Africa and Latin America*, 21 (3): 33-37.
- Mündel, H. H., Morrison, R. J., Blackshaw, R. E. and Roth, B. 1992. Safflower Production on the Canadian Prairies. Lethbridge Research and Development Center, Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada. pp. 1-35.
- Mündel, H. H., Riverland, N. and Tanaka, D. L. 1997. Safflower Agro-production I: Yield. In: A. Corleto and H. H. Mündel (Eds.), *Proceedings of the Fourth International Safflower Conference, 2-7<sup>th</sup> June, 1997*. Bari, Italy. pp. 47-55.
- Nagy, Z., Tuba, Z., Zsoldus, F. and Erdei, L. 1995. CO<sub>2</sub> Exchange and Water Retention Responses of Sorghum and Maize during Water and Salt Stress. *Journal of Plant Physiology*, 145: 539-544.
- Nikan, S. M., Tendulkar, A. V., and Deokar, A. B. 1987. Production Potential of Safflower-Chickpea Intercropping Under Rain-fed Conditions. *Indian Journal of Agricultural Science*, 57 (3): 151-156.
- Oelke, E. A., Oplinger, E. S., Putnam, D. H., Durgan, B. R., Doll, J. D. and Undersander, D. J. 1990. Millets, in *Alternative Field Crops Manual*. University of Wisconsin Madison Extension Services, University of

Minnesota Extension Services and University of Minnesota Confidential Peer Assistance Program (CAPAP). Minneapolis, USA.

- Oomah, B. D. 2001. Flaxseed as a Functional Food Source. *Journal of the Science of Food and Agriculture*, 81: 889-894.
- Oseni, T. O. 2010. Evaluation of Sorghum-Cowpea Intercrop Productivity in Savanna Agro-ecology using Competition Indices. *Journal of Agricultural Science*. 2 (3): 229-234.
- Osman A. N., Raebild, A., Christiansen, J. L. and Bayala, J. 2011. Performance of Cowpea (*Vigna unguiculata*) and Pearl Millet (*Pennisetum glaucum*) Intercropped under *Parkia biglobosa* in an Agroforestry System in Burkina Faso. *African Journal of Agricultural Research* 6 (4): 882-891.
- Pal, U. R. and Sheshu, Y. 2001. Direct and Residual Contribution of Symbiotic Nitrogen Fixation by Legumes to the Yield and Nitrogen Uptake of Maize (*Zea mays* L.) in the Nigerian Savannah. *Journal of Agronomy and Crop Science*, 187: 53-58.
- Rao, B. D., Kalpana, K., Srinivas, K. and Patil, J. V. 2014. Development and Standardization of Sorghum-Rich Multigrain Flour and Assessment of Its Storage Stability with Addition of TBHQ. *Journal of Food Processing and Preservation*, 39 (5): 451-456.
- Reddy, B. V. S., Kumar, A. A., Reddy, P. S., Ibrahim, M., Ramaiah, B., Dakheel, A. J., Ramesh, S. and Krishnamurthy, L. 2010. Cultivar Options for Salinity Tolerance in Sorghum. *Journal of SAT Agricultural Research*, 8: 1-5.
- Reddy, B. V. S., Ramesh, S., Reddy, P. S. and Kumar, A. A. 2009. Genetic Enhancement for Drought Tolerance in Sorghum. *Plant Breeding Reviews*, 31: 189-222.
- Reddy, S. R. 2004. *Agronomy of Field Crops: Soybeans*. Kalyani Publishers, Ludhiana, India. pp. 143-513.
- Riley, K. W., Setharam A., Harinarayana G. 1989. Recommendations on Breeding and Varietal Improvement. In: *Proceedings of the First International Small Millets in Global Agriculture Workshop*, 29<sup>th</sup> October to 2<sup>th</sup> November, 1986, Bangalore, India. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, p. 29.
- Rohini, V. K. and Sankara, K. R. 2000. Embryo Transformation, a Practical Approach for Realizing Transgenic Plants of Safflower (*Carthamus tinctorius* L.). *Annals of Botany*, 86: 1043-1049.
- Saballos, A. 2008. Development and Utilization of Sorghum as a Bioenergy Crop. In: W. Vermerris (Ed.), *Genetic Improvement of Bioenergy Crops*, Springer-Verlag, New York, USA. pp. 211-248.
- Saeid, A., Hoque, S., Kumar, U., Das, M., Muhammad, N., Rahman, M. M. and Ahmed, M. 2015. Comparative Studies on Nutritional Quality of Commercial Wheat Flour in Bangladesh. *Bangladesh Journal of Scientific and Industrial Research*, 50(3): 181-188
- Saini, H. S. and Westgate, M. E. 1999. Reproductive Development in Grain Crops during Drought. *Advances in Agronomy*, 68: 59-96.
- Saleh, A. S. M., Zhang, Q., Chen, J. and Shen, Q. 2013. Millet Grains: Nutritional Quality, Processing, and Potential Health Benefits. *Comprehensive Reviews in Food Science and Food Safety*, 12(3): 281- 295.
- Sawant, A. R., Deshpande, S. L. and Nadkarni, P. G. 1993. Safflower Intercropping in Gram and Linseed. In: *Proceedings of the Third International Safflower Conference*, Dajue, L. and Yuanzhou, H. (Eds.), Beijing, China, Chinese Academy of Sciences, June 14-18, pp.: 646-651.
- Shahid, M. and Jaradat, A. A. 2013. Barley: A salt tolerant cereal crop. *Biosalinity News*, 14(1): 3-4.
- Shrestha, P., Subedi, A., and Sthapit, B. R. 2013. Enhancing Awareness of the Value of Local Biodiversity in Nepal, In: W. S. de Boef, A. Subedi, N. Peroni, M. H. Thijssen and E. O'Keeffe (Eds.), *Community Biodiversity Management: Promoting Resilience and the Conservation of Plant Genetic Resources*, Earthscan from Routledge, London, UK, pp. 72-76.

- Singh, P., Singh, G., Srivastava, S. and Agarwal, P. 2005. Physico-Chemical Characteristics of Wheat Flour and Millet Flour Blends. *Journal of Food Science and Technology*, 42(4): 340-343.
- Singh, R. K., Kumar, H. and Singh, A. K. 2010. Brassica Based Intercropping Systems - A Review. *Agricultural Review*, 31(4):253-266
- Singh, S. P. and Ahuja, K. N. 1990. Intercropping Grain Sorghum with Fodder Legume under Dry land Condition of North-West India. *Indian Journal of Agronomy*, 35(3): 287-296.
- Slavin, J. L. 2005. Dietary Fiber and Body Weight. *Nutrition*, 21(3):411-418
- Spollen, W., Sharp, R., Saab, I. and Wu, Y. 1993. Regulation of Cell Expansion in Roots and Shoots at Low Water Potentials. In: *Water Deficits: Plant Responses from Cell to Community*, J.A.C. Smith and H. Griffiths (Eds.). BIOS Scientific Publishers, Oxford.pp.37-52.
- Steiner, K. G. 1982. Intercropping in Tropical Smallholder Agriculture with Special Reference to West Africa. *Schriftenreihe der GTZ, Monographic Series No. 137*, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eischbon, Germany. pp. 235-250
- Sthapit, B., Rana, R. B., Subedi, A., Gyawali, S., Bajracharya, J., Chaudhary, P., Joshi, B. k., Sthapit, S., Joshi, k. D., and Upadhyay, M. P. 2006. Participatory Four Cell Analysis (FCA) for Local Crop Diversity, In: *Good Practices: On-Farm Management of Agricultural Biodiversity in Nepal* by B. R. Sthapit, P. k. Shrestha, and M. P. Upadhyay (Eds.), NARC, LI-BIRD, IPGRI and IDRC.
- Stoop, W. A. 1987. Adaptation of Sorghum/Maize and Sorghum/Pearl Millet Intercrop Systems to the Toposequence Land Types in the North Sudanian Zone of the West African Savanna. *Field Crop Research*, 16(3): 255-272.
- Tama's, C., Kisgyo'rgy, B. N., Rakszegi, M., Wilkinson, M. D., Yang, M., La'ng, L., Tama's, L. and Bedo, Z. 2009. Transgenic Approach to Improve Wheat (*Triticum aestivum* L.) Nutritional Quality. *Plant cell Reports*, 28(7): 1085-1094.
- Taylor, J. R. N., and Duodu, K. G. 2015. Effects of Processing Sorghum and Millets on their Phenolic Phytochemicals and the Implications of this to the Health-Enhancing Properties of Sorghum and Millet Food and Beverage Products. *Journal of the Science of Food and Agriculture*, 95(2):225- 237.
- Uddin, M. K. B., Naznin, S., Kawochar, M. A., Choudhury, R. U. and Awal, M. A. 2014. Productivity of Wheat and Peanut in Intercropping System. *Journal of Experimental Biosciences*, 5(2): 19-26.
- Ukatua, A. C. 2006. A Modified Threshing Unit for Soyabeans. Department of Agricultural Engineering, University of Agriculture, PMB 2240, Abeokuta, Ogun State, Nigeria. 95(5):371-377.
- Verma, S. P. and Modgal, S. C.1983. Production Potential and Economics of Fertilizer Application as Resources Constraints in Maize, Wheat Crop Sequence. *Himachal Journal of Agricultural Research*, 9(2): 89-92.
- Verma, S. S., Singh, A., and Shahi, N. C. 2014. Response Surface Methodology for Selection of Machine Parameters for Enhancing Pearling Efficiency of Finger Millet Dehuller-Cum-Pearler. *International Journal of Science and Research*, 3(10): 1469-1472.
- Weiss, E. A. 1971. *Castor, Sesame and Safflower*. Barnes and Nobles, New York, USA. pp. 311-525.
- Weiss, E. A. 1983. *Oilseed Crops*. Longman Group Limited, Longman House, London, United Kingdoms (UK), pp.:216-281.
- Willey, R. W. 1985. Evaluation and Presentation of Intercropping Advantages. *Experimental Agriculture*, 21: 119-133.
- Willey, R. W. and Rao, M. R. 1980. A Competitive Ratio for Quantifying Competition between Intercrops. *Experimental Agriculture*, 16: 117-125.

- Wood, P. 1997. Functional Foods for Health: Opportunities for Novel Cereal Processes and Products. In: Cereals Novel Uses and Processes by Campbell, G. M., Webb, C. and McKee, S. L. (Eds.), Plenum Press, New York, pp.: 233-239.
- Yang, Y. and Chen, Y. 1993. Cultivation Technique of Safflower in North Western Region of Liaoning. In: Proceedings of the Third International Safflower Conference, Dajue, L. and Yuanzhou, H. (Eds.), Beijing, China, Chinese Academy of Sciences, June 14-18, pp.:762-777.
- Yau, S. K. 2004. Safflower Agronomic Characters, Yield and Economic Revenue in Comparison with Other Rainfed Crops in a High Elevation, Semiarid Mediterranean Environment. *Experimental Agriculture*, 40:453-462.d
- Zafaranih, M. 2015. Effect of Various Combinations of Safflower and Chickpea Intercropping on Yield and Yield Components of Safflower. *Agriculture Science Developments*, 4:31-34.
- Zheng, Y., Zhao, Z. and Dongru, G. 1993. Safflower Intercropping Systems. In: Proceedings of the Third International Safflower Conference, Dajue, L. and Yuanzhou, H. (Eds.), Beijing, China, Chinese Academy of Sciences, June 14-18, pp.: 778-782.
- Zougmore, R., Kambou, F. N., Ouattara, K. and Guillobez, S. 2000. Sorghum-Cowpea Intercropping: An Effective Technique against Runoff and Soil Erosion in the Sahel (Saria, Burkina Faso). *Arid Soil Research and Rehabilitation*, 14:329-342.

## **B. Implementation Position**

### **1. Procurement:**

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	1)Laptop 2)Laser printer	1)60000 2)20000	1)Laptop 2)Laser printer	1)60000 2)20000	
(b) Lab &field equipment	1)EC Meter 2)Moisture Meter 3)PH meter 4)Distil water 5)Threshing machine	1) 60000 2)12000 3)24000 4)7500 5)150000	1)EC Meter 2)Moisture Meter 3)PH meter 4)Distil water 5)Threshing machine	1) 60000 2)12000 3)24000 4)7500 5)108942	
(c) Other capital items					

### **2. Establishment/renovation facilities:**

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

### **3. Training/study tour/ seminar/workshop/conference organized:**

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training (02)	18X2=36		36	1 (for each training)	2training were organized
(b) Workshop					N/A

**C. Financial and physical progress****Fig in Tk**

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	248328	216824	216824	00	100	
B. Field research/lab expenses and supplies	576088	576087	576087	00	100	
C. Operating expenses	230014	230491	229811	680	99.70	
D. Vehicle hire and fuel, oil & maintenance	100855	100855	100855	00	100	
E. Training/workshop/seminar etc.	50000	50000	50000	00	100	
F. Publications and printing	71970	14971	14971	00	100	
G. Miscellaneous	10303	7803	7803	00	100	
H. Capital expenses	212442	212442	212442	00	100	

#### **D. Achievement of Sub-project by objectives: (Tangible form)**

<b>Specific objectives of the sub-project</b>	<b>Major technical activities performed in respect of the set objectives</b>	<b>Output(i.e. product obtained, visible, measurable)</b>	<b>Outcome(short term effect of the research)</b>
To increase crop diversification and cropping intensity by introducing and cultivation of newly developed high yielding varieties of underutilized crops (Barley, Foxtail millets, Proso millet, Sorghum, Safflower and Linseed) as well as collection and evaluation of local planting materials available in other areas.	Collection of varieties/advanced lines/germplasms/ cultivars from Plant breeding division, Plant Genetic Resource Center, BARI, Gazipur; Bangladesh Livestock Research Institute, Savar; On-Farm Research Division, Shylet, Patuakhali & Bandarban.	A total of fifteen (15) varieties included exotic variety, eight (08) advanced line, twenty (20) Germplasms and nine (09) cultivars of six (06) underutilized crops were collected from different Research Organizations and farmers.	All the materials were included in the researcher led participatory variety selection trials.
To concentrate on developing a suitable management system for untested saline fallow lands in coastal char area which not yet go through this practice.	Conduction of researcher led participatory variety selection trials where line sowing, IPNS and IPM approaches were included. Moreover, different cropping system such as mixed cropping, intercropping and border cropping were included.	Eighteen (18) researcher led participatory variety selection trials were conducted. Twenty seven cropping system were also evaluated.	Among six (06) underutilized crops four (04) crops namely-Proso millet, Safflower, Sorghum and Linseed found more suitable for cultivation in moderate to strong (6.1 to 12 dSm <sup>-1</sup> ) saline areas. Barley was suitable for moderate (6.1to 8 dSm <sup>-1</sup> ) saline areas whereas Foxtail millet was found suitable for slightly (4 to 6 dSm <sup>-1</sup> ) saline areas. Out of twenty seven (27) cropping systems twelve (12) systems found promising for coastal area. Among the cropping systems Linseed (100%)+Mustard(30%) and Linseed (100%)+ Grass pea (30%) are mixed cropping system; Linseed + Safflower (2:1), Sorghum + Grass pea (2:3), Sorghum + Cowpea (2:3), safflower + Linseed (2:2), Safflower + Mustard (2:2), Safflower + Sorghum (1:1), Safflower + Cowpea (2:2), Safflower + Grass pea (2:2) are intercropping systems and Linseed surrounding by safflower, linseed surrounding by mustard are border cropping system found economically viable for scaling up in similar agro-ecological zones.
To develop suitable post-harvest machineries for using household level and prepare different kinds of food products, assess their quality and make it familiar with consumer level through active participation of farmers.	Dehuller and multicrops threshing machine development. Recipe development Multigrain atta by mixing of four types (04) of millet (Foxtail millet, Proso millet, Barley, Sorghum) and two types of oil seed crops (Flax seed and soybean) were prepared and chemical analysis was done	Two dehuller machine and one multicrops thresher were developed through reverse engineering Multigrain flour which rich in protein, fiber and energy. Twenty four (24) types of food preparation recipe were documented and distributed among the farmers for utilization of underutilized crops.	Farmers can dehusk millets like foxtail and proso millet and also barley can be threshed by multicrops thresher. Farmers could adept more recipes to prepare diversify foods from the underutilized crops. Value added food products may be developed from the underutilized crops.

**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.			
Journal publication	Will be published		Prospects of underutilized crops cultivation in follow moderate and strong saline lands in the coastal saline areas of Noakhali
Information development	Twenty four (24) food recipes from underutilized crops		
Other publications, if any			

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

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

Value added product could be developed from the underutilized crops which further needed to be analysed and prepared bakery items such as biscuits, breads and cakes, etc.

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

Crops were identified for cultivation in moderately to strong saline soils which should be scaling up in the saline areas of Bangladesh with proper management practices.

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

Farmers of similar saline ecosystems of Bangladesh will be enabled to cultivate underutilized crops in their saline fallow lands with minimum inputs for increasing productivity as well as income. Moreover, postharvest operation will be easier by using the machineries developed under the project.

#### **iv. Policy Support**

- The machineries developed under the project period needs to be evaluated in the larger dimension as well as fine tuning and continuous modification of the machineries is essential to create employment opportunity in such type of environmental hash areas.
- Scaling up of the promising underutilized crops in the similar agro ecological zone.

#### **G. Information regarding Desk and Field Monitoring**

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

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

Field monitoring was done by two members from Crop Division (PSO), BARC during 01-02 February, 2018 for evaluating the activities accomplished from 25/05/2017 to 31/01/2018 period. Moreover, Director from Research Wing of BARI along with CSO and PSO from OFRD, BARI, Gazipur visited the experimental sites during 23 to 24 April, 2018 and expressed their continues support for undertaking such types of underutilized crops research activities. Furthermore, respected Upazilla Agriculture Officer and SAO from DAE, Agriculture Officer from different NGOs as well as adjacent farmers visited trials plot to know more about the potentiality of the underutilized crops. In general, PI, Co-PI and Scientific Assistant visited the experimental sites frequently to collect data and observing other farmers attitude towards underutilized crops.

#### **I. Lesson Learned/Challenges (if any)**

Long duration crops may be damaged due to natural hazards such early storm during crop maturation period whereas short duration crops like Proso millet and flaxseed could be easily grown in this areas. Moreover, drought and saline tolerant crops like safflower and sorghum might be feasible to fit into Fallow-Fallow-T. Aman cropping pattern. Duration of the project was the major challenges for conducting such type of research activities. However, manpower and other logistic support was limited.

#### **J. Challenges (if any)**

Widely field testing of the developed machineries in the project period and fine tuning based on the client feedback. On the other hand, Seed- Gene bank may not be functional due to various reason such as short duration of the project, marketing facilities of the underutilized crops and aggressiveness of the cash crops or lack of co-ordination among the farmers after completion of the project. However, scaling up of the production of the underutilized crops was not possible within the short period of time. Government and other development agencies should focused on this issues as underutilized crops known to as climate smart crops which have the potentiality of feed the future. Last but not least, it is possible to prepare value added product from underutilized crops which was not possible within the time frame. Moreover, the mentioned crops has the potential for type II diabetic patients' food as well as cardiovascular diseases patients. In this circumstances, taking up client oriented researches to address the research findings and gaps mentioned above are necessary steps to combat with climate change and poverty in the saline prone areas.

Signature of the Principal Investigator

Date .....

Seal

Counter signature of the Head of the  
organization/authorized representative

Date .....

Seal